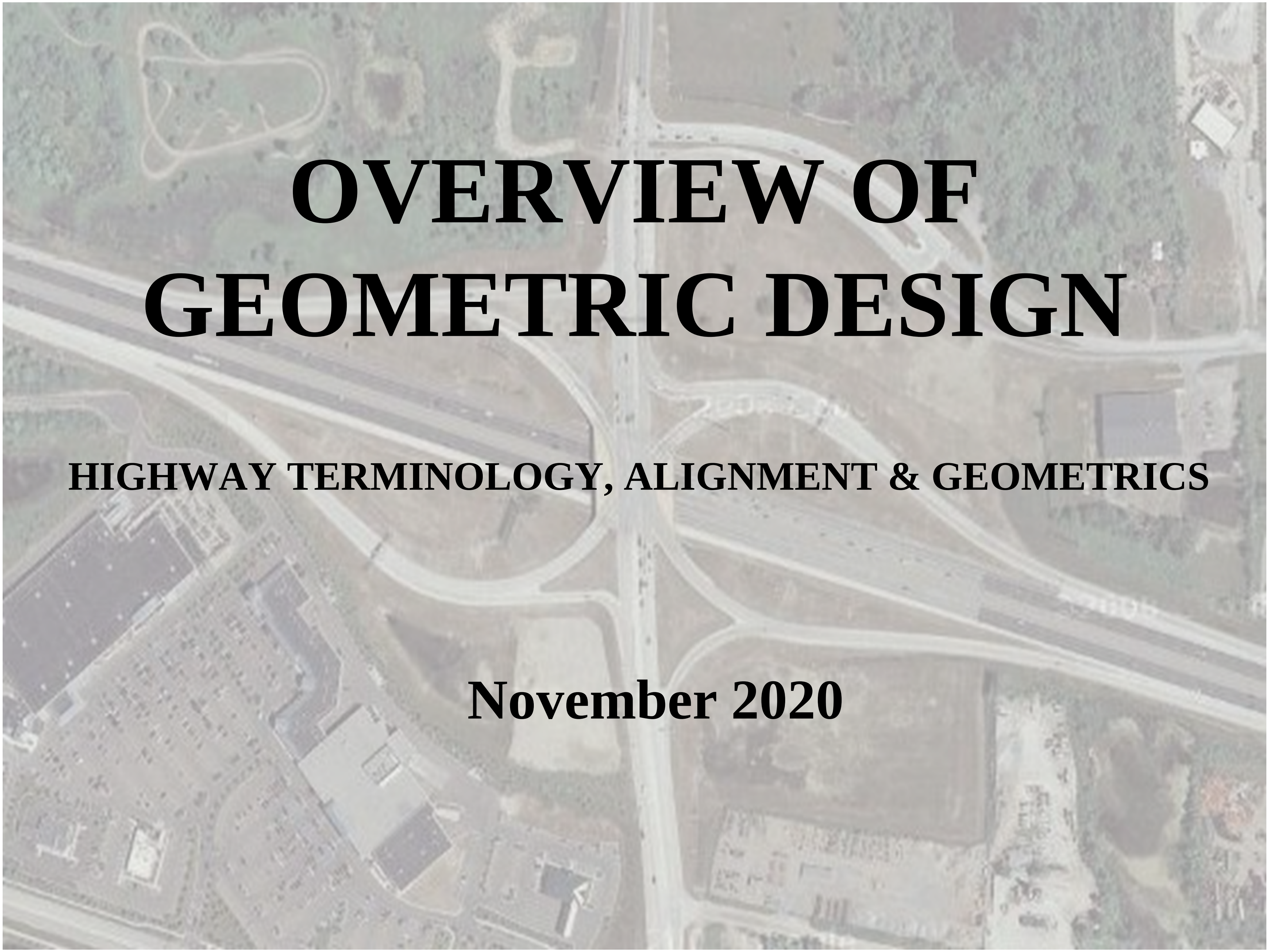


OVERVIEW OF GEOMETRIC DESIGN

HIGHWAY TERMINOLOGY, ALIGNMENT & GEOMETRICS

November 2020

Class Instructors

- Mark Fisher, Engineer – Geometrics Unit

  fisherm@michigan.gov; (517) 335-1204

- William Taylor, Engineer – Geometrics Unit

  taylorw@michigan.gov; (517) 335-2992

- Imad Gedaoun, P.E., Supervisor – Geometrics Unit

  gedaouni@michigan.gov; (517) 335-2986

CLASS OBJECTIVES

GEOMETRIC DESIGN

What is Geometric Design?

- Physical Elements of Design
- Horizontal and Vertical Curves
- Grades
- Cross-Sectional Elements
- Cross-Slope and Superelevation
- Sight Distance
- Intersection and Interchange Design
- General Layout of the Roadway

FUNCTIONAL CLASS

AASHTO

- Provides Definitions for Various Functional Classes of Highways
- Design Criteria Vary According to the Type of Highway Facility
    - Freeways
    - Arterials
    - Collectors
    - Local Roads
- NHS/Non-NHS
- National Truck Network

DESIGN VEHICLES

- Physical Characteristics
- Operating Characteristics
- Classes
  - Passenger Car
  - Buses
  - Trucks (WB-50, WB-62, WB-67)
  - Recreational Vehicles
- Bicycles

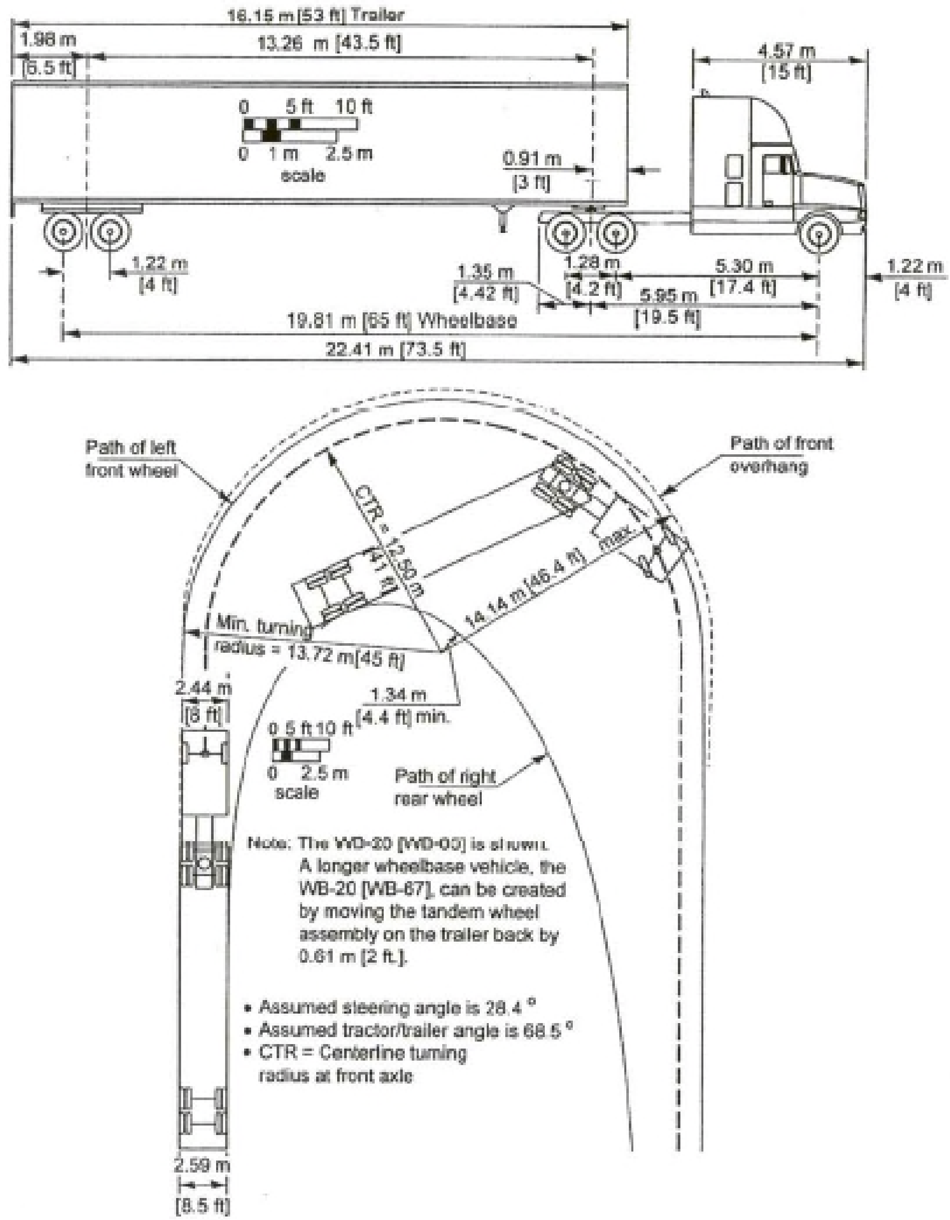


Exhibit 2-16. Minimum Turning Path for Interstate Semitrailer (WB-20 [WB-65 and WB-67]) Design Vehicle

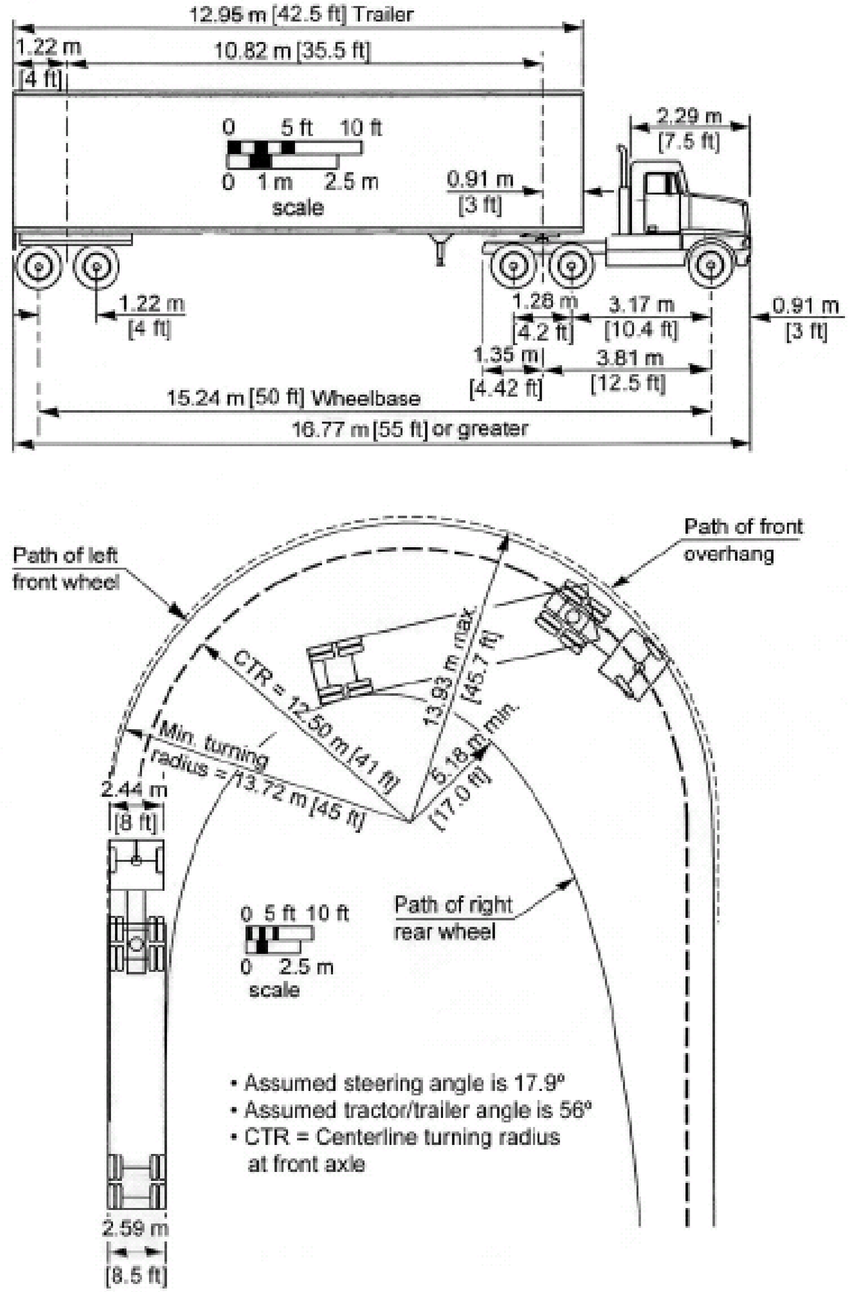


Exhibit 2-14. Minimum Turning Path for Intermediate Semitrailer (WB-15 [WB-50]) Design Vehicle

IMPORTANT PRACTICES

Make Field Visits to Existing Locations

Get Old Plans and Look at Them

Obtain Traffic Volumes & Review Safety

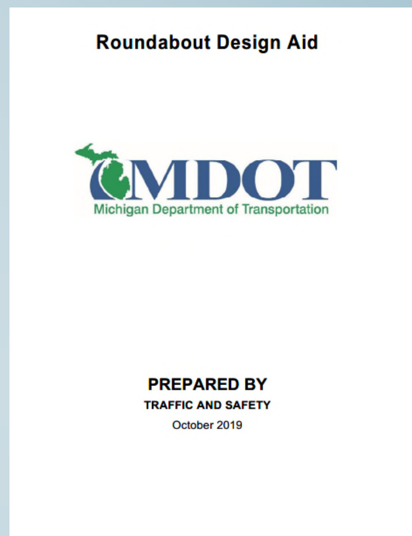
Keep Your Design Documents Up to Date

Get to Know Your Geometrics Area Engineer

REFERENCES

MDOT

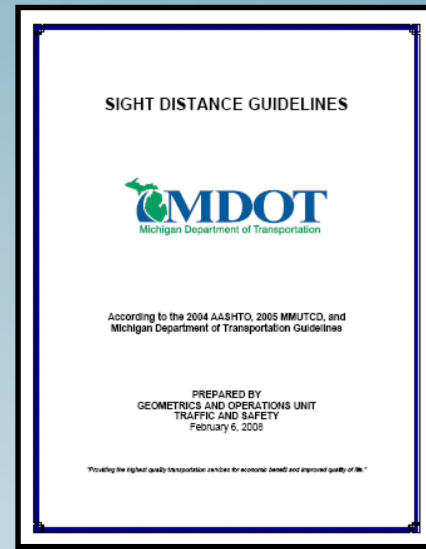
- Road Design Manual
- Bridge Design Manual
- Bridge Design Guides
- Standard Plans
- Geometric Design Guides
- Sight Distance Guidelines
- Roundabout Design Aid
- T&S Geometric Design Guidance
- DDI Guide



Roundabout Design Aid

MDOT Michigan Department of Transportation

PREPARED BY
TRAFFIC AND SAFETY
October 2019

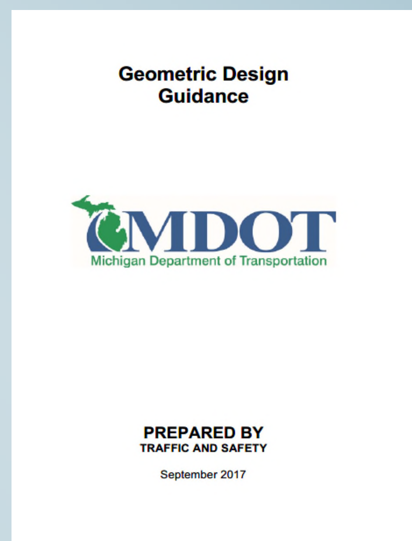


SIGHT DISTANCE GUIDELINES

MDOT Michigan Department of Transportation

According to the 2004 AASHTO, 2005 MMUTCD, and Michigan Department of Transportation Guidelines

PREPARED BY
GEOMETRICS AND OPERATIONS UNIT
TRAFFIC AND SAFETY
February 6, 2008



Geometric Design Guidance

MDOT Michigan Department of Transportation

PREPARED BY
TRAFFIC AND SAFETY

September 2017

REFERENCES

AASHTO

- Guide for the Development of Bicycle Facilities
- A Policy on Design Standards – Interstate System
- A Policy on Geometric Design of Highways & Streets
- Roadside Design Guide

DEFINITION OF TERMS

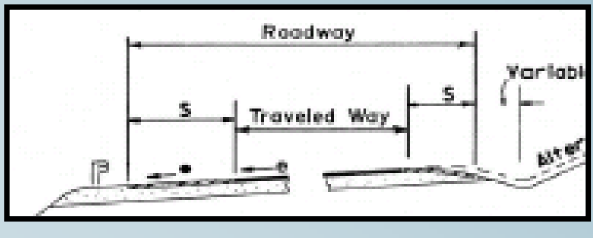
- **Acceleration Lane** – An auxiliary lane, including tapers, for the acceleration of vehicles entering another roadway.
- **Arterial Road** – A roadway which provides a high speed, high volume, network for travel between major points.
- **Average Daily Traffic (ADT)** – The average 24 hour traffic volume, based on a yearly total.
- **Broken Back Curve** – Two curves in the same direction joined by a short tangent distance.
- **Collector Road** – Roadway linking a local road to an arterial road, usually serving moderate traffic volumes.

DEFINITION OF TERMS

- **Compound Curve** – Two connecting horizontal curves in the same direction having different radii (no tangent).
- **Crash Analysis** – A site specific safety review of crash data performed to identify whether or not a specific geometric design element has either caused, or contributed, to a pattern or concentration of crashes at the location in question. The analysis is a critical component used in determining the appropriate application of geometric design criteria and in the evaluation of design exception approval requests.

DEFINITION OF TERMS

- **Critical Grade** – The grade and length that causes a typical truck or other heavy vehicle to have a speed reduction of 10 mph or greater.
- **Cross Slope** – Transverse slope rate of traveled lane or shoulder.



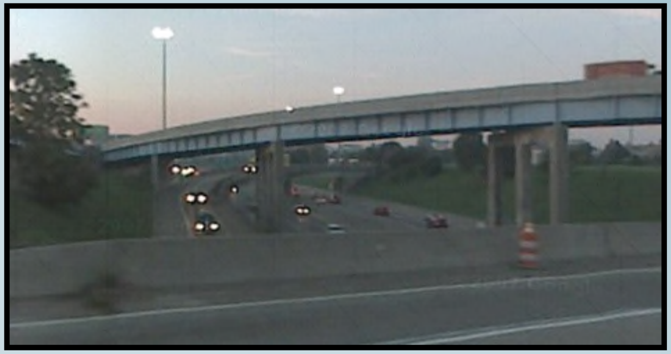
- **Crown Runoff (also called Tangent Runout)** – The distance necessary to remove adverse crown before transitioning into superelevation on curves. (Referred to as “C” distance in Standard Plan R-107 Series.)
- **Deceleration Lane** – An auxiliary lane that enables a vehicle to slow down and exit the highway with minimum interference from through traffic.

DEFINITION OF TERMS

- **Design Hour Volume (DHV)** – The hourly volume used to design a particular segment of highway.
- **Design Speed** – A selected speed used to determine the various geometric design features of the roadway.
- **Directional Design Hour Volume (DDHV)** – The directional distribution of traffic during DHV
- **Free Access Highway** – A highway, with no control of access, usually having at grade intersections, which may or may not be divided.
- **Freeway** – A divided arterial highway with full control of access and grade separations at intersections. (Limited Access).

DEFINITION OF TERMS

- **Gore Area** – The "V" area immediately beyond the divergence of two roadways bounded by the edges of those roadways. (2' to 22' points.)
- **Grade Separation** – A structure which provides for highway traffic to pass over or under another highway or the tracks of a railway.



- **Horizontal Clearance** – An operational offset which provides vehicle clearance for things such as mirrors on trucks and buses, and for opening curbside doors of parked vehicles. (1'6" minimum from face of curb.)

DEFINITION OF TERMS

- **Interchange** – A system of interconnecting roadways in conjunction with grade separations providing for the interchange of traffic between two or more intersecting roadways.
- **Level of Service** – A qualitative measure describing operational conditions within a traffic stream; generally described in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety. Levels of service are given letter designations from A to F, with LOS A representing the best operating conditions and LOS F the worst.

DEFINITION OF TERMS

- **Local Road** – A road which serves primarily to provide access to farms, residences, businesses or other abutting properties.

- **Passing Lane Section (PLS)** – Extra lane(s) to provide additional capacity and reduce delay caused by slow moving vehicles, such as recreational vehicles, during peak periods. These are often desirable in areas where slower vehicles are not necessarily the result of long steep grades.

DEFINITION OF TERMS

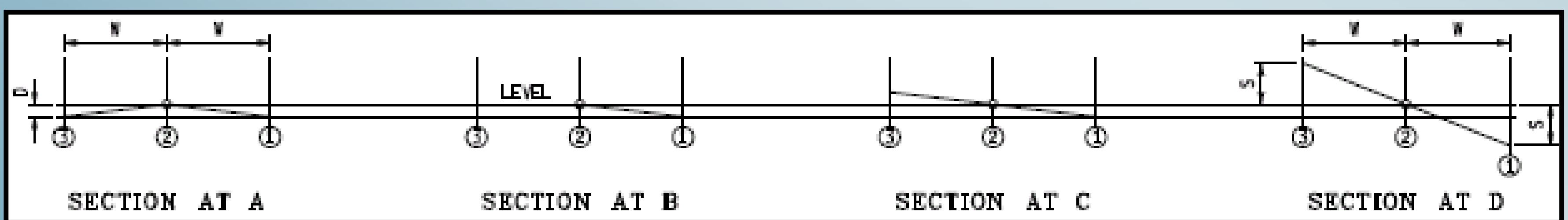
- **Passing Relief Lane (PRL)** – Common all-inclusive reference to a traffic lane provided for increased passing opportunities along a route, can be a Truck Climbing Lane (TCL) or a Passing Lane Section (PLS).
- **Ramp** – A connecting roadway between two intersecting roadways, usually at grade separations.
- **Reverse Curve** – Horizontal curves in the opposite direction joined by a short tangent distance or common point.

DEFINITION OF TERMS

- **Rollover** – Algebraic difference in rate of cross slope between traveled lane and shoulder.
- **Service Road (also Frontage Road)** – A local street or road usually parallel and adjacent to a controlled access highway for service to abutting properties.
- **Sight Distance** – The unobstructed distance that can be viewed along a roadway – usually referenced to decision points for drivers.

DEFINITION OF TERMS

- **Spiral Curve Transition** – A variable radii curve between a circular curve and the tangent. The radii of the transition and the curve are the same at the curve and increase to infinity at the tangent end of the transition.
- **Superelevation** – Tilting of the road surface on curves to help counter balance or offset the perceived "centrifugal force" on the vehicle.



DEFINITION OF TERMS

- **Superelevation Transition (sometimes referred to as superelevation runoff)** - The length of highway needed to change the pavement cross slope from a section with adverse crown removed to a fully superelevated section or vice versa. (Referred to as the “L” distance in Standard Plan R-107 Series.)
- **Truck Climbing Lane (TCL)** – An extra lane for heavy vehicles slowed by the presence of a long steep “critical grade” that provides passing opportunities for non-slowed vehicles.

QUESTIONS

3R / 4R WORK

4R PROJECTS

NEW CONSTRUCTION

AND

RECONSTRUCTION

EXAMPLES OF 4R WORK

New Roadways or Bridges

Complete Removal and Replacement of Pavement (Including Subbase)

Major Alignment Improvements

Addition of Thru Lanes

Complete Bridge Deck or Superstructure Replacement

EXAMPLES OF 4R WORK

Intermittent Grade Modifications that Leave the Existing Pavement in Service for <u>Less</u> than 50% of the Total Project Length

3R PROJECTS

RESURFACING

RESTORATION

REHABILITATION

Code of Federal Regulations 23 CFR

"…work undertaken to extend the service life of an existing highway and enhance highway safety."

EXAMPLES OF 3R WORK

Resurfacing, Milling, or Profiling

Concrete Overlays and Inlays

Lane or Shoulder Widening (No Added Thru Lane)

Roadway Base Corrections

Minor Alignment Improvements

Roadside Safety Improvements




EXAMPLES OF 3R WORK

Signing, Pavement Markings, and Traffic Signals

Intersection and Railroad Crossing Upgrades

Pavement Joint Repair

Passing Relief Lanes

Crush & Shape and Resurfacing

Rubblize and Resurfacing

EXAMPLES OF 3R WORK

Intermittent Grade Modifications that Leave the Existing Pavement in Service for <u>More</u> than 50% of the Total Project Length

Bridge 3R Work is Defined in Chapter 12 of the MDOT…

EXAMPLES OF 3R WORK

Deep or Shallow Overlays

Superstructure Repairs

Railing Replacements

Partial Deck or Superstructure Replacement

Deck Widening (No Added Through Lanes)

Substructure Repair or Replacement

COMBINED 3R & 4R PROJECTS

RDM Section 3.08.01C

3R Standards Apply Where 3R Work is Performed

4R Standards Apply Where 4R Work is Performed

Note: The Applicable Standards Apply Where Other Work Types are Performed

(CPM, M-Funded, Signal & Signing Corridor Projects, Etc.)

4R ROAD GUIDELINES

Non-Freeway Reconstruction/New Construction

RDM 3.10 & RDM Appendix 3A

3R/4R Freeway Projects

RDM 3.11 & RDM Appendix 3A

Design Criteria for Interstate Freeways Based on
“A Policy on Design Standards – Interstate System”

Non-Interstate Freeways Based on
“AASHTO Green Book”

RDM APPENDIX 3A

Appendix 3A
GEOMETRIC DESIGN ELEMENTS
New Construction / Reconstruction

<table>
<tr><th>Element</th><th></th><th>Urban</th><th colspan="5">Rural</th></tr>
<tr><td rowspan="3">Design Speed</td><td>Freeway</td><td>The greater of posted speed, or 60 mph.</td><td colspan="5">The greater of posted speed, or 70 mph.</td></tr>
<tr><td>Non Freeway (Arterial)</td><td>The greater of posted speed, or 30 mph.</td><td colspan="5">The greater of posted speed, or 40 mph..</td></tr>
<tr><td>Collector Roads</td><td>Posted speed (minimum).</td><td colspan="5">Posted speed (minimum)..</td></tr>
<tr><td rowspan="26">Lane Width</td><td>Freeway</td><td>12 ft.</td><td colspan="5">12 ft.</td></tr>
<tr><td rowspan="12">Non Freeway (Arterial)</td><td rowspan="12">12 ft, lanes are most desirable and should be used where practical. 11 ft. lanes are often used for low speed (45 mph design)

Lane widths of 10 ft. may be used in more constrained areas where truck and bus volumes are relatively low and speeds are less than 35 mph.

12 ft. lanes on the National Network (NN). Design exceptions / variances are required to maintain existing narrower lanes. A high burden of justification is required in a design exception / variance to reduce existing lane widths less than or equal to 12'-0".</td><td rowspan="3">Design Speed, (mph)</td><td colspan="4">Minimum Lane Width, ft.</td></tr>
<tr><td colspan="4">ADT, vehicles/day</td></tr>
<tr><td>Under 400</td><td>400 to 1500</td><td>1500 to 2000</td><td>Over 2000</td></tr>
<tr><td>40</td><td>11*</td><td>11*</td><td>11*</td><td>12</td></tr>
<tr><td>45</td><td>11*</td><td>11*</td><td>11*</td><td>12</td></tr>
<tr><td>50</td><td>11*</td><td>11*</td><td>12</td><td>12</td></tr>
<tr><td>55</td><td>11*</td><td>11*</td><td>12</td><td>12</td></tr>
<tr><td>60</td><td>12</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td>65</td><td>12</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td>70</td><td>12</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td>75</td><td>12</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td colspan="5">*12 ft. desirable</td></tr>
<tr><td rowspan="13">Collector Roads</td><td rowspan="5">Added turn lanes at intersections 10-12 ft.
Where right-of-way is restricted. 11 ft.
Industrial Areas 12 ft.</td><td rowspan="3">Design Speed, (mph)</td><td colspan="4">Minimum Lane Width, ft.</td></tr>
<tr><td colspan="4">ADT, vehicles/day</td></tr>
<tr><td>Under 400</td><td>400 to 1500</td><td>1500 to 2000</td><td>Over 2000</td></tr>
<tr><td>20</td><td>10*</td><td>10*</td><td>11*</td><td>12</td></tr>
<tr><td>25</td><td>10*</td><td>10*</td><td>11*</td><td>12</td></tr>
<tr><td rowspan="8">Where shoulders are used, see guidelines for Rural Collectors</td><td>30</td><td>10*</td><td>10*</td><td>11*</td><td>12</td></tr>
<tr><td>35</td><td>10*</td><td>11*</td><td>11*</td><td>12</td></tr>
<tr><td>40</td><td>10*</td><td>11*</td><td>11*</td><td>12</td></tr>
<tr><td>45</td><td>10*</td><td>11*</td><td>11*</td><td>12</td></tr>
<tr><td>50</td><td>10*</td><td>11*</td><td>11*</td><td>12</td></tr>
<tr><td>55</td><td>11*</td><td>11*</td><td>12</td><td>12</td></tr>
<tr><td>60</td><td>11*</td><td>11*</td><td>12</td><td>12</td></tr>
<tr><td colspan="5">*12 ft. desirable</td></tr>
</table>

RDM APPENDIX 3A

Appendix 3A
GEOMETRIC DESIGN ELEMENTS
New Construction / Reconstruction

Element: Shoulder Width — Urban & Rural

Freeway

Mainline Median	Mainline Outside	Ramp (one lane and two lanes) Left	Ramp (one lane and two lanes) Right
8 ft. (4ft. paved) (8 ft. paved at bridge and barrier sections) For 6 or more lane sections (3 or more lanes directional) use 10 ft. paved min and consider 12 ft. paved where truck traffic exceeds 250 DDHV.	10 ft. min (paved) For non-interstate freeways, use 12 ft. paved where truck traffic exceeds 250 DDHV. For interstate freeways consider using 12 ft. paved where truck traffic exceeds 250 DDHV.	6 ft. (4 ft. paved)	8 ft. (7ft. paved)

For new construction and reconstruction, the mainline outside paved shoulder is extended with 1 ft. of aggregate to the shoulder hinge for stabilization.
When widening existing paved shoulders to meet current standard widths, it is desirable to provide the additional foot of aggregate when feasible.

Non Freeway (Arterial)

Urban: In those instances where sufficient right-of-way exists to include shoulders, refer to the guidance for non freeway rural shoulders.* ☞

Rural: **Min paved shoulder, ft. for specified ADT, veh/day — Undivided Roadways***

Under 400	400 to 1500	1500 to 2000	Over 2000
4	6	6	8

Use 8ft. right and 4 ft. left for divided arterials.
Use full width (8 ft.) on both sides of divided arterials with 3 lanes in each direction.

For new construction and reconstruction and when feasible on shoulder widening, the paved shoulder is extended with 1 ft. of aggregate to the shoulder hinge for stabilization.

A minimum 4 ft. (3 ft. paved) shoulder is acceptable adjacent to right turn lanes.
* Minimum shoulder widths apply for posted speeds greater than 45 mph. At lower speeds, minimum shoulders are desirable.

Collector Roads

Where shoulders are used, refer to requirements for rural arterials. ☞

Min shoulder, ft. for specified ADT, veh/day

Under 400	400 to 1500	1500 to 2000	Over 2000
2	5	6	8

The above ranges apply on uncurbed roads and when shoulders are feasible on curbed roads. A minimum paved width of 1 ft. is desirable.

RDM APPENDIX 3A

Appendix 3A
GEOMETRIC DESIGN ELEMENTS
New Construction / Reconstruction

<table>
<tr><th>Element</th><th></th><th colspan="2">Urban & Rural</th></tr>
<tr><td rowspan="5">Design Loading Structural Capacity
(Also see Bridge Design Manual)</td><td>Freeway</td><td colspan="2">HS-25/HL93</td></tr>
<tr><td rowspan="4">Non Freeway</td><td>State Trunkline</td><td>HS-25/HL93</td></tr>
<tr><td>Local Roads Over Freeways and State Trunkline</td><td>HS-25/HL93</td></tr>
<tr><td>Local Roads and Streets</td><td>Design according to county or city standards, HS20/HL93 min.</td></tr>
<tr><td colspan="2">Use HS-25/HL93 for all structures in an interchange regardless of route type</td></tr>
<tr><td rowspan="5">Horizontal Curve Radius</td><td>Freeway</td><td colspan="2" rowspan="5">See Standard Plan R-107-Series and Section 3.04.03</td></tr>
<tr><td>Non Freeway (Arterial)</td></tr>
<tr><td>Collector Roads</td></tr>
<tr><td>Non Freeway (Arterial)</td></tr>
<tr><td>Collector Roads</td></tr>
</table>

RDM APPENDIX 3A

Appendix 3A
GEOMETRIC DESIGN ELEMENTS
New Construction / Reconstruction

Maximum Grade — Maximum Grade (%) for specified design speed (mph)

Freeway

Type of Terrain	50	55	60	65	70	75
Level	4	4	3	3	3	3
Rolling	5	5	4	4	4	4

Grades 1% steeper may be provided in urban areas.

Non Freeway (Arterial)

Type of Terrain	Urban 30	Urban 35	Urban 40	Urban 45	Urban 50	Urban 55	Urban 60	Rural 40	Rural 45	Rural 50	Rural 55	Rural 60
Level	8	7	7	6	6	5	5	5	5	4	4	3
Rolling	9	8	8	7	7	6	6	6	6	5	5	4

Collector Roads — Urban

Type of Terrain	20	25	30	35	40	45	50	55	60
Level	9	9	9	9	9	8	7	7	6
Rolling	12	12	11	10	10	9	8	8	7

Collector Roads — Rural

Type of Terrain	20	25	30	35	40	45	50	55	60
Level	7	7	7	7	7	7	6	6	5
Rolling	10	10	9	9	8	8	7	7	6

Stopping Sight Distance	Follow 2011 6th Edition of AASHTO "A Policy on Geometric Design of Highways and Streets" (AKA AASHTO Green Book). The MDOT Sight Distance Guidelines also provide detailed information on sight distance calculation.
Cross Slope	Traveled way cross slope = 2.0%, Paved shoulder cross slope = 4.0% (Also see Section 6.05.05)
Superelevation Rate	AASHTO Method 5 "Curvilinear Relation" is used for new construction/reconstruction. Maximum rate of 7%. (See Standard Plan R-107-Series.)
	AASHTO Method 1 "Straight Line Relation" is allowed when Method 5 is not feasible. Maximum rate of 6%. (See Section 3.04.03)
	The above methods also apply to urban freeways and urban ramps, except the maximum rate is 5% for 60 mph design speed.

Vertical Clearance

	NHS	Non NHS
Freeway	16'-0"	14'-6"
Non Freeway (Arterial)	16'-0"	14'-6"
Collectors & "Special Routes"	14'-6" (1 ft. greater than Michigan legal vehicle height.)	14'-6"

For pedestrian bridges provide 1 ft. additional clearance over non-freeway and 17 ft. minimum under clearance over freeways. A vertical clearance of 23'-0" is required for grade separations over railroads. *(See Bridge Design Manual 7.01.08 and Bridge Design Guides 5.24.03-04.)*

3R/4R GUIDELINES

Freeway Safety Considerations (3.11.03)

Design Speed

Ramp Geometrics and Taper Lengths

Vertical Curbs

Sight Distance

Crown Location/Pavement Cross Slope

3R/4R GUIDELINES

Safety Considerations (3.11.03)

Superelevation

Guardrail
and
Concrete Barrier

Attenuation

Shoulder and Slopes

3R/4R GUIDELINES

Safety Considerations (3.11.03)

Clear Zones

&

Fixed Objects

Culvert End

Treatments

4R BRIDGE GUIDELINES

MDOT Bridge Design Guides

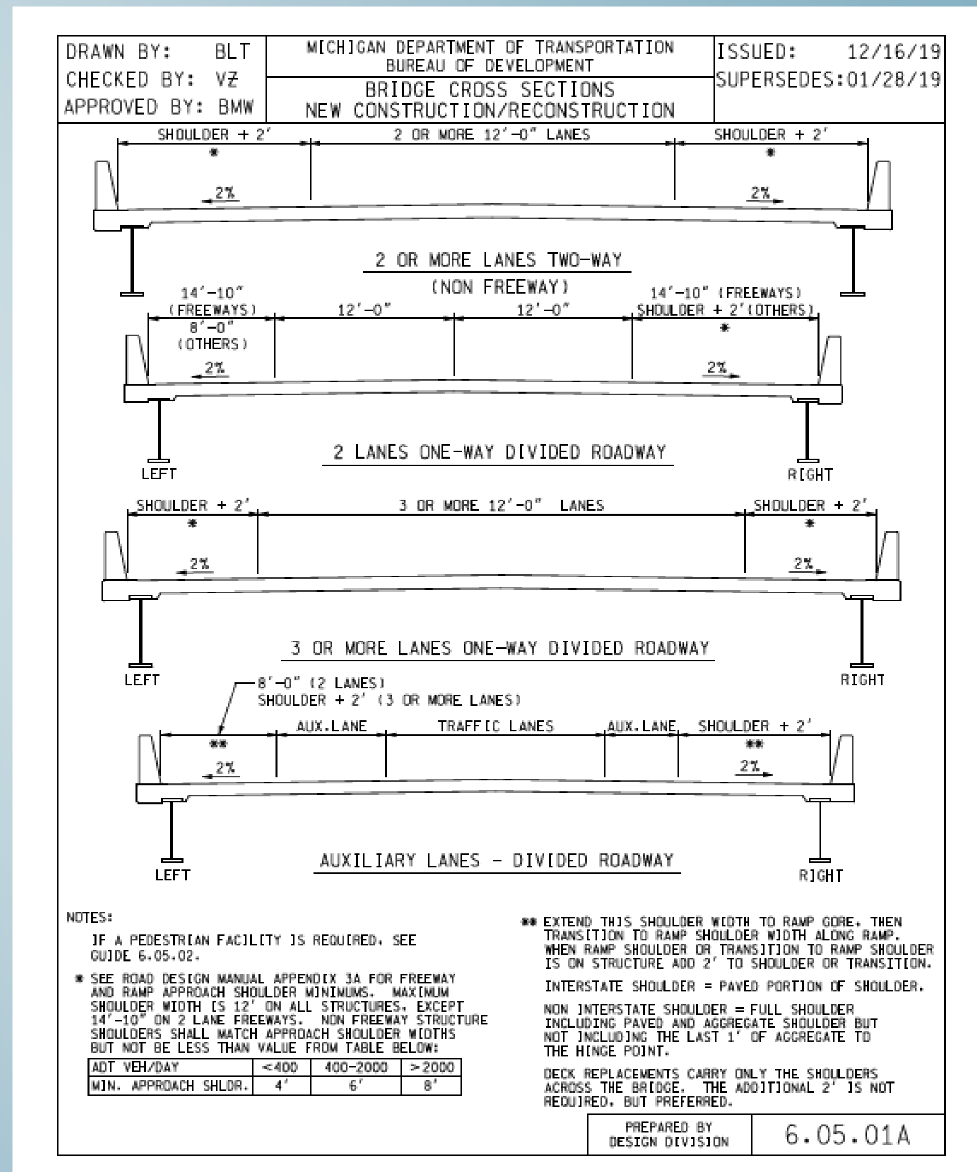
Cover Most Design Elements for Most 4R Work

MDOT Bridge Design Manual – Chapter 7

Deck Replacements and Underclearance Requirements

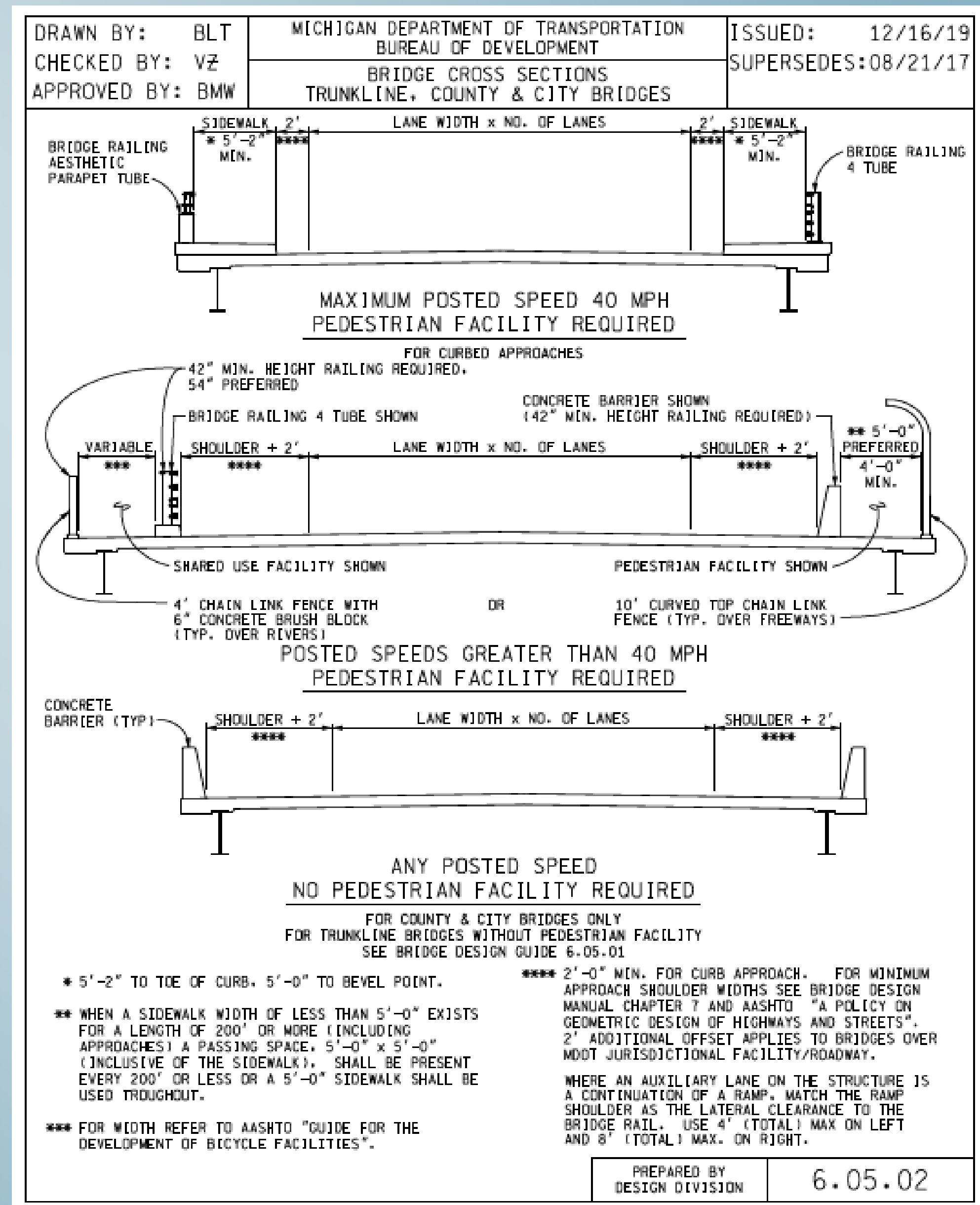
BRIDGE DESIGN GUIDE

(BDG 6.05.01A)



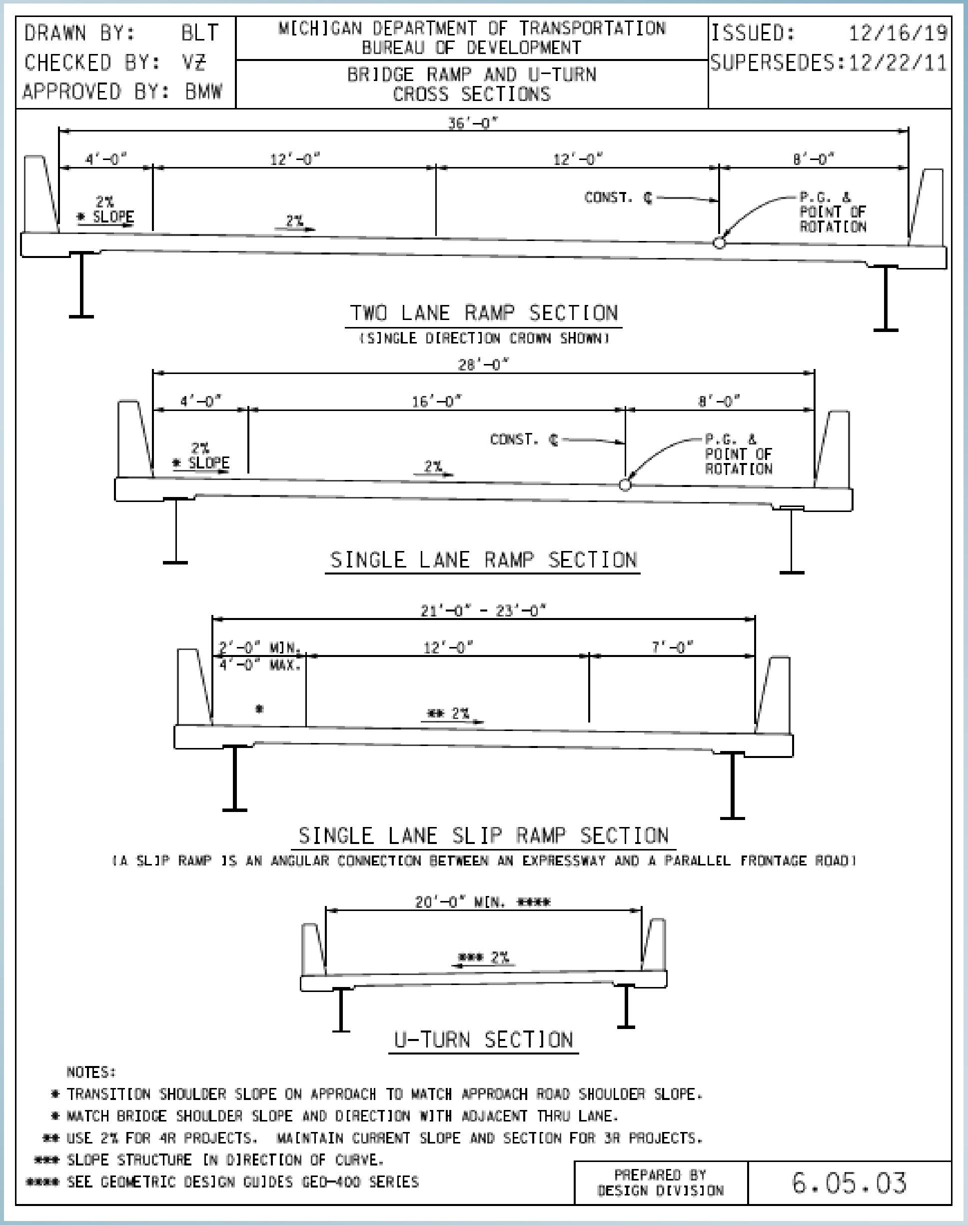
BRIDGE DESIGN GUIDE

(BDG 6.05.02)



BRIDGE DESIGN GUIDE

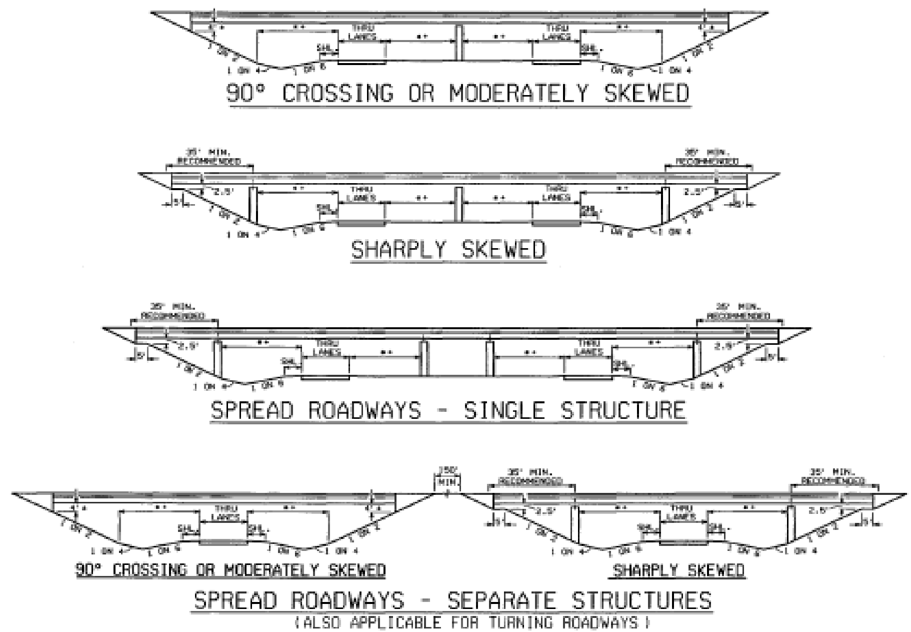
(BDG 6.05.03)



BRIDGE DESIGN GUIDE

(BDG 6.06.01)

DRAWN BY: BLT CHECKED BY: VZ APPROVED BY: TGF	MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT SUBSTRUCTURE CLEARANCES RURAL STATE TRUNKLINES	ISSUED: 08/15/03 SUPERSEDES: 11/27/01



WHERE CONDITIONS, SUCH AS TERRAIN AND COST DIFFERENTIAL, MAY BE SUCH THAT IT WOULD BE MORE DESIRABLE TO USE TWO STRUCTURES RATHER THAN ONE AND WHERE THE DISTANCE BETWEEN STRUCTURES WILL BE LESS THAN 150 FEET, CONSULT A DESIGN SUPERVISOR.

NOTES:

* MINIMUM DIMENSION IS THE CLEAR ZONE DISTANCE GIVEN IN BRIDGE DESIGN GUIDE 6.06.05. USE THE MIDDLE OF RANGE AT THE APPROPRIATE DESIGN ADT. WHERE ROADWAY IS ON A CURVE WITH A RADIUS OF 2860' OR LESS, DISTANCE TO TOE OF 1-ON-2 SLOPE SHOULD BE INCREASED ON OUTSIDE OF CURVE PER BRIDGE DESIGN GUIDE 6.06.05A OR GUARDRAIL PROTECTION OF SLOPE OR PIER SHOULD BE PROVIDED.

+ IF DISTANCE TO PIER OR TOE OF 1-ON-2 SLOPE IS LESS THAN THE CLEAR ZONE DISTANCE PROVIDE GUARDRAIL PROTECTION OF PIER OR SLOPE.

APPROACH SLOPE FACING TRAFFIC MUST BE GRADED TO 1-ON-6 WHEN THE TOE OF THE SLOPE IN FRONT OF THE ABUTMENT IS WITHIN THE CLEAR ZONE. SEE STANDARD PLAN R-105-SERIES.

SECTIONS ARE APPLICABLE GENERALLY FOR STRUCTURES WITH APPROACHES ON FILL OR WHEN DRAINAGE IS CARRIED THROUGH STRUCTURE AREA BY USE OF CULVERTS. FOR EXPRESSWAYS IN DEEP CUT, CARRY SAME DITCH SECTION THROUGH STRUCTURE AS CALLED FOR ON EXPRESSWAY SECTION.

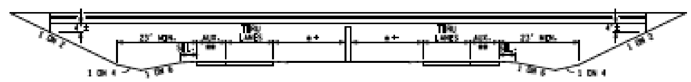
ALL DIMENSIONS ARE AT RIGHT ANGLES TO ROADWAY

PREPARED BY DESIGN SUPPORT AREA	6.06.01

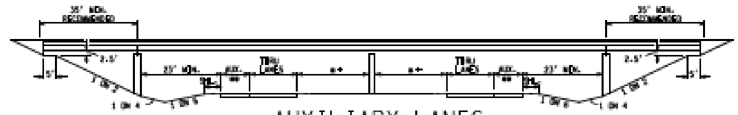
BRIDGE DESIGN GUIDE

(BDG 6.06.02)

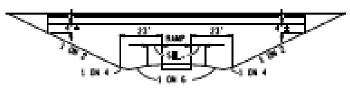
DRAWN BY: BLT CHECKED BY: VZ APPROVED BY: TGF	MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT SUBSTRUCTURE CLEARANCES RURAL STATE TRUNKLINES	ISSUED: 02/14/11 SUPERSEDES: 08/15/03



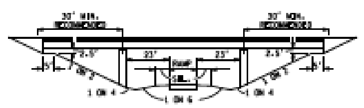
AUXILIARY LANES
90° CROSSING OR MODERATELY SKEWED



AUXILIARY LANES
SHARPLY SKEWED



RAMP
90° CROSSING OR MODERATELY SKEWED



RAMP
SHARPLY SKEWED

NOTES:

* MINIMUM DIMENSION IS THE CLEAR ZONE DISTANCE GIVEN IN BRIDGE DESIGN GUIDE 6.06.05. USE THE MIDDLE OF RANGE AT THE APPROPRIATE DESIGN ADT. WHERE ROADWAY IS ON A CURVE WITH A RADIUS OF 2860' OR LESS, DISTANCE TO TOE OF 1 ON 2 SLOPE SHOULD BE INCREASED ON OUTSIDE OF CURVE PER BRIDGE DESIGN GUIDE 6.06.05A OR GUARDRAIL PROTECTION OF SLOPE OR PIER SHOULD BE PROVIDED.

\+ IF DISTANCE TO PIER OR TOE OF 1 ON 2 SLOPE IS LESS THAN THE CLEAR ZONE DISTANCE PROVIDE GUARDRAIL PROTECTION OF PIER OR SLOPE.

APPROACH SLOPE FACING TRAFFIC MUST BE GRADED TO 1 ON 6 WHEN THE TOE OF THE SLOPE IN FRONT OF THE ABUTMENT IS WITHIN THE CLEAR ZONE. SEE STANDARD PLAN R-105-SERIES.

** AT AUXILIARY LANE TAPER SEE BRIDGE DESIGN GUIDE 6.06.01 AND CALCULATE CLEAR ZONE BASED ON THRU LANES. SEE SECTION 7.01 OF THE ROAD DESIGN MANUAL.

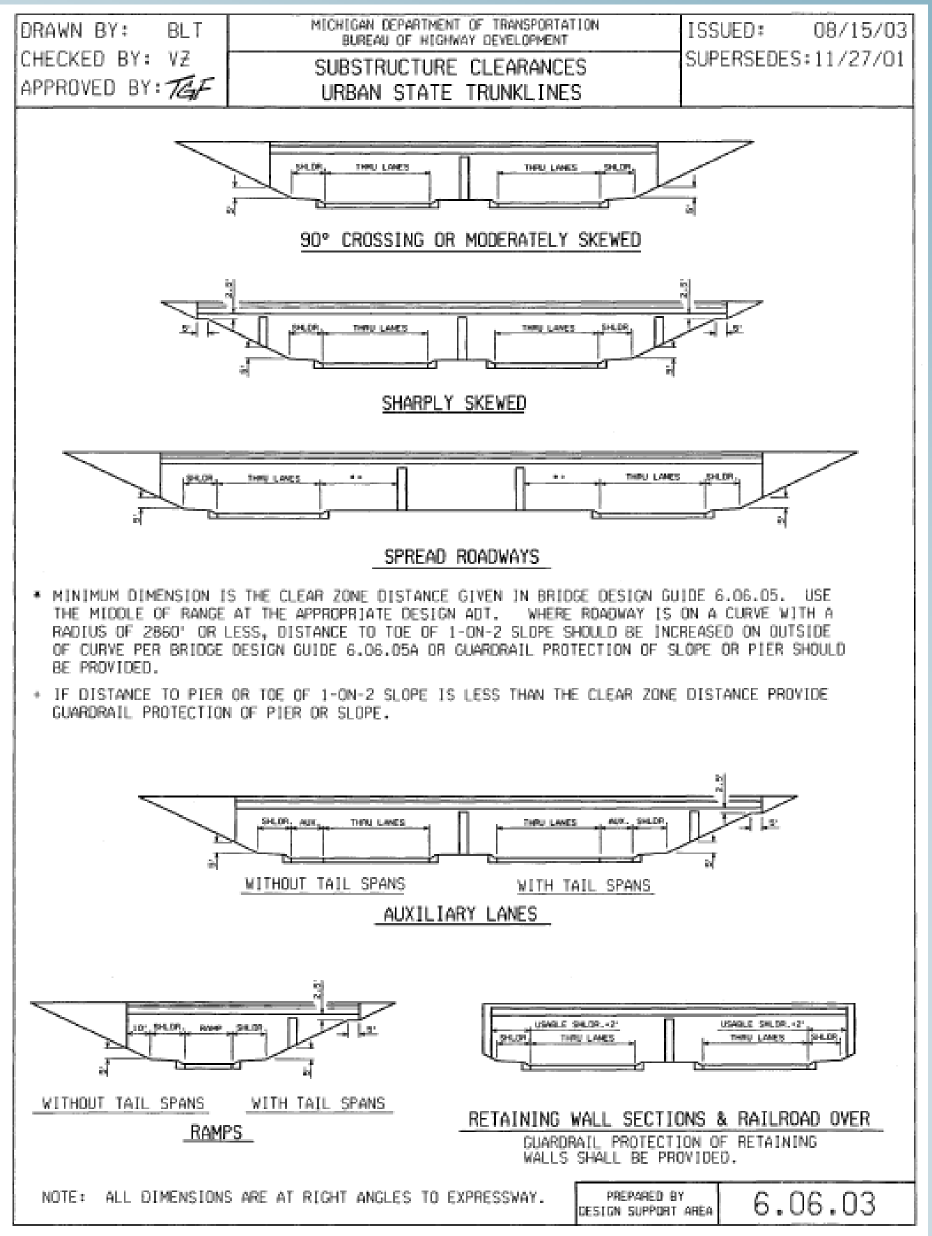
SECTIONS ARE APPLICABLE GENERALLY FOR STRUCTURES WITH APPROACHES ON FILL OR WHEN DRAINAGE IS CARRIED THROUGH STRUCTURE AREA BY USE OF CULVERTS. FOR EXPRESSWAYS IN DEEP CUT, CARRY SAME DITCH SECTION THROUGH STRUCTURE AS CALLED FOR ON EXPRESSWAY SECTION.

ALL DIMENSIONS ARE AT RIGHT ANGLES TO ROADWAY

PREPARED BY DESIGN DIVISION	6.06.02

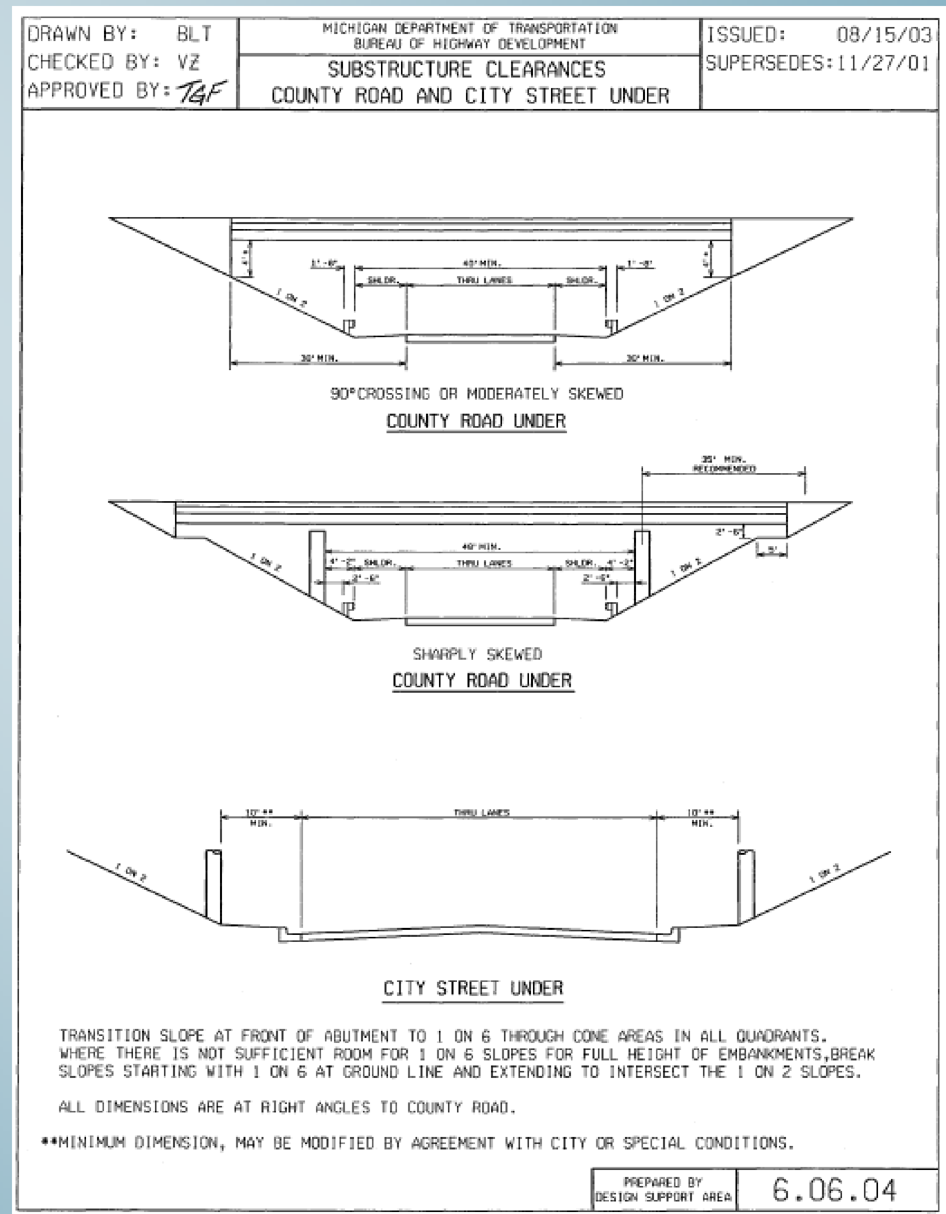
BRIDGE DESIGN GUIDE

(BDG 6.06.03)



BRIDGE DESIGN GUIDE

(BDG 6.06.04)



DECK REPLACEMENT GUIDELINES

(BDM 7.02.31)

MICHIGAN DESIGN MANUAL
BRIDGE DESIGN - CHAPTER 7: LRFD

7.02.31 Deck Replacements (Cont.)

CLEAR ROADWAY WIDTHS AND DESIGN LOADING FOR DECK REPLACEMENTS			
Type of Roadway		**Minimum Clear Roadway Width**	**Minimum Design Loading**
Non-Interstate Freeway		A, C	HS-20
Interstate Freeway		B, C	HS-20
Arterial (Non-Freeway Trunkline)	Rural	Exhibit 7-3.	HS-20
	Urban	D, C	HS-20
Collector (Non-Trunkline)	Rural	Exhibit 6-6.	HS-20
	Urban	Exhibit 6-5., E	HS-20
Local (Non-Trunkline)	Rural	Exhibit 5-6.	HS-20
	Urban	Exhibit 5-5., E	HS-20

(A) The minimum clear roadway provided shall accommodate the pavement and full shoulders of the approach roadway or the minimum AASHTO requirements for lane and shoulder widths, whichever is greater.

(B) The minimum clear roadway provided shall accommodate the pavement and full shoulders of the approach roadway.

(C) For bridges in excess of 200'-0" in length, where the nearest offset from the edge of traveled way to either curb or barrier is greater than 4'-0" on the approaches, the nearest offset on the bridge shall be at least 4'-0"on each side. (12-5-2005)

(D) The minimum clear width on the bridge shall be the same as the curb-to-curb width of the street.

(E) The minimum clear roadway shall be the traveled way plus 1'-0" to each curb face. However, consideration should be given to providing the same width as the curb-to-curb approach width if it is cost effective to do so.

DECK REPLACEMENT GUIDELINES

(BDM 7.02.31)

MICHIGAN DESIGN MANUAL
BRIDGE DESIGN - CHAPTER 7: LRFD

The tables shown below are derived from A Policy on Geometric Design of Highways and Streets, 2011, 6th Edition published by AASHTO and do not include clearances for bridge rail offset. See the Bridge Design Guides for MDOT offset criteria. (7-20-2015) (3-21-2016)

MINIMUM WIDTH OF TRAVELED WAY FOR RURAL ARTERIALS (FROM Exhibit 7-3.)				
	Design Traffic Volume (veh/day)			
Design Speed(mph)	Under 400	400-1500	1500 -2000	over 2000
	Width of Traveled Way (ft)[a]			
40-45	22	22	22	24
50-55	22	22	24	24
60-75	24	24	24	24

(a) Where the width of traveled way is shown to be 24 ft, it may remain 22 ft on reconstructed bridges where alignment and safety record are satisfactory.

MINIMUM CLEAR ROADWAY WIDTHS FOR RURAL ARTERIAL BRIDGES BEING RECONSTRUCTED (FROM Exhibit 7-3.)	
Design Traffic Volume(veh/day)	Min. Clear Roadway Width of Bridge
under 400	Traveled way + 4 ft (ea. side)
400-2000	Traveled way + 6 ft (ea. side)[b]
over 2000	Traveled way + 8 ft (ea. side)[b]

(b) For bridges in excess of 200 ft in length, a minimum width of traveled way + 4 ft on each side will be acceptable.

Exhibit 6-5. MINIMUM WIDTH OF TRAVELED WAY FOR COLLECTOR ROADS				
Design	Design Traffic Volumes (veh/day)			
Speed(mph)	Under 400	400-1500	1500 -2000	over 2000
	Width of Traveled Way (ft)			
20-30	20[a]	20	22	24
35-40	20[a]	22	22	24
45-50	20	22	22	24
55-60	22	22	24	24

On roadways to be reconstructed, a 22 ft traveled way may be retained where the alignment and safety records are satisfactory.

(a) A 18 ft minimum width may be used for roadways with design volumes under 250 veh/day.

DECK REPLACEMENT GUIDELINES

(BDM 7.02.31)

Exhibit 6-6. MINIMUM ROADWAY WIDTHS FOR NEW AND RECONSTRUCTED BRIDGES CARRYING RURAL COLLECTOR ROADS

Design Traffic Volume(veh/day)	Minimum Roadway Width of Bridge	Design Loading Structural Capacity
400 and Under	Traveled way + 2 ft (each side)	HS -20
400 to 1500	Traveled way + 3 ft (each side)	HS -20
1500 to 2000	Traveled way + 4 ft (each side)[a]	HS -20
over 2000	Traveled way + shoulders[a]	HS -20

Where the approach traveled way plus shoulders is surfaced, that surfaced width shall be carried across all structures.

[a] For bridges in excess of 100 ft in length, the minimum width of traveled way plus 3 ft on each side will be acceptable.

Exhibit 5-5. MINIMUM WIDTH OF TRAVELED WAY FOR LOCAL ROADS

	Design Traffic Volumes (veh/day)			
Design Speed(mph)	Under 400	400-1500	1500 -2000	over 2000
	Width of Traveled Way (ft)			
15	18	20	20	22
20-40	18	20	22	24
45-50	20	22	22	24
55-60	22	22	24	24

Where the width of traveled way is shown as 24 ft, the width may remain 22 ft m on reconstructed bridges where alignment and safety records are satisfactory.

Exhibit 5-6. MINIMUM CLEAR ROADWAY WIDTHS AND DESIGN LOADINGS FOR NEW AND RECONSTRUCTED BRIDGES CARRYING RURAL LOCAL ROADS

Design Traffic Volume(veh/day)	Min. Clear Roadway Width of Bridge	Design Loading Structural Capacity
ADT 400 & under	Traveled way + 2 ft (ea. side)	HS -20
ADT 400-2000	Traveled way + 3 ft (ea. side)	HS -20
ADT over 2000	Traveled way + shoulders	HS -20

VERTICAL CLEARANCE

Bridge Design Manual, Section 7.01.08
Road Design Manual, Section 3.12

VERTICAL CLEARANCE REQUIREMENT TABLE (8-20-2009) (6-22-2015)

Route Classification Under the Structure	All Construction (Desired)	New Construction (Min *)	Road 4R Construction (Min *)	Bridge 4R Construction (Min *)	3R Construction (Min *)
Freeways	16'-3"	16'-0"	16'-0"	16'-0"	16'-0" ***
NHS Arterials (Local & Trunkline)	16'-3"	16'-0"	Maintain Existing** and 14'-6" Min	16'-0"	Maintain Existing** and 14'-0" Min
Non NHS Arterials (Local & Trunkline)	16'-3"	14'-6"	Maintain Existing** and 14'-6" Min	Maintain Existing** and 14'-6" Min	Maintain Existing** and 14'-0" Min
Collectors, Local Roads & Special Routes[1]	14'-9"	14'-6"	Maintain Existing** and 14'-6" Min	Maintain Existing** and 14'-6" Min	Maintain Existing** and 14'-0" Min

3R = Rehabilitation, Restoration, Resurfacing

* Minimum Vertical Clearance must be maintained over complete usable shoulder width.

** Existing vertical clearances greater than or equal to the minimums shown may be retained without a design exception. Vertical clearance reductions that fall below the minimums for new construction require a design exception. (6-22-2015)

*** Existing vertical clearances may be retained (or increased) without a design exception unless a pattern of high load hits exist. Vertical clearance reductions below the standard (table value) require design exceptions. (5-27-2020)

(1) Special Routes are in Highly Urbanized Areas (where little if any undeveloped land exists adjacent to the roadway) where an alternate route of 16'-0" is available or has been designated. Bridges located over Special Routes in Highly Urbanized Areas can be found on the MDOT website at: http://mdotcf.state.mi.us/public/design/files/englishbridgemanual/Exempt_Structures.pdf. (5-28-2013)

Ramps and roadways connecting a Special Route and a 16'-0" route require a vertical clearance minimum of 14'-6" (14'-9" desired). Ramps and roadways connecting two 16'-0" routes require a vertical clearance minimum of 16'-0" (16'-3" desired). (8-20-2009)

4R = Reconstruction

Information on the NHS systems can be obtained by contacting the Statewide Planning Section, Bureau of Transportation Planning or found on the MDOT website at: http://www.michigan.gov/mdot-nfc (11-28-2011)

Pedestrian bridges are to provide 1'-0" more underclearance than that required for a vehicular bridge. For Freeways (Interstate and non Interstate), including Special Route Freeways, the desired underclearance shall be 17'-3" (minimum 17'-0"). (8-20-2009)

A vertical underclearance of 23'-0" is required for highway grade separations over railroads when constructing a new bridge or removing the existing superstructure. For preventative maintenance, rehabilitation and deck replacement projects the existing railroad vertical underclearance does not need to be increased unless requested by the Railroad. (11-28-2011)

Clearance signs are to be present for structures with underclearance of 16'-0" or less (show dimensions 2" less than actual). See MDOT Traffic and Safety Sign Design, Placement, and Application Guidelines for additional information and guidelines. (8-20-2009) (11-28-2011) (11-21-2013) (3-25-2019)

3R ROAD GUIDELINES

Design Guidelines for New/Reconstruct May not be Cost Effective

Freeway

- **RDM Section 3.11**

(3R/4R Freeway Guidelines)

- **3R Freeway Allowances**

Non-Freeway

- **RDM Section 3.09**

(Non-Freeway 3R Minimum Design Guidelines)

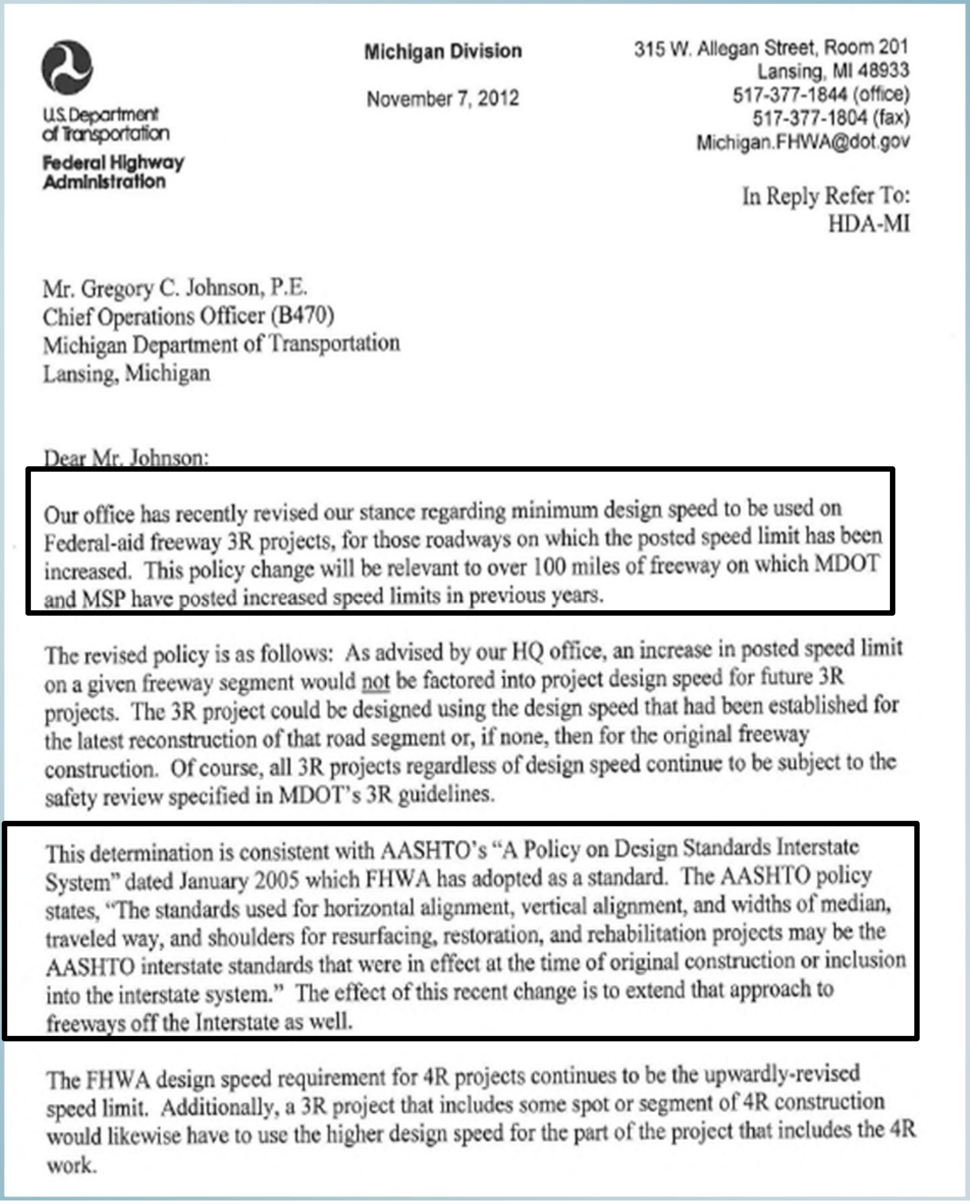
3R GUIDELINES

Two Types of Non-Freeway 3R Guidelines

- **NHS (National Highway System) - RDM 3.09.02A**
- **Non-NHS - RDM 3.09.02B**

3R FREEWAY ALLOWANCES

FHWA Letter:



U.S. Department of Transportation
Federal Highway Administration

Michigan Division

November 7, 2012

315 W. Allegan Street, Room 201
Lansing, MI 48933
517-377-1844 (office)
517-377-1804 (fax)
Michigan.FHWA@dot.gov

In Reply Refer To:
HDA-MI

Mr. Gregory C. Johnson, P.E.
Chief Operations Officer (B470)
Michigan Department of Transportation
Lansing, Michigan

Dear Mr. Johnson:

Our office has recently revised our stance regarding minimum design speed to be used on Federal-aid freeway 3R projects, for those roadways on which the posted speed limit has been increased. This policy change will be relevant to over 100 miles of freeway on which MDOT and MSP have posted increased speed limits in previous years.

The revised policy is as follows: As advised by our HQ office, an increase in posted speed limit on a given freeway segment would not be factored into project design speed for future 3R projects. The 3R project could be designed using the design speed that had been established for the latest reconstruction of that road segment or, if none, then for the original freeway construction. Of course, all 3R projects regardless of design speed continue to be subject to the safety review specified in MDOT's 3R guidelines.

This determination is consistent with AASHTO's "A Policy on Design Standards Interstate System" dated January 2005 which FHWA has adopted as a standard. The AASHTO policy states, "The standards used for horizontal alignment, vertical alignment, and widths of median, traveled way, and shoulders for resurfacing, restoration, and rehabilitation projects may be the AASHTO interstate standards that were in effect at the time of original construction or inclusion into the interstate system." The effect of this recent change is to extend that approach to freeways off the Interstate as well.

The FHWA design speed requirement for 4R projects continues to be the upwardly-revised speed limit. Additionally, a 3R project that includes some spot or segment of 4R construction would likewise have to use the higher design speed for the part of the project that includes the 4R work.

3R FREEWAY ALLOWANCES

Design Speed:

"an increase in posted speed limit on a given freeway segment would not be factored into project design speed for future 3R projects. The 3R project could be designed using the design speed that had been established for the latest reconstruction of that road segment or, if none, then for the original freeway construction."

3R FREEWAY ALLOWANCES

Geometric Design Elements:

"The standards used for horizontal alignment, vertical alignment, and widths of median, traveled way, and shoulders for resurfacing, restoration, and rehabilitation projects may be the AASHTO interstate standards that were in effect at the time of original construction or inclusion into the interstate system."

3R FREEWAY ALLOWANCES

GEOMETRIC REQUIREMENTS FOR FREEWAY PROJECTS INVOLVING 3R WORK TYPES

Geometric Design Element		Minimum Required Standard *	Compliance Determination
Design Speed		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Horizontal Curve Radius ($R_{min.}$)		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Longitudinal Grade (Min./Max.)		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Stopping Sight Distance (Horizontal and/or Vertical))		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Lane Width		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Shoulder Width		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Superelevation		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Cross-Slope	***(Excluding parabolic – Parabolic cross-slopes still require a DE/DV)***	Standard at the time of construction or the most recent 4R project ***(Unless parabolic; Parabolic cross-slopes must be removed or a DE/DV is required)***	Compliance Assumed ***(Unless parabolic; Parabolic cross-slopes must be removed or a DE/DV is required)***
Structural Capacity		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Vertical Clearance		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Acceleration/Deceleration Length		Existing Length	Compliance Assumed

*** If the project-wide Safety Review identifies a pattern of crashes associated with a particular design element (or elements), then that design element (or those elements) must be bought up to current standards (i.e. the existing design values may not be retained if they do not meet current standards).**

Non-Fr

3.09.02 (continued)

A. Non-Freeway, NHS

Geometric Elements	Non-Freeway, NHS 3R Minimum Guidelines			
Design Speed (see Section 3.06)	Posted Speed Minimum			
Shoulder Width *NOTE: Minimum shoulder widths apply for posted speeds greater than 45 mph. Restrictions such as right of way and roadside context sensitivity issues may preclude the use of minimum shoulders within city, village or township limits with posted speeds of 45 mph and less.*	Current ADT Two-Way		Inside Shoulder	Outside Shoulder
	Two Lane (and three lane when the center lane is a left turn lane)	<750		3'-0" Gravel
		750 - 5000		6'-0" (3'-0" Paved)
		>5000 - 10,000		8'-0" (3'-0" Paved)
		>10,000		8'-0" (7'-0" Paved)
	Multi-Lane Undivided	≤ 10,000 > 10,000		6'-0" (3'-0" Paved) 8'-0" (3'-0" Paved)
	Multi-Lane Divided	≤ 10,000 > 10,000	3'-0" Paved 3'-0" Paved	6'-0" (3'-0" Paved) 8'-0" (3'-0" Paved)
	See Bridge Design Manual Appendix 12.02 for Bridge Widths			
Lane Width	ADT	Lane Width		
	≤750	10'-0"		
	>750	11'-0"		
		10'-0" lanes may be considered in urban areas for multi-lane un-divided (regardless of ADT) and multi-lane divided (ADT < 10,000). 12'-0" lanes are desirable on the Priority Commercial Network (PCN). 12'-0" lanes are required on the National Network (also known as the National Truck Network). Design Exceptions / Design Variances to maintain existing narrower lanes generally receive favorable consideration but a high burden of justification is placed on requests to reduce lane widths to less than 12'-0".		
Design Loading Structural Capacity	Rural	Urban		
	Minimum Design Loading HS20.	Minimum Design Loading HS20.		
	(See Bridge Design Manual Appendix 12.02 for other trunkline classifications)			
Horizontal Curve Radius and Stopping Sight Distance	Existing curve radius and stopping sight distance may be retained if the design speed of the existing curve is not more than 15 mph below the project design speed and there is no crash concentration. Otherwise standards for new construction apply. See 2011 6th Edition AASHTO Green Book or MDOT Sight Distance Guidelines.			
Maximum Grade	Review crash data. Existing grade may be retained without crash concentration.			
Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05			
Superelevation Rate	Standard Plan R-107-Series or reduced maximum (6%) Straight Line Superelevation Chart using the project design speed.			
Vertical Clearance	See Section 3.12.			

Non-Fr

3.09.02 (continued)

B. Non-Freeway, Non-NHS

Geometric Elements	Non-Freeway, Non-NHS 3R Minimum Guidelines		
Design Speed	Posted Speed Minimum		
Shoulder Width *NOTE: Minimum shoulder widths apply for posted speeds greater than 45 mph. Restrictions such as right of way and roadside context sensitivity issues may preclude the use of minimum shoulders within city, village or township limits with posted speeds of 45 mph and less.*	Current ADT Two-Way	Inside and Outside Shoulder Width	
	≤750 750 - 2000 > 2000	2'-0" (Gravel) 3'-0" (Paved) 6'-0" (3'-0" Paved)	
	Multi-Lane (Divided & Undivided)	Inside (Divided)	Outside (Both sides for un-divided)
		3'-0" Paved	6'-0" (3'-0" Paved)
	See Bridge Design Manual Appendix 12.02 for Bridge Widths		
Lane Width	ADT	Lane Width	
	≤750 >750	10'-0" 11'-0" 10'-0" lanes may be considered in urban areas for multi-lane un-divided (regardless of ADT) and multi-lane divided (ADT < 10,000). 12'-0" lanes are desirable on the Priority Commercial Network (PCN) and the National Network (also known as the National Truck Network). Existing narrower lanes may be retained without Design Exceptions / Design Variances. Reduction of existing lane widths on the National Network to less than 12-0" require a Design Exceptions / Design Variances request having a high burden of justification.	
Design Loading Structural Capacity **(Existing Bridges to remain in place)**	ADT (Design Year)	Minimum Design Loading	
	0 - 750	H15	
	> 750	HS15	
Horizontal Curve Radius and Stopping Sight Distance	Existing curve radius and stopping sight distance may be retained if the design speed of the existing curve is not more than 15 mph (horizontal) or 20 mph (vertical) below the project design speed and there is no crash concentration. Otherwise standards for new construction apply. See 2011 6th Edition AASHTO Green Book or MDOT Sight Distance Guidelines.		
Maximum Grade	Review crash data. Existing grade may be retained without crash concentration.		
Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05		
Superelevation Rate	Standard Plan R-107-Series or reduced maximum (6%) Straight Line Superelevation Chart using the project design speed.		
Vertical Clearance	See Section 3.12.		

3R GUIDELINES

Non-Freeway Safety Considerations (3.09.03)

Signing

Evaluation of Guardrail and Bridge Rail

Tree Removal

(Crash Frequency, Curves, Sight Distance, Clear Zone, etc…)

Roadside Obstacles (Culvert Headwalls, Utility Poles, etc…)

3R GUIDELINES

Non-Freeway Safety Considerations (3.09.03)

Cross Section Elements (Crown Location, Side Slopes)

Crown Location:

Existing pavement crown point location may be retained on a project where the rate of resurfacing is less than 4" in thickness. Otherwise, standard crown location should be used.

Side Slopes:

			Current ADT Two-Way	Foreslope
Side Slopes	Review crash history for improvement needs.	Two-Lane	≤ 750 > 750	1:3 1:4
		Multi-Lane Undivided	≤ 10,000 > 10,000	1:3 1:4
		Multi-Lane Divided	All	1:4

3R BRIDGE GUIDELINES

MDOT Bridge Design Manual

Chapter 12 – Most Design Elements

Chapter 7 – Underclearance Requirements

MICHIGAN DESIGN MANUAL
BRIDGE DESIGN

CHAPTER 12

MICHIGAN DESIGN MANUAL
BRIDGE DESIGN

CHAPTER 7

3R BRIDGE GUIDELINES

(BDM 12.05.01)

12.05.01

Approved MDOT Railings
(5-1-2000) (11-25-2019) (9-28-2020)

Current MDOT approved railings are:

A. Bridge Barrier Railing, Type 6
(B-29-Series)
B. Bridge Barrier Railing, Type 7
(B-28-Series)
C. Bridge Railing, Aesthetic Parapet Tube
(B-25-Series)
D. Bridge Railing, 2 Tube
(B-21-Series)
E. Bridge Railing, Thrie Beam Retrofit
(B-22&23-Series)
F. Bridge Railing, 4 Tube (9-2-2003)
(B-26-Series)
G. Bridge Railing, 3 Tube With Pickets
(B-27-Series)
H. Bridge Railing, Concrete Block Retrofit
(B-50-Series)
I. Bridge Barrier Railing, Type 6, Modified *
(B-29-Series & Bridge Design Guides)

* **Type 6 modified (adhesive anchored) railing must only be used for non-NHS routes.**

3R BRIDGE GUIDELINES

(BDM Appendix 12.02)

CLEAR ROADWAY WIDTHS AND DESIGN LOADING FOR BRIDGES BEING REHABILITATED (3-26-2012)			
Type of Roadway		**Minimum Clear Roadway Width**	**Minimum Design Loading**
Non-Interstate Freeway		A, B	HS-20
Interstate Freeway		A, B	HS-20
Arterial (Non-Freeway Trunkline)	Rural	C	HS-20
	Urban	D	HS-20
Collector (Non-Trunkline)	Rural	Exhibit 6-7.	H 15
	Urban	Exhibit 6-5., E	H 15
Local (Non-Trunkline)	Rural	Exhibit 5-7.	ADT≤50:H 10 ADT>50:H 15
	Urban	Exhibit 5-5., E	

(A) As constructed.

(B) Consideration should be given to carrying the full shoulders of the approach roadway across the structure if it is cost effective to do so.

(C) The minimum clear roadway should accommodate the traveled way plus 2'-0" on each side. (12-5-2005)

(D) The minimum clear width on the bridge shall be the same as the curb-to-curb width of the street.

(E) The minimum clear roadway shall be the traveled way plus 1'-0" to each curb face. However, consideration should be given to providing the same width as the curb-to-curb approach width if it is cost effective to do so.

3R BRIDGE GUIDELINES

(BDM Appendix 12.02)

The tables shown in this appendix are derived from A Policy on Geometric Design of Highways and Streets, 2011, 6th Edition, published by AASHTO and do not include clearances for bridge rail offset. See the Bridge Design Guides for MDOT offset criteria. (3-26-2012) (7-20-2015) (3-21-2016)

Exhibit 6-7. **STRUCTURAL CAPACITIES AND MINIMUM ROADWAY WIDTHS FOR BRIDGES BEING REHABILITATED CARRYING RURAL COLLECTOR ROADS**

Design Traffic Volume(veh/day)	Design Loading Structural Capacity	Minimum Clear Roadway Width (ft)[a]
Under 400	H 15	22
400 to 1500	H 15	22
1500 to 2000	H 15	24
over 2000	H 15	28

[a] Clear width between curbs or railings, whichever is the lesser, shall be equal to or greater than the approach traveled way width, wherever practical.

The values in Exhibit 6-7. do not apply to structures with a total length greater than 100 ft. These structures should be analyzed individually by taking into consideration the clear width provided, safety, traffic volumes, remaining life of the structure, design speed, and other pertinent factors.

Exhibit 6-5. **MINIMUM WIDTH OF TRAVELED WAY FOR COLLECTOR ROADS**

Design Speed(mph)	Design Traffic Volumes (veh/day)			
	Under 400	400-1500	1500 -2000	over 2000
	Width of Traveled Way (ft)			
20-30	20[a]	20	22	24
35-40	20[a]	22	22	24
45-50	20	22	22	24
55-60	22	22	24	24

[a] A 18 ft minimum width may be used for roadways with design volumes under 250 veh/day.

On roadways to be reconstructed, a 22 ft traveled way may be retained where the alignment and safety records are satisfactory.

3R BRIDGE GUIDELINES

(BDM Appendix 12.02)

Exhibit 5-7. **MINIMUM STRUCTURAL CAPACITIES AND MINIMUM CLEAR ROADWAY WIDTHS FOR BRIDGES BEING REHABILITATED CARRYING RURAL LOCAL ROADS**

Design Traffic Volume(veh/day)	Design Loading Structural Capacity	Minimum Clear Roadway Width (ft)[(a) (b)]
0-50	H 10	20[(c)]
51-250	H 15	20
250-1500	H 15	22
1500-2000	H 15	24
over 2000	H 15	28

(a) Clear width between curbs or railings, whichever is the lesser.
(b) Minimum clear widths that are 2 ft narrower may be less than the approach traveled way width.
(c) For one-lane bridges use 18 ft.

The values in Exhibit 5-7. do not apply to structures with total length greater than 100 ft. These structures should be analyzed individually, taking into consideration the clear width provided, traffic volumes, remaining life of the structure, pedestrian volumes, snow storage, design speed, crash record, and other pertinent factors.

Exhibit 5-5. **MINIMUM WIDTH OF TRAVELED WAY FOR LOCAL ROADS**

	Design Traffic Volumes (veh/day)			
Design Speed(mph)	Under 400	400-1500	1500 -2000	over 2000
	Width of Traveled Way (ft)			
15	18	20	20	22
20-40	18	20	22	24
45-50	20	22	22	24
55-60	22	22	24	24

Where the width of traveled way is shown as 24 ft, the width may remain 22 ft m on reconstructed bridges where alignment and safety records are satisfactory.

VERTICAL CLEARANCE

Bridge Design Manual, Section 7.01.08
Road Design Manual, Section 3.12

VERTICAL CLEARANCE REQUIREMENT TABLE (8-20-2009) (6-22-2015)

Route Classification Under the Structure	All Construction (Desired)	New Construction (Min *)	Road 4R Construction (Min *)	Bridge 4R Construction (Min *)	3R Construction (Min *)
Freeways	16'-3"	16'-0"	16'-0"	16'-0"	16'-0" ***
NHS Arterials (Local & Trunkline)	16'-3"	16'-0"	Maintain Existing** and 14'-6" Min	16'-0"	Maintain Existing** and 14'-0" Min
Non NHS Arterials (Local & Trunkline)	16'-3"	14'-6"	Maintain Existing** and 14'-6" Min	Maintain Existing** and 14'-6" Min	Maintain Existing** and 14'-0" Min
Collectors, Local Roads & Special Routes(1)	14'-9"	14'-6"	Maintain Existing** and 14'-6" Min	Maintain Existing** and 14'-6" Min	Maintain Existing** and 14'-0" Min

3R = Rehabilitation, Restoration, Resurfacing

* Minimum Vertical Clearance must be maintained over complete usable shoulder width.

** Existing vertical clearances greater than or equal to the minimums shown may be retained without a design exception. Vertical clearance reductions that fall below the minimums for new construction require a design exception. (6-22-2015)

*** Existing vertical clearances may be retained (or increased) without a design exception unless a pattern of high load hits exist. Vertical clearance reductions below the standard (table value) require design exceptions. (5-27-2020)

(1) Special Routes are in Highly Urbanized Areas (where little if any undeveloped land exists adjacent to the roadway) where an alternate route of 16'-0" is available or has been designated. Bridges located over Special Routes in Highly Urbanized Areas can be found on the MDOT website at: http://mdotcf.state.mi.us/public/design/files/englishbridgemanual/Exempt_Structures.pdf. (5-28-2013)

Ramps and roadways connecting a Special Route and a 16'-0" route require a vertical clearance minimum of 14'-6" (14'-9" desired). Ramps and roadways connecting two 16'-0" routes require a vertical clearance minimum of 16'-0" (16'-3" desired). (8-20-2009)

4R = Reconstruction

Information on the NHS systems can be obtained by contacting the Statewide Planning Section, Bureau of Transportation Planning or found on the MDOT website at: http://www.michigan.gov/mdot-nfc (11-28-2011)

Pedestrian bridges are to provide 1'-0" more underclearance than that required for a vehicular bridge. For Freeways (Interstate and non Interstate), including Special Route Freeways, the desired underclearance shall be 17'-3" (minimum 17'-0"). (8-20-2009)

A vertical underclearance of 23'-0" is required for highway grade separations over railroads when constructing a new bridge or removing the existing superstructure. For preventative maintenance, rehabilitation and deck replacement projects the existing railroad vertical underclearance does not need to be increased unless requested by the Railroad. (11-28-2011)

Clearance signs are to be present for structures with underclearance of 16'-0" or less (show dimensions 2" less than actual). See MDOT Traffic and Safety Sign Design, Placement, and Application Guidelines for additional information and guidelines. (8-20-2009) (11-28-2011) (11-21-2013) (3-25-2019)

QUESTIONS

DESIGN SPEED

DESIGN SPEED

(RDM 3.06)

Design Speed

- Selected Speed
- Used to Determine Various Geometric Design Features of the Roadway

Once Selected…

- All Pertinent Design Features Should be Related to It to Obtain a Balanced Design

DESIGN SPEED (RDM 3.06)

MDOT Desirable Practice

Design Roadway Geometrics for 4R Projects Based on an MDOT Recommended Project Design Speed 5 mph Greater than the Posted Speed

Research shows that Operating Speeds are Typically Greater than the Posted Speeds.

Posted Speeds May be Used as Minimum Project Design Speeds

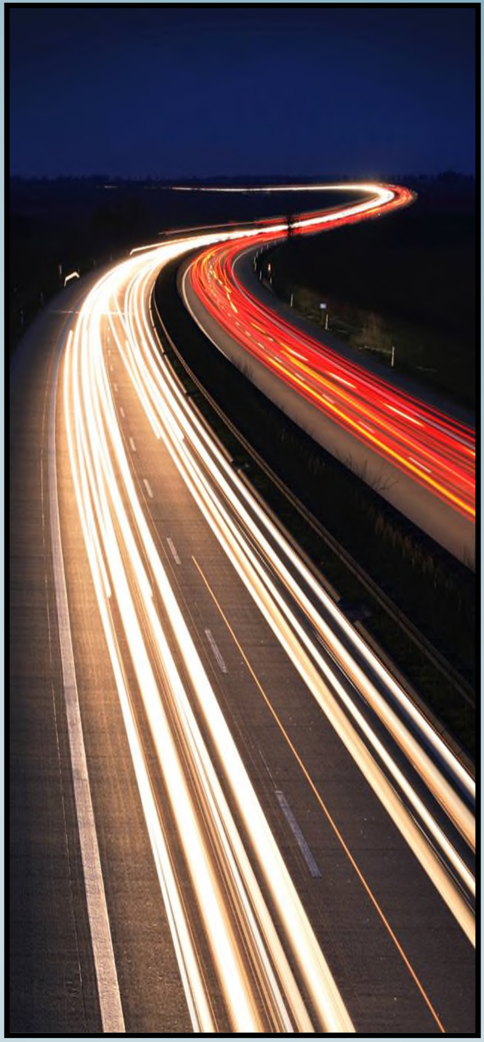
DESIGN SPEED

3R / 4R Freeway Projects

Recommended Design Speed: 5 mph Greater than Posted Speed

Minimum Design Speed: The Greater of Posted Speed, or 70 mph

3R Freeway Allowance: The Design Speed at the Time of Construction or the Last 4R Project



"Urban" Freeway Projects

Recommended Design Speed: 5 mph Greater than Posted Speed

Minimum Design Speed: The Greater of Posted Speed, or 60 mph

3R Freeway Allowance: The Design Speed at the Time of Construction or the Last 4R Project

Freeway Clear Zones

Design Speed – 70 mph

DESIGN SPEED (RDM Appendix 3A)

Appendix 3A
GEOMETRIC DESIGN ELEMENTS
New Construction / Reconstruction

Element		Urban	Rural
Design Speed	**Freeway**	The greater of posted speed, or 60 mph.	The greater of posted speed, or 70 mph.
	Non Freeway (Arterial)	The greater of posted speed, or 30 mph.	The greater of posted speed, or 40 mph..
	Collector Roads	Posted speed (minimum).	Posted speed (minimum)..
Lane Width	**Freeway**	12 ft.	12 ft.
	Non Freeway (Arterial)	12 ft, lanes are most desirable and should be used where practical. 11 ft. lanes are often used for low speed (45 mph design) Lane widths of 10 ft. may be used in more constrained areas where truck and bus volumes are relatively low and speeds are less than 35 mph. 12 ft. lanes on the National Network (NN). Design exceptions / variances are required to maintain existing narrower lanes. A high burden of justification is required in a design exception / variance to reduce existing lane widths less than or equal to 12'-0".	
	Collector Roads	Added turn lanes at intersections 10-12 ft. Where right-of-way is restricted. 11 ft. Industrial Areas 12 ft. Where shoulders are used, see guidelines for Rural Collectors ☞	

Design Speed, (mph)	Minimum Lane Width, ft. ADT, vehicles/day			
	Under 400	400 to 1500	1500 to 2000	Over 2000
40	11*	11*	11*	12
45	11*	11*	11*	12
50	11*	11*	12	12
55	11*	11*	12	12
60	12	12	12	12
65	12	12	12	12
70	12	12	12	12
75	12	12	12	12

*12 ft. desirable

Design Speed, (mph)	Minimum Lane Width, ft. ADT, vehicles/day			
	Under 400	400 to 1500	1500 to 2000	Over 2000
20	10*	10*	11*	12
25	10*	10*	11*	12
30	10*	10*	11*	12
35	10*	11*	11*	12
40	10*	11*	11*	12
45	10*	11*	11*	12
50	10*	11*	11*	12
55	11*	11*	12	12
60	11*	11*	12	12

*12 ft. desirable

<u>Note</u>: An Allowance is Provided for 3R Work Types

DESIGN SPEED

Non-Freeway, NHS, 3R (3.09.02 A)

MICHIGAN DESIGN MANUAL
ROAD DESIGN

3.09.02 (continued)

A. Non-Freeway, NHS

Geometric Elements	Non-Freeway, NHS 3R Minimum Guidelines			
Design Speed (see Section 3.06)	Posted Speed Minimum			
Shoulder Width	Current ADT Two-Way		Inside Shoulder	Outside Shoulder
	Two Lane (and three lane when the center lane is a left turn lane)	<750		3'-0" Gravel
		750 - 5000		6'-0" (3'-0" Paved)
		>5000 - 10,000		8'-0" (3'-0" Paved)
NOTE: Minimum shoulder widths apply for posted speeds greater than 45 mph. Restrictions such as right of way and roadside context sensitivity issues may preclude the use of minimum shoulders within city, village or township limits with posted speeds of 45 mph and less.		>10,000		8'-0" (7'-0" Paved)
	Multi-Lane Undivided	≤ 10,000 > 10,000		6'-0" (3'-0" Paved) 8'-0" (3'-0" Paved)
	Multi-Lane Divided	≤ 10,000 > 10,000	3'-0" Paved 3'-0" Paved	6'-0" (3'-0" Paved) 8'-0" (3'-0" Paved)
	See Bridge Design Manual Appendix 12.02 for Bridge Widths			
Lane Width	ADT	Lane Width		
	≤750	10'-0"		
	>750	11'-0"		
		10'-0" lanes may be considered in urban areas for multi-lane un-divided (regardless of ADT) and multi-lane divided (ADT < 10,000). 12'-0" lanes are desirable on the Priority Commercial Network (PCN). 12'-0" lanes are required on the National Network (also known as the National Truck Network). Design Exceptions / Design Variances to maintain existing narrower lanes generally receive favorable consideration but a high burden of justification is placed on requests to reduce lane widths to less than 12'-0".		
Design Loading Structural Capacity	Rural		Urban	
	Minimum Design Loading HS20.		Minimum Design Loading HS20.	
	(See Bridge Design Manual Appendix 12.02 for other trunkline classifications)			
Horizontal Curve Radius and Stopping Sight Distance	Existing curve radius and stopping sight distance may be retained if the design speed of the existing curve is not more than 15 mph below the project design speed and there is no crash concentration. Otherwise standards for new construction apply. See 2011 6th Edition AASHTO Green Book or MDOT Sight Distance Guidelines.			
Maximum Grade	Review crash data. Existing grade may be retained without crash concentration.			
Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05			
Superelevation Rate	Standard Plan R-107-Series or reduced maximum (6%) Straight Line Superelevation Chart using the project design speed.			
Vertical Clearance	See Section 3.12.			

DESIGN SPEED

Non-Freeway, Non-NHS, 3R (3.09.02 B)

MICHIGAN DESIGN MANUAL
ROAD DESIGN

3.09.02 (continued)

B. Non-Freeway, Non-NHS

Geometric Elements	Non-Freeway, Non-NHS 3R Minimum Guidelines		
Design Speed	Posted Speed Minimum		
Shoulder Width	Current ADT Two-Way	Inside and Outside Shoulder Width	

Posted Speed Minimum

than 45 mph where sufficient right-of-way exists to include shoulders. *At lower speeds, minimum shoulders are desirable.*	Multi-Lane (Divided & Undivided)	Inside (Divided)	Outside (Both sides for un-divided)
		3'-0" Paved	8'-0" (3'-0" Paved)
Lane Width	ADT	Lane Width	
	≤750	10'-0"	
	>750	11'-0" 10'-0" lanes may be considered in urban areas for multi-lane un-divided (regardless of ADT) and multi-lane divided (ADT < 10,000). 12'-0" lanes are desirable on the Priority Commercial Network (PCN) and the National Network (also known as the National Truck Network). Existing narrower lanes may be retained without design exceptions. Reduction of existing lane widths on the National Network to less than 12-0" require a design exception request having a high burden of justification.	
Bridge Width, Structural Capacity & Horizontal Clearances **(Existing Bridges to remain in place)**	ADT (Design Year)	Minimum Design Loading	Usable Width
	0 - 750	H15	Width of traveled way.
	751 - 1500	HS15	Width of traveled way.
	1501 - 2000	HS15	Width of traveled way plus 1' each side.
	2001 - 4000	HS15	Width of traveled way plus 2' each side.
	> 4000	HS15	Width of traveled way plus 3' each side.
Horizontal / Vertical Alignment and Stopping Sight Distance	Existing alignment and stopping sight distance may be retained if the design speed of the existing curve is not more than 15 mph (horizontal alignment) or 20 mph (vertical alignment) below the project design speed and there is no crash concentration. Otherwise standards for new construction apply. . See current AASHTO Green Book or MDOT Sight Distance Guidelines.		
Grade	Review crash data. Existing grade may be retained without crash concentration.		
Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05		
Superelevation	Standard Plan R-107-Series or reduced maximum (6%) Straight Line Superelevation Chart using the project design speed.		
Vertical Clearance	See Section 3.12.		

DESIGN SPEED (RDM 3.06)

Geometric Design Elements that Do Not Meet Current Standards (or Allowances) Based on <u>Minimum</u> Design Speeds Require:

- A Formal Safety Review
- A Crash Analysis
- Documented Justification in the Form of:
  - A Design Exception (Form DE26)
  - A Design Variance (Form DV26)

"If the highest attainable design corresponds to criteria for speeds less than the <u>minimum</u> design speed, a design exception or design variance must be submitted for approval."

DESIGN SPEED (RDM 3.06)

Documentation Required for Each Geometric Element

No Blanket Design Exceptions

A Design Speed Reduction for Individual Geometric Elements Does Not Redefine the Overall "Project Design Speed"

DESIGN SPEED
(RDM 3.06)

Additional Allowances to Retain Existing Horizontal and Vertical Alignments and Stopping Sight Distances Based on a Range of Reduced Design Speeds are Provided Under the 3R Non-Freeway Guidelines (3.09.02A & 3.09.02B)

QUESTIONS

SIGHT DISTANCE

SIGHT DISTANCE

SIGHT DISTANCE GUIDELINES

MDOT
Michigan Department of Transportation

According to the 2004 AASHTO, 2005 MMUTCD, and
Michigan Department of Transportation Guidelines

PREPARED BY
GEOMETRICS AND OPERATIONS UNIT
TRAFFIC AND SAFETY
February 6, 2008

"Providing the highest quality transportation services for economic benefit and improved quality of life."

SIGHT DISTANCE

"Sight distance is the distance along a roadway throughout which an object of specified height is continuously visible to the driver. This distance is dependent on the height of the driver's eye above the road surface, the specified object height above the road surface, and the height and lateral position of sight obstructions within the driver's line of sight."

(2011 AASHTO, Section 3.2.6)

SIGHT DISTANCE

Four Types

Stopping Sight Distance

Passing Sight Distance

Decision Sight Distance

Intersection Sight Distance

SIGHT DISTANCE

Stopping Sight Distance…

…is the minimum sight distance required along a roadway to enable a vehicle traveling at or near the design speed to stop before reaching a stationary object in its path.

(2011 AASHTO, Section 3.2.2)

Brake Reaction Distance + Braking Distance

SIGHT DISTANCE

Stopping Sight Distance

BRAKE REACTION DISTANCE	+	BRAKING DISTANCE
$1.47Vt$		$1.075V^2/a$

V = Design Speed (mph)

t = Brake Reaction Time (2.5 seconds assumed)

a= Deceleration Rate (11.2 ft/s^2 assumed)

Simplified…

$$\mathbf{SSD = 3.675V + 0.096V^2}$$

SIGHT DISTANCE

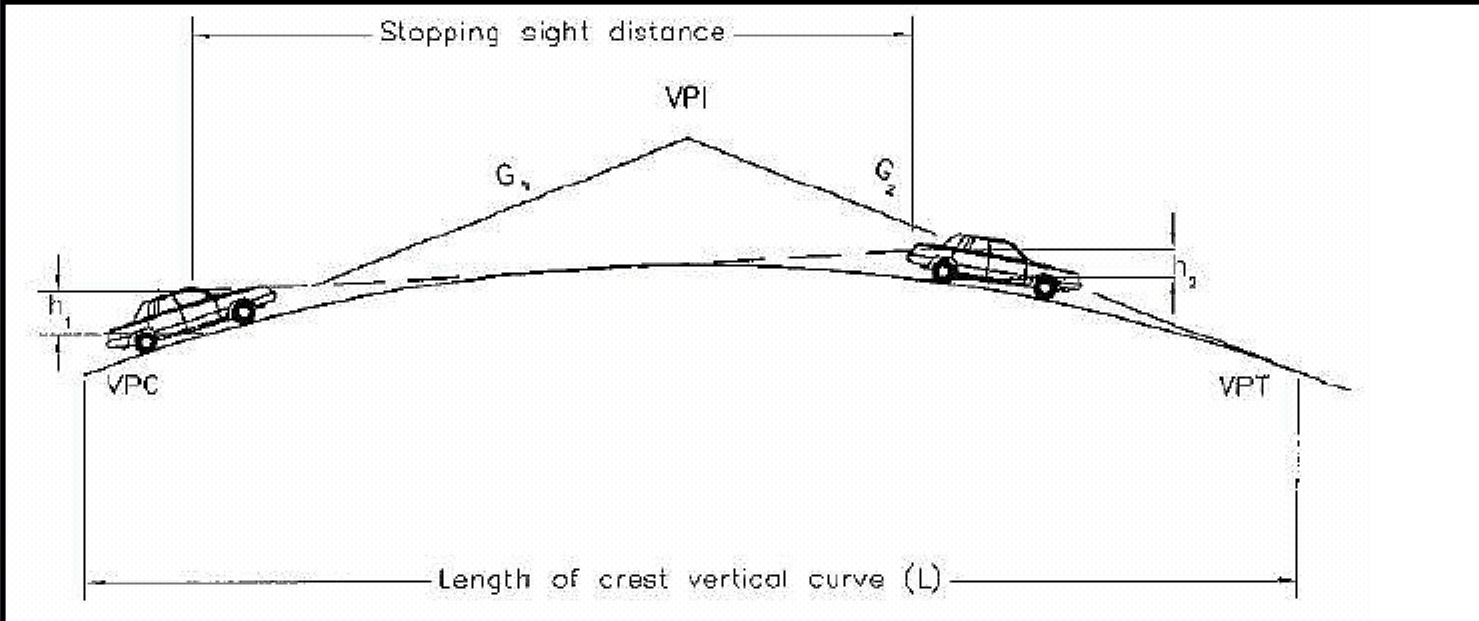


Exhibit 4 Parameters Considered in Determining the Length of a Crest Vertical Curve to Provide Sight Distance (2004 AASHTO, Exhibit 3-70, 268)

HEIGHT OF EYE	HEIGHT OF OBJECT
3.5 ft	2.0 ft

SIGHT DISTANCE

Design Speed (mph)	Brake Reaction Distance (ft)	Braking Distance on Level (ft)	Stopping Sight Distance	
			Calculated (ft)	Design (ft)
15	55.1	21.6	76.7	80
20	73.5	38.4	111.9	115
25	91.9	60.0	151.9	155
30	110.3	86.4	196.7	200
35	128.6	117.6	246.2	250
40	147.0	153.6	300.6	305
45	165.4	194.4	359.8	360
50	183.8	240.0	423.8	425
55	202.1	290.3	492.4	495
60	220.5	345.5	566.0	570
65	238.9	405.5	644.4	645
70	257.3	470.3	727.6	730
75	275.6	539.9	815.5	820
80	294.0	614.3	908.3	910

Exhibit 1. Stopping Sight Distance (2004 AASHTO Exhibit 3-1, 112)

SIGHT DISTANCE

Horizontal Sightline Offset…

…is the minimum distance required between the roadside and an obstruction, measured from the centerline of the inside lane to the face of the obstruction.

(2011 AASHTO, Section 3.3.12)

$$\mathbf{HSO = R\,[1-\mathit{cos}((28.65S) / R)]}$$

R = Radius of Curve (feet)
HSO = Horizontal Sightline Offset (feet)
SSD = Stopping Sight Distance (feet)

SIGHT DISTANCE

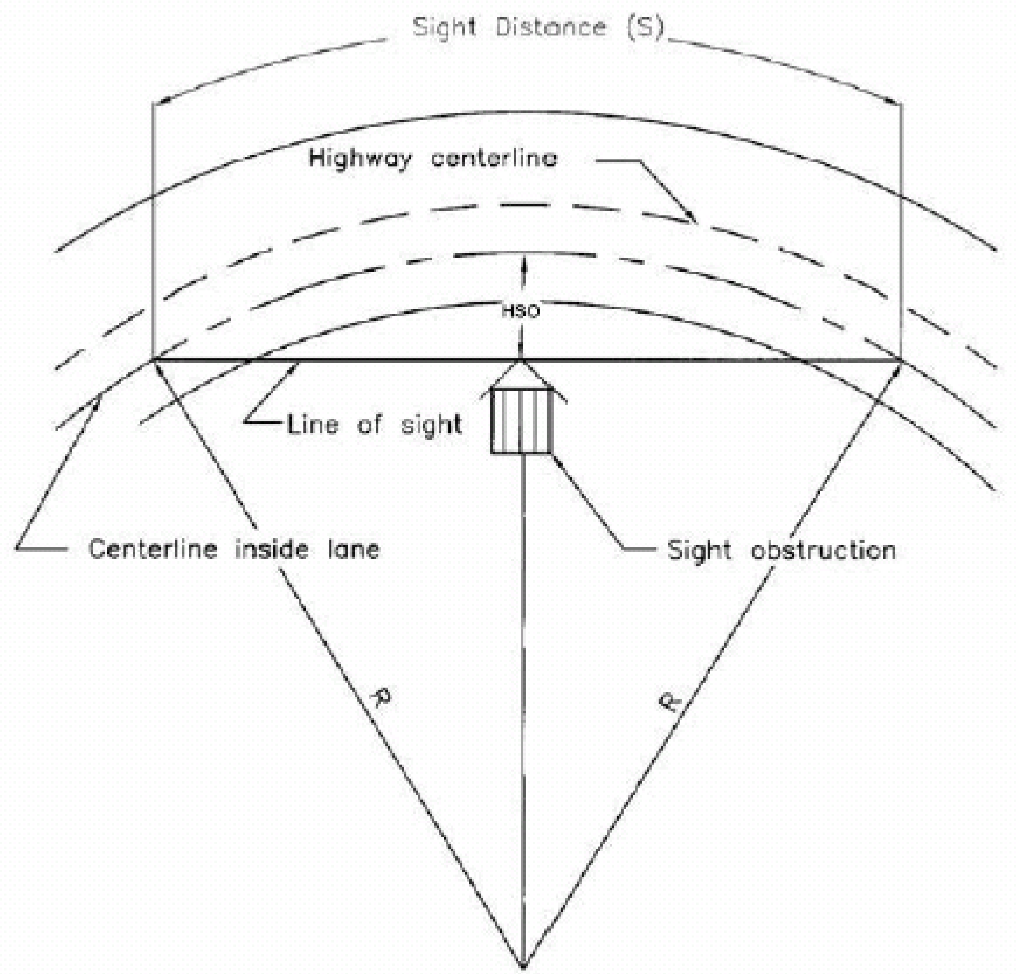


Exhibit 2 Diagram Illustrating Components for Determining Horizontal Sight Distance
(2004 AASHTO Exhibit 3-54, 227)

HEIGHT OF SIGHT LINE

2.75 ft

SIGHT DISTANCE

Decision Sight Distance…

"…is the distance required for a driver to detect an unexpected or otherwise difficult-to-perceive information source or condition in a roadway environment that may be visually cluttered, recognize the condition or its threat potential, select an appropriate speed and path, and initiate and complete complex maneuvers."

(2011 AASHTO, Section 3.2.3)

SIGHT DISTANCE

Decision Sight Distance

Avoidance Maneuvers A and B	**Avoidance Maneuvers C, D, and E**
$d = 1.47\,Vt + 1.075\,V^2/a$	$d = 1.47\,Vt_m$

V = Design Speed (mph)

t = Pre-maneuver Time (See Exhibit 3-3)

a= Deceleration Rate (11.2 ft/s^2 assumed)

t_m = Total Pre-Maneuver and Maneuver Time

HEIGHT OF EYE	HEIGHT OF OBJECT
3.5 ft	2.0 ft

SIGHT DISTANCE

Quick Chart for Decision Sight Distance

Design Speed (mph)	Decision Sight Distance (ft)				
	Avoidance Maneuver				
	A	B	C	D	E
30	220	490	450	535	620
35	275	590	525	625	720
40	330	690	600	715	825
45	395	800	675	800	930
50	465	910	750	890	1030
55	535	1030	865	980	1135
60	610	1150	990	1125	1280
65	695	1275	1050	1220	1365
70	780	1410	1105	1275	1445
75	875	1545	1180	1365	1545
80	970	1685	1260	1455	1650

Avoidance Maneuver A: Stop on Rural Road – (t = 3.0 sec)

Avoidance Maneuver B: Stop on Urban Road – (t = 9.1 sec)

Avoidance Maneuver C: Speed/Path/Direction Change on Rural Road – (t_m varies between 10.2 and 11.2 sec)

Avoidance Maneuver D: Speed/Path/Direction Change on Suburban Road – (t_m varies between 12.1 and 12.9 sec)

Avoidance Maneuver E: Speed/Path/Direction Change on Urban Road – (t_m varies between 14.0 and 14.5 sec)

Decision Sight Distance

(2004 AASHTO, Exhibit 3-3, 116)

SIGHT DISTANCE

Passing Sight Distance…

…is the distance required for a passing vehicle to be able to see a sufficient distance ahead, clear of traffic, to complete the passing maneuver without cutting off the passed vehicle before meeting an opposing vehicle.

(2011 AASHTO, Section 3.2.4)

Minimum Passing Sight Distance is the Sum of Four Distances

$$\mathbf{d_1 + d_2 + d_3 + d_4}$$

SIGHT DISTANCE

Passing Sight Distance – d_1

Distance Traversed During Perception and Reaction Time and During the Initial Acceleration to the Point of Encroachment on the Opposing Lane.

$$d_1 = 1.47t_i[v\text{-}m + (at_i / 2)]$$

t_i = Time of Initial Maneuver (sec)

a = Average Acceleration (mph/s)

v = Average Speed of Passing Vehicle

m = Difference in Speed of Passed Vehicle and Passing Vehicle (mph)

SIGHT DISTANCE

Passing Sight Distance – d_2

Distance Traveled while the Passing Vehicle Occupies the Left Lane.

$$d_2 = 1.47vt_2$$

t_2 = Time Passing Vehicle Occupies the Left Lane

v = Average Speed of Passing Vehicle

SIGHT DISTANCE

Passing Sight Distance – d_3

Distance Between the Passing Vehicle at the End of its Maneuver and the Opposing Vehicle

d_3 = 100 to 250 ft

Length was Found in the Passing Study to Vary

SIGHT DISTANCE

Passing Sight Distance – d_4

Distance Traversed by an Opposing Vehicle for Two-Thirds of the Time the Passing Vehicle Occupies the Left Lane, or 2/3 of d_2

$$d_4 = 2d_2/3$$

SIGHT DISTANCE

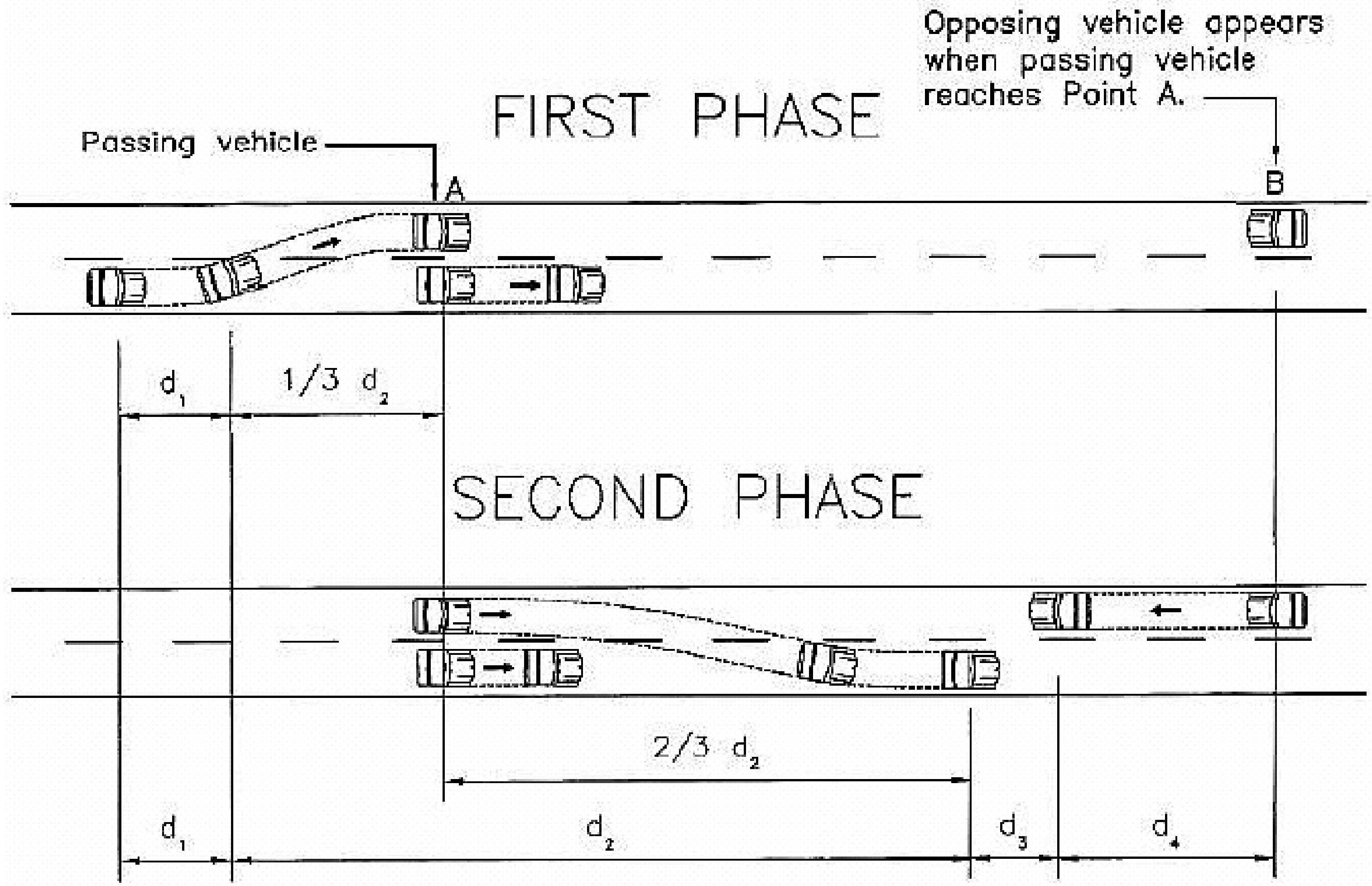


Exhibit 7 Elements of Passing Sight Distance for Two-Lane Highways
(2004 AASHTO, Exhibit 3-4, 119)

SIGHT DISTANCE

Design Speed (mph)	Assumed Speeds (mph)		Passing Sight Distance (ft)	
	Passed Vehicle	Passing Vehicle	From Exhibit 9	Rounded for Design
20	18	28	706	710
25	22	32	897	900
30	26	36	1088	1090
35	30	40	1279	1280
40	34	44	1470	1470
45	37	47	1625	1625
50	41	51	1832	1835
55	44	54	1984	1985
60	47	57	2133	2135
65	50	60	2281	2285
70	54	64	2479	2480
75	56	66	2578	2580
80	58	68	2677	2680

Exhibit 10 Passing Sight Distance for Design of Two-Lane Highways

(2004 AASHTO, Exhibit 3-7, 124)

HEIGHT OF EYE

3.5 ft

HEIGHT OF OBJECT

3.5 ft

SIGHT DISTANCE

Passing Sight Distance – Pavement Markings

Warrants for Placing No-Passing Zone Markings On Existing and Proposed Highways

85th-Percentile or Posted or Statutory Speed Limit (mph)	Minimum Passing Sight Distance (ft)
25	450
30	500
35	550
40	600
45	700
50	800
55	900
60	1000
65	1100
70	1200

Exhibit 12 Minimum Passing Sight Distances for Pavement Marking Criteria

(2011 MMUTCD, Table 3B-1, page 352)

SIGHT DISTANCE

Intersection Sight Distance…

…is the sight distance needed to allow the drivers of stopped vehicles to decide when to enter or cross an intersecting roadway. (2011 AASHTO, Section 9.5)

SIGHT DISTANCE

Intersection Sight Distance

$$ISD = 1.47\ V\ t_g$$

V = Design Speed of Major Road (mph)

t_g = Time Gap for Minor-Road Vehicle to Cross the Major Road (sec)

SIGHT DISTANCE

Design Vehicle	Time Gap (t_g) (seconds) at Design Speed of Major Road
Passenger Car	7.5
Single-Unit Truck	9.5
Combination Truck	11.5
Note: Time gaps shown are for a stopped vehicle to turn left onto a two-lane road with no median and approach grades of 3 percent or less. The table values require adjustment as follows:	
For Two-Way Roadways with More than Two Lanes: Add 0.5 seconds for passenger cars or 0.7 seconds for trucks for each additional lane, from the left, in excess of one, to be crossed by the left-turning vehicle.	
For Minor Road Approach Grades: If the rear wheels of the design vehicle are located on an upgrade which exceeds 3 percent, Add 0.2 seconds for each percent of grade.	

Exhibit 16 Time Gap for Case B1 – Left-Turn from Stop

(2004 AASHTO, Exhibit 9-54, 660)

SIGHT DISTANCE

Design Vehicle	Time Gap (t_g) (seconds) at Design Speed of Major Road
Passenger Car	6.5
Single-Unit Truck	8.5
Combination Truck	10.5

Note: Time gaps shown are for a stopped vehicle to turn right onto or cross a two-lane road with no median and approach grades of 3 percent or less. The table values require adjustment as follows:

For Roadways with More than Two Lanes:

For crossing a major road with more than two lanes, add 0.5 seconds for passenger cars or 0.7 seconds for trucks for each additional lane to be crossed, and for narrow medians that cannot store the design vehicle.

For Minor Road Approach Grades:

If the rear wheels of the design vehicle are located on an upgrade which exceeds 3 percent, add 0.1 seconds for each percent of grade.

Exhibit 19 (2004 AASHTO, Exhibit 9-57, 664)

Time Gap for Case B2 – Right-Turn from Stop and Case B3 – Crossing Maneuver

SIGHT DISTANCE

Quick Charts for Intersection Sight Distance

Design Speed (mph)	Stopping Sight Distance (ft)	Intersection Sight Distance for Passenger Cars (ft)	
		Calculated	Design
15	80	165.4	170
20	115	220.5	225
25	155	275.6	280
30	200	330.8	335
35	250	385.9	390
40	305	441.0	445
45	360	496.1	500
50	425	551.3	555
55	495	606.4	610
60	570	661.5	665
65	645	716.6	720
70	730	771.8	775
75	820	826.9	830
80	910	882.0	885

Note: The given intersection sight distance values are for a stopped passenger car to turn left onto a two-lane road with no median and minor road approach grades of 3 percent or less. For other conditions, the sight distance must be recalculated.

Design Intersection Sight Distance – Case B1 – Left-Turn from Stop
(2004 AASHTO, Exhibit 9-55, 661)

SIGHT DISTANCE

Design Speed (mph)	Stopping Sight Distance (ft)	Intersection Sight Distance for Passenger Cars (ft)	
		Calculated	Design
15	80	143.3	145
20	115	191.1	195
25	155	238.9	240
30	200	286.7	290
35	250	334.4	335
40	305	382.2	385
45	360	430.0	430
50	425	477.8	480
55	495	525.5	530
60	570	573.3	575
65	645	621.1	625
70	730	668.9	670
75	820	716.6	720
80	910	764.4	765

Note: The given intersection sight distances are for a stopped passenger car to turn right onto, or cross, a two-lane road with no median and minor road approach grades of 3 percent or less. For other conditions, the sight distance must be recalculated.

Design Intersection Sight Distance – Case B2 – Right-Turn from Stop and Case B3 – Crossing Maneuver (2004 AASHTO, Exhibit 9-58, 664)

SIGHT DISTANCE

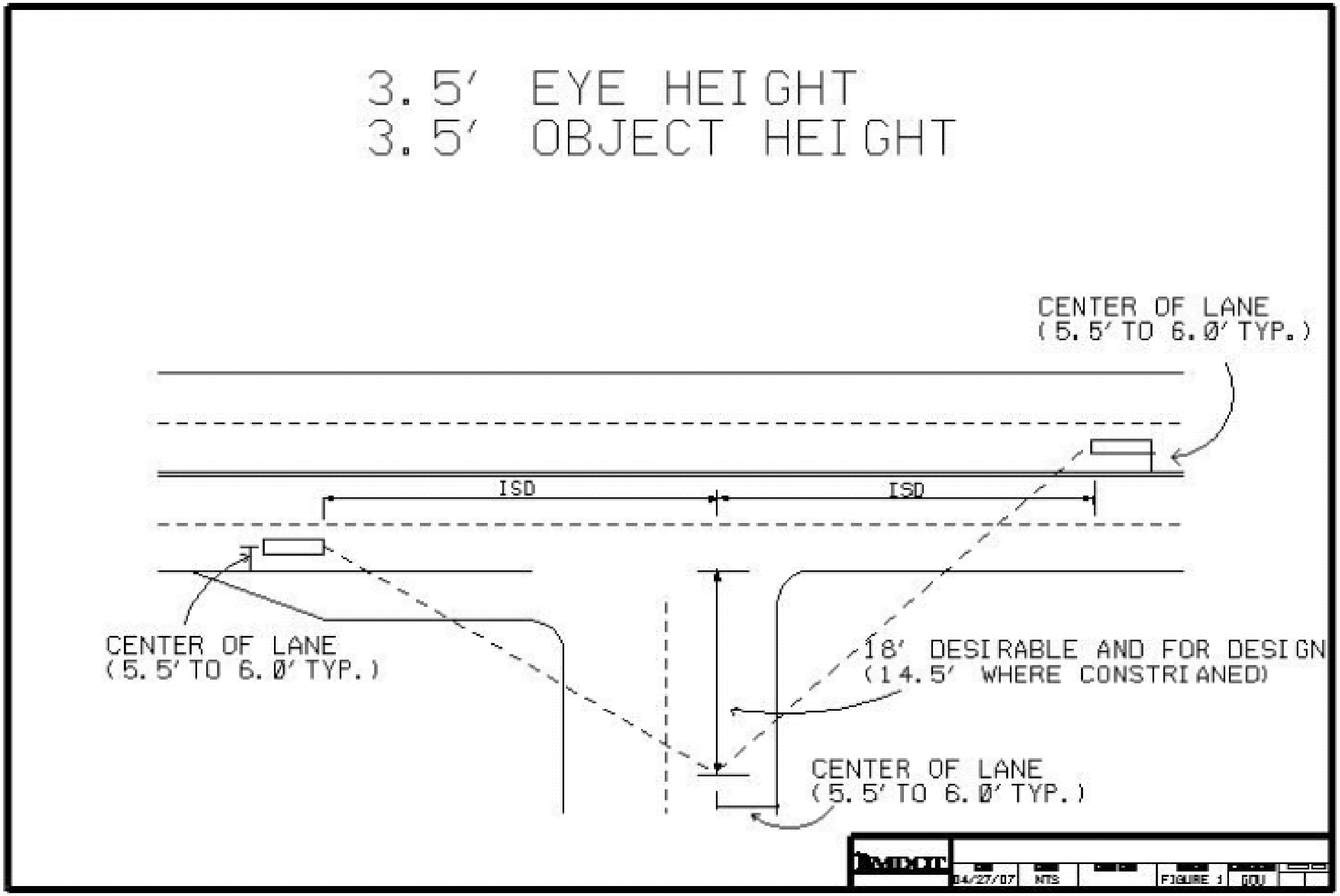


Figure 1. Measurement of Intersection Sight Distance

QUESTIONS

Problem 1: Non-Freeway, Non-NHS Corridor with a 3R Work Type
Undivided, Two-Lane Roadway
ADT = 12,500
Level Terrain
Posted Speed Limit is 55 mph
2350’ Radius Horizontal Curve

a). What is the minimum allowable design speed?

b). Minimum required Stopping Sight Distance?

c). Minimum required Horizontal Sightline Offset (HSO)?

d). Minimum required Intersection Sight Distance?

Left-Turns:

Right-Turns/Crossing:

<u>Problem 1</u>: Non-Freeway, Non-NHS Corridor with a 3R Work Type
Undivided, Two-Lane Roadway
(Solutions) ADT = 12,500
Level Terrain
Posted Speed Limit is 55 mph
2350' Radius Horizontal Curve

a). What is the minimum allowable design speed?

55 mph (minimum) ***(RDM 3.09.02B)***

(60 mph still preferred, if feasible).

b). Minimum required Stopping Sight Distance?

495' for 55 mph

(***570' for 60 mph)*** ***(MDOT Sight Distance Guidelines)***

c). Required Horizontal Sightline Offset (HSO)?

13.0' for 55 mph

(***17.3' for 60 mph)*** ***(MDOT Sight Distance Guidelines)***

d). Required Intersection Sight Distance?

Left-Turns: ***610' for 55 mph***

(***665' for 60 mph)***

(MDOT Sight Distance Guidelines)

Right-Turns/Crossing: ***530' for 55 mph***

(***575' for 60 mph)***

Problem 2: Non-Freeway, NHS Corridor with a 4R Work Type
Divided Roadway, 36’ Median Width, 3 Lanes in Each Direction
ADT = 36,000
Level Terrain
Posted Speed Limit is 45 mph
1800’ Radius Horizontal Curve

a). What is the MDOT recommended design speed?

b). What is the minimum allowable design speed?

c). Required Stopping Sight Distance?

d). Required Horizontal Sightline Offset (HSO)?

e). Required Intersection Sight Distance?

* (Assume the Design Vehicle is a Passenger Car)
* (Further assume a design speed of 50 mph is utilized)

Left-Turns:

Right-Turns/Crossing:

<u>Problem 2</u>: Non-Freeway, NHS Corridor with a 4R Work Type
Divided Roadway, 36' Median Width, 3 Lanes in Each Direction
(Solutions) ADT = 36,000
Level Terrain
Posted Speed Limit is 45 mph
1800' Radius Horizontal Curve

a). What is the MDOT recommended design speed?

50 mph ***(RDM 3.06)***

b). What is the minimum allowable design speed?

45 mph ***(RDM Appendix 3A)***

c). Required Stopping Sight Distance?

425' (50 mph design speed.)

360' (45 mph design speed)

(MDOT Sight Distance Guidelines)

d). Required Horizontal Sightline Offset (HSO)?

12.5' (50 mph design speed)

9.0' (45 mph design speed)

(MDOT Sight Distance Guidelines)

e). Required Intersection Sight Distance?
* (Assumed Design Vehicle is a Passenger Car)
* (Assumed design speed is 50 mph)

Right-Turns/Crossing:

(6.5 sec.)(1.47)(50) = 480' for Right-Turn Movement

(MDOT Sight Distance Guidelines)

(6.5 sec. + 0.5 sec.)(1.47)(50) = 515' for Crossing Movement

- ***Use 515' to cover both movements***

Left-Turns/Crossing:

(6.5 sec. + 0.5 sec.)(1.47)(50) = 515' for Crossing Movement

(MDOT Sight Distance Guidelines)

(7.5 sec.)(1.47)(50) = 555' for Left-Turn Movement

- ***Use 555' to cover both movements***

HORIZONTAL ALIGNMENT

HORIZONTAL ALIGNMENT

Major Factor
in Determining

Safety

Driving Comfort

Highway Capacity

HORIZONTAL ALIGNMENT

Important Factors to Consider…

Passing Sight Distance on Two-Lane, Two-Way Roadways Should be Maximized

Curves Should be as Flat as Possible and Abrupt Changes in Alignment Avoided

HORIZONTAL ALIGNMENT

Important Factors to Consider…

Broken Back Curves Should be Avoided

Minimum Distance Between Curves Should be the Sum of the Transitions Plus Crown Runout Lengths

HORIZONTAL ALIGNMENT

Minimum Radius

- Limiting Value of Curvature for a Given Design Speed
- Determined from the Maximum Rate of Superelevation and the Maximum Side Friction Factor
- To be Avoided Wherever Practical

HORIZONTAL ALIGNMENT

Minimum Radius

$$R_{min} = \frac{V^2}{15(0.01e_{max} + f_{max})}$$

R = Radius (feet)

V = Design Speed (mph)

e = Rate of Superelevation (%)

f = Side Friction Factor (From AASHTO)

HORIZONTAL ALIGNMENT

Minimum Radius

R-107

RATE OF SUPERELEVATION AND SUPERELEVATION TRANSITION SLOPE

RADIUS (FEET)	30 MPH		35 MPH		40 MPH		45 MPH		50 MPH		55 MPH		60 MPH		65 MPH		FREEWAYS				URBAN FREEWAYS AND URBAN RAMPS	
																	70 MPH		75 MPH		60 MPH	
	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%
23000	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——
20000	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——
17000	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——
14000	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	2.0	0.31	2.0	0.30	NC	——
12000	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	2.0	0.32	2.0	0.31	2.0	0.30	NC	——
10000	NC	——	NC	——	NC	——	NC	——	NC	——	NC	——	2.0	0.36	2.0	0.32	2.1	0.31	2.3	0.31	2.0	0.34
8000	NC	——	NC	——	NC	——	NC	——	2.0	0.40	2.0	0.38	2.1	0.36	2.3	0.33	2.6	0.32	2.9	0.31	2.0	0.34
6000	NC	——	NC	——	NC	——	2.0	0.40	2.0	0.40	2.3	0.39	2.7	0.37	3.0	0.34	3.3	0.33	3.7	0.33	2.4	0.36
5000	NC	——	NC	——	2.0	0.40	2.0	0.40	2.3	0.41	2.7	0.39	3.1	0.38	3.5	0.35	3.9	0.34	4.4	0.34	2.8	0.37
4000	NC	——	2.0	0.45	2.0	0.40	2.4	0.41	2.8	0.42	3.3	0.40	3.8	0.39	4.2	0.37	4.7	0.36	5.3	0.35	3.3	0.39
3500	NC	——	2.0	0.45	2.2	0.41	2.6	0.42	3.1	0.42	3.6	0.41	4.2	0.40	4.7	0.38	5.2	0.37	5.9	0.36	3.5	0.40
3000	2.0	0.50	2.0	0.45	2.5	0.42	3.0	0.43	3.5	0.43	4.1	0.42	4.7	0.41	5.2	0.39	5.9	0.38	6.5	0.37	3.8	0.41
2500	2.0	0.50	2.4	0.46	2.9	0.43	3.5	0.44	4.1	0.44	4.7	0.43	5.3	0.42	5.9	0.41	6.5	0.39	7.0	0.38	4.2	0.42
2000	2.3	0.51	2.9	0.48	3.5	0.45	4.1	0.46	4.7	0.45	5.4	0.44	6.1	0.43	6.6	0.42	7.0	0.40	R MIN.= 2344'		4.6	0.44
1800	2.5	0.52	3.1	0.49	3.8	0.46	4.4	0.47	5.1	0.46	5.7	0.45	6.4	0.44	6.9	0.43	R MIN.= 1922'				4.8	0.44
1600	2.7	0.52	3.4	0.50	4.1	0.48	4.8	0.48	5.4	0.47	6.1	0.45	6.7	0.44	7.0	0.43					4.9	0.45
1400	3.0	0.53	3.7	0.51	4.5	0.49	5.1	0.49	5.8	0.48	6.5	0.46	6.9	0.45	R MIN.= 1565'						R MIN.= 1412'	
1200	3.4	0.54	4.1	0.52	4.9	0.50	5.6	0.50	6.3	0.49	6.8	0.47	R MIN.= 1263'									
1150	3.5	0.55	4.3	0.53	5.0	0.51	5.7	0.50	6.4	0.49	6.9	0.47										
1000	3.8	0.56	4.6	0.54	5.4	0.52	6.1	0.52	6.7	0.49	R MIN.= 1008'											
900	4.1	0.57	4.8	0.55	5.7	0.53	6.4	0.52	6.9	0.50												
820	4.3	0.57	5.1	0.55	5.9	0.54	6.6	0.53	7.0	0.50												
800	4.4	0.58	5.1	0.56	6.0	0.54	6.7	0.53	7.0	0.50												

300	6.7	0.65	R MIN.= 327'
265	6.9	0.66	
225	7.0	0.66	
	R MIN.= 222'		

NOTES:

LOOP RAMPS SHALL HAVE A 7% RATE OF SUPERELEVATION.

SPECIAL CONSIDERATION SHOULD BE GIVEN TO CURVES WHICH APPROACH A RAMP TERMINAL (STOPPING CONDITION).

IF DELTA VALUES FROM THE CHART CANNOT BE OBTAINED FOR THE DESIGN RADIUS, USE THE MAXIMUM DELTA VALUE FOR THE CORRESPONDING SPEED.

FOR RADII LESS THAN THOSE TABULATED, (BUT NOT LESS THAN R MIN.), USE e_{max}. MAXIMUM SUPERELEVATION FOR URBAN FREEWAYS AND URBAN RAMPS (WITH A 60 MPH DESIGN SPEED) IS 5%. OTHERWISE e_{max} = 7% .

HORIZONTAL ALIGNMENT

Minimum Radius

Straight Line Method

STRAIGHT LINE SUPERELEVATION

RADIUS Feet	30 mph		35 mph		40 mph		45 mph		50 mph		55 mph		60 mph		65 mph		Freeways 70 mph		Freeways 75 mph		Urban Freeways and Urban Ramps 60 mph	
	e	Δ%	E	Δ%	e	Δ%	e	Δ%	e	Δ%	e	Δ%	e	Δ%	e	Δ%	e	Δ%	e	Δ%	e	Δ%
20000	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–
17000	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	2.0	0.30	N.C.	–
14000	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	2.0	0.32	2.0	0.31	2.0	0.30	N.C.	–
12000	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	2.0	0.36	2.0	0.32	2.0	0.31	2.0	0.30	2.0	0.36
10000	N.C.	–	N.C.	–	N.C.	–	N.C.	–	N.C.	–	2.0	0.38	2.0	0.36	2.0	0.32	2.0	0.31	2.0	0.30	2.0	0.36
8000	N.C.	–	N.C.	–	N.C.	–	N.C.	–	2.0	0.40	2.0	0.38	2.0	0.36	2.0	0.32	2.0	0.31	2.0	0.30	2.0	0.36
6000	N.C.	–	N.C.	–	N.C.	–	2.0	0.40	2.0	0.40	2.0	0.38	2.0	0.36	2.0	0.32	2.0	0.31	2.5	0.31	2.0	0.36
5000	N.C.	–	N.C.	–	2.0	0.40	2.0	0.40	2.0	0.40	2.0	0.38	2.0	0.36	2.0	0.32	2.5	0.32	3.0	0.32	2.0	0.36
4000	N.C.	–	2.0	0.45	2.0	0.40	2.0	0.40	2.0	0.40	2.0	0.38	2.0	0.36	2.5	0.33	3.1	0.33	3.8	0.34	2.0	0.36
3500	N.C.	–	2.0	0.45	2.0	0.40	2.0	0.40	2.0	0.40	2.0	0.38	2.3	0.37	2.8	0.34	3.5	0.34	4.3	0.35	2.0	0.36
3000	2.0	0.50	2.0	0.45	2.0	0.40	2.0	0.40	2.0	0.40	2.1	0.38	2.7	0.38	3.3	0.36	4.1	0.36	5.0	0.36	2.4	0.37
2500	2.0	0.50	2.0	0.45	2.0	0.40	2.0	0.40	2.0	0.40	2.5	0.39	3.2	0.39	4.0	0.37	4.9	0.38	6.0	0.38	2.8	0.38
2050	2.0	0.50	2.0	0.45	2.0	0.40	2.0	0.40	2.4	0.41	3.1	0.40	3.9	0.40	4.8	0.40	6.0	0.40			3.4	0.39
1800	2.0	0.50	2.0	0.45	2.0	0.40	2.1	0.41	2.8	0.42	3.5	0.41	4.4	0.42	5.5	0.42					3.9	0.40
1675	2.0	0.50	2.0	0.45	2.0	0.40	2.3	0.41	3.0	0.42	3.8	0.42	4.8	0.42	5.9	0.43					4.2	0.41
1425	2.0	0.50	2.0	0.45	2.0	0.40	2.7	0.42	3.5	0.44	4.5	0.44	5.6	0.44							5.0	0.43
1350	2.0	0.50	2.0	0.45	2.2	0.41	2.9	0.43	3.7	0.44	4.7	0.44	5.9	0.45								
1150	2.0	0.50	2.0	0.45	2.5	0.42	3.4	0.45	4.3	0.46	5.5	0.46										
1075	2.0	0.50	2.0	0.45	2.7	0.43	3.6	0.46	4.7	0.47	5.9	0.47										
850	2.0	0.50	2.4	0.47	3.4	0.46	4.5	0.49	5.9	0.50												
820	2.0	0.50	2.5	0.47	3.5	0.47	4.7	0.49														
800	2.0	0.50	2.6	0.47	3.6	0.47	4.8	0.50														
720	2.0	0.50	2.8	0.49	4.0	0.49	5.4	0.52														
														0.45		0.43		0.40		0.38		0.45
													1333		1657		2042		2500		1412	

...ration should be given to curves which approach a ramp terminal (stopping ... use Δ% max for the corresponding design speed.

...herwise e max = 6%.

300	4.6	0.61		
232	6.0	0.66		
$\Delta\%_{max}$		0.66		0.62
Rmin	232		340	

HORIZONTAL ALIGNMENT

Minimum Curve Length

<u>Minimum</u>

15 x Design Speed

<u>Preferred</u>

30 x Design Speed

HORIZONTAL ALIGNMENT

Compound Curves

Use With Caution

Open Highway – Ratio of Flatter Radius to Sharper Radius

1.5 to 1

Ramps – Ratio of Flatter Radius to Sharper Radius

2 to 1

Sharper Curves in Advance of Flatter Curves

HORIZONTAL ALIGNMENT

Remember the Four Types…

Stopping Sight Distance

Passing Sight Distance

Decision Sight Distance

Intersection Sight Distance

“The designer must be aware that both horizontal and vertical alignments need to be considered when designing for sight distance.”

HORIZONTAL ALIGNMENT

Stopping Sight Distance

$$SSD = \frac{R \cos^{-1}\left(1 - \frac{HSO}{R}\right)}{28.65}$$

Horizontal Sightline Offset

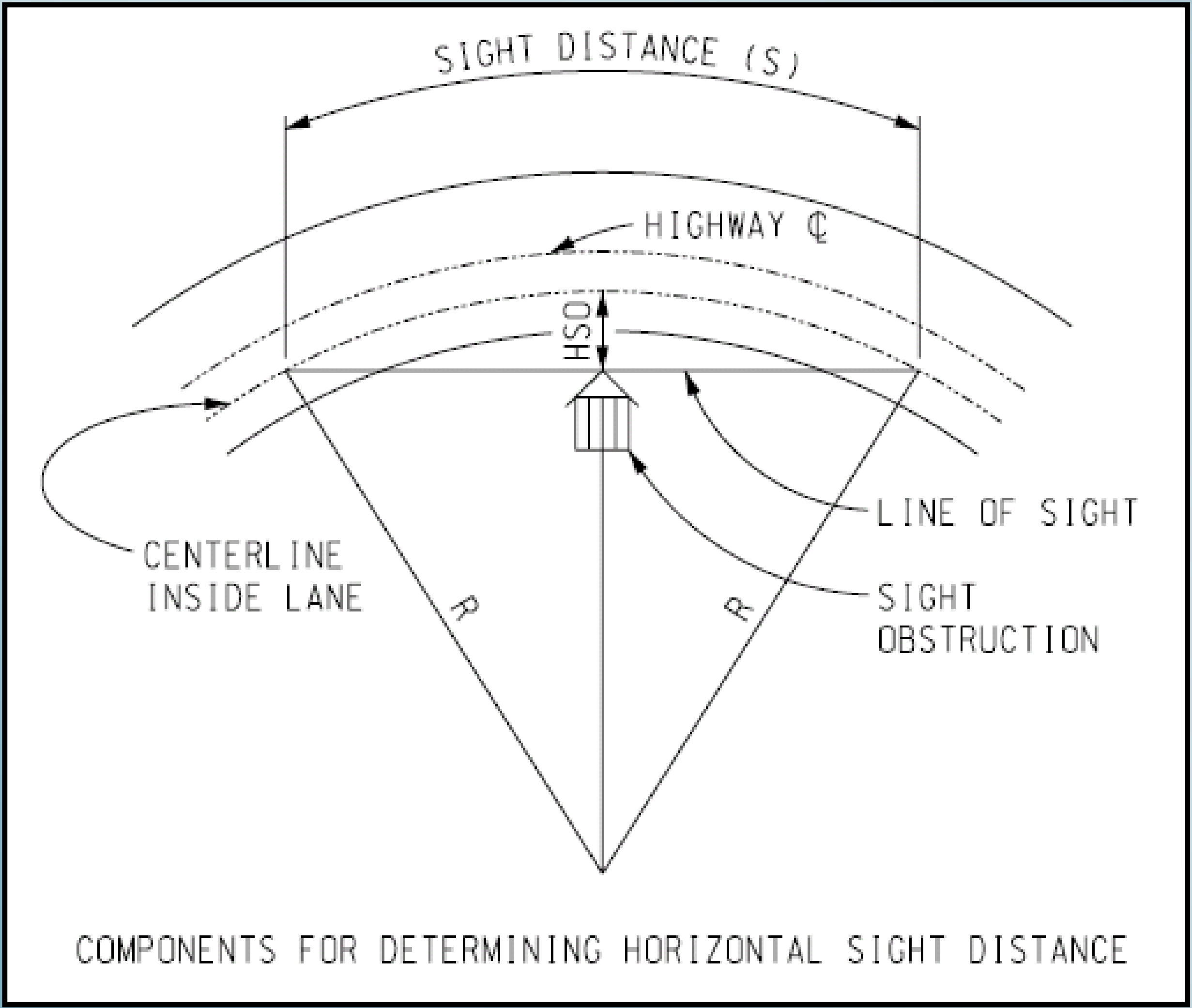
$$HSO = R\,[1 - \cos((28.65\ SSD) / R)]$$

R = Radius of Curve (feet)

HSO = Horizontal Sightline Offset (feet)

SSD = Stopping Sight Distance (feet)

HORIZONTAL ALIGNMENT



HEIGHT OF SIGHT LINE

2.75 ft

HORIZONTAL ALIGNMENT

Design Speed	Stopping Sight Distance (Design)
25	155
30	200
35	250
40	305
45	360
50	425
55	495
60	570
65	645
70	730
75	820

HORIZONTAL ALIGNMENT

Intersection Sight Distance

- Generally, 7.5 Seconds of Entering Sight Distance is Used
  - **Passenger Vehicle Stopped on a Minor Road, Grade 3% Max, Turning Left on a Two-Lane Roadway**
- Additional 0.5 Seconds Added for Each Lane

Clear Vision

For At Grade Intersections it is Very Important for Safety Reasons, Particularly on High Speed Trunklines

HORIZONTAL ALIGNMENT

E. Horizontal Curve Computations

Δ = Deflection or Central Angle (Delta), degrees

R = Radius of Curve, ft

T = Length of Tangent (P.C. to P.I. or P.I. to P.T.) = R Tan (Δ/2), ft

E = External Distance = R [Sec (Δ/2) - 1] or T Tan (Δ/4), ft

HSO = Horizontal Sightline Offset = R Versine (Δ/2) or E Cos (Δ/2), ft

L = Length of Curve = Δ x R ÷ 57.2958, ft

P.C. = Point of Curvature

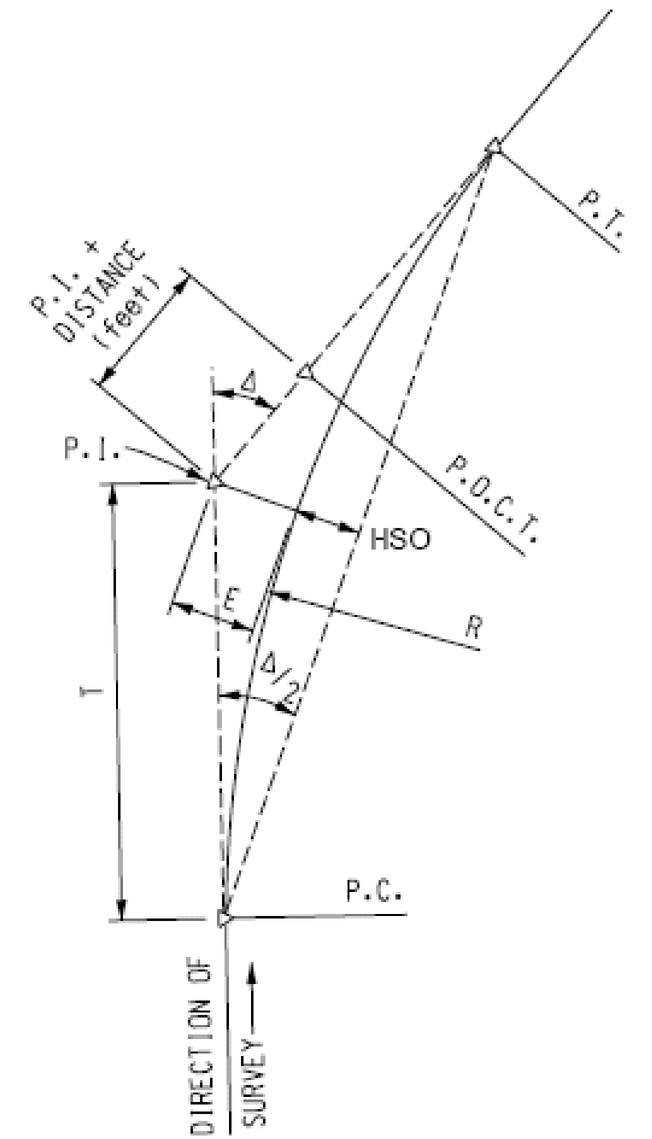
P.I. = Point of Intersection of Tangents

P.O.C.T. = Point on Curve Tangent

P.T. = Point of Tangency

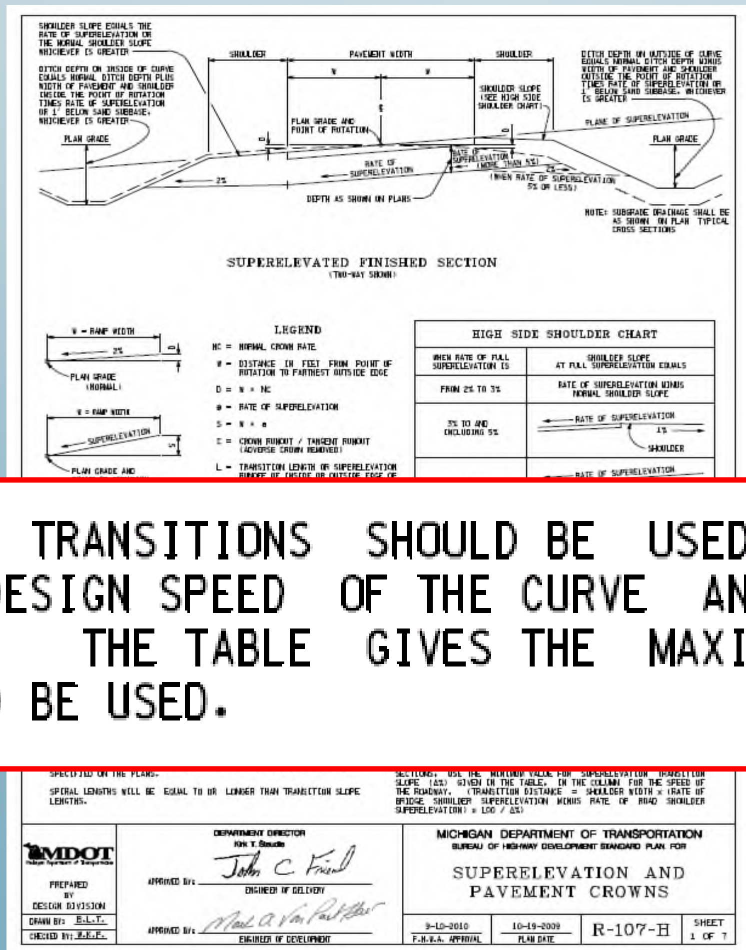
D = Degree of Curvature =

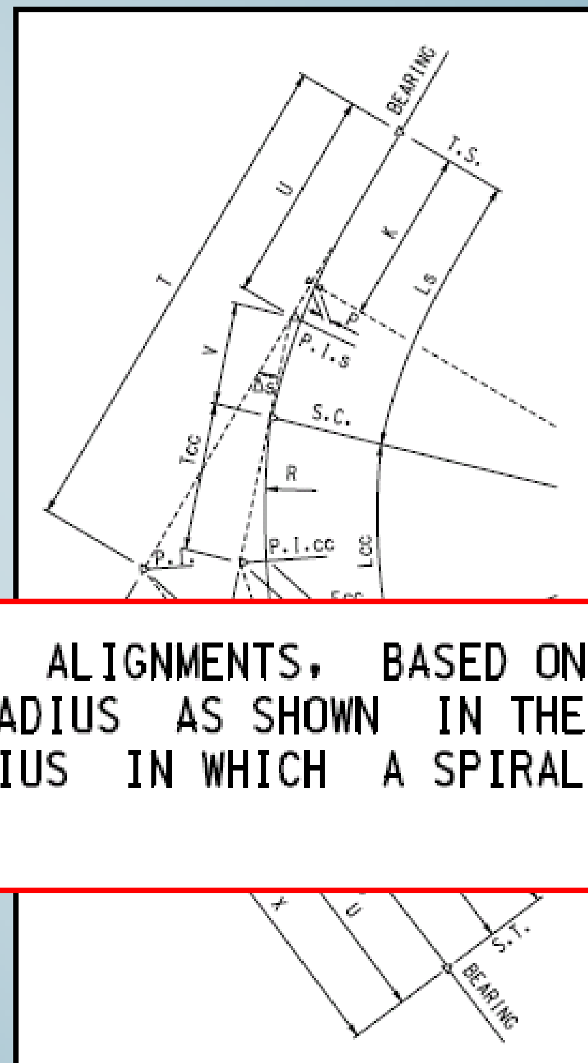
$$\frac{5729.58}{R\ (ft)} \text{ degrees}$$



HORIZONTAL ALIGNMENT

Spirals





IRAL TRANSITIONS SHOULD BE USED ON NEW ALIGNMENTS. BASED ON
E DESIGN SPEED OF THE CURVE AND THE RADIUS AS SHOWN IN THE
BLE. THE TABLE GIVES THE MAXIMUM RADIUS IN WHICH A SPIRAL
OULD BE USED.

HORIZONTAL ALIGNMENT

Standard Plan R-107

SPIRAL CURVE TRANSITIONS			
DESIGN SPEED (MPH)	MAXIMUM RADIUS (FEET)	DESIGN SPEED (MPH)	MAXIMUM RADIUS (FEET)
30	456	60	1822
35	620	65	2138
40	810	70	2479
45	1025	75	2846
50	1265	80	3238
55	1531		

HORIZONTAL ALIGNMENT

- Horizontal Deflections
  - Undesirable - Should be Avoided Wherever Practical
  - Should Not be Used on New Construction
  - Should be Limited to 3R Jobs (i.e. Existing Deflections)
  - Should be Limited to Low-Speed Roads (i.e. Posted Speeds of 45 mph or Less)
  - Deflections Should Not Exceed the Rates Given in Geometric Design Guide GEO-650 (i.e. L=W*V or 1/Design Speed)

QUESTIONS

VERTICAL ALIGNMENT

VERTICAL ALIGNMENT

Based on Several Factors

Design Speed

Existing Terrain

Drainage Considerations

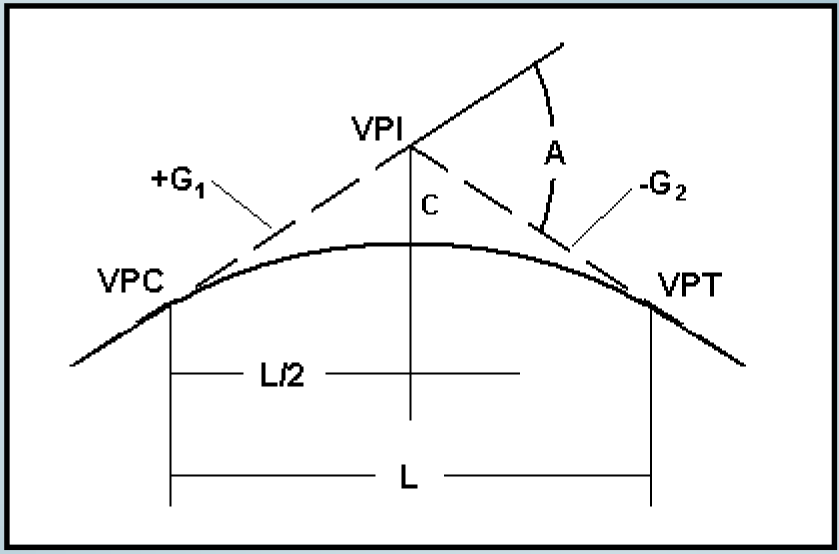
Bridge Elevations & Locations

Cross Road Elevations & Locations

Earthwork Balance

Coordination with Horizontal Alignment

VERTICAL ALIGNMENT



Establishes the Profile Grade of the Roadway

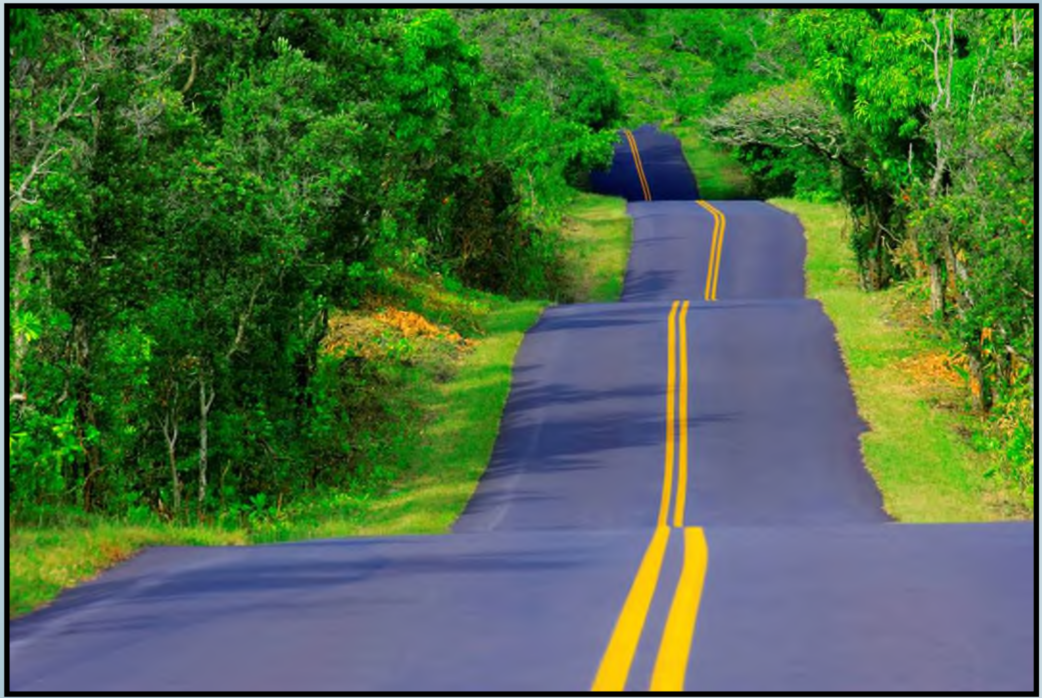
Two Basic Components

Longitudinal Grades	Vertical Curves

GRADES

<u>Maximum</u> Grades Depend On :

- Functional Class of the Roadway
- Urban or Rural
- Design Speed
- Terrain
- Scope of Work



GRADES

Minimum Grades: (RDM 3.03.02D)

- Typically Dictated by/Related to Drainage Considerations
- Uncurbed Roadways
  - Minimum Longitudinal Grade of 0% (level) Acceptable
  - Independent Ditches When Grade < 0.30%
- Curbed Roadways
  - Minimum Longitudinal Grade of 0.30%
  - Desirable Minimum of 0.50%

GRADES (RDM Appendix 3A)

Appendix 3A
GEOMETRIC DESIGN ELEMENTS
New Construction / Reconstruction

Grade — Maximum Grade (%) for specified design speed (mph)

Freeway

Type of Terrain	50	55	60	65	70	75
Level	4	4	3	3	3	3
Rolling	5	5	4	4	4	4

Grades 1% steeper may be provided in urban areas. Curbed roadway 0.3% min, 0.5% desirable minimum

Non Freeway (Arterial)

Type of Terrain	Urban							Rural				
	30	35	40	45	50	55	60	40	45	50	55	60
Level	8	7	7	6	6	5	5	5	5	4	4	3
Rolling	9	8	8	7	7	6	6	6	6	5	5	4

Curbed roadway 0.3% min, 0.5% desirable minimum

Collector Roads

Type of Terrain	Urban									Rural								
	20	25	30	35	40	45	50	55	60	20	25	30	35	40	45	50	55	60
Level	9	9	9	9	9	8	7	7	6	7	7	7	7	7	7	6	6	5
Rolling	12	12	11	10	10	9	8	8	7	10	10	9	9	8	8	7	7	6

Curbed roadway 0.3% min, 0.5% desirable minimum

Element	Requirement
Stopping Sig[illegible]t Distance	Follow current edition of AASHTO "A Policy on Geometric Design of Highways and Streets" (AKA AASHTO Green Book). The MDOT Sight Dista[illegible] [illegible]uidelines also provide detailed information on sight distance calculation.
Cross Slope	Travele[illegible] cross slope = 2.0%, Paved shoulder cross slope = 4.0% (Also see Section 6.05.05)
Superelevation	AASHTO Method 5 "[illegible]inear Relation" is used for new construction/reconstruction. Maximum rate of 7%. (Se[illegible]ard Plan R-107-Series.) AASHTO Method 1 "Straight Line R[illegible] is allowed when Method 5 is not feasible. Maximum[illegible]%. (See Section 3.04.03) The above methods also apply to urban freeways and urban ramps, except the maximum rate is 5% for 60 mph design speed.

Vertical Clearance

	NHS	Non NHS
Freeway	16'-0"	14'-6"
Non Freeway (Arterial)	16'-0"	14'-6"
Collectors & "Special Routes"	14'-6" (1 ft. greater than Michigan legal vehicle height.)	14'-6"

For pedestrian bridges provide 1 ft. additional clearance over non-freeway and 17 ft. minimum under clearance over freeways. A vertical clearance of 23'-0" is required for grade separations over railroads. *(See Bridge Design Manual 7.01.08 and Bridge Design Guides 5.24.03-04.)*

Horizontal Clearance / Bridge Width: *See definition of terms in this chapter. Also, see Bridge Design Guides, Section 6*

Note: Allowances are Provided for 3R Work Types

GRADES

Tangent Grade Lines are Connected & Smoothed Out by Use of Parabolic Vertical Curves.

VERTICAL CURVES (RDM 3.03.02)

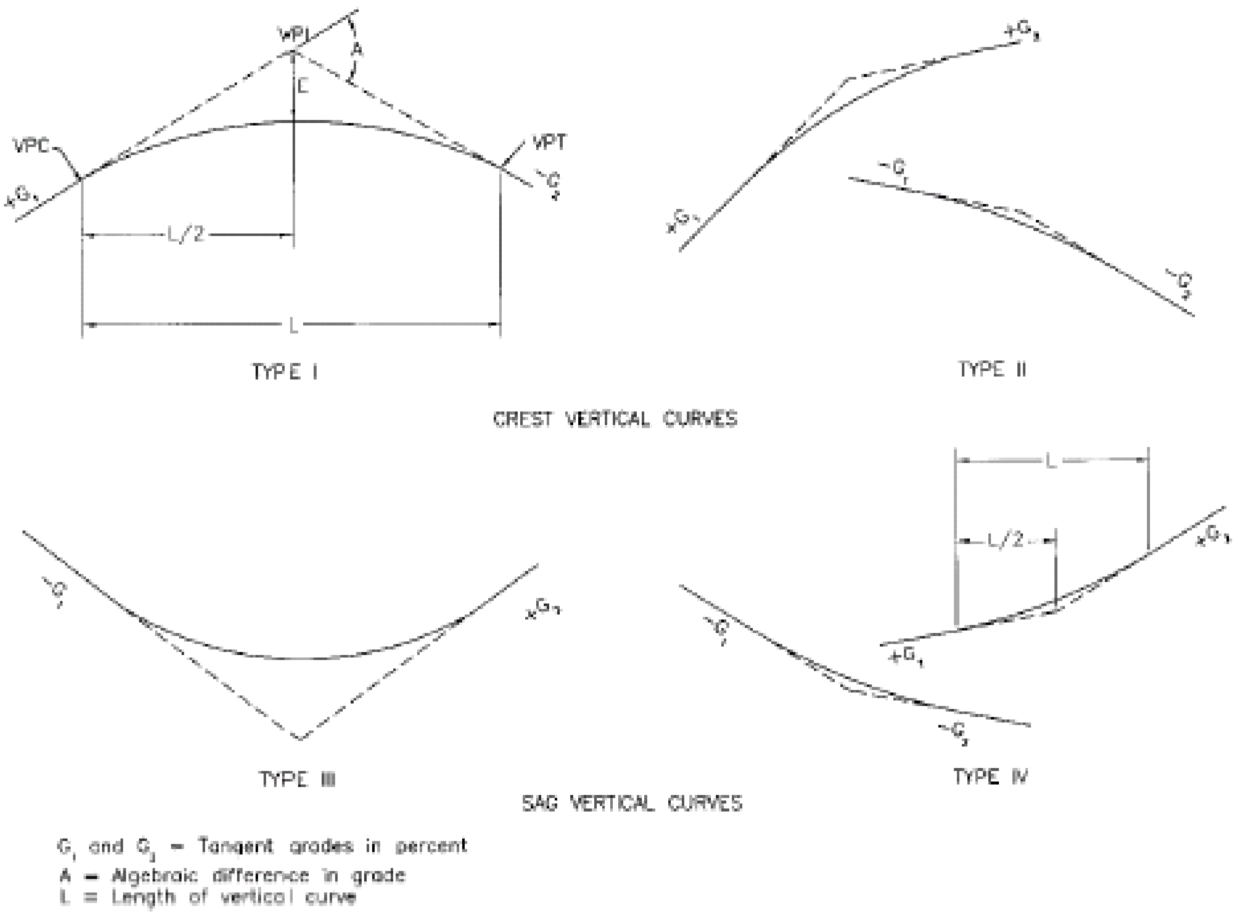
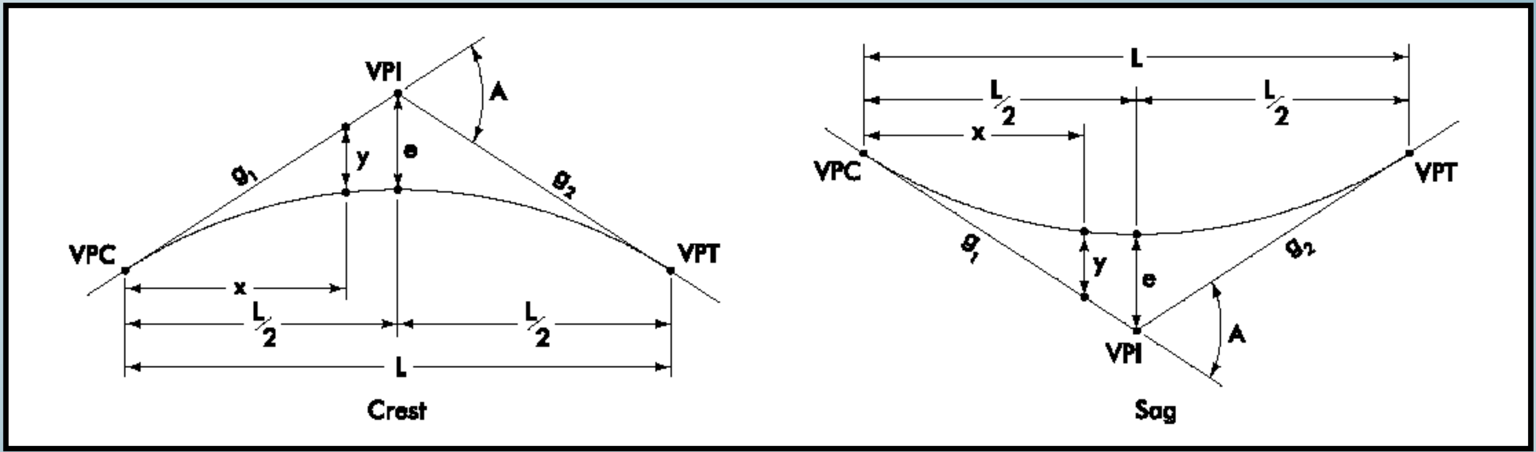


Exhibit 3-69. Types of Vertical Curves

VERTICAL CURVES (RDM 3.03.02)



A = Algebraic Difference in Gradients, g_2-g_1 (In Percent)

L = Total Length of Vertical Curve (In Feet)

K = Rate of Vertical Curvature, L/A

VPC = The Vertical Point of Curvature

VPI = The Vertical Point of Intersection

VPT = The Vertical Point of Tangency

VERTICAL CURVES (RDM 3.03.02)

AASHTO Controls (Crest)

Based on Stopping Sight Distance

Minimum Length Must Provide Sight Distance S

Assumes 3.5’ & 2.0’ Eye/Object Heights

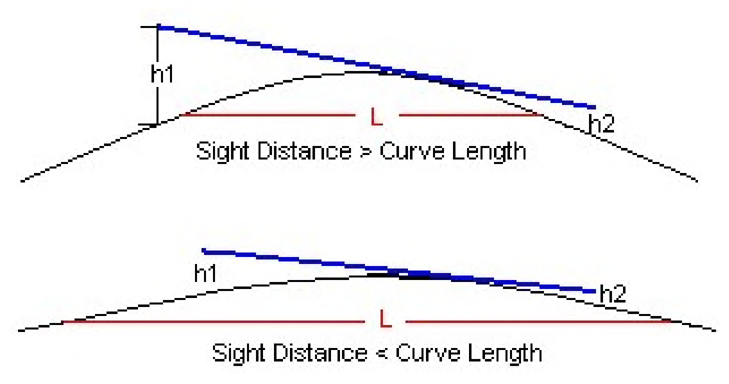


Figure 1.0: Sight Distance Possibilities

SIGHT DISTANCE

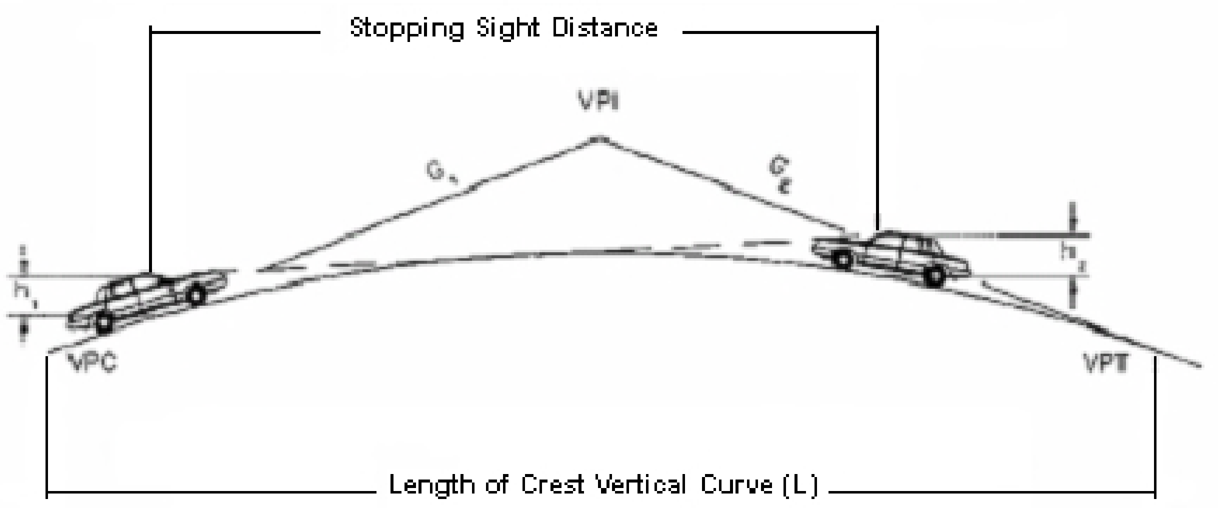


Exhibit 3-70. Parameters Considered in Determining the Length of a Crest Vertical Curve to Provide Sight Distance

HEIGHT OF EYE
3.5 ft

HEIGHT OF OBJECT
2.0 ft

CREST VERTICAL CURVES

S < L

$$L = \frac{AS^2}{100(\sqrt{2h_1} + \sqrt{2h_2})^2} \quad (3\text{-}41)$$

S > L

$$L = 2S - \frac{200(\sqrt{h_1} + \sqrt{h_2})^2}{A} \quad (3\text{-}42)$$

L = Length of Vertical Curve (ft)   S = Sight Distance (ft)

A = Algebraic Difference in Grades (percent) h_1 = Height of Eye Above Roadway Surface (ft)

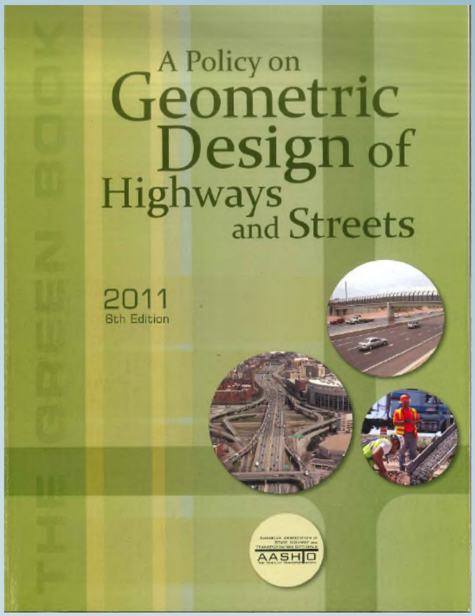
h_2 = Height of Object Above Roadway Surface (ft)

VERTICAL CURVES

AASHTO Controls (Crest)

S < L

$$L = \frac{AS^2}{2158} \qquad (3\text{-}43)$$



S > L

$$L = 2S - \frac{2158}{A} \qquad (3\text{-}44)$$

SSD CREST CURVES

US Customary			
Design speed (mph)	Stopping sight distance (ft)	Rate of vertical curvature, K^a	
		Calculated	Design
15	80	3.0	3
20	115	6.1	7
25	155	11.1	12
30	200	18.5	19
35	250	29.0	29
40	305	43.1	44
45	360	60.1	61
50	425	83.7	84
55	495	113.5	114
60	570	150.6	151
65	645	192.8	193
70	730	246.9	247
75	820	311.6	312
80	910	383.7	384

VERTICAL CURVES

AASHTO Controls (Sag)

- Based on Headlight Illumination Sight Distance
- Minimum Length Must Provide Adequate Sight Distance
- Assumes 2.0’ Object Height

- Assumes 2.0’ Headlight Height with 1° Upward Divergence of Light Beam

SAG VERTICAL CURVES

(AASHTO Equations 3-47 through 3-50)

When S < L

$$L = \frac{AS^2}{200[2.0 + S(\mathit{tan}1°)]} \quad \text{or} \quad \frac{AS^2}{400 + 3.5S}$$

When S > L

$$L = 2S - \frac{200[2.0 + S(\mathit{tan}1°)]}{A} \quad \text{or} \quad 2S - \frac{400 + 3.5S}{A}$$

L = Length of Sag Vertical Curve (ft) S = Light Beam Distance (ft)

A = Algebraic Difference in Grades (percent)

SSD SAG CURVES

US Customary			
Design speed (mph)	Stopping sight distance (ft)	Rate of vertical curvature, K^a	
		Calculated	Design
15	80	9.4	10
20	115	16.5	17
25	155	25.5	26
30	200	36.4	37
35	250	49.0	49
40	305	63.4	64
45	360	78.1	79
50	425	95.7	96
55	495	114.9	115
60	570	135.7	136
65	645	156.5	157
70	730	180.3	181
75	820	205.6	206
80	910	231.0	231

VERTICAL ALIGNMENT

General Controls

- Minimum Desirable Length of Vertical Curves Should be 3 X Design Speed
- Smooth Grade Line with Gradual Changes
- Avoid
  - Hidden Dips/Roller Coaster Profile
  - Avoid Broken Back Vertical Curves
- Desirable to Reduce Grades at At-Grade Intersections on Roadways with Moderate to Steep Grades

VERTICAL ALIGNMENT

General Controls (Continued)

- Sag Vertical Curves Should Be Avoided in Cuts Unless Adequate Drainage Can Be Provided

Feathering (RDM 6.03.11C)

- Where Discontinuing HMA Resurfacing…

  …Transition at a Rate of ¾” Vertical per 25’ Linear

VERTICAL ALIGNMENT

- Vertical Deflections
  - Undesirable - Should be Avoided Wherever Practical
  - Should Not be Used on New Construction
  - Should be Limited to 3R Jobs
  - Should be Limited to Low-Speed Roads
    (i.e. Posted Speeds of 45 mph or Less)
  - Maximum 1% Algebraic Grade Differential

QUESTIONS

COORDINATION OF HORIZONTAL AND VERTICAL ALIGNMENT

COORDINATION OF HORIZONTAL & VERTICAL ALIGNMENT

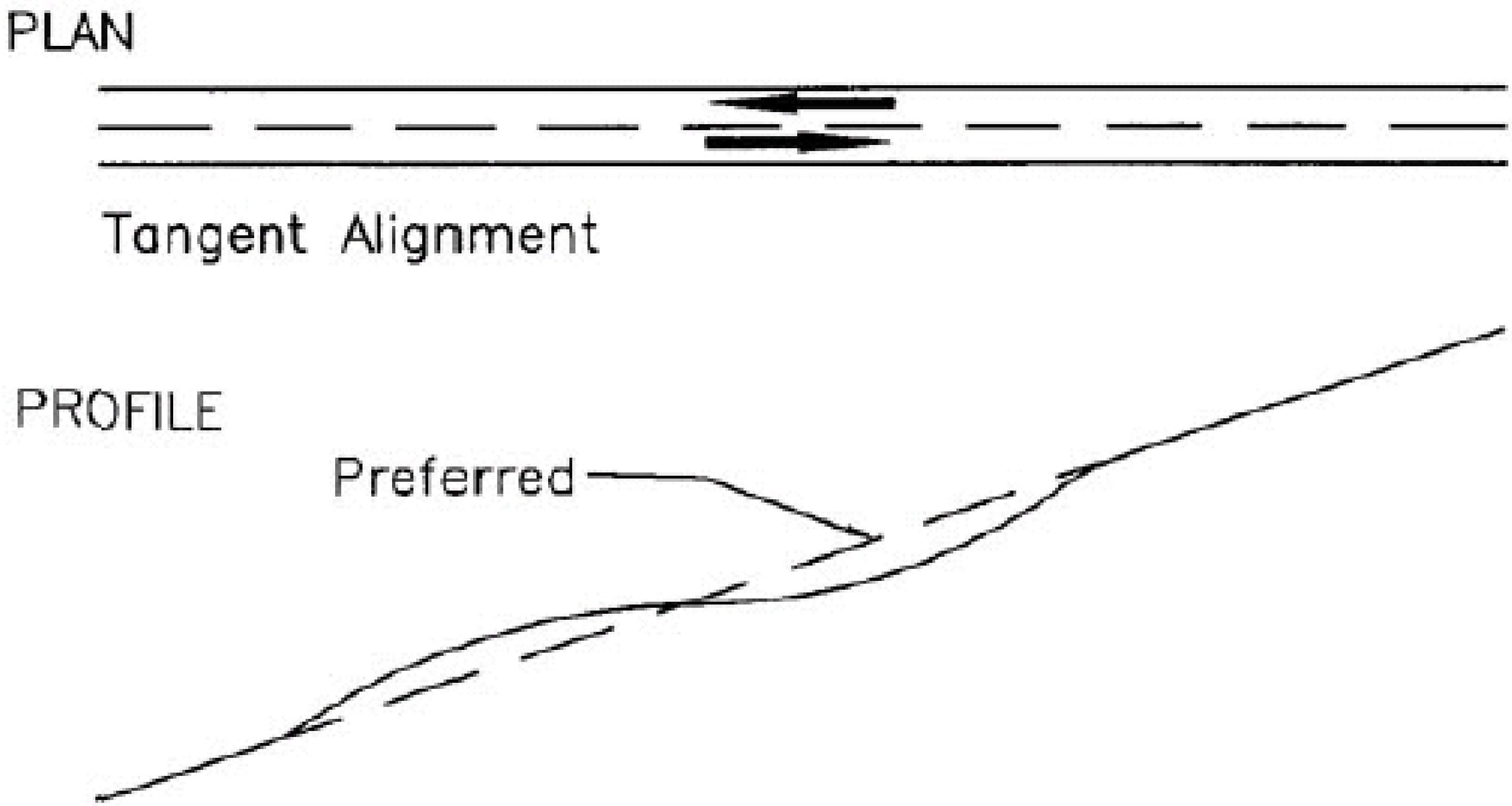
- Curve and Grade Should be in Proper Balance
- Vertical Curvature Imposed on Horizontal Curvature or Vice Versa
- Sharp Horizontal Curvature Should Not Be Introduced At or Near the Top of a Pronounced Crest Curve

COORDINATION OF HORIZONTAL & VERTICAL ALIGNMENT

- Sharp Horizontal Curvature Should Not Be Introduced
  At or Near the Bottom of a Steep Grade Near the Low Point of a Pronounced Sag Curve
- Horizontal Curvature and Profile Should Be Made as Flat as Possible at Intersections

Ramps

- Design Speed of Vertical Alignment Must Meet or Exceed Design Speed of Horizontal Alignment

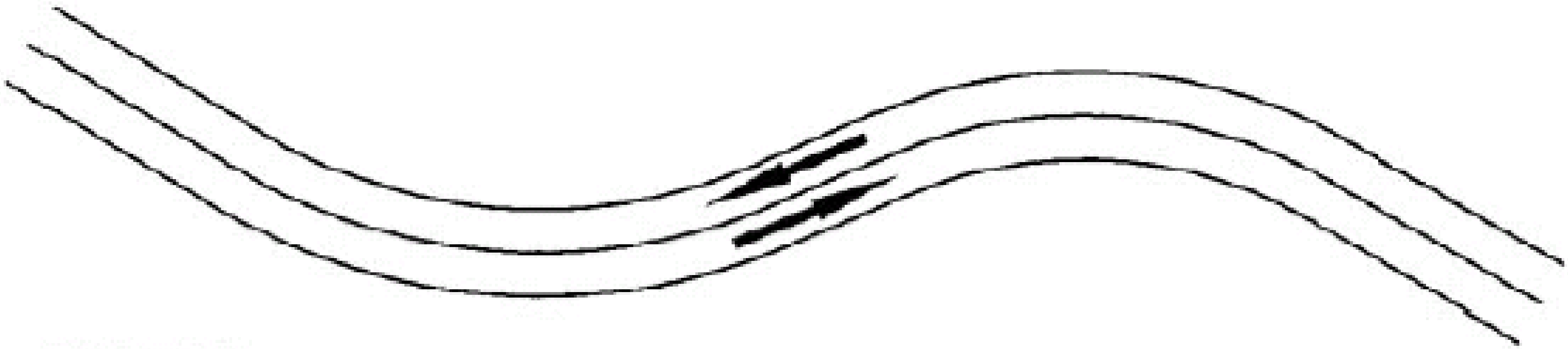


Avoid designing little local dips in an otherwise long, uniform grade. These dips usually result from a desire to balance cut and fill and to reduce overhaul.

Profile with tangent alignment

–A–

PLAN

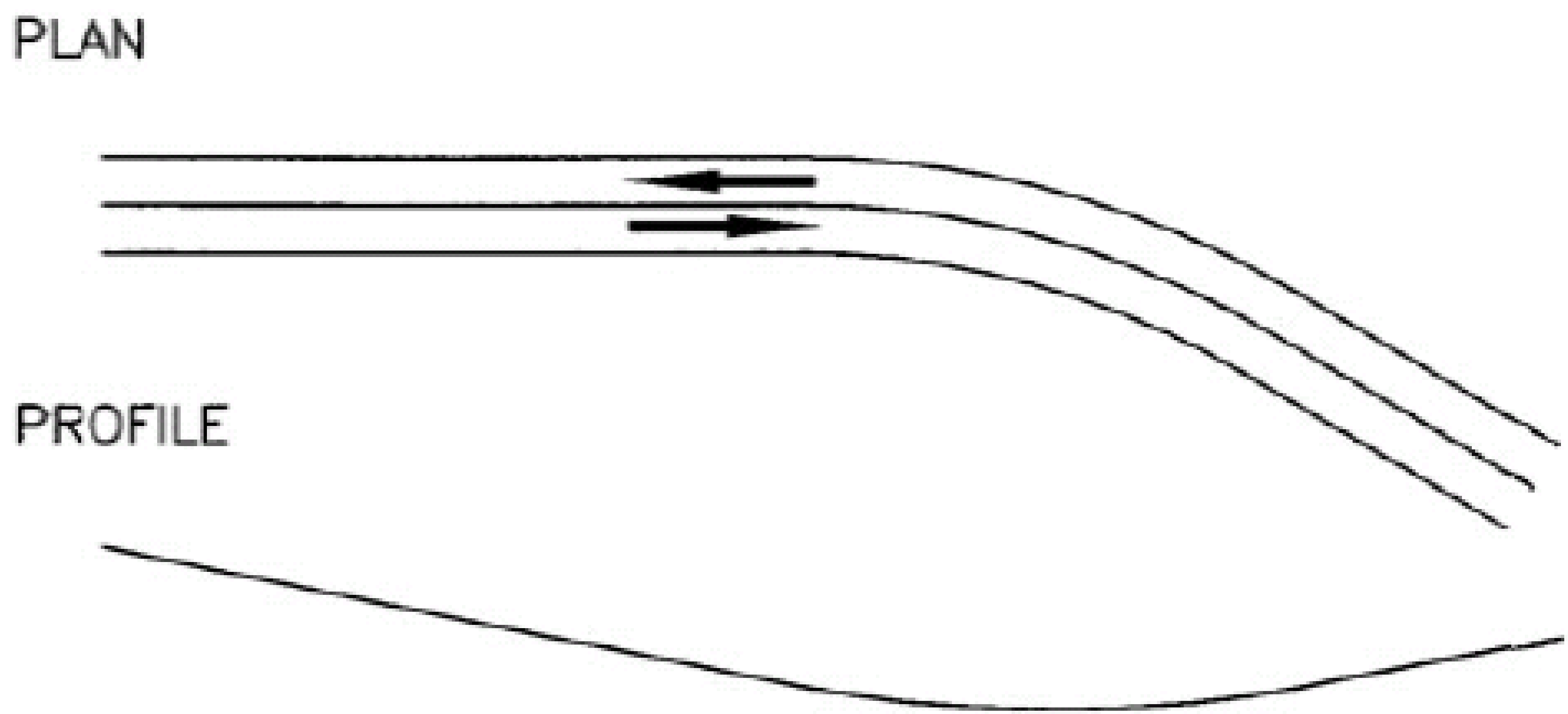


PROFILE

This combination is deficient for two reasons. The tangent between the curves is too short, and the reverse occurs on a crest.

Short tangent on a crest between two horizontal curves

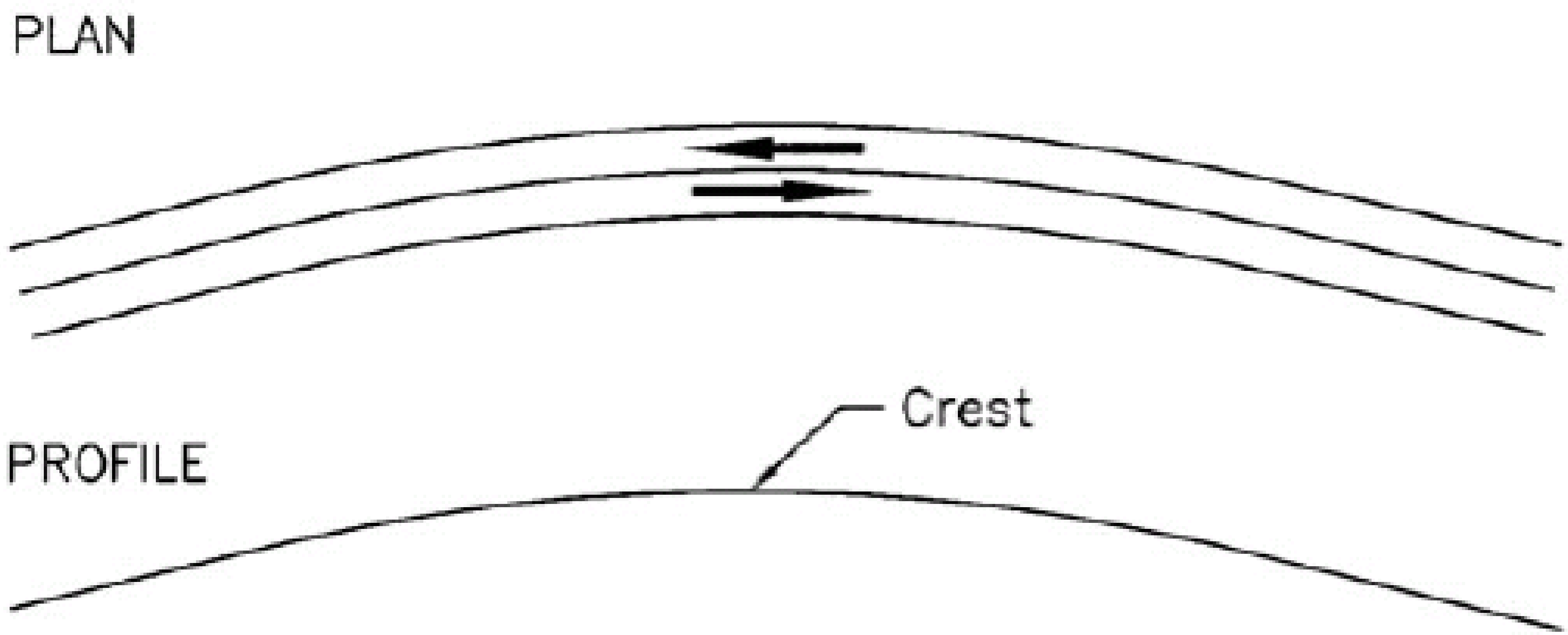
–D–



This combination presents a poor appearance — the horizontal curve looks like a sharp angle.

Sharp angle appearance

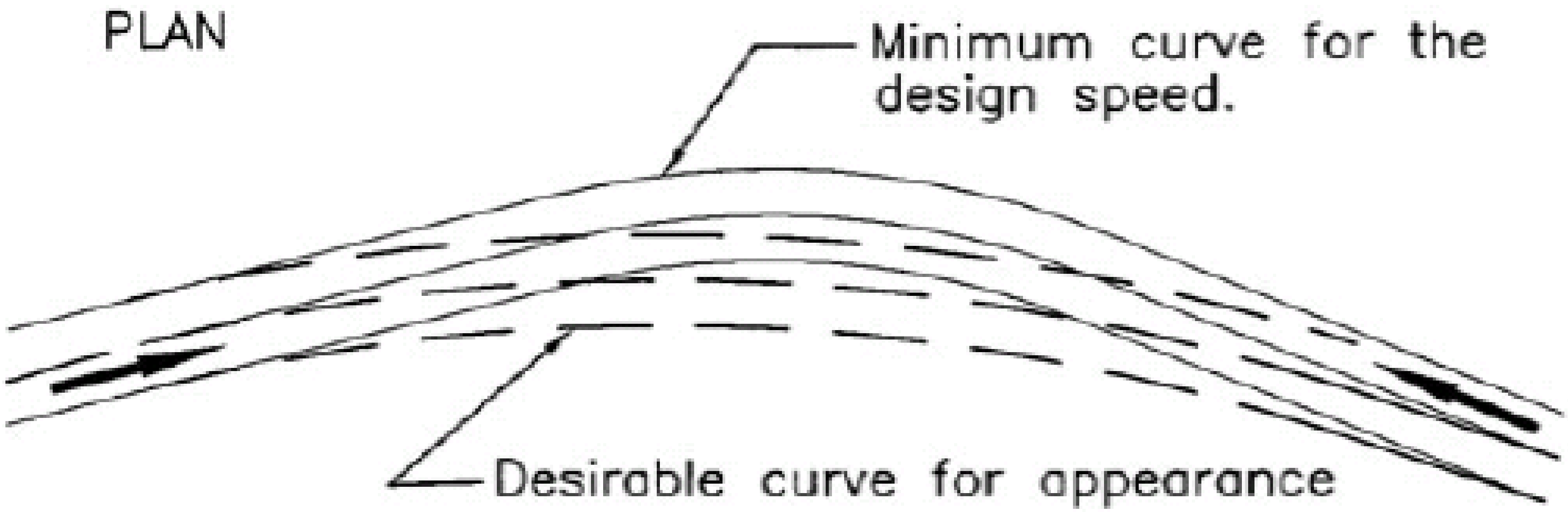
—E—



When horizontal and vertical curves coincide, a very satisfactory appearance results.

Coinciding curves in horizontal and vertical dimension

—F—



Very long flat curves, even where not required by a design speed and regardless of profile, also have a pleasing appearance when the central angle is very small.

Horizontal alignment with small central angles.
-H-

PLAN

The upper line is an example of poor design because the alignment consists of a long tangent with short curves, whereas the balance between the curves and tangents in the lower alignment is the preferred design.

Horizontal alignment should be balanced

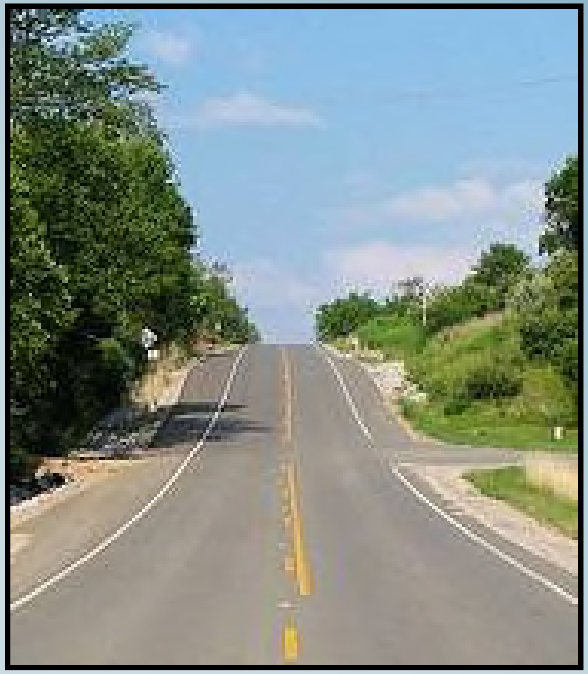
-L-

QUESTIONS

LANE WIDTH

LANE WIDTH

Lane Width Impacts



Driver's Safety and Comfort

- Wider Lanes Provide for More Desirable Lateral Clearance (Especially Commercial Vehicles on Two-Lane, Two-Way Roads)

Highway Level of Service

- Narrow Lanes Force Drivers to Operate with Less than Desirable Lateral Clearances Between Opposing Traffic, Adjacent Traffic and Roadside Obstacles

LANE WIDTH

Lane Width Impacts

Highway Capacity (Two Lane Rural Roads)

- 12’ Lane Width (or More) - Usually Will Not Reduce Capacity
- 11’ Lane Width – Capacity Reduction of 7%
- 10’ Lane Width – Capacity Reduction of 16%

Additional Costs to Provide 12’ Lanes Over Narrower Lanes is Partially Offset by Reduced Surface and Shoulder Maintenance

LANE WIDTH

Appendix 3A
GEOMETRIC DESIGN ELEMENTS
New Construction / Reconstruction

Element		Urban	Rural
Design Speed	**Freeway**	The greater of [illegible]	The greater of posted speed, or 70 mph.
	Non Freeway (Arterial)	The greater of posted speed, or 30 mph.	The greater of posted speed, or 40 mph..
	Collector Roads	Posted speed (minimum).	Posted speed (minimum)..
Lane Width	**Freeway**	12 ft.	12 ft.
	Non Freeway (Arterial)	12 ft, lanes are most desirable and should be used where practical. 11 ft. lanes are often used for low speed (45 mph design) Lane widths of 10 ft. may be used in more constrained areas where truck and bus volumes are relatively low and speeds are less than 35 mph. 12 ft. lanes on the National Network (NN). Design exceptions / variances are required to maintain existing narrower lanes. A high burden of justification is required in a design exception / variance to reduce existing lane widths less than or equal to 12'-0".	See Rural table for Non Freeway (Arterial) below
	Collector Roads	Added turn lanes at intersections 10-12 ft. Where right-of-way is restricted. 11 ft. Industrial Areas 12 ft. Where shoulders are used, see guidelines for Rural Collectors ☞	See Rural table for Collector Roads below

Rural – Lane Width – Non Freeway (Arterial):

Design Speed, (mph)	Minimum Lane Width, ft. — ADT, vehicles/day: Under 400	400 to 1500	1500 to 2000	Over 2000
40	11*	11*	11*	12
45	11*	11*	11*	12
50	11*	11*	12	12
55	11*	11*	12	12
60	12	12	12	12
65	12	12	12	12
70	12	12	12	12
75	12	12	12	12

*12 ft. desirable

Rural – Lane Width – Collector Roads:

Design Speed, (mph)	Minimum Lane Width, ft. — ADT, vehicles/day: Under 400	400 to 1500	1500 to 2000	Over 2000
20	10*	10*	11*	12
25	10*	10*	11*	12
30	10*	10*	11*	12
35	10*	11*	11*	12
40	10*	11*	11*	12
45	10*	11*	11*	[illegible]
50	10*	11*	11*	12
55	11*	11*	12	12
60	11*	11*	12	12

*12 ft. desirable

3A-1

<u>Note</u>: Allowances are Provided for 3R Work Types

3R FREEWAY ALLOWANCES

GEOMETRIC REQUIREMENTS FOR FREEWAY PROJECTS INVOLVING 3R WORK TYPES

Geometric Design Element	Minimum Required Standard *	Compliance Determination
Design Speed	Standard at the time of construction or the most recent 4R project	Compliance Assumed
Horizontal Curve Radius (Rmin.)	Standard at the time of construction or the most recent 4R project	Compliance Assumed
Longitudinal Grade (Min./Max.)	Standard at the time of construction or the most recent 4R project	Compliance Assumed
Stopping Sight Distance (Horizontal and/or Vertical))	Standard at the time of construction or the most recent 4R project	Compliance Assumed
Lane Width	Standard at the time of construction or the most recent 4R project	Compliance Assumed
Shoulder Width	Standard at the time of construction or the most recent 4R project	Compliance Assumed
Superelevation	Standard at the time of construction or the most recent 4R project	Compliance Assumed
Cross-Slope *(Excluding parabolic – Parabolic cross-slopes still require a DE/DV)*	Standard at the time of construction or the most recent 4R project *(Unless parabolic; Parabolic cross-slopes must be removed or a DE/DV is required)*	Compliance Assumed *(Unless parabolic; Parabolic cross-slopes must be removed or a DE/DV is required)*
Structural Capacity	Standard at the time of construction or the most recent 4R project	Compliance Assumed
Vertical Clearance	Standard at the time of construction or the most recent 4R project	Compliance Assumed
Acceleration/Deceleration Length	Existing Length	Compliance Assumed

*** If the project-wide Safety Review identifies a pattern of crashes associated with a particular design element (or elements), then that design element (or those elements) must be bought up to current standards (i.e. the existing design values may not be retained if they do not meet current standards).**

LANE WIDTH

Non-Freeway, NHS, 3R (3.09.02 A)

MICHIGAN DESIGN MANUAL
ROAD DESIGN

3.09.02 (continued)

A. Non-Freeway, NHS

Geometric Elements	Non-Freeway, NHS 3R Minimum Guidelines
Design Speed (see Section 3.06)	Posted Speed Minimum
Shoulder Width *NOTE: Minimum shoulder widths apply for posted speeds greater than 45 mph. Restrictions such as right of way and roadside context sensitivity issues may preclude the use of minimum shoulders within city, village or township limits with posted speeds of 45 mph and less.*	
Lane Width	
Design Loading Structural Capacity	(See Bridge Design Manual Appendix 12.02 for other trunkline classifications)
Horizontal Curve Radius and Stopping Sight Distance	Existing curve radius and stopping sight distance may be retained if the design speed of the existing curve is not more than 15 mph below the project design speed and there is no crash concentration. Otherwise standards for new construction apply. See 2011 6th Edition AASHTO Green Book or MDOT Sight Distance Guidelines.
Maximum Grade	Review crash data. Existing grade may be retained without crash concentration.
Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05
Superelevation Rate	Standard Plan R-107-Series or reduced maximum (6%) Straight Line Superelevation Chart using the project design speed.
Vertical Clearance	See Section 3.12.

	ADT	Lane Width
Lane Width	≤750	10'-0"
	>750	11'-0"
		10'-0" lanes may be considered in urban areas for multi-lane un-divided (regardless of ADT) and multi-lane divided (ADT < 10,000). 12'-0" lanes are desirable on the Priority Commercial Network (PCN). 12'-0" lanes are required on the National Network (also known as the National Truck Network). Design Exceptions / Design Variances to maintain existing narrower lanes generally receive favorable consideration but a high burden of justification is placed on requests to reduce lane widths to less than 12'-0".

LANE WIDTH

Non-Freeway, Non-NHS, 3R (3.09.02 B)

MICHIGAN DESIGN MANUAL
ROAD DESIGN

3.09.02 (continued)

B. Non-Freeway, Non-NHS

Geometric Elements	Non-Freeway, Non-NHS 3R Minimum Guidelines		
Design Speed	Posted Speed Minimum		
Shoulder Width *Minimum shoulder widths apply for:* ***Rural:*** *Posted speeds greater than 45 mph.* ***Urban:*** *Posted speeds greater than 45 mph where sufficient right-of-way exists to include shoulders.* *At lower speeds, minimum shoulders are desirable.*	Current ADT	Inside and Outside Shoulder Width	
Lane Width			
Bridge Width, Structural Capacity & Horizontal Clearances **(Existing Bridges to remain in place)**	2001 - 4000	HS15	Width of traveled way plus 2' each side.
	> 4000	HS15	Width of traveled way plus 3' each side.
Horizontal / Vertical Alignment and Stopping Sight Distance	Existing alignment and stopping sight distance may be retained if the design speed of the existing curve is not more than 15 mph (horizontal alignment) or 20 mph (vertical alignment) below the project design speed and there is no crash concentration. Otherwise standards for new construction apply. . See current AASHTO Green Book or MDOT Sight Distance Guidelines.		
Grade	Review crash data. Existing grade may be retained without crash concentration.		
Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05		
Superelevation	Standard Plan R-107-Series or reduced maximum (6%) Straight Line Superelevation Chart using the project design speed.		
Vertical Clearance	See Section 3.12.		

	ADT	Lane Width
Lane Width	≤750	10'-0"
	>750	11'-0"
		10'-0" lanes may be considered in urban areas for multi-lane un-divided (regardless of ADT) and multi-lane divided (ADT < 10,000). 12'-0" lanes are desirable on the Priority Commercial Network (PCN) and the National Network (also known as the National Truck Network). Existing narrower lanes may be retained without Design Exceptions / Design Variances. Reduction of existing lane widths on the National Network to less than 12-0" require a Design Exceptions / Design Variances request having a high burden of justification.

LANE WIDTH

Freeway Ramps:

- 16’ Lane Width Used for One-Lane Ramps
- 12’ Lane Width Used for “Slip” Ramps
- 12’ Lane Widths Used for Multi-Lane Ramps
- Greater Lane Widths May Be Required to Accommodate Off-Tracking of Large Vehicles on Small Radius Curves

Collector-Distributor (C-D) Roads:

- 16’ Lane Width Used for One-Lane C-D Roads
- 12’ Lane Widths Used for Multi-Lane C-D Roads

LANE WIDTH

Metric

Radius on inner edge of pavement, *R* (m)	Pavement width (m): Case I — One-lane, one-way operation—no provision for passing a stalled vehicle			Case II — One-lane, one-way operation—with provision for passing a stalled vehicle			Case III — Two-lane operation—either one way or two way		
	Design traffic conditions								
	A	B	C	A	B	C	A	B	C
15	5.4	5.5	7.0	6.0	7.8	9.2	9.4	11.0	13.6
25	4.8	5.0	5.8	5.6	6.9	7.9	8.6	9.7	11.1
30	4.5	4.9	5.5	5.5	6.7	7.6	8.4	9.4	10.6
50	4.2	4.6	5.0	5.3	6.3	7.0	7.9	8.8	9.5
75	3.9	4.5	4.8	5.2	6.1	6.7	7.7	8.5	8.9
100	3.9	4.5	4.8	5.2	5.9	6.5	7.6	8.3	8.7
125	3.9	4.5	4.8	5.1	5.9	6.4	7.6	8.2	8.5
150	3.6	4.5	4.5	5.1	5.8	6.4	7.5	8.2	8.4
Tangent	3.6	4.2	4.2	5.0	5.5	6.1	7.3	7.9	7.9

Width modification regarding edge treatment	Case I	Case II	Case III
No stabilized shoulder	None	None	None
Sloping curb	None	None	None
Vertical curb: one side	Add 0.3 m	None	Add 0.3 m
Vertical curb: two sides	Add 0.6 m	Add 0.3 m	Add 0.6 m
Stabilized shoulder, one or both sides	Lane width for conditions B & C on tangent may be reduced to 3.6 m where shoulder is 1.2 m or wider	Deduct shoulder width; minimum width as under Case I	Deduct 0.6 where shoulder is 1.2 m or wider

Note: A = predominantly P vehicles, but some consideration for SU trucks.
B = sufficient SU vehicles to govern design, but some consideration for semitrailer combination trucks.
C = sufficient bus and combination-trucks to govern design.

US Customary

Radius on inner edge of pavement, *R* (ft)	Pavement width (ft): Case I — One-lane, one-way operation—no provision for passing a stalled vehicle			Case II — One-lane, one-way operation—with provision for passing a stalled vehicle			Case III — Two-lane operation—either one way or two way		
	Design traffic conditions								
	A	B	C	A	B	C	A	B	C
50	18	18	23	20	26	30	31	36	45
75	16	17	20	19	23	27	29	33	38
100	15	16	18	18	22	25	28	31	35
150	14	15	17	18	21	23	26	29	32
200	13	15	16	17	20	22	26	28	30
300	13	15	15	17	20	22	25	28	29
400	13	15	15	17	19	21	25	27	28
500	12	15	15	17	19	21	25	27	28
Tangent	12	14	14	17	18	20	24	26	26

Width modification regarding edge treatment	Case I	Case II	Case III
No stabilized shoulder	None	None	None
Sloping curb	None	None	None
Vertical curb: one side	Add 1 ft	None	Add 1 ft
Vertical curb: two sides	Add 2 ft	Add 1 ft	Add 2 ft
Stabilized shoulder, one or both sides	Lane width for conditions B & C on tangent may be reduced to 12 ft where shoulder is 4 ft or wider	Deduct shoulder width; minimum pavement width as under Case I	Deduct 2 ft where shoulder is 4 ft or wider

Note: A = predominantly P vehicles, but some consideration for SU trucks.
B = sufficient SU vehicles to govern design, but some consideration for semitrailer combination trucks.
C = sufficient bus and combination-trucks to govern design.

Exhibit 3-51. Design Widths of Pavements for Turning Roadways

QUESTIONS

SHOULDER WIDTH

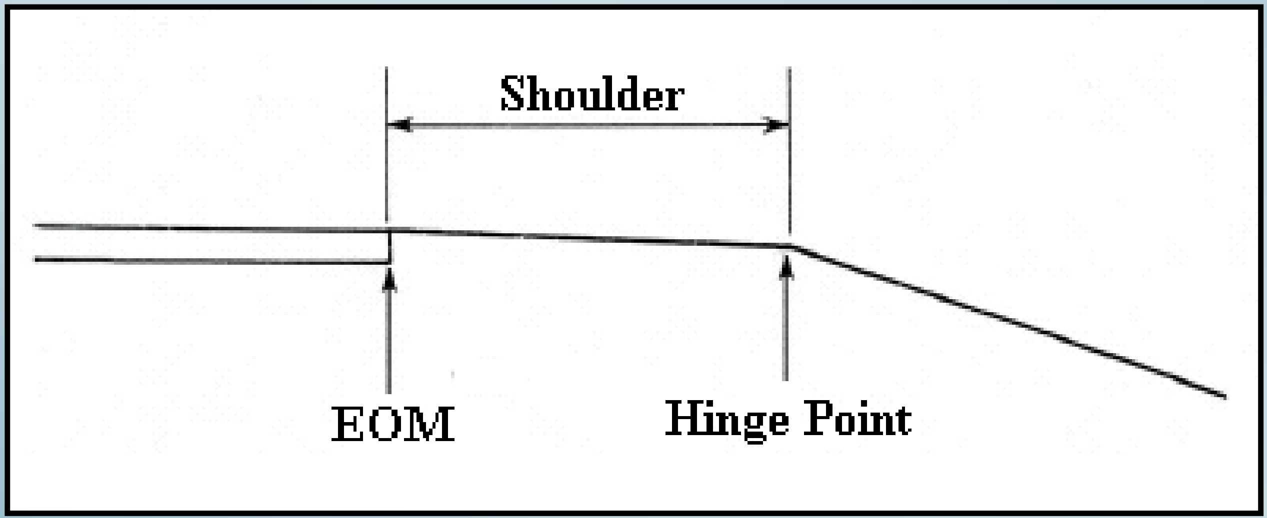
SHOULDER WIDTH

Advantages of Using Paved or Improved Shoulders

- Accommodates Stopped Vehicles
- Provides Increased Lateral Clearance
- Provides Lateral Support for Subbase, Base, and Surface Courses
- Provides for Mail Delivery, Bus Stops, Possible Bike Paths
- Sight Distance is Improved in Cut Section, Thereby Potentially Improving Safety
- Space is Provided for Maintenance Operations such as Snow Removal and Storage

SHOULDER WIDTH

- **Shoulder** – Measured from the edge of the traveled way to the intersection of the shoulder slope and foreslope planes (the hinge point).



- **Hinge Point** – The point of intersection between the shoulder slope and the foreslope.

SHOULDER WIDTH

- **Shoulder Drop-Off** - Condition where edge of pavement is higher than the abutting shoulder
- **Shoulder Ribbon** – Paved shoulder (usually HMA material) placed normally on a two-lane, two-way roadway, typically 3' wide, used to mitigate shoulder drop-off.

Usable Shoulder – (AASHTO 2011 Definition)

"…the actual width that can be used when a driver makes an emergency or parking stop."

May include rounding at hinge point if foreslope is 1:4 or flatter.

Valley gutter and the gutter pan of Type G curb & gutter can be considered part of the useable shoulder.

Gutter pans of mountable curb & gutter types (Types B & D) *may* be considered part of the usable shoulder width where constrained conditions exist.

SHOULDER WIDTH

MDOT Practice

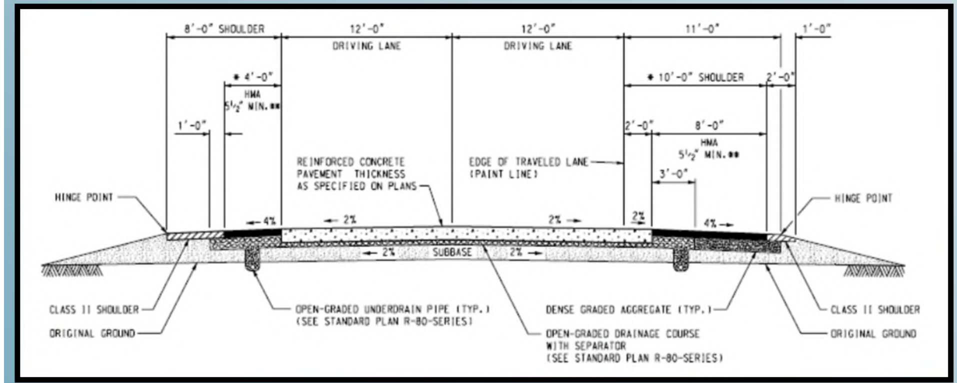
To Construct Hard Surfaced Shoulders Adjacent to Travel Lanes on State Trunklines

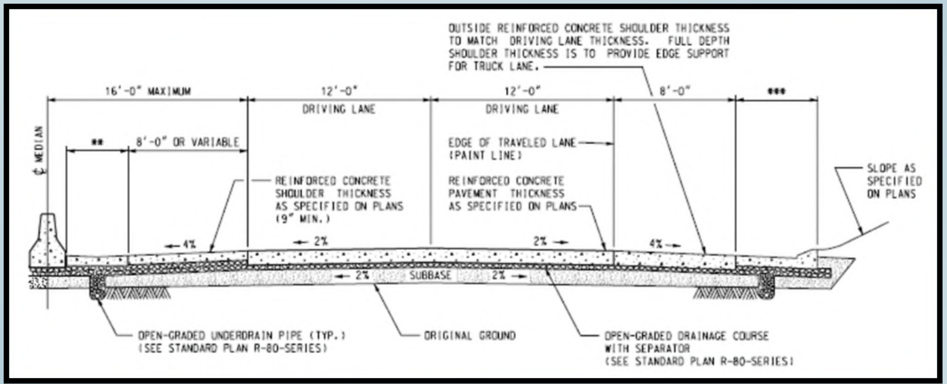
To Place a Strip of Aggregate (Gravel) Between the Edge of Paved Shoulder and the Shoulder Hinge Point (minimum 1’ in width) for Stabilization

SHOULDER WIDTH

New Urban or Rural Construction Projects Should Include Full Shoulders, Where Practical

Flush Shoulders are Required for New Urban Freeways, however, this *May* Not Apply to Urban Freeway Reconstruction





SHOULDER WIDTH

Freeway Design Criteria

Road Design Manual (Appendix 3A & Appendix 6A)
(section 3.11.01)

- Standards Do Not Differ between New Construction and Reconstruction. An Allowance is Provided for 3R Work Types.
- 3 or More Lanes Directional – Median Shoulder Width Should be the Same as the Right Shoulder Width
- Truck Traffic Exceeds 250 DDHV – Use 12’ Paved Width Shoulders on Non-Interstate Freeways; Consider Using 12’ Paved Width Shoulders on Interstate Freeways (Confer with Geometrics Unit)
- Ramp Gores Should be Paved to the 22’ Point

SHOULDER WIDTH

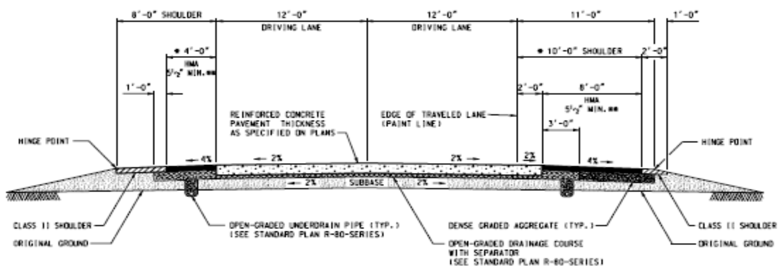
Appendix 3A

Element		
Shoulder Width	Freeway	8 ft. (8 ft. secti For more min 12 ft exce For to th Whe foot
	Non Freeway (Arterial)	In th suffi exist refer non shou ☞ For new construction and reconstruction and when feasible on shoulder widening, the paved shoulder is extended with 1 ft. of aggregate to the shoulder hinge for stabilization. A minimum 4 ft. (3 ft. paved) shoulder is acceptable adjacent to right turn lanes. * Minimum shoulder widths apply for posted speeds greater than 45 mph. At lower speeds, minimum shoulders are desirable.
Collector Roads	Where shoulders are used, refer to requirements for rural arterials. ☞	Min shoulder, ft. for specified ADT, veh/day: Under 400 – 2; 400 to 1500 – 5; 1500 to 2000 – 6; Over 2000 – 8. The above ranges apply on uncurbed roads and when shoulders are feasible on curbed roads. A minimum paved width of 1 ft. is desirable.

3A-2

	Mainline		Ramp (one lane and two lanes)	
	Median	Outside	Left	Right
Freeway	8 ft. (4ft. paved) (8 ft. paved at bridge and barrier sections) For 6 or more lane sections (3 or more lanes directional) use 11ft. min (10 ft. paved) and consider 12 ft. paved where truck traffic exceeds 250 DDHV.	10 ft. min (paved) For non-interstate freeways, use 12 ft. paved where truck traffic exceeds 250 DDHV. For interstate freeways consider using 12 ft. paved where truck traffic exceeds 250 DDHV.	6 ft. (4 ft. paved)	8 ft. (7ft. paved)
	For new construction and reconstruction, the mainline outside paved shoulder is extended with 1 ft. of aggregate to the shoulder hinge for stabilization. When widening existing paved shoulders to meet current standard widths, it is desirable to provide the additional foot of aggregate when feasible.			

Appendix 6A



* RIGHT (OUTSIDE): CONSIDER 12' PAVED SHOULDER WHERE TRUCK TRAFFIC EXCEEDS 250 DDHV.

* LEFT (MEDIAN): FOR THREE OR MORE DRIVING LANES. USE A 10' PAVED SHOULDER SECTION. CONSIDER 12' PAVED SHOULDER WHERE TRUCK TRAFFIC EXCEEDS 250 DDHV AND THREE OR MORE DRIVING LANES EXIST.

** SHOULDER THICKNESS DETERMINATION MUST ALSO FOLLOW OTHER DEPARTMENT GUIDELINES INCLUDING THE HMA MIXTURE AND SELECTION GUIDELINES.

RURAL FREEWAY WITH REINFORCED CONCRETE PAVEMENT

SHOULDER WIDTH

Non-Freeway Design Criteria

Road Design Manual Appendix 3A (4R) & 3.09.02 (3R)

Widths are Determined by

Type of Work: 4R or 3R

Highway Classification

Average Daily Traffic

Design Speed

SHOULDER WIDTH

Non-Freeway, 4R (Appendix 3A)

<table>
<tr><td rowspan="11">Shoulder Width</td><td rowspan="6">Non Freeway (Arterial)</td><td>Urban</td><td colspan="4">Rural</td></tr>
<tr><td rowspan="4">In those instances where sufficient right-of-way exists to include shoulders, refer to the guidance for non freeway rural shoulders.*
☞</td><td colspan="4">Min paved shoulder, ft. for specified ADT, veh/day
Undivided Roadways*</td></tr>
<tr><td>Under 400</td><td>400 to 1500</td><td>1500 to 2000</td><td>Over 2000</td></tr>
<tr><td>4</td><td>6</td><td>6</td><td>8</td></tr>
<tr><td colspan="4">Use 8ft. right and 4 ft. left for divided arterials.
Use full width (8 ft.) on both sides of divided arterials with 3 lanes in each direction.

For new construction and reconstruction and when feasible on shoulder widening, the paved shoulder is extended with 1 ft. of aggregate to the shoulder hinge for stabilization.</td></tr>
<tr><td colspan="5">A minimum 4 ft. (3 ft. paved) shoulder is acceptable adjacent to right turn lanes.
* Minimum shoulder widths apply for posted speeds greater than 45 mph. At lower speeds, minimum shoulders are desirable.</td></tr>
<tr><td rowspan="5">Collector Roads</td><td rowspan="5">Where shoulders are used, refer to requirements for rural arterials.
☞</td><td colspan="4">Min shoulder, ft. for specified ADT, veh/day</td></tr>
<tr><td>Under 400</td><td>400 to 1500</td><td>1500 to 2000</td><td>Over 2000</td></tr>
<tr><td>2</td><td>5</td><td>6</td><td>8</td></tr>
<tr><td colspan="4">The above ranges apply on uncurbed roads and when shoulders are feasible on curbed roads. A minimum paved width of 1 ft. is desirable.</td></tr>
</table>

SHOULDER WIDTH

Non-Freeway, 3R, NHS (3.09.02 A)

Shoulder Width

Minimum shoulder widths apply for:

Rural: Posted speeds greater than 45 mph.

Urban: Posted speeds greater than 45 mph where sufficient right-of-way exists to include shoulders.

At lower speeds, minimum shoulders are desirable.

	Current ADT Two-Way	Inside Shoulder	Outside Shoulder
Two Lane (and three lane when the center lane is a left turn lane)	<750		3'-0" Gravel
	750 - 5000		6'-0" (3'-0" Paved)
	>5000 - 10,000		8'-0" (3'-0" Paved)
	>10,000		8'-0" (7'-0" Paved)
Multi-Lane Undivided	≤ 10,000 > 10,000		6'-0" (3'-0" Paved) 8'-0" (3'-0" Paved)
Multi-Lane Divided	≤ 10,000 > 10,000	3'-0" Paved 3'-0" Paved	6'-0" (3'-0" Paved) 8'-0" (3'-0" Paved)

MICHIGAN DESIGN MANUAL

3.09.02 (continued)

A. Non-Freeway, NHS

Geometric Elements		
Design Speed (see Section 3.06)		
Shoulder Width *Minimum shoulder widths apply for:* ***Rural:*** *Posted speeds greater than 45 mph.* ***Urban:*** *Posted speeds greater than 45 mph where sufficient right-of-way exists to include shoulders.* *At lower speeds, minimum shoulders are desirable.*		
Lane Width	12'-0" lanes are required on the National Network (also known as the National Truck Network). Design exceptions to maintain existing narrower lanes generally receive favorable consideration but a high burden of justification is placed on requests to reduce lane widths to less than 12'-0".	
Bridge Width, Structural Capacity & Horizontal Clearances	Rural	Urban
	Traveled way width plus 2'-0" each side. Minimum Design Loading HS20.	Curb to curb approach width. Minimum Design Loading HS20.
	(See Bridge Design Manual Appendix 12.02 for other trunkline classifications)	
Horizontal / Vertical Alignment and Stopping Sight Distance	Existing alignment and stopping sight distance may be retained if the design speed of the existing curve is not more than 15 mph below the project design speed and there is no crash concentration. Otherwise standards for new construction apply. See current AASHTO Green Book or MDOT Sight Distance Guidelines.	
Grade	Review crash data. Existing grade may be retained without crash concentration.	
Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05	
Superelevation	Standard Plan R-107-Series or reduced maximum (6%) Straight Line Superelevation Chart using the project design speed.	
Vertical Clearance	See Section 3.12.	

SHOULDER WIDTH

Non-Freeway, 3R, Non-NHS (3.09.02 B)

MICHIGAN DESIGN MANUAL
ROAD DESIGN

3.09.02 (continued)

B. Non-Freeway, Non-NH

Shoulder Width	Current ADT Two-Way	Inside and Outside Shoulder Width	
Minimum shoulder widths apply for: *Rural: Posted speeds greater than 45 mph.* *Urban: Posted speeds greater than 45 mph where sufficient right-of-way exists to include shoulders.* *At lower speeds, minimum shoulders are desirable.*	≤750	2'-0" (Gravel)	
	750 - 2000	3'-0" (Paved)	
	> 2000	6'-0" (3'-0" Paved)	
	Multi-Lane (Divided & Undivided)	Inside (Divided)	Outside (Both sides for un-divided)
		3'-0" Paved	6'-0" (3'-0" Paved)

Geometric Elements			
Design Speed			
Shoulder Width			
Lane Width			
Bridge Width, Structural Capacity & Horizontal Clearances (Existing Bridges to remain in place)	ADT (Design Year)	Minimum Design Loading	Usable Width
	0 - 750	H15	Width of traveled way.
	751 - 1500	HS15	Width of traveled way.
	1501 - 2000	HS15	Width of traveled way plus 1' each side.
	2001 - 4000	HS15	Width of traveled way plus 2' each side.
	> 4000	HS15	Width of traveled way plus 3' each side.
Horizontal / Vertical Alignment and Stopping Sight Distance	Existing alignment and stopping sight distance may be retained if the design speed of the existing curve is not more than 15 mph (horizontal alignment) or 20 mph (vertical alignment) below the project design speed and there is no crash concentration. Otherwise standards for new construction apply. . See current AASHTO Green Book or MDOT Sight Distance Guidelines.		
Grade	Review crash data. Existing grade may be retained without crash concentration.		
Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05		
Superelevation	Standard Plan R-107-Series or reduced maximum (6%) Straight Line Superelevation Chart using the project design speed.		
Vertical Clearance	See Section 3.12.		

SHOULDER WIDTH

Adjacent to Truck Climbing Lanes and Passing Relief Lanes

Road Design Manual 3.09.05

Adjacent to Right Turn Lane

4'/(3' Paved) Shoulder or Curb & Gutter

Adjacent to Auxiliary Lanes of 1.0 Mile or Less (Freeway)

2011 AASHTO Page 10-76

SHOULDER WIDTHS

(Revised 2-21-13)

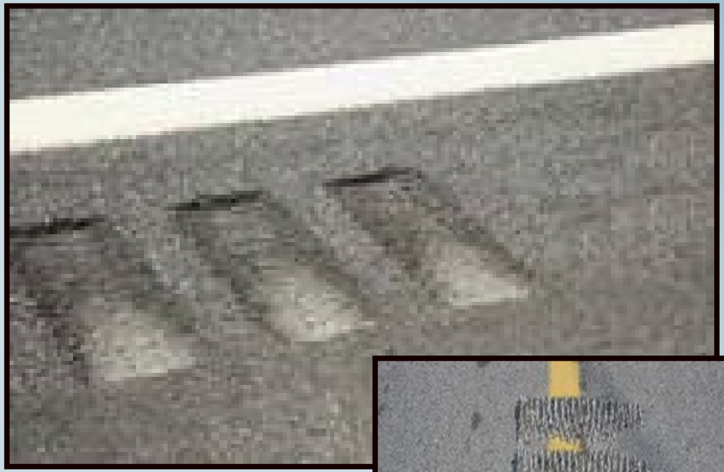
APPLICATION	MINIMUM REQUIRED SHOULDER WIDTH	REFERENCE
3R/4R Freeway (Typical Width)	Variable: As specified in the Michigan Road Design Manual: Chapter 3, Appendix 3-A; Chapter 6, Appendix 6-A	Michigan Road Design Manual: Chapter 3, Appendix 3-A; Chapter 6, Appendix 6-A
4R Non-Freeway (Typical Width)	Variable: As specified in the Michigan Road Design Manual: Chapter 3, Appendix 3-A.	Michigan Road Design Manual: Chapter 3, Appendix 3-A.
3R Non-Freeway, NHS (Typical Width)	Variable: As specified in the Michigan Road Design Manual: Section 3.09.02A	Michigan Road Design Manual: Section 3.09.02A
3R Non-Freeway, Non-NHS (Typical Width)	Variable: As specified in the Michigan Road Design Manual: Section 3.09.02B	Michigan Road Design Manual: Section 3.09.02B
Auxiliary Lane (Less than or equal to one mile in length)	Width should desirably match the shoulder widths on adjacent roadway sections. A minimum width of 6.0' is allowable.	Michigan Road Design Manual: Section 6.05.04F 2011 AASHTO, p. 10-76
Auxiliary Lane (Greater than one mile in length)	Typical mainline shoulder width as referenced above for roadway and work types (3R/4R, Freeway/Non-Freeway, etc.)	Michigan Road Design Manual: Chapter 3, Appendix 3-A; Chapter 6, Appendix 6-A; Section 3.09.02A; Section 3.09.02B
Left-Turn Passing Flare	4.0' total width/3.0' paved width; *-OR-* curb & gutter along tangent portion only.	Geometrics Unit Internal Policy/Practice; FHWA Concurrence (e-mail) 2011 AASHTO, p. 3-134
Right-Turn Lane	4.0' total width/3.0' paved width; *-OR-* curb & gutter along tangent (storage) portion only.	Michigan Road Design Manual: Chapter 3, Appendix 3-A; FHWA Concurrence (e-mail) 2011 AASHTO, p. 9-124
Passing Lane Section	Width should desirably match the shoulder widths on adjacent roadway sections. A minimum 4.0' total width/3.0' paved width shoulder is allowable.	Michigan Road Design Manual: Section 3.09.05C 2011 AASHTO, p. 3-134
Truck Climbing Lane	Width should desirably match the shoulder widths on adjacent roadway sections. A minimum 4.0' total width/3.0' paved width shoulder is allowable.	Michigan Road Design Manual: Section 3.09.05B; Section 6.05.04E 2011 AASHTO, p. 3-129
C-D Road (One Lane) (Use 16' Lane Width)	8.0' total width/7.0' paved width on right; 6.0' total width/4.0' paved width on left. (The same as an Interchange Ramp).	Geometrics Unit Internal Policy/Practice (Total paved width is 27', including shoulders; Exceeds AASHTO by 1')
C-D Road (Two or More Lanes) (Use 12' Lane Width)	10.0' paved width on right; 8.0' total width/4.0' paved width on left. (The same as a four-lane freeway).	2011 AASHTO. p. 8-34; p. 10-81
Interchange Ramp	8.0' total width/7.0' paved width on right; 6.0' total width/4.0' paved width on left.	Michigan Road Design Manual: Chapter 3, Appendix 3-A; Chapter 6, Appendix 6-A

NOTE: Minimum shoulder widths apply to roadways with posted speeds greater than 45 mph. Shoulders are desirable on roadways with posted speeds of 45 mph or less, however, they are not required.

SHOULDERS

Corrugations in Paved Shoulders

Refer to R-112-H for Freeway and Non-Freeway Corrugations



Freeway – Outside and Median Shoulders
No Ramps

Non-Freeway - Shoulder and Centerline on Candidate Roadways

QUESTIONS

Problem 3:

Non-Freeway, NHS Corridor with a 4R Work Type
Divided Arterial, 36’ Median Width
3 Lanes in Each Direction
ADT = 36,000
Rolling Terrain
Posted Speed 40 mph

a. What is the MDOT recommended design speed?

b. What is the required lane width?

c. Required shoulder widths – left and right?

d. Required Stopping Sight Distance?

e. Maximum Allowable Grade (%)?

<u>Problem 3</u>: Non-Freeway, NHS Corridor with a 4R Work Type
Divided Arterial, 36’ Median Width
(Solutions) 3 Lanes in Each Direction
ADT = 36,000
Rolling Terrain
Posted Speed 40 mph

a. What is the MDOT recommended design speed?

45 mph ***(RDM 3.06)***

(A 40 mph <u>minimum</u> design speed may be used per RDM Appendix 3A)

b. What is the required lane width?

<u>Rural</u>: 12’

<u>Urban</u>: 12’ Desirable/11’ Minimum (Unless NTN; then 12’ min.) ***(RDM Appendix 3A)***

<u>Urban Restricted Area</u>: 10’ (Almost Never Applies)

c. Required shoulder widths – left and right?

<u>Rural and/or Urban</u>: 8’ Right and 8’ Left Desirable. ***(RDM Appendix 3A)***

[*However, No Shoulders are Required Due to Low Speed (Posted Speed Limit < 50 mph).*]

d. Required Stopping Sight Distance?

360’

(MDOT Sight Distance Guidelines)

(305’ if 40 mph design speed is used)

e. Maximum Allowable Grade (%)?

<u>Rural</u>: 6% (40 mph or 45 mph design speed)

<u>Urban</u>: 7% (45 mph design speed) ***(RDM Appendix 3A)***

8% (40 mph design speed)

Problem 4:

Non-Freeway, Non-NHS Corridor with a 3R Work Type
Undivided, 2-lane Arterial
ADT = 12,300
Rolling Terrain
Posted Speed 55 mph

a. What is the minimum allowable design speed?

b. What is the required lane width?

c. Required shoulder widths – left and right?

d. Required Stopping Sight Distance?

e. Maximum Allowable Grade (%)?

<u>Problem 4</u>:

(Solutions)

Non-Freeway, Non-NHS Corridor with a 3R Work Type
Undivided, 2-lane Arterial
ADT = 12,300
Rolling Terrain
Posted Speed 55 mph

a. What is the minimum allowable design speed?

55 mph Minimum ***(RDM 3.06 and RDM 3.09.02B)***

b. What is the required lane width?

11' Minimum ***(RDM 3.09.02B)***

12' Desirable on the NTN, but existing widths of less than 12' may be retained.

c. Required shoulder width?

Rural: 6' Total / 3' Paved

(RDM 3.09.02B)

Urban: 6' Total / 3' Paved – If <u>Not</u> Constrained by ROW.
If ROW <u>Not</u> sufficient, <u>No</u> Shoulders are Required.

d. Required Stopping Sight Distance?

495' ***(MDOT Sight Distance Guidelines)***

e. Maximum Allowable Grade (%)?

If there are <u>NO</u> crash patterns/concentrations related to the existing longitudinal grades, the existing grades may be retained (i.e. <u>No</u> Maximum).

(RDM 3.09.02B)

If there <u>IS</u> a crash pattern related to the existing longitudinal grades, then the maximum grades are as follows:

Rural: 5%

(RDM Appendix 3A)

Urban: 6%

CURB & GUTTER

(RDM 6.06)

CURB & GUTTER (RDM 6.06)

Purpose

Control and Direct Drainage

Visually and Physically Define the Travel Way

Define Driveway Locations

Promote Aesthetics of Roadside Development

C&G IN CONJUNCTION WITH SHOULDER

Curb & Gutter Should Not be Used on Roadways with Flush Shoulders, if Feasible

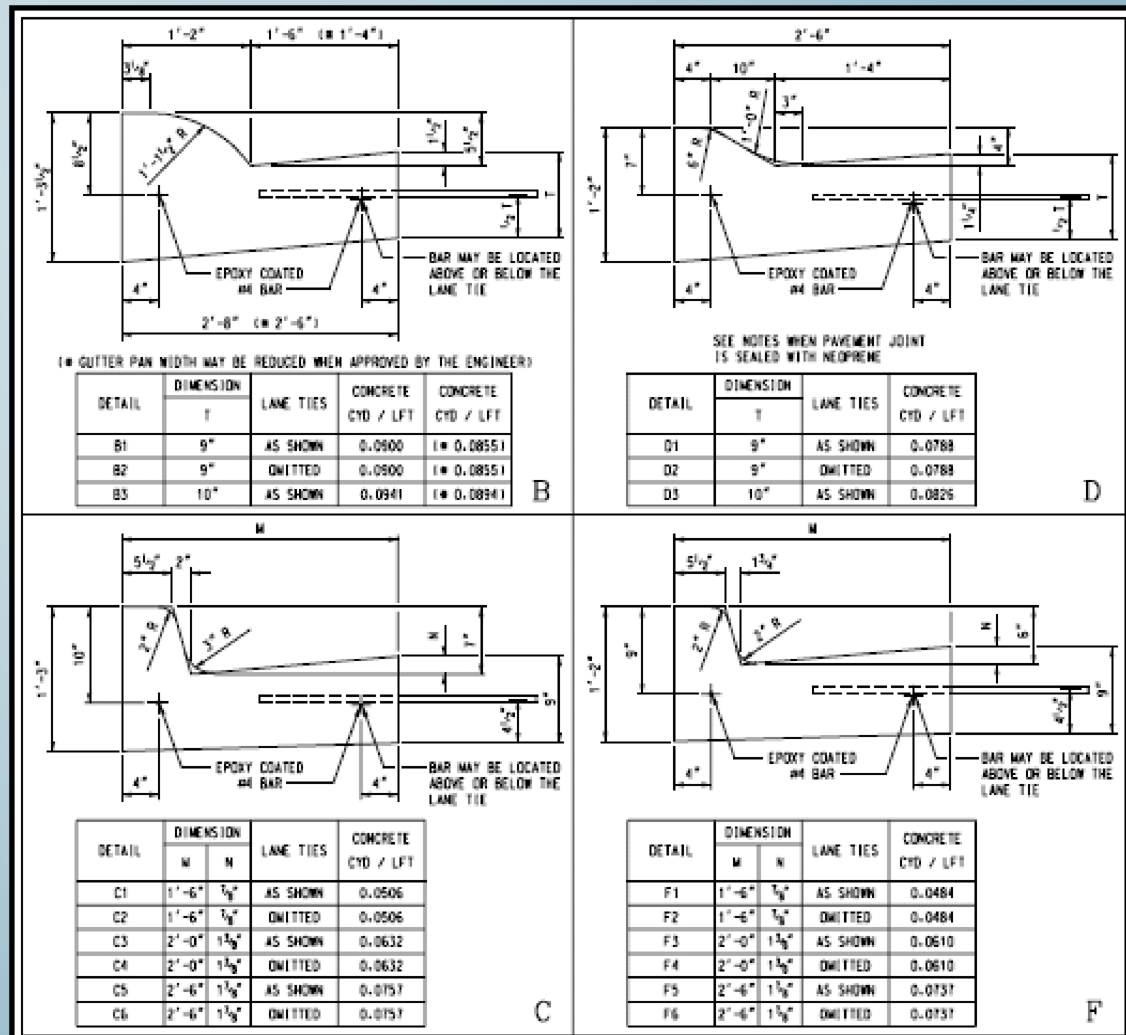
Curb & Gutter Should Not be Used Adjacent to the Travel Lane Where Posted Speeds are 50 mph or Greater

Roll Curb & Gutter is Frequently Used to Define the Radii of Rural Crossroad Intersections, but These are Placed Beyond the Edge of Shoulder and Therefore are not Adjacent to the Traveled Way

CURB & GUTTER IN CONJUNCTION WITH SHOULDER

MDOT
Standard Plan
R-30-G

Curb & Gutter Should Not be Used Where Open Drainage Ditches Can be Utilized



DETAIL	DIMENSION T	LANE TIES	CONCRETE CYD / LFT	CONCRETE CYD / LFT
B1	9"	AS SHOWN	0.0900	(* 0.0855)
B2	9"	OMITTED	0.0900	(* 0.0855)
B3	10"	AS SHOWN	0.0941	(* 0.0894)

DETAIL	DIMENSION T	LANE TIES	CONCRETE CYD / LFT
D1	9"	AS SHOWN	0.0788
D2	9"	OMITTED	0.0788
D3	10"	AS SHOWN	0.0826

DETAIL	DIMENSION M	DIMENSION N	LANE TIES	CONCRETE CYD / LFT
C1	1'-6"	7/8"	AS SHOWN	0.0506
C2	1'-6"	7/8"	OMITTED	0.0506
C3	2'-0"	1 3/8"	AS SHOWN	0.0632
C4	2'-0"	1 3/8"	OMITTED	0.0632
C5	2'-6"	1 7/8"	AS SHOWN	0.0757
C6	2'-6"	1 7/8"	OMITTED	0.0757

DETAIL	DIMENSION M	DIMENSION N	LANE TIES	CONCRETE CYD / LFT
F1	1'-6"	7/8"	AS SHOWN	0.0484
F2	1'-6"	7/8"	OMITTED	0.0484
F3	2'-0"	1 3/8"	AS SHOWN	0.0610
F4	2'-0"	1 3/8"	OMITTED	0.0610
F5	2'-6"	1 7/8"	AS SHOWN	0.0737
F6	2'-6"	1 7/8"	OMITTED	0.0737

CURB & GUTTER (RDM 6.06.06)

Most Curb and Curb & Gutter Types are Defined as Either Mountable/Roll or Barrier

<u>MDOT's Detail "B"</u>

May be Used at Any Posted Speed

Usually Used on the Back of Flush Shoulders at Rural Intersections

<u>MDOT's Detail "D"</u>

May be Used at Any Posted Speed

Primarily for Drainage and In Conjunction with Guardrail Sections

CURB & GUTTER (RDM 6.06.06)

Most Curb and Curb & Gutters are Defined as Either Mountable/Roll or Barrier

<u>MDOT's Detail "C"</u>

May be Used Where Posted Speeds are 35 mph or Less

Typical Usage is with Sidewalks, Trees, or Utility Poles Close to Edge of Pavement, Parking Areas, or to Match Existing Pavement

<u>MDOT's Detail "F"</u>

May be Used Where Posted Speeds are 45 mph or Less

May be Used to Replace Detail "C", or in Place of Detail "B" or "D"

CURB & GUTTER (RDM 6.06)

MDOT's Detail "G" (Urban Freeway Curb)

- Considered Mountable
- Usually Used on Urban Freeways (Only in Cut Sections), in front of Earth Berms, or Adjacent to Retaining Walls at the Back of Shoulder

Refer to RDM 6.06.10 and MDOT Special Detail R-33-G

MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN FOR

CONCRETE VALLEY GUTTER AND URBAN FREEWAY CURB

F.H.W.A. APPROVAL	9-26-2007 PLAN DATE	R-33-F	SHEET 1 OF 2

These Curb Details May be Used at Non-Freeway Locations when Approved.

CURB & GUTTER (RDM 6.06)

Concrete Valley Gutter - Developed to be Used on Freeways in Order to Provide Flush Shoulders

Replaced Curb & Gutter That was Previously Used Between the Travel Lane and the Paved Shoulder

MDOT Practice

To Place Concrete Valley Gutter at the Outside Edge of the Shoulder and Adjacent to CMB or Single Face Barrier, if Present

CURB & GUTTER (RDM 6.06)

Bridge Approach Curb & Gutter Details

Should be Determined by the Bridge Designer

If a Road Plan is Included with the Bridge Plan, the Quantities will be in the Road Plan

Refer to RDM 6.06.08 and MDOT Special Detail R-32-F

QUESTIONS

CROSS SLOPE

CROSS SLOPE / CROWN

- **Cross Slope** – Transverse slope rate of travel lane or shoulder.
- **Normal Crown** – Uniform slope towards the outside edge of pavement

Undivided Roadways	**Divided Roadways**
Typically Crowned at Centerline or Edge of Center Lane	**May be Crowned at Centerline or at Inside or Outside Edge of Pavement**

CROSS SLOPE / CROWN

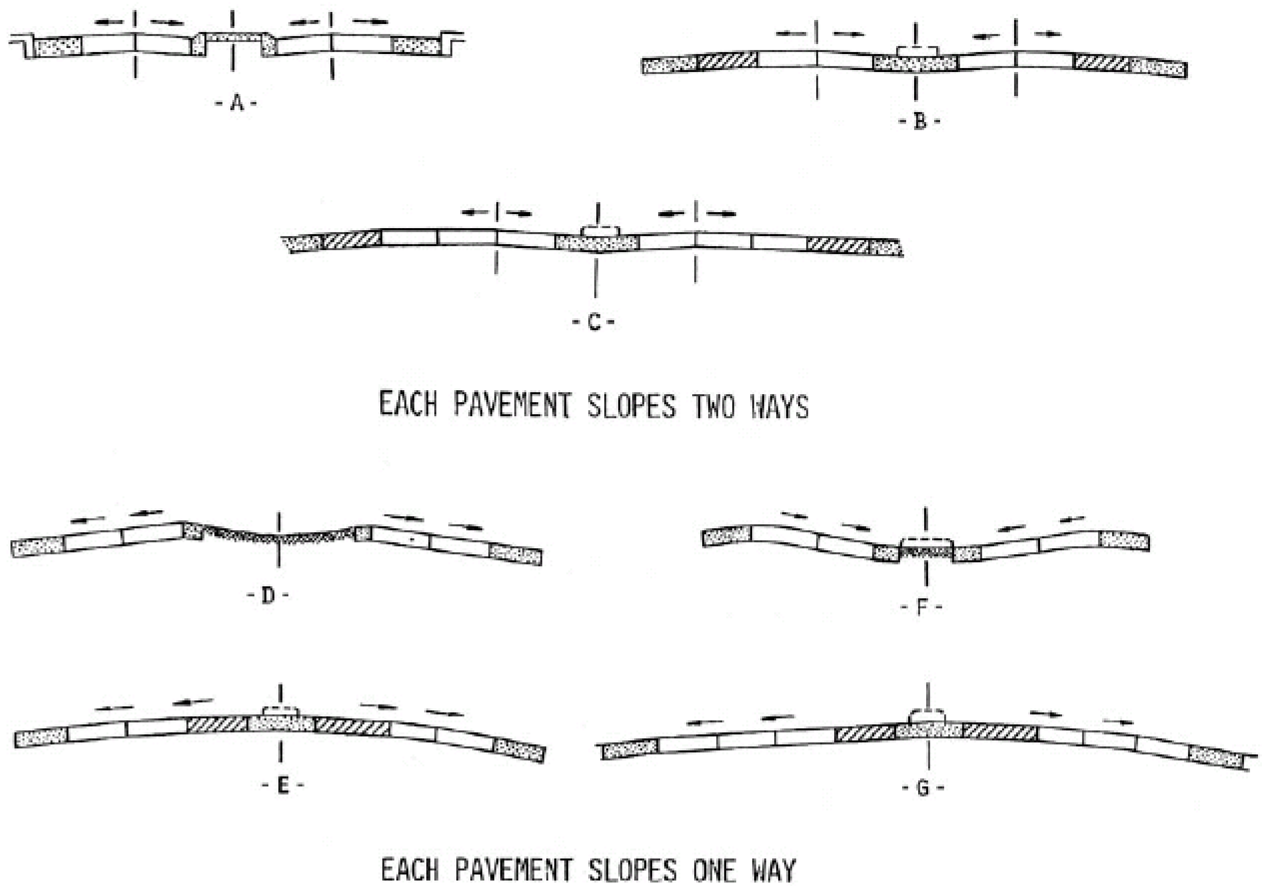


Exhibit 4-3. Roadway Sections for Divided Highway (Basic Cross-Slope Arrangements)

CROSS SLOPE / CROWN

The Department Uses a Standard Cross Slope of

2.0%

Allowable Cross Slope Variances for 3R Projects are Given in RDM 3.09.02

A Design Exception is Needed for Cross Slopes that are Less than the Required Minimums, Greater than 2%, or Parabolic in Nature.

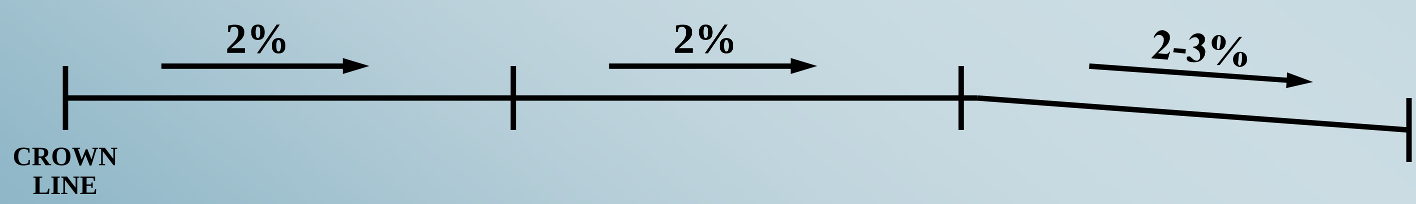
Except…

CROSS SLOPE / CROWN

Three or More Lanes Inclined in the Same Direction

(Free Access Curbed Highways)

- Slope May be Increased After the First Two Lanes from the Crown Line
  - Up to 1%
- When Existing Side Conditions Do Not Allow the Preferred Uniform Standard Crown Rate



- Requires Additional Transition in Superelevated Sections

CROSS SLOPE / CROWN

Appendix 3A
GEOMETRIC DESIGN ELEMENTS
New Construction / Reconstruction

Grade

Freeway							
	Type of Terrain	**Maximum Grade (%) for specified design speed (mph)** 50	55	60	65	70	75
	Level	4	4	3	3	3	3
	Rolling	5	5	4	4	4	4
		Grades 1% steeper may be provided in urban areas. Curbed roadway 0.3% min, 0.5% desirable minimum					

Non Freeway (Arterial)	Urban							Rural					
Type of Terrain	30	35	40	45	50	55	60	40	45	50	55	60
Level	8	7	7	6	6	5	5	5	5	4	4	3
Rolling	9	8	8	7	7	6	6	6	6	5	5	4
	Curbed roadway 0.3% min, 0.5% desirable minimum												

Collector Roads	Urban									Rural									
Type of Terrain	20	25	30	35	40	45	50	55	60	20	25	30	35	40	45	50	55	60
Level	9	9	9	9	9	8	7	7	6	7	7	7	7	7	7	6	6	5
Rolling	12	12	11	10	10	9	8	8	7	10	10	9	9	8	8	7	7	6
	Curbed roadway 0.3% min, 0.5% desirable minimum																		

Element	Requirement
Stopping Sight Distance	Follow current edition of AASHTO "A Policy on Geometric Design of Highways and [illegible]" (AKA AASHTO Green Book). The MDOT Sight Distance Guidelines also provide detailed information on sight distance calculation.
Cross Slope	Traveled way cross slope = 2.0%, Paved shoulder cross slope = 4.0% (Also see Section 6.05.05)
Superelevation	AASHTO Method 5 "Curvilinear Relation" is used for new construction/reconstruction. Maximum rate of 7[illegible] (See Standard Plan R-107-Series.) AASHTO Method 1 "Straight Line Relation" is allowed when Method 5 is not [illegible] maximum rate of 6%. (See Section 3.04.03) The above methods also apply to urban freeways and urban ramps, except the maximum rate is 5% for 60 mph design speed.

Vertical Clearance

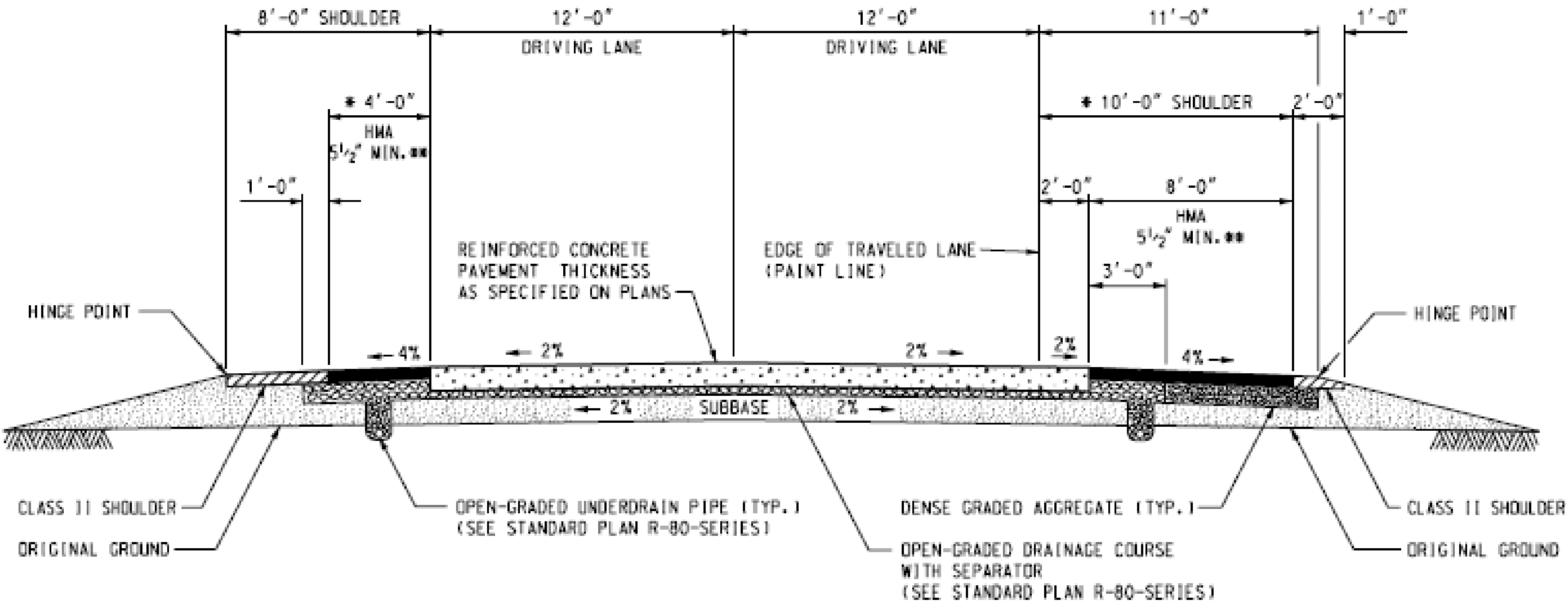
	NHS	Non NHS
Freeway	16'-0"	14'-6"
Non Freeway (Arterial)	16'-0"	14'-6"
Collectors & "Special Routes"	14'-6" (1 ft. greater than Michigan legal vehicle height.)	14'-6"

For pedestrian bridges provide 1 ft. additional clearance over non-freeway and 17 ft. minimum under clearance over freeways. A vertical clearance of 23'-0" is required for grade separations over railroads. *(See Bridge Design Manual 7.01.08 and Bridge Design Guides 5.24.03-04.)*

Horizontal Clearance / Bridge Width

See definition of terms in this chapter. Also, see Bridge Design Guides, Section 6

CROSS SLOPE / CROWN



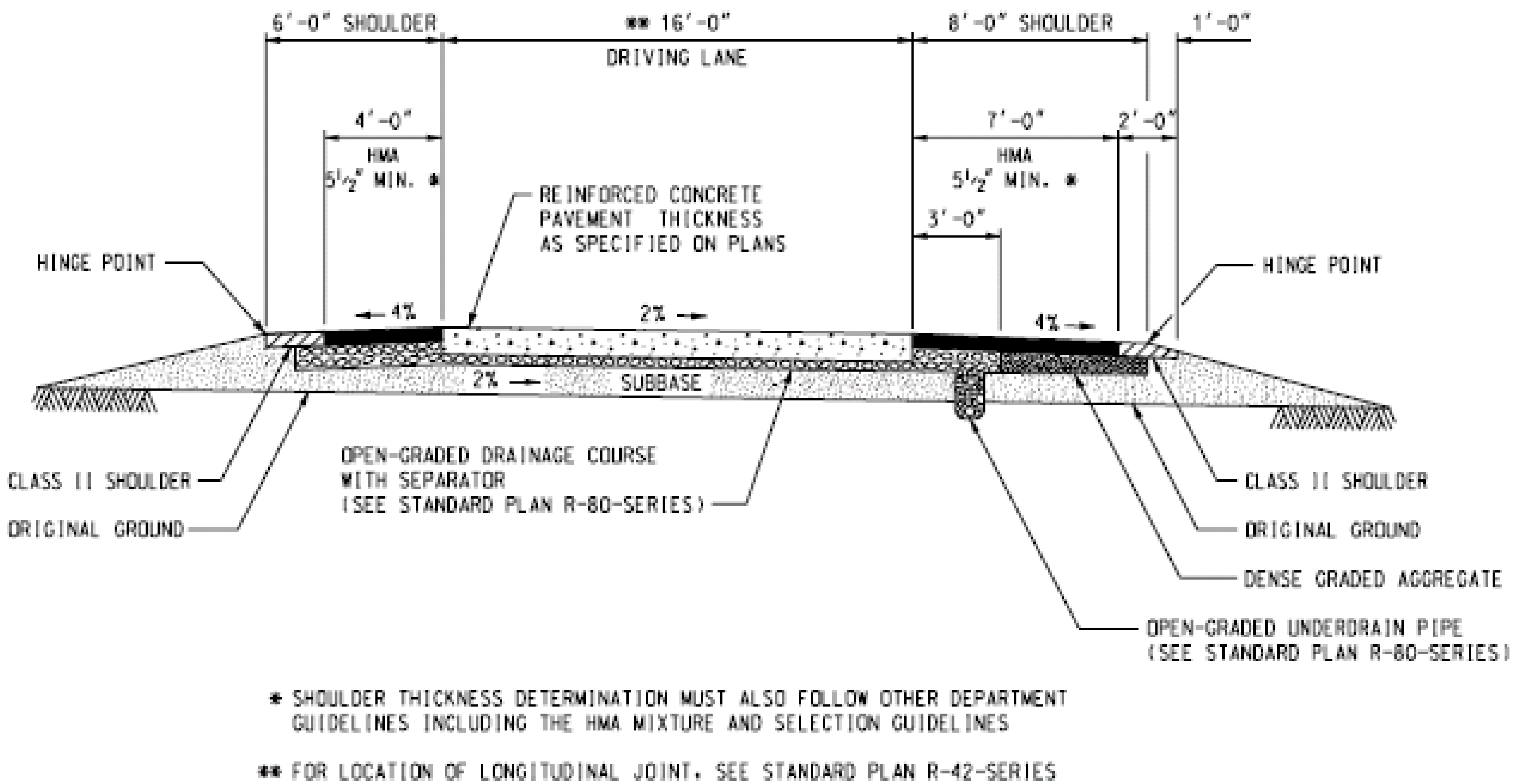
* RIGHT (OUTSIDE): CONSIDER 12' PAVED SHOULDER WHERE TRUCK TRAFFIC EXCEEDS 250 DDHV.

* LEFT (MEDIAN): FOR THREE OR MORE DRIVING LANES. USE A 10' PAVED SHOULDER SECTION. CONSIDER 12' PAVED SHOULDER WHERE TRUCK TRAFFIC EXCEEDS 250 DDHV AND THREE OR MORE DRIVING LANES EXIST.

** SHOULDER THICKNESS DETERMINATION MUST ALSO FOLLOW OTHER DEPARTMENT GUIDELINES INCLUDING THE HMA MIXTURE AND SELECTION GUIDELINES.

FREEWAY

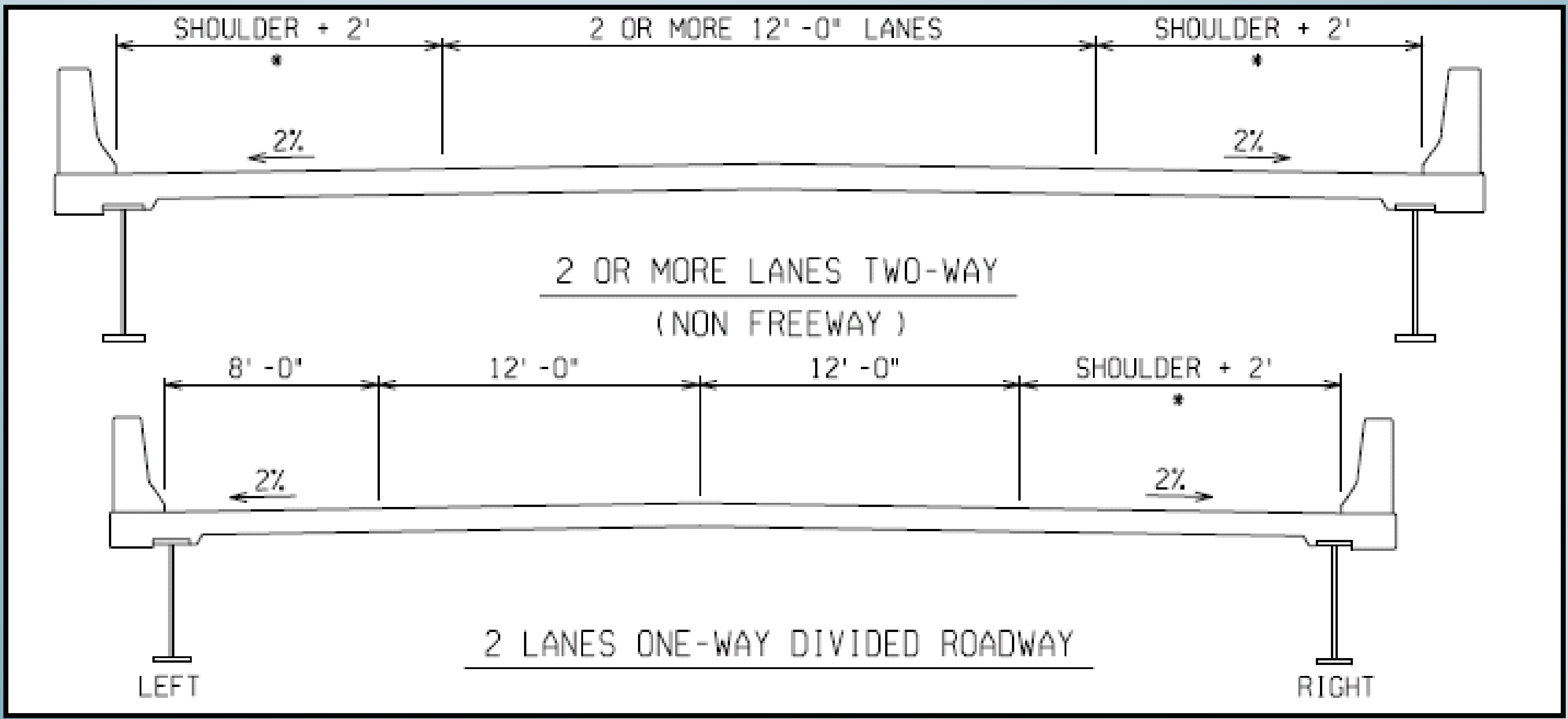
CROSS SLOPE / CROWN



RAMP

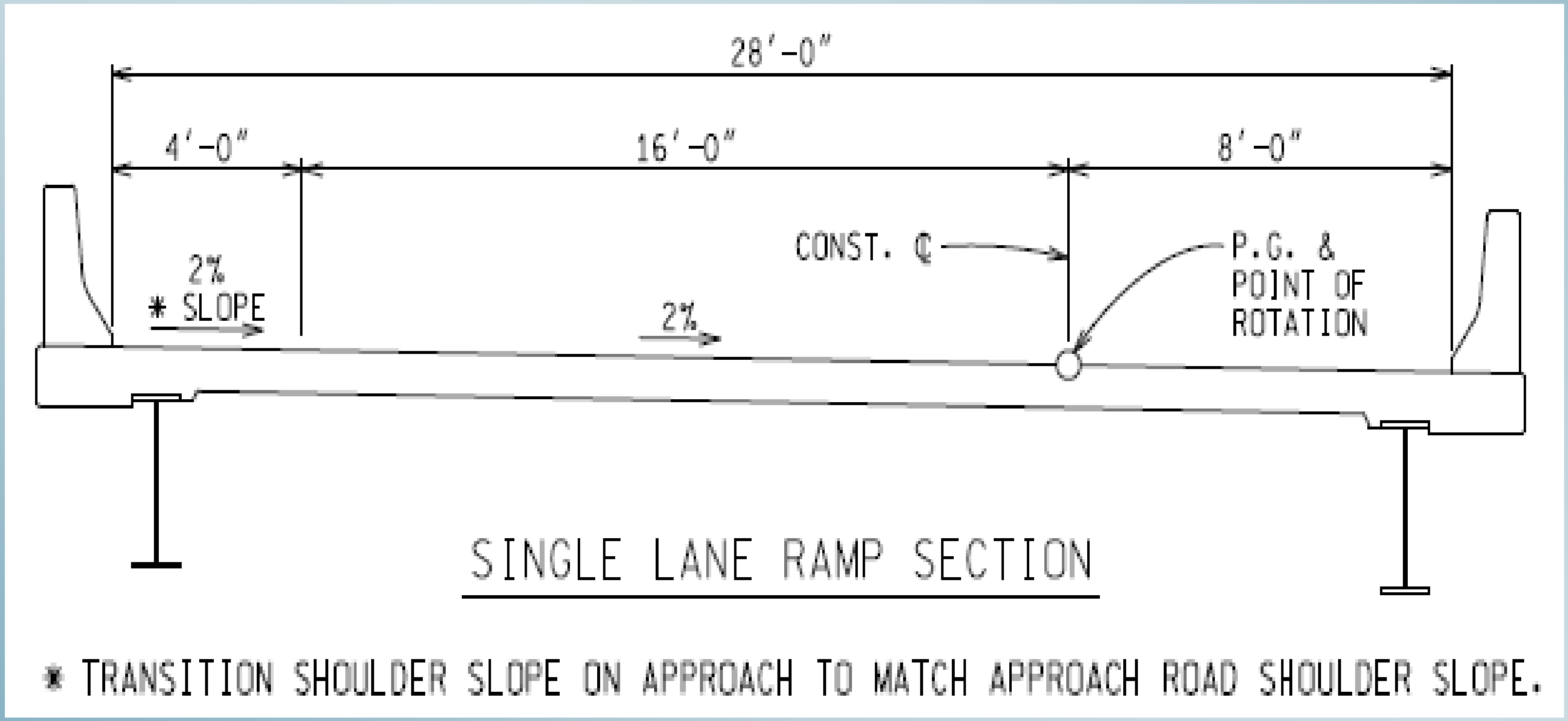
CROSS SLOPE / CROWN

Bridge Design Guides (6.05.01)



CROSS SLOPE / CROWN

Bridge Design Guides (6.05.03)



CROSS SLOPE / CROWN

Non-Freeway, NHS, 3R (3.09.02 A)

MICHIGAN DESIGN MANUAL
ROAD DESIGN

3.09.02 (continued)

A. Non-Freeway, NHS

Geometric Elements	Non-Freeway, NHS 3R Minimum Guidelines			
Design Speed (see Section 3.06)	Posted Speed + 5 mph			
Shoulder Width *Minimum shoulder widths apply for:* ***Rural:*** *Posted speeds greater than 45 mph.* ***Urban:*** *Posted speeds greater than 45 mph where sufficient right-of-way exists to include shoulders.* *At lower speeds, minimum shoulders are desirable.*	Current ADT Two-Way		Inside Shoulder	Outside Shoulder
	Two Lane (and three lane when the center lane is a left turn lane)	<750		3'-0" Gravel
		750 - 5000		6'-0" (3'-0" Paved)
		>5000 - 10,000		8'-0" (3'-0" Paved)
		>10,000		8'-0" (7'-0" Paved)
	Multi-Lane Undivided	≤ 10,000 > 10,000		6'-0" (3'-0" Paved) 8'-0" (3'-0" Paved)
	Multi-Lane Divided	≤ 10,000 > 10,000	3'-0" Paved 3'-0" Paved	6'-0" (3'-0" Paved) 8'-0" (3'-0" Paved)
Lane Width	ADT	Lane Width		
	≤750	10'-0"		
	>750	11'-0" 10'-0" lanes may be considered in urban areas for multi-lane un-divided (regardless of ADT) and multi-lane divided (ADT < 10,000). 12'-0" lanes are desirable on the Priority Commercial Network (PCN). 12'-0" lanes are required on the National Network (also known as the National Truck Network). Design exceptions to maintain existing narrower lanes generally receive favorable consideration but a high burden of justification is placed on requests to reduce lane widths to less than 12'-0".		
Bridge Width, Structural Capacity & Horizontal Clearances	Rural		Urban	
	Traveled way width plus 2'-0" each side. Minimum Design Loading HS20.		Curb to curb approach width. Minimum Design Loading HS20.	
Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05			
Superelevation	Standard Plan R-107-Series or reduced maximum (6%) Straight Line Superelevation Chart using the project design speed.			
Vertical Clearance	See Section 3.12.			

Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05

CROSS SLOPE / CROWN

Non-Freeway, Non-NHS, 3R (3.09.02 B)

MICHIGAN DESIGN MANUAL
ROAD DESIGN

3.09.02 (continued)

B. Non-Freeway, Non-NHS

Geometric Elements	Non-Freeway, Non-NHS 3R Minimum Guidelines		
Design Speed	Posted Speed Minimum		
Shoulder Width *Minimum shoulder widths apply for:* ***Rural:** Posted speeds greater than 45 mph.* ***Urban:** Posted speeds greater than 45 mph where sufficient right-of-way exists to include shoulders.* *At lower speeds, minimum shoulders are desirable.*	Current ADT Two-Way	Inside and Outside Shoulder Width	
	≤750	2'-0" (Gravel)	
	750 - 2000	3'-0" (Paved)	
	> 2000	6'-0" (3'-0" Paved)	
	Multi-Lane (Divided & Undivided)	Inside (Divided)	Outside (Both sides for un-divided)
		3'-0" Paved	6'-0" (3'-0" Paved)
Lane Width	ADT	Lane Width	
	≤750	10'-0"	
	>750	11'-0" 10'-0" lanes may be considered in urban areas for multi-lane un-divided (regardless of ADT) and multi-lane divided (ADT < 10,000). 12'-0" lanes are desirable on the Priority Commercial Network (PCN) and the National Network (also known as the National Truck Network). Existing narrower lanes may be retained without design exceptions. Reduction of existing lane widths on the National Network to less than 12-0" require a design exception request having a high burden of justification.	
Bridge Width, Structural Capacity & Horizontal Clearances **(Existing Bridges to remain in place)**	ADT (Design Year)	Minimum Design Loading	Usable Width
	0 - 750	H15	Width of traveled way.
	751 - 1500	HS15	Width of traveled way.
	1501 - 2000	HS15	Width of traveled way plus 1' each side.
	2001 - 4000	HS15	Width of traveled way plus 2' each side.
	> 4000	HS15	Width of traveled way plus 3' each side.

Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05

	Chart using the project design speed.
Vertical Clearance	See Section 3.12.

CROSS SLOPE / CROWN

Where Resurfacing is Less Than 4"…

The Crown Point *May* be Retained in Its Existing Location

2% Cross Slope Should be Established or Maintained

Where Resurfacing is 4"or More…

The Crown Point Should be Moved to Meet Current Standards

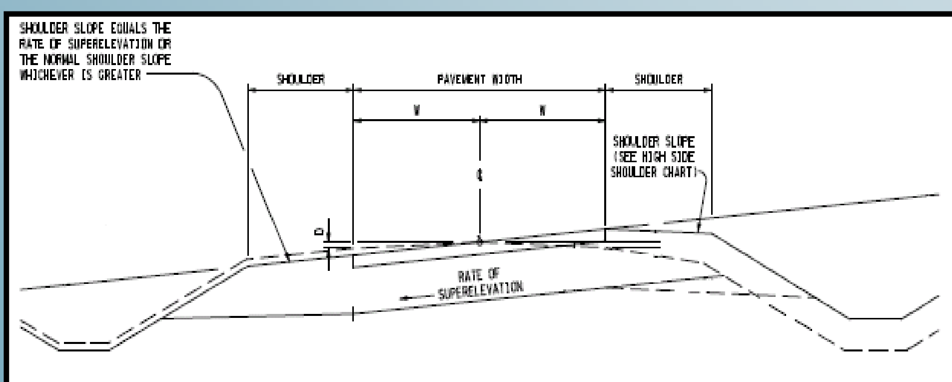
CROSS SLOPE / CROWN

Shoulder Slopes

Road Design Manual 6.05.05 and Standard Plan R-107

- Standard Slope for Gravel or Earth Surfaced Shoulder and Shoulder Ribbon is 6% (0.06ft/ft)
- Standard Slope for Paved Shoulder is 4% (0.04ft/ft)
- Standard Slopes for Superelevated Sections

  See R-107



HIGH SIDE SHOULDER CHART	
WHEN RATE OF FULL SUPERELEVATION IS	SHOULDER SLOPE AT FULL SUPERELEVATION EQUALS
FROM 0 TO 3%	RATE OF SUPERELEVATION MINUS NORMAL SHOULDER SLOPE
3% TO AND INCLUDING 5%	RATE OF SUPERELEVATION; 1%; SHOULDER
OVER 5%	RATE OF SUPERELEVATION; SHOULDER

CROSS SLOPE / CROWN

Shoulder Slopes

Slope Rates Between 4% and 6% are Generally Acceptable for Aggregate Shoulders

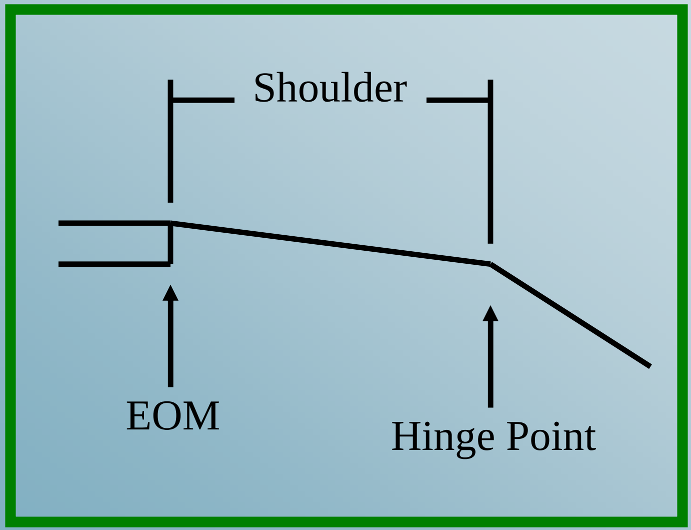
Slope Rates Between 4% and 6% *May* be Used for Paved Shoulders *if* Side Conditions are Constrained, and *if* it Does Not Result in a Rollover of Greater Than 6%

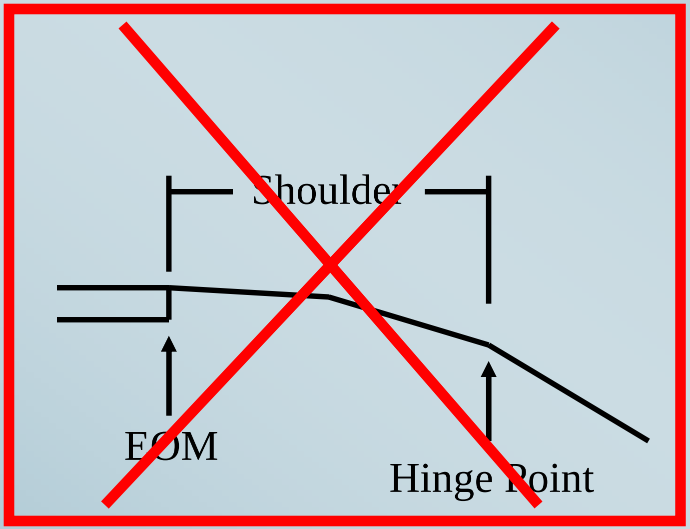
Slopes of Less Than 4% (Except on Bridges or in Superelevated Sections) or Greater Than 6% (Except in Superelevated Sections) Require a Design Exception

CROSS SLOPE / CROWN

Shoulder Slopes

Do NOT Change Slope Rates Within the Plane of the Shoulder – Keep Paved and Unpaved in Same Plane





CROSS SLOPE / CROWN

Retaining an Existing Parabolic Crown will
Require a Design Exception

The Desirable Rollover (Algebraic Difference in Cross Slope)
between Traveled Lanes and Shoulders is 6% or Less

MDOT Maximum Rollover: 6%
AASHTO/FHWA Maximum Rollover: 8%

(Design Exceptions Required if These Values are Exceeded)

QUESTIONS

SUPERELEVATION

SUPERELEVATION

- **Superelevation** – The banking of the roadway in the direction of the curve to help counter balance the perceived "centrifugal force" on the vehicle

The Appropriate Rate of Superelevation is Determined From…

- Design Speed
- Curve Radius
- Maximum Allowable Side Friction Factor
- Superelevation Method

SUPERELEVATION

Michigan's Climate Limits Superelevation to 7% on…

- Rural Freeways
- Free Access Trunklines
- Rural Ramps

For Maximum Superelevation on "Urban" Freeways (DS = 60 mph) and Ramps See R-107

SUPERELEVATION

Obtaining Superelevation Rates

Preferred

MDOT Standard Plan R-107

Minimum

Straight Line Method (RDM 3.04.03)

Interpolating ***between*** the AASHTO 6% and 8% E_{max} charts is not appropriate! Interpolating ***within*** the R-107 or Straight-Line charts is allowable!

If the Straight-Line superelevation rates cannot be met, a Design Exception/Design Variance is required.

SUPERELEVATION

Appendix 3A
GEOMETRIC DESIGN ELEMENTS
New Construction / Reconstruction

			Maximum Grade (%) for specified design speed (mph)					
Maximum Grade	Freeway	Type of Terrain	**50**	**55**	**60**	**65**	**70**	**75**
		Level	4	4	3	3	3	3
		Rolling	5	5	4	4	4	4
			Grades 1% steeper may be provided in urban areas.					

			Urban							Rural				
Maximum Grade	Non Freeway (Arterial)	Type of Terrain	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**40**	**45**	**50**	**55**	**60**
		Level	8	7	7	6	6	5	5	5	5	4	4	3
		Rolling	9	8	8	7	7	6	6	6	6	5	5	4

			Urban									Rural								
Maximum Grade	Collector Roads	Type of Terrain	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**
		Level	9	9	9	9	9	8	7	7	6	7	7	7	7	7	7	6	6	5
		Rolling	12	12	11	10	10	9	8	8	7	10	10	9	9	8	8	7	7	6

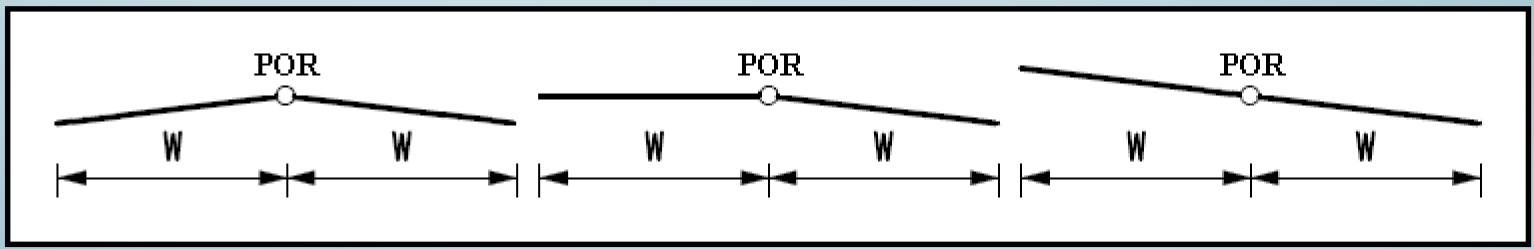
Stopping Sight Distance	Follow 2011 6th Edition of AASHTO "A Policy on Geometric Design of Highways and Streets" (AKA AASHTO Green Book). The MDOT Sight Distance Guidelines also provide detailed information on sight distance calculation.
Cross Slope	Traveled way cross slope = 2.0%, Paved shoulder cross slope = 4.0% (Also see Section 6.05.05)
Superelevation Rate	AASHTO Method 5 "Curvilinear Relation" is used for new construction/reconstruction. Maximum rate of 7%. (See Standard Plan R-107-Series.)
	AASHTO Method 1 "Straight Line Relation" is allowed when Method 5 is not feasible. Maximum rate of 6%. (See Section 3.04.03)
	The above methods also apply to urban freeways and urban ramps, except the maximum rate is 5% for 60 mph design speed.

		NHS	Non NHS
Vertical Clearance	**Freeway**	16'-0"	14'-6"
	Non Freeway (Arterial)	16'-0"	14'-6"
	Collectors & "Special Routes"	14'-6" (1 ft. greater than Michigan legal vehicle height.)	14'-6"
	For pedestrian bridges provide 1 ft. additional clearance over non-freeway and 17 ft. minimum under clearance over freeways. A vertical clearance of 23'-0" is required for grade separations over railroads. *(See Bridge Design Manual 7.01.08 and Bridge Design Guides 5.24.03-04.)*		

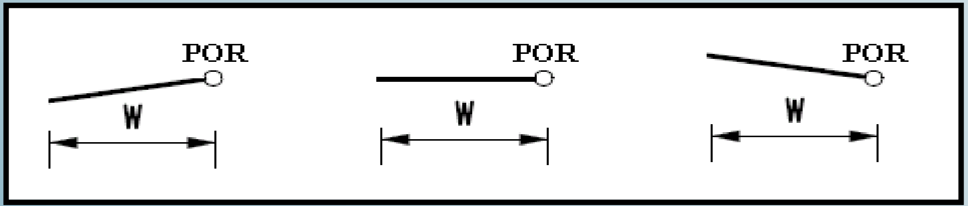
SUPERELEVATION

Point of Rotation (RDM 3.04.01)

Crowned Multi-Lane Roadways



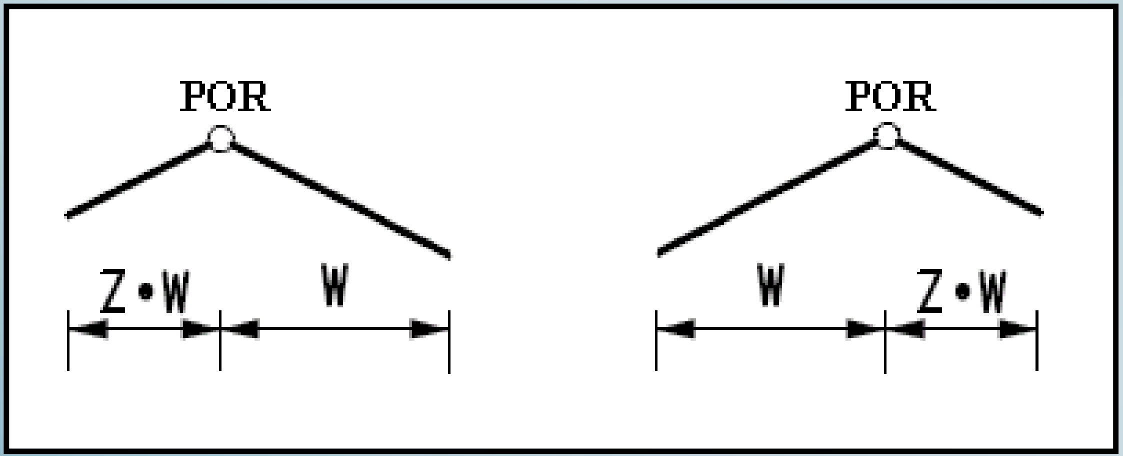
Single-Lane or Unidirectionally Crowned Roadways (i.e. Ramps)



SUPERELEVATION

Point of Rotation (RDM 3.04.01)

Special consideration should be given to superelevating an odd number of lanes (i.e. three-lane or five-lane sections) as the point of rotation should be determined by site conditions. See Standard Plan R-107-Series.



SUPERELEVATION

Superelevation Transitions (RDM 3.04.02)

Consists Of…

Tangent Runout (Crown Runout (C))	**Superelevation Transition** (Transition (L))
Length of Roadway Needed to Accomplish a Change in Outside-Lane Cross Slope from the Normal Cross Slope Rate to Zero (Flat) or Vice Versa	**Length of Roadway Needed to Accomplish a Change in Outside-Lane Cross Slope from Zero (Flat) to Full Superelevation or Vice Versa**

SUPERELEVATION

Superelevation Transitions (RDM 3.04.02)

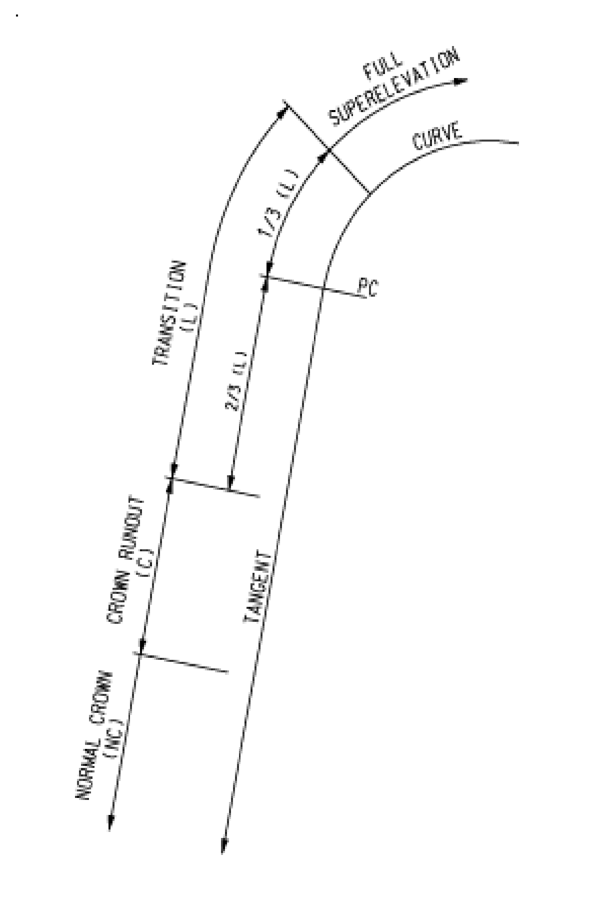
Relative Gradient
Along the Edges of the Pavement

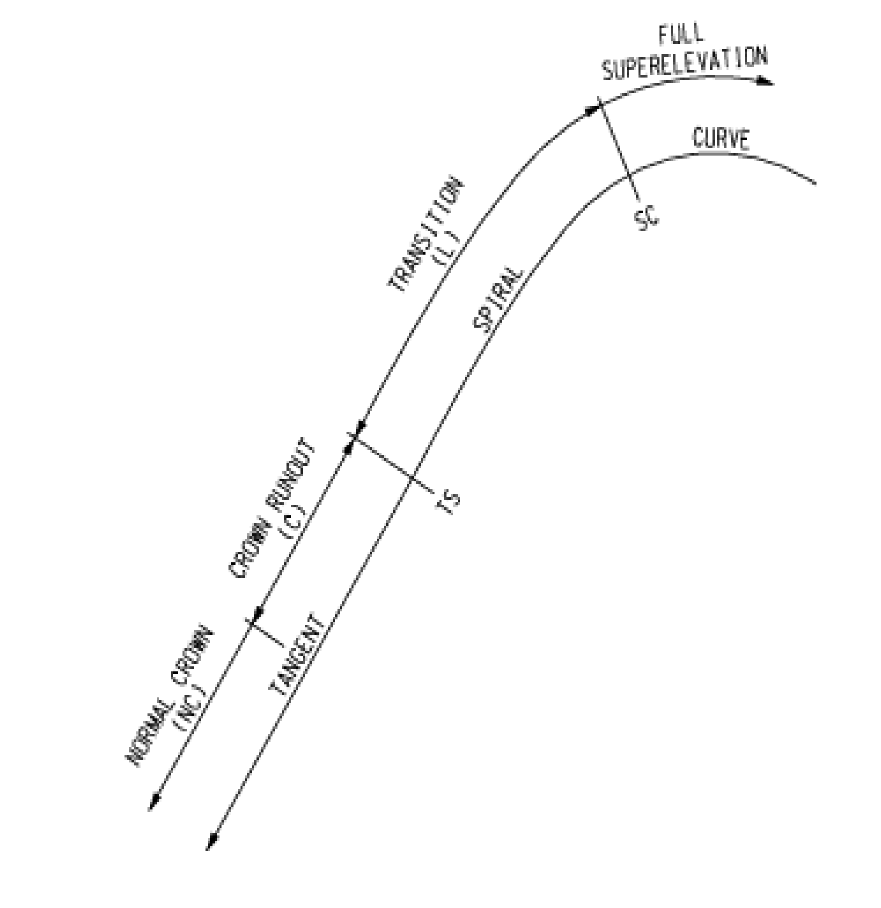
(Delta Percent), (Δ%)

- Dependent on Superelevation Rates and Design Speeds
- May be Increased as Needed Up to the Maximum Relative Gradient for the Design Speed
- Requires a Design Variance if Values Exceed the Maximum for the Design Speed

SUPERELEVATION

Superelevation Transitions (RDM 3.04.02)





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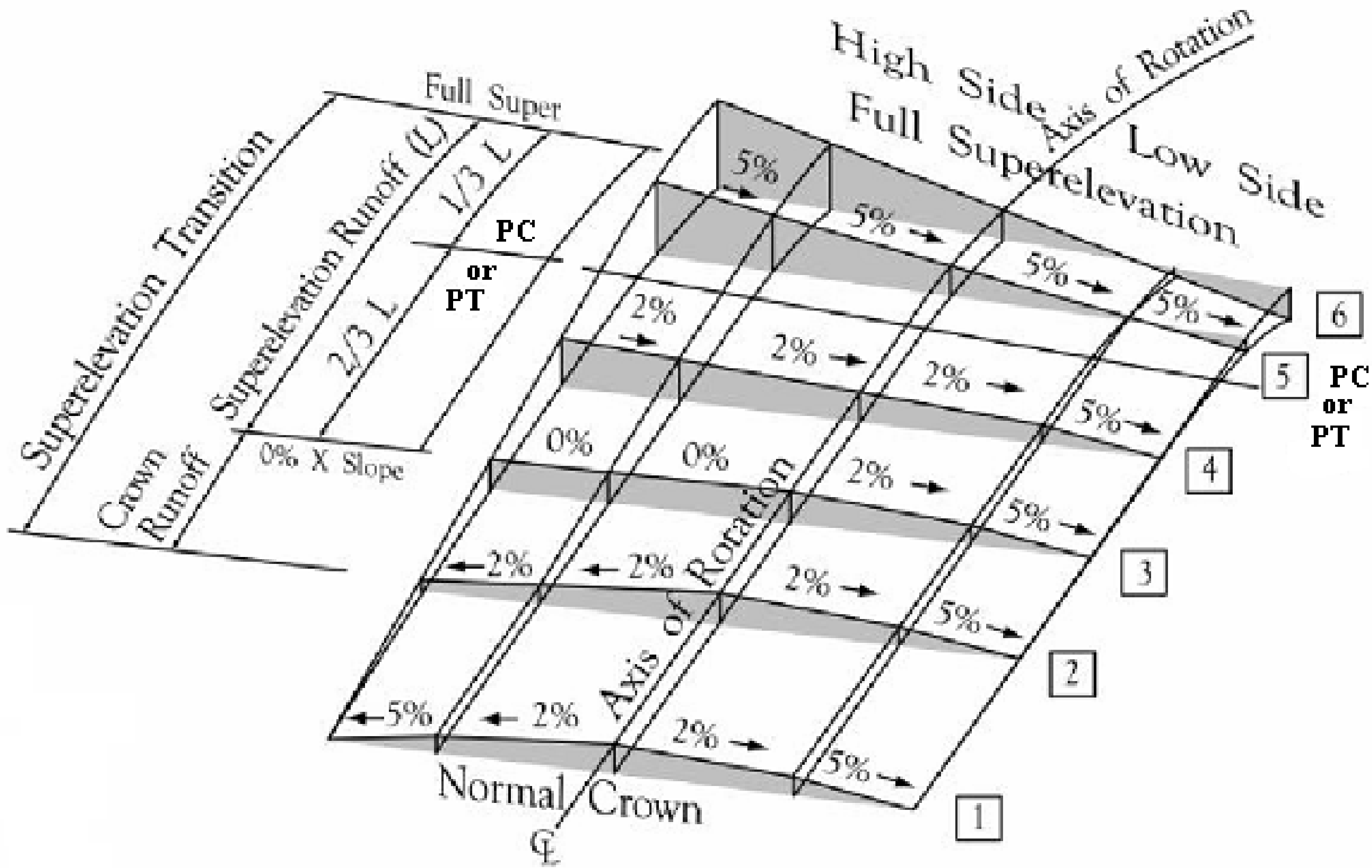
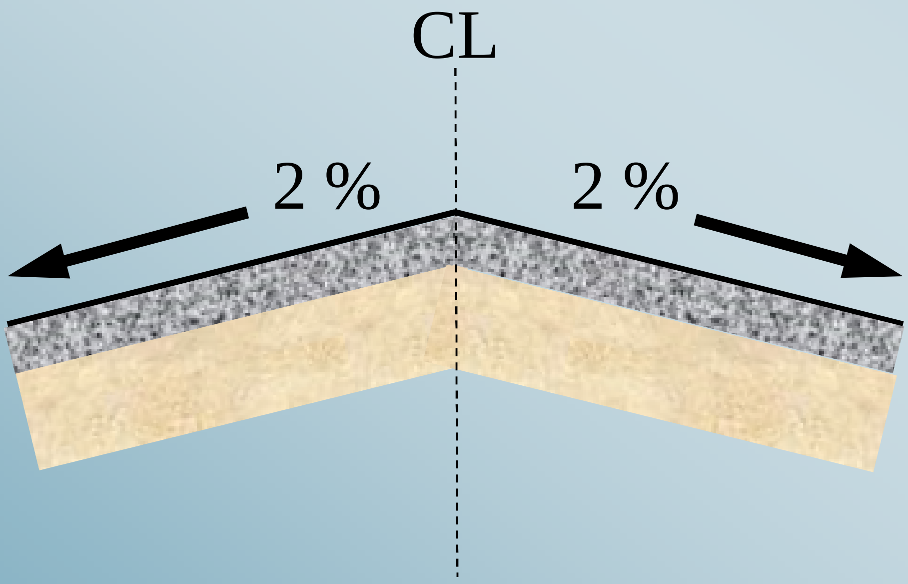
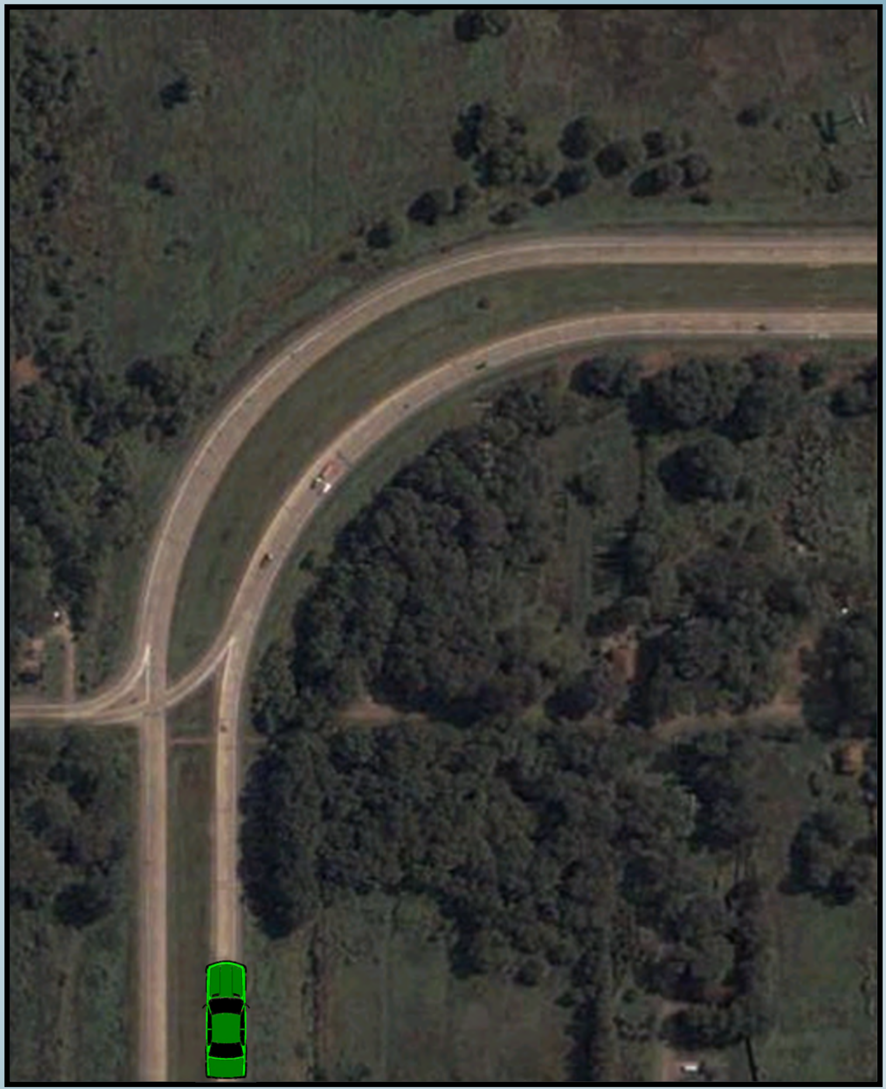


Elements of a Superelevation Transition (Right Curve)

SUPERELEVATION



Road Cross Section



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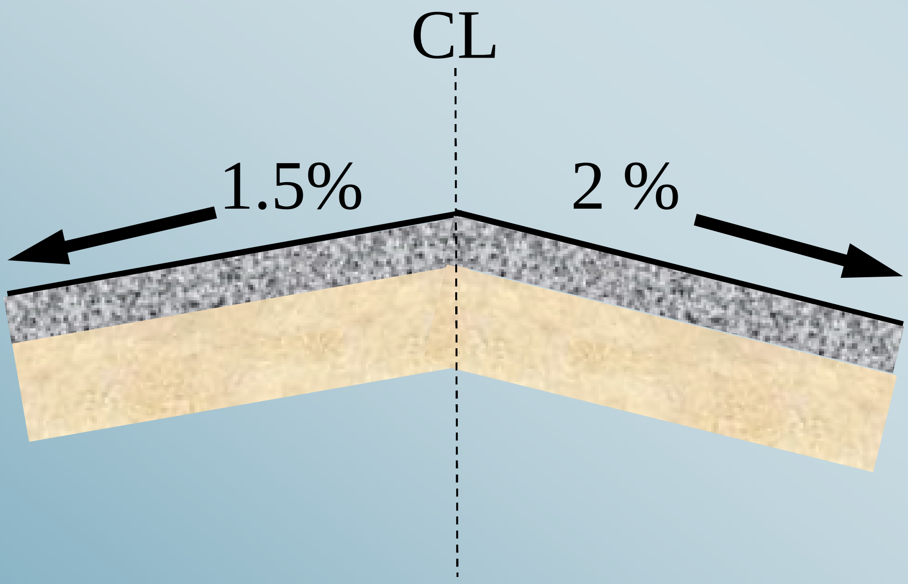

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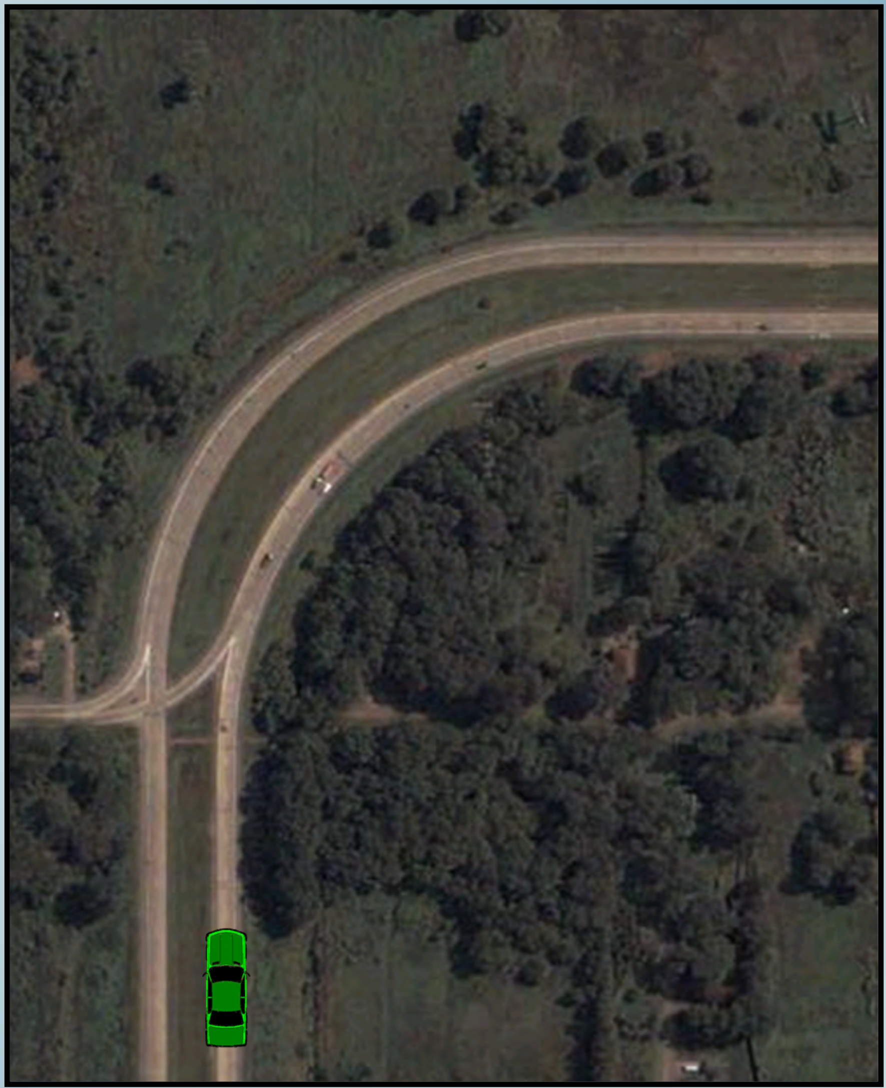

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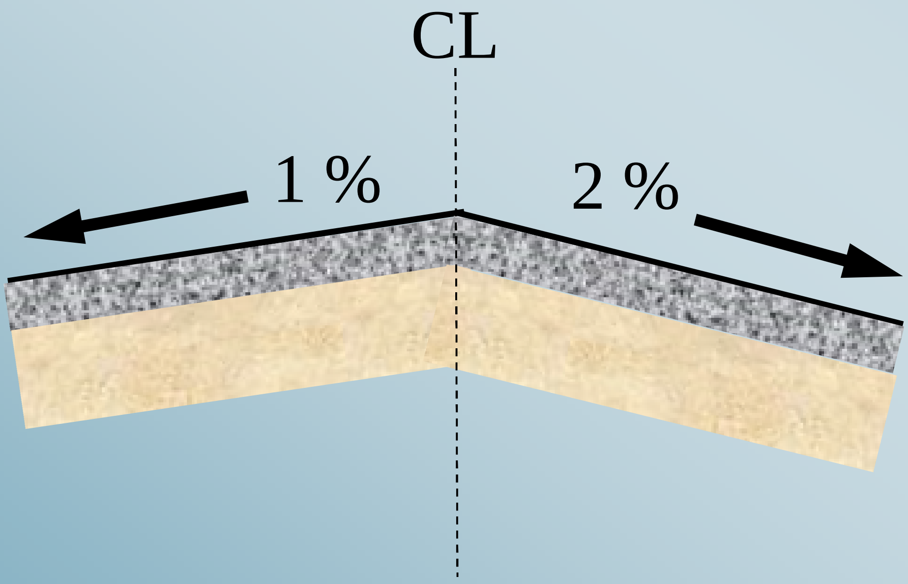

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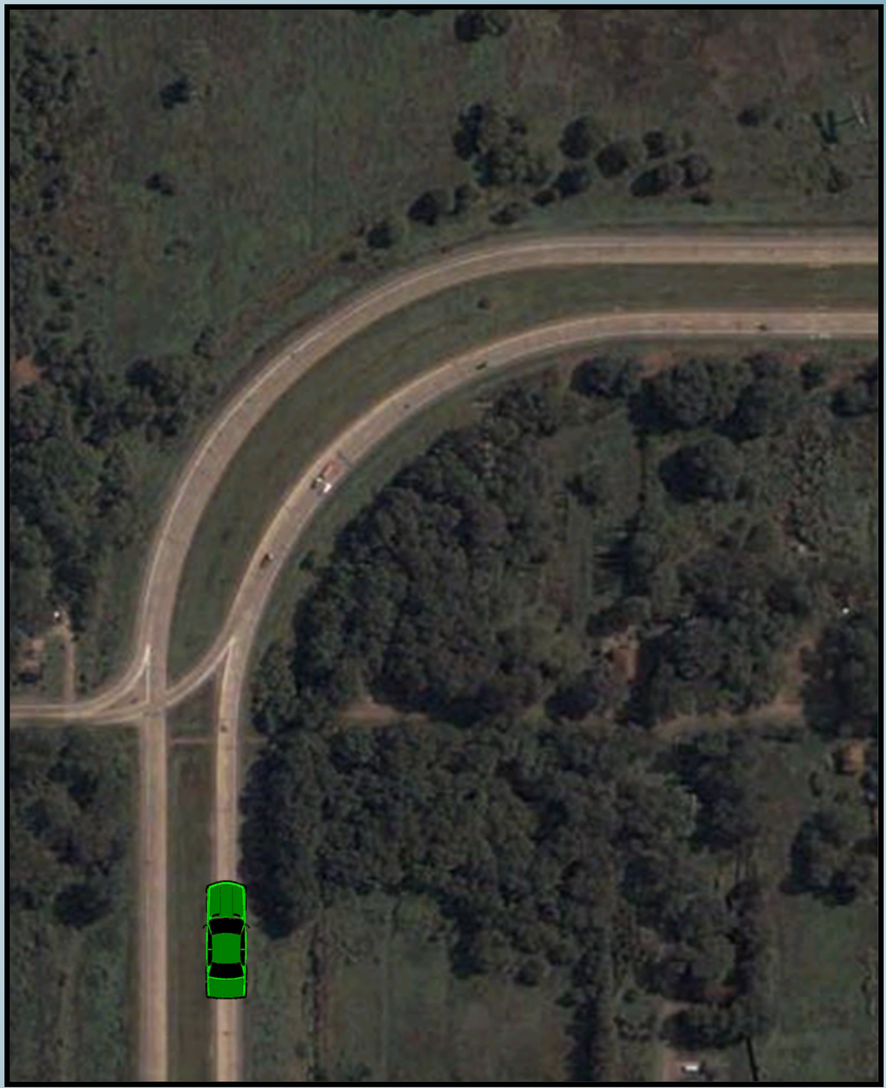

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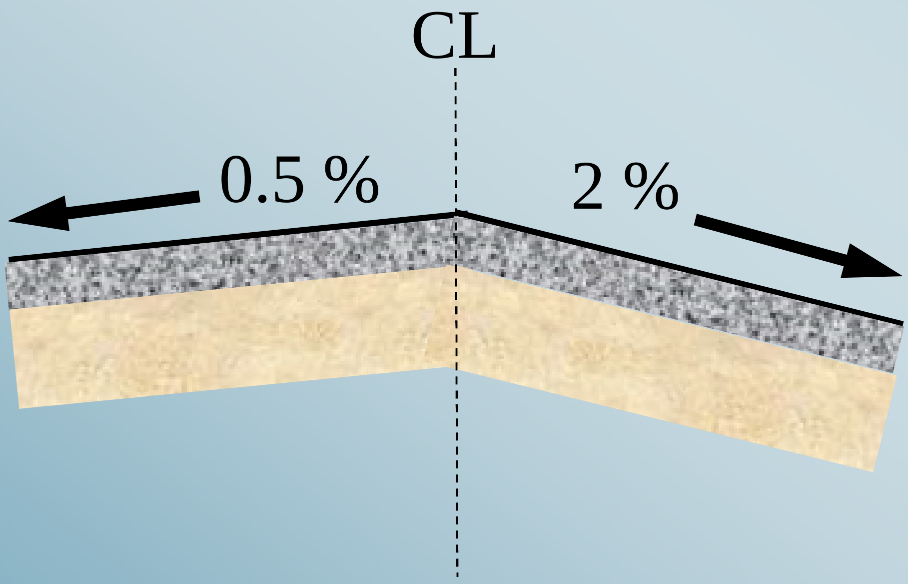

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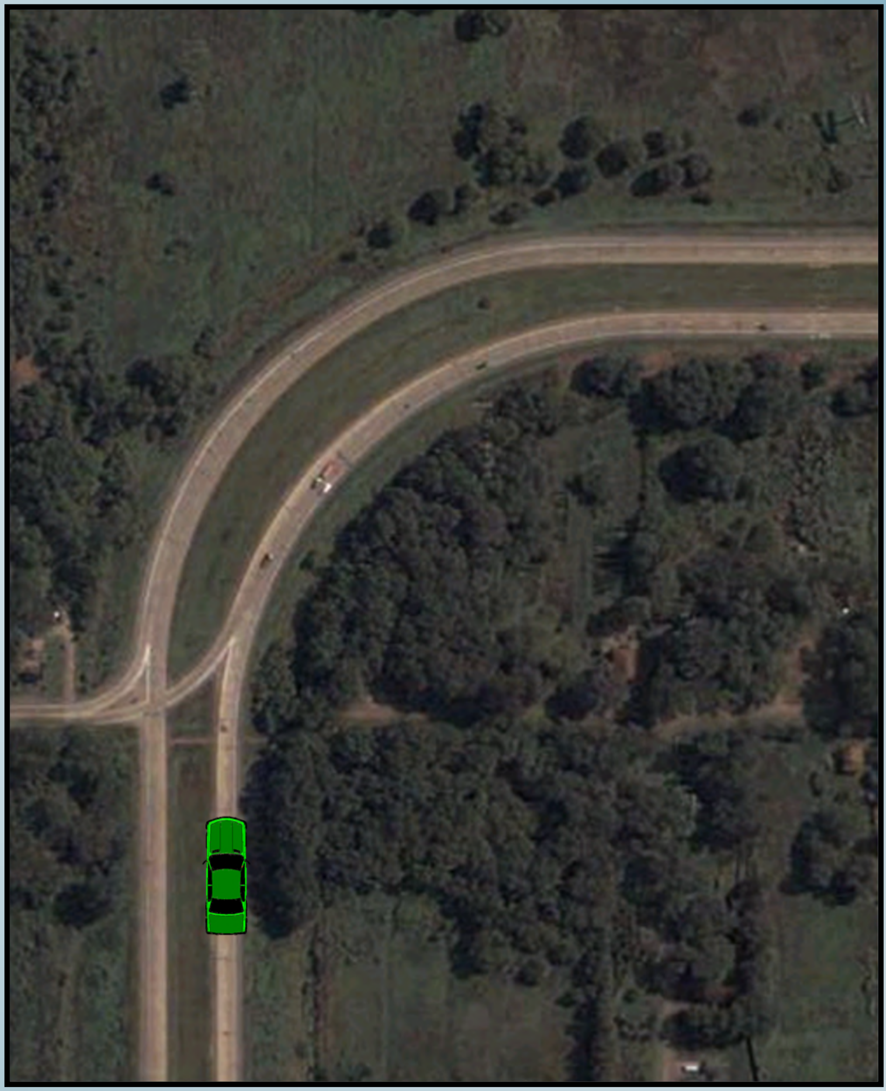

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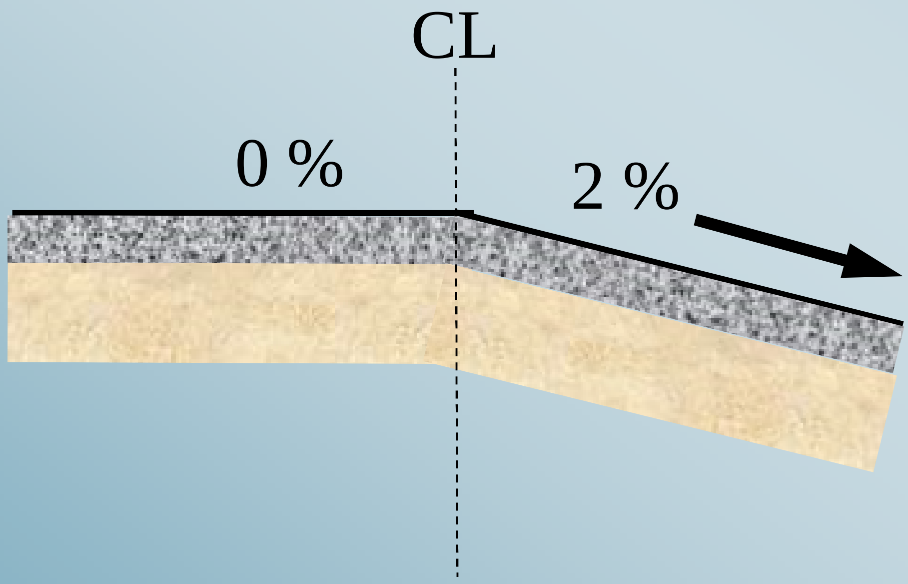

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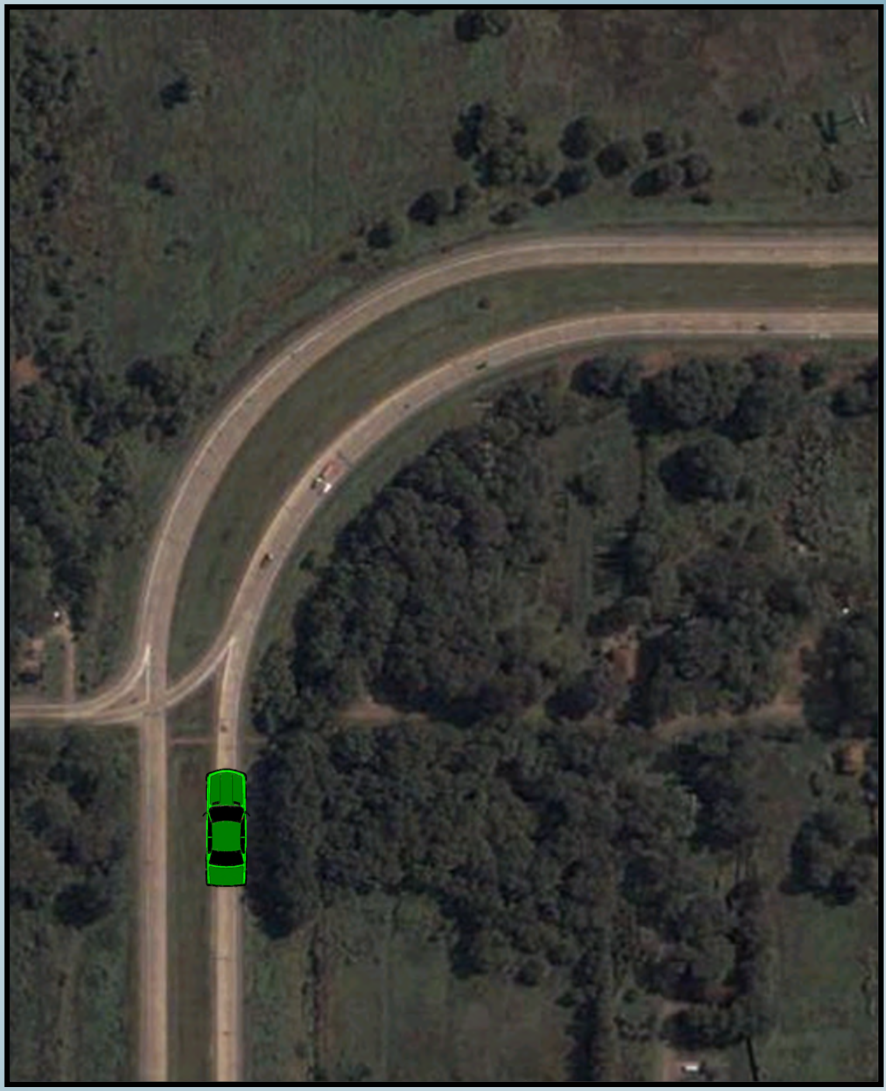

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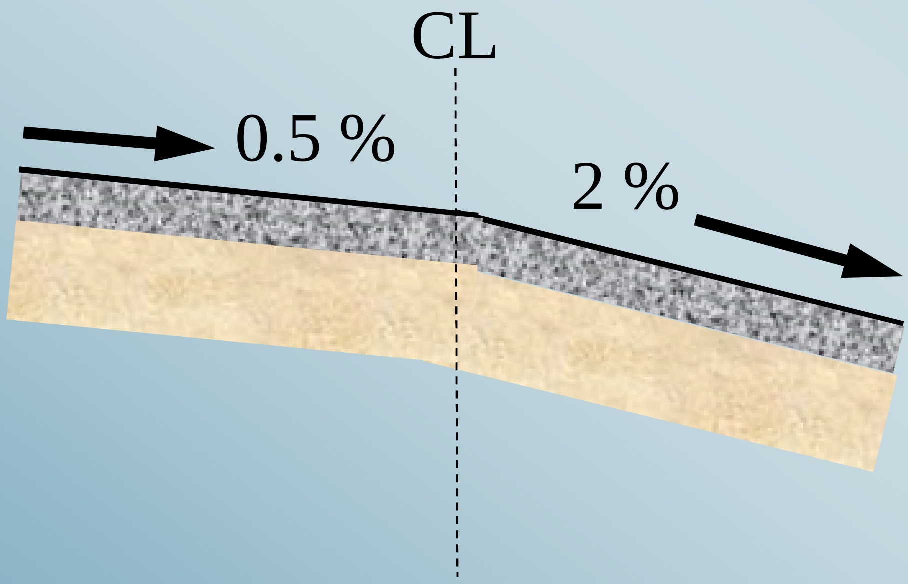

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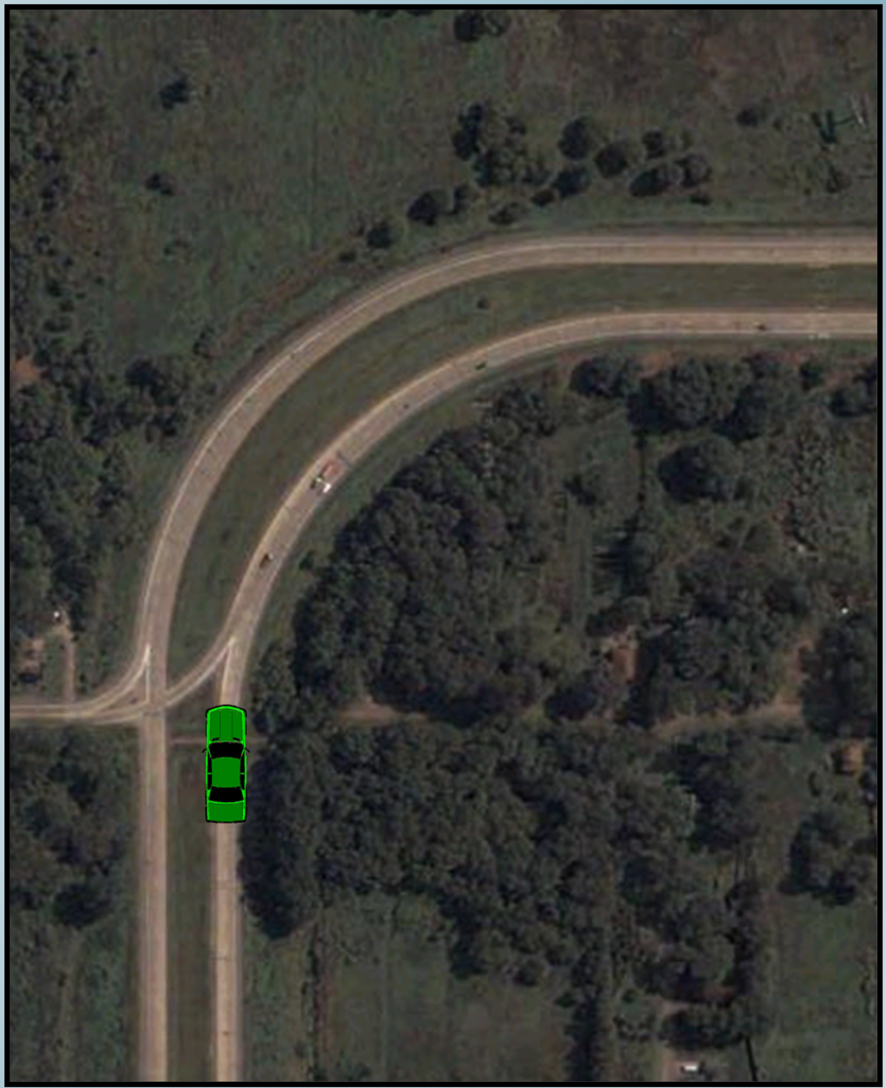

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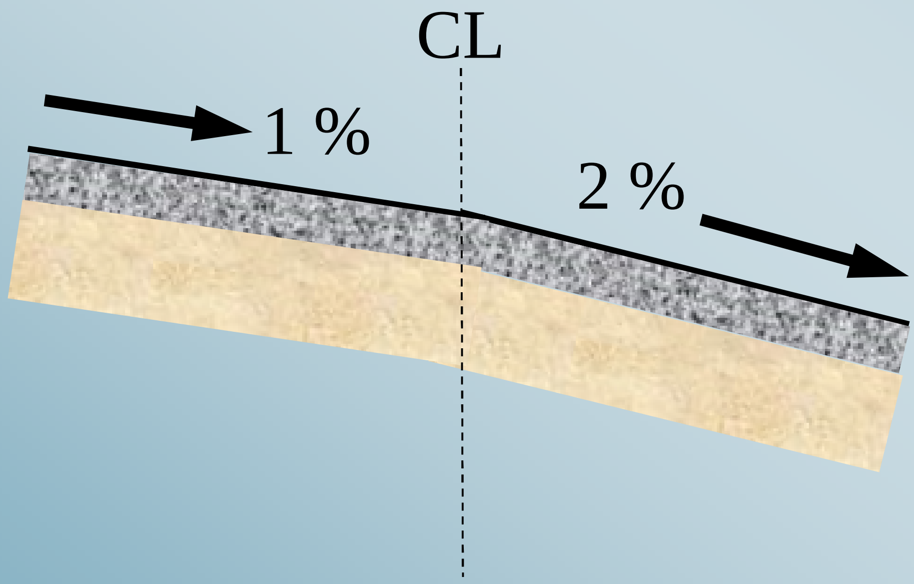

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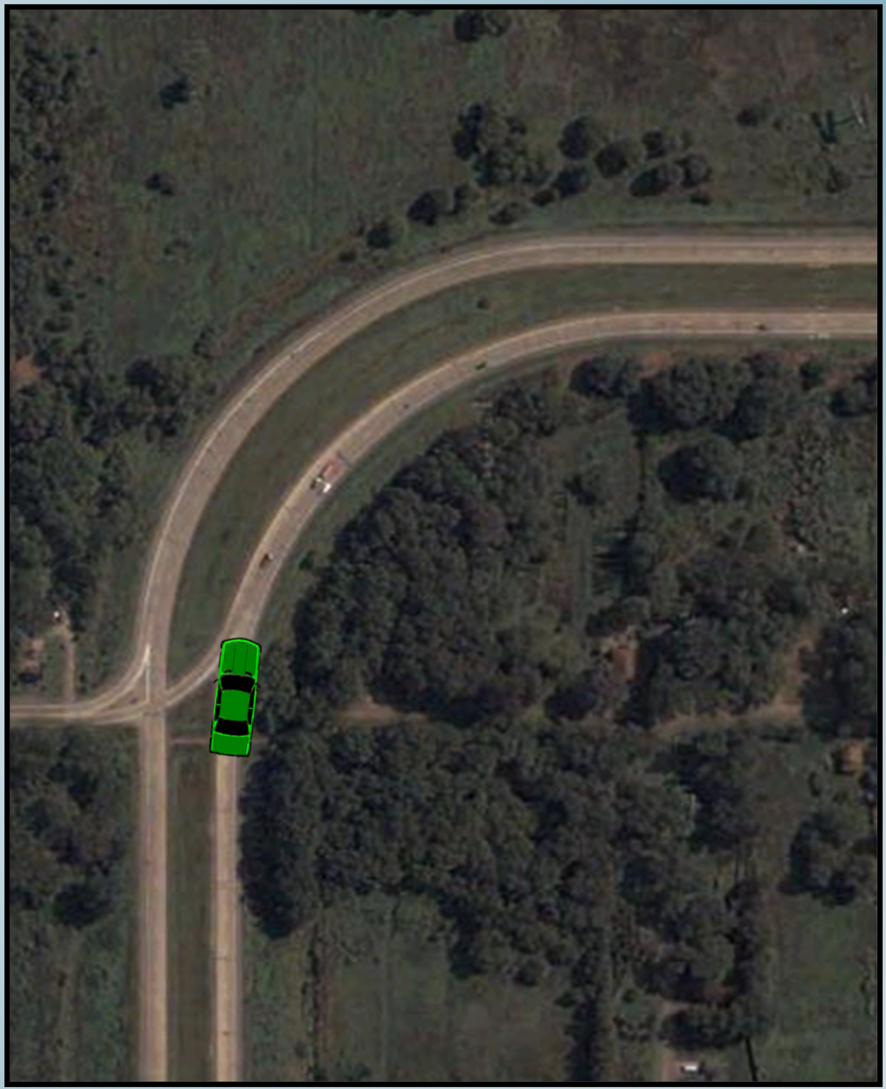

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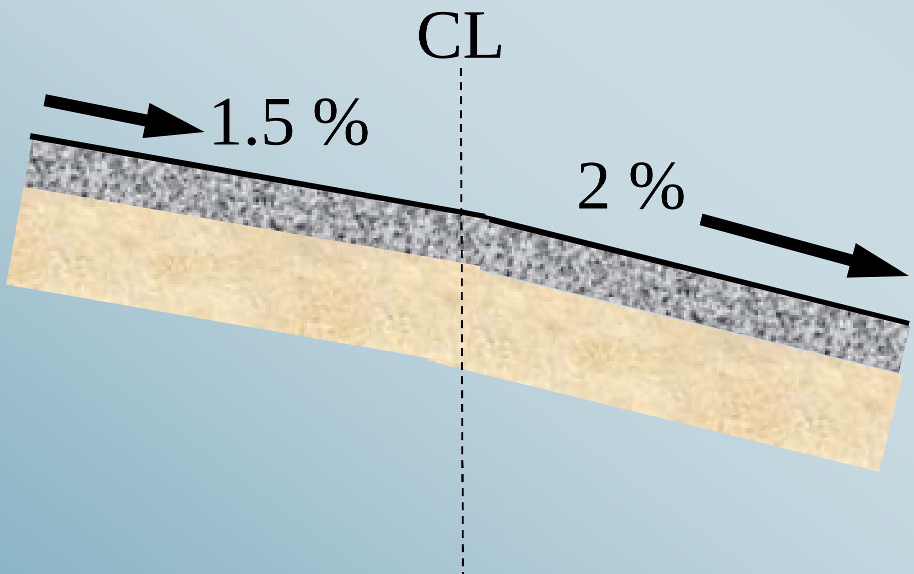

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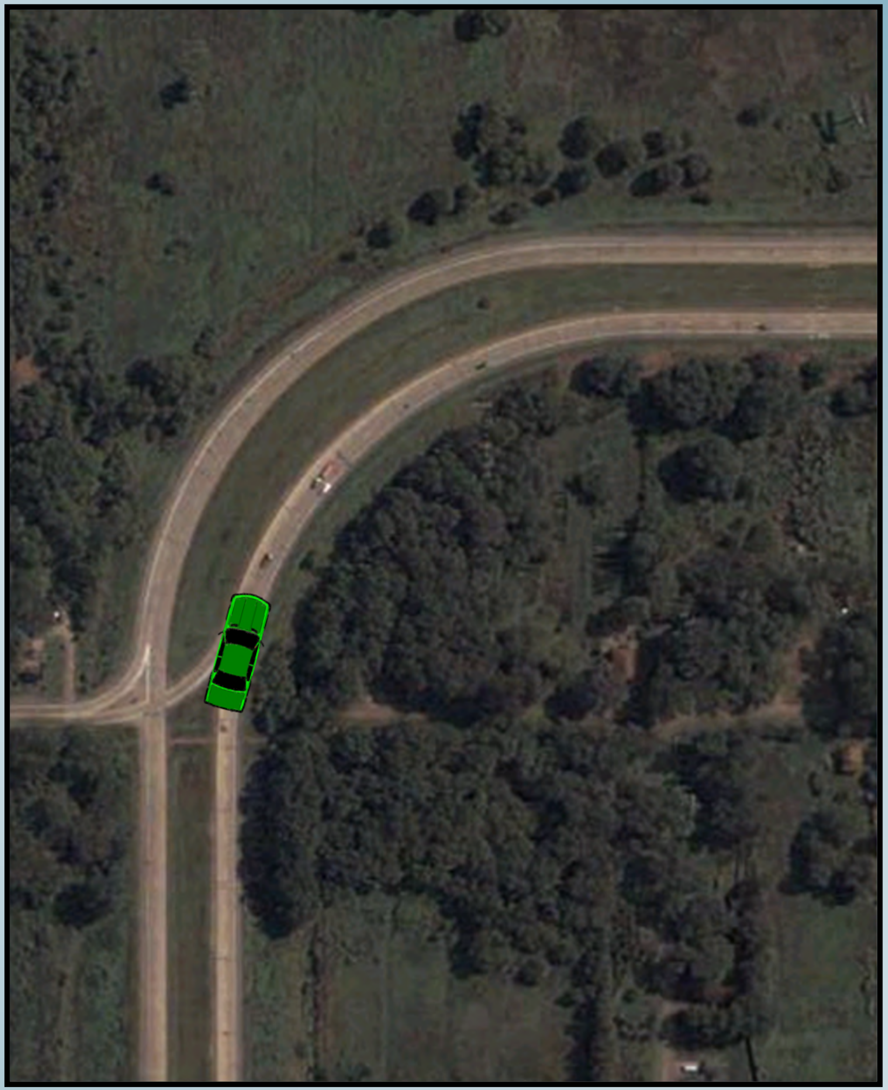

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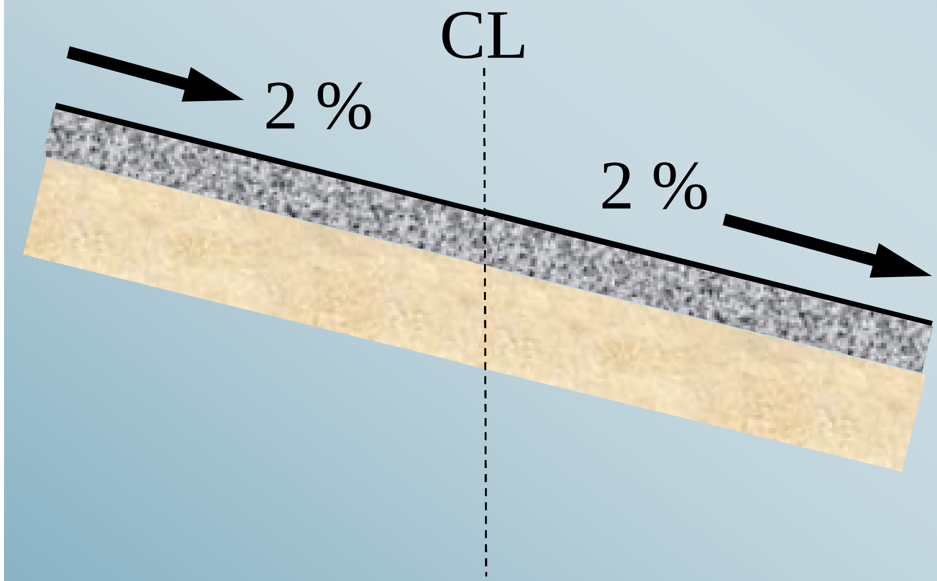

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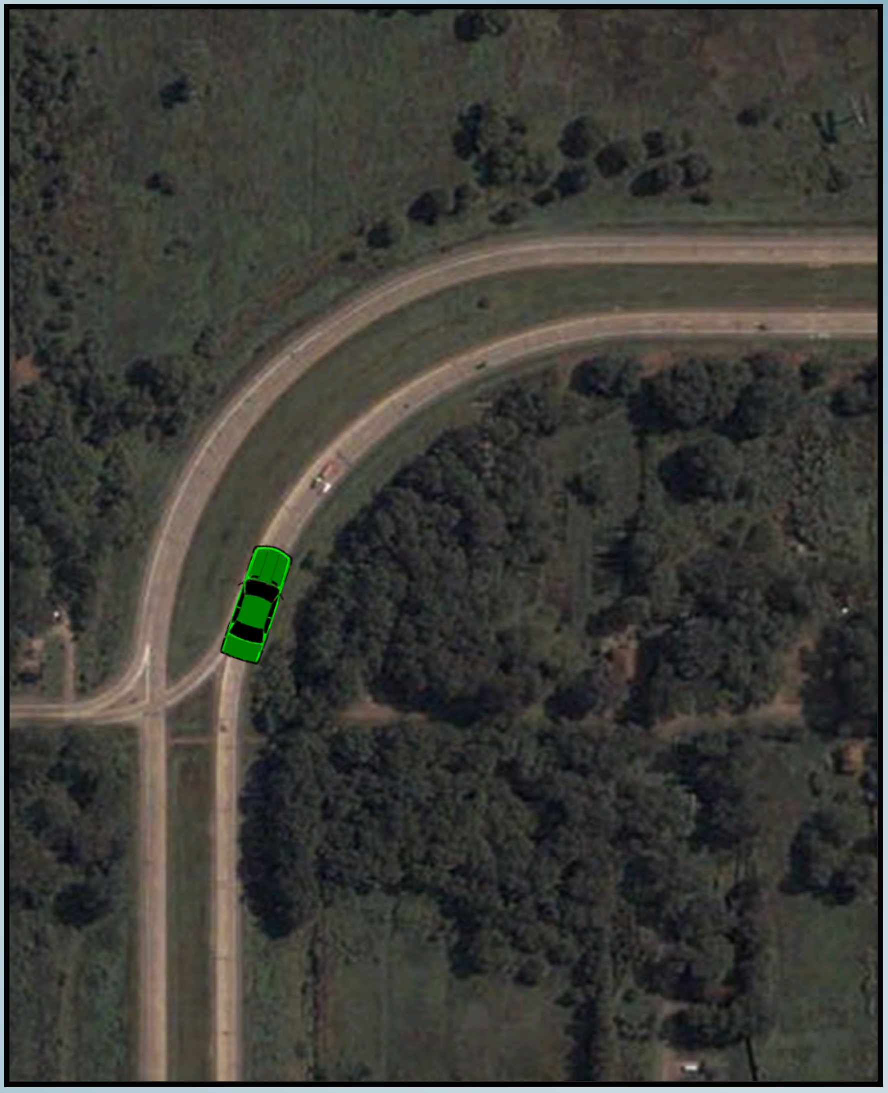

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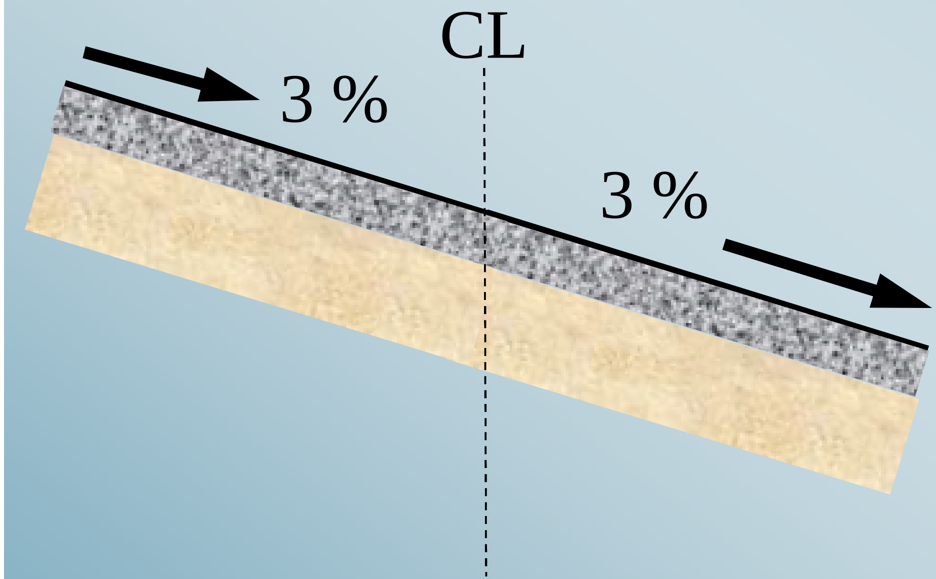

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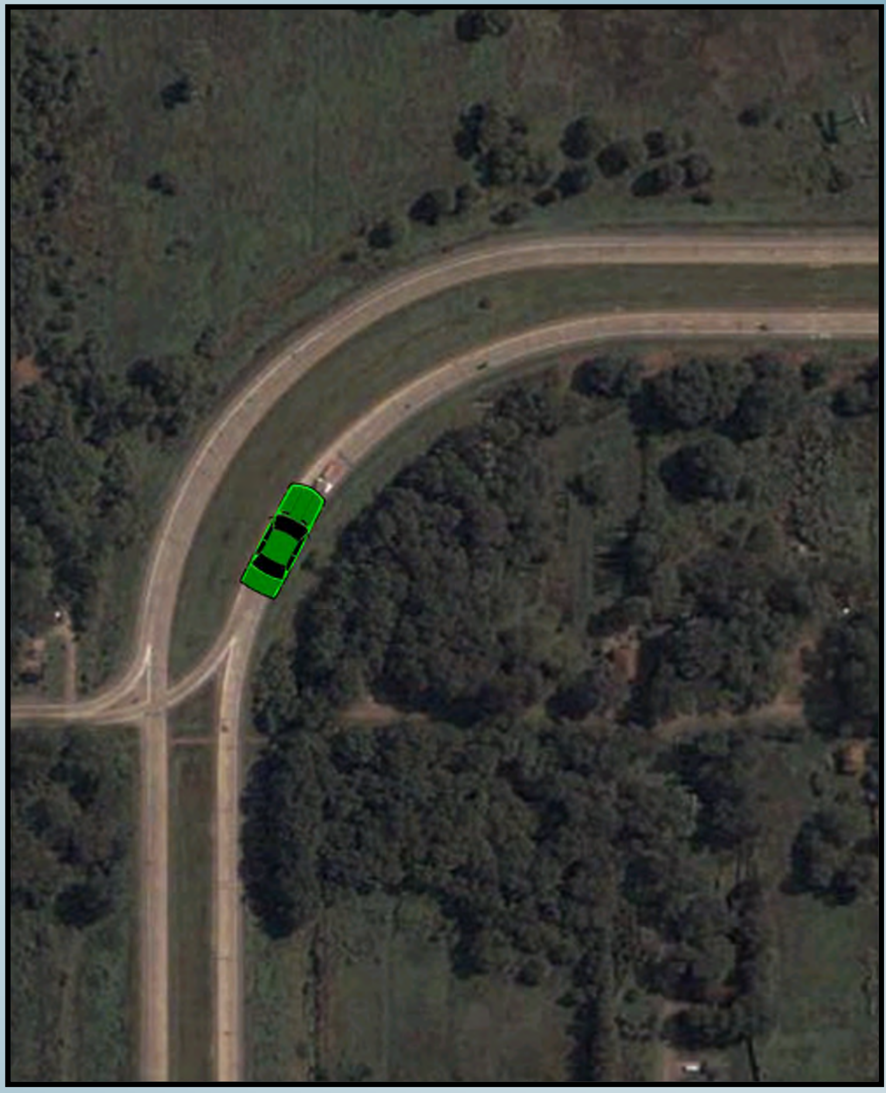

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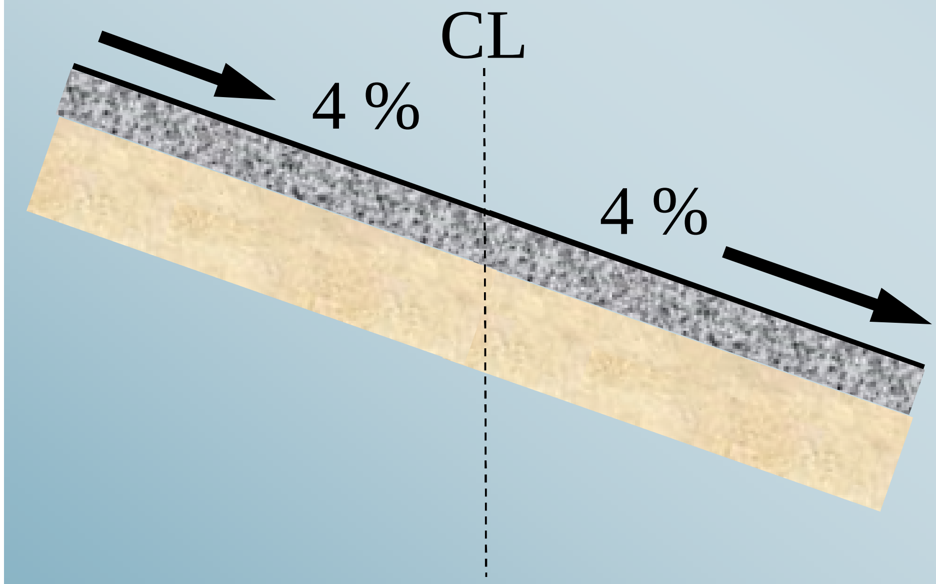

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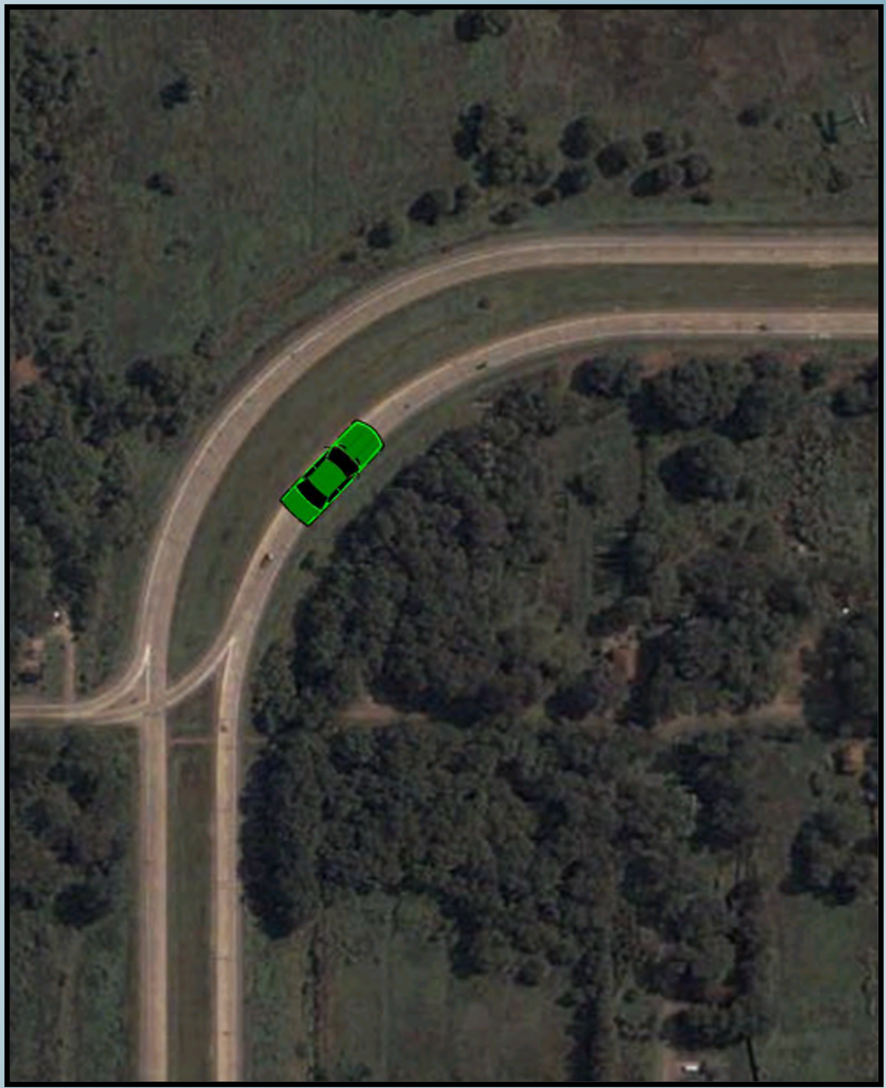

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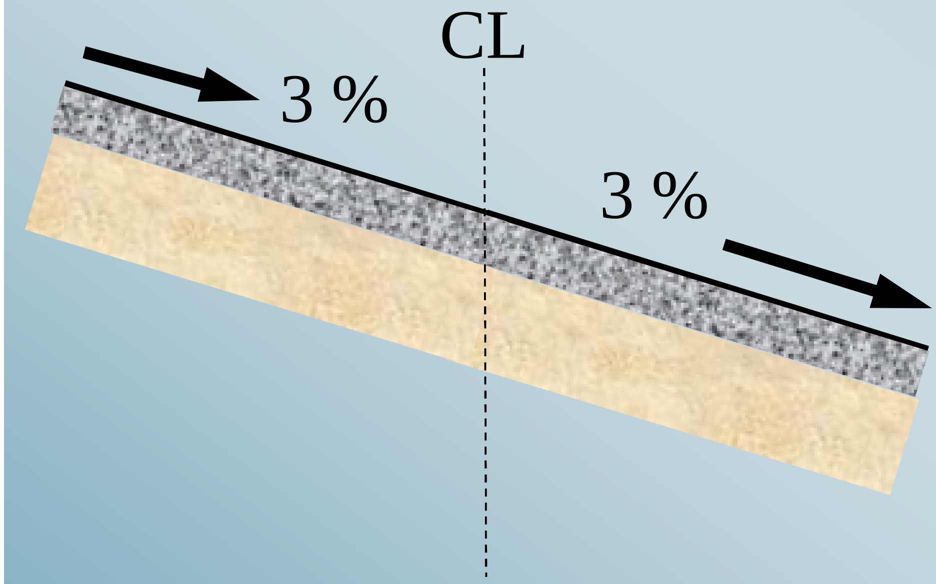

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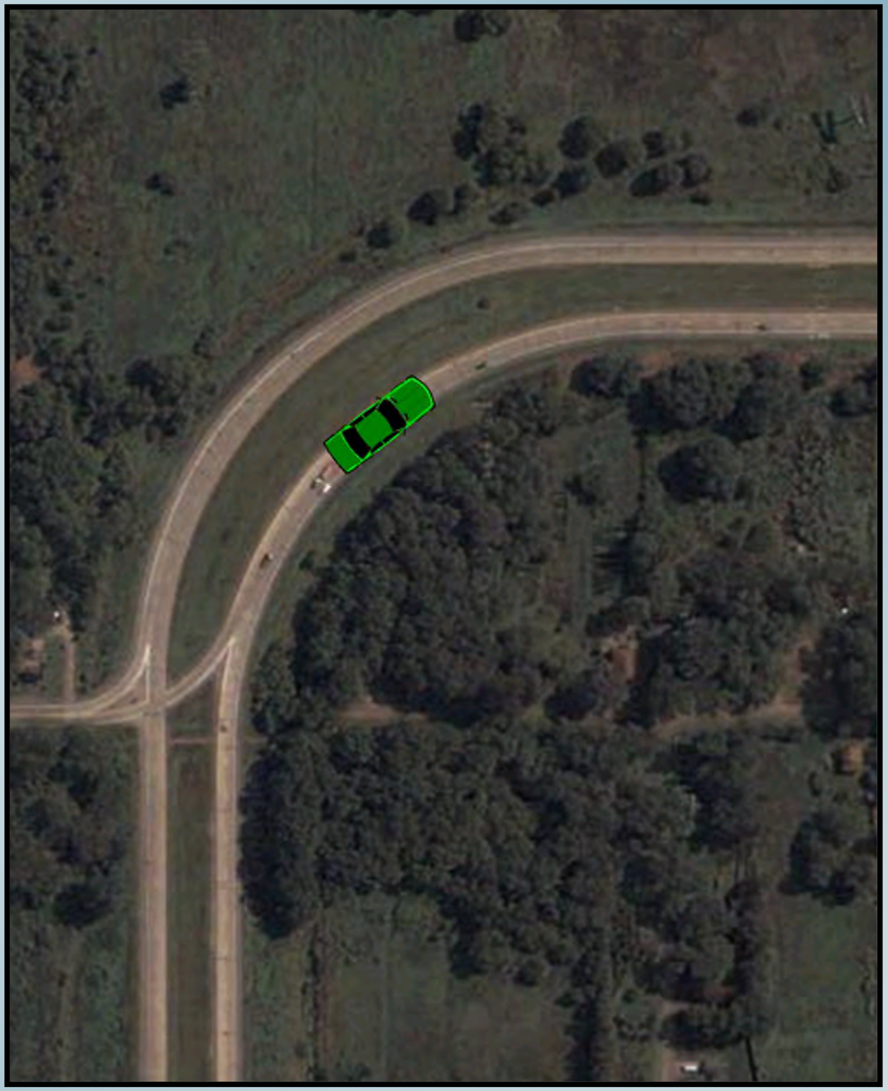

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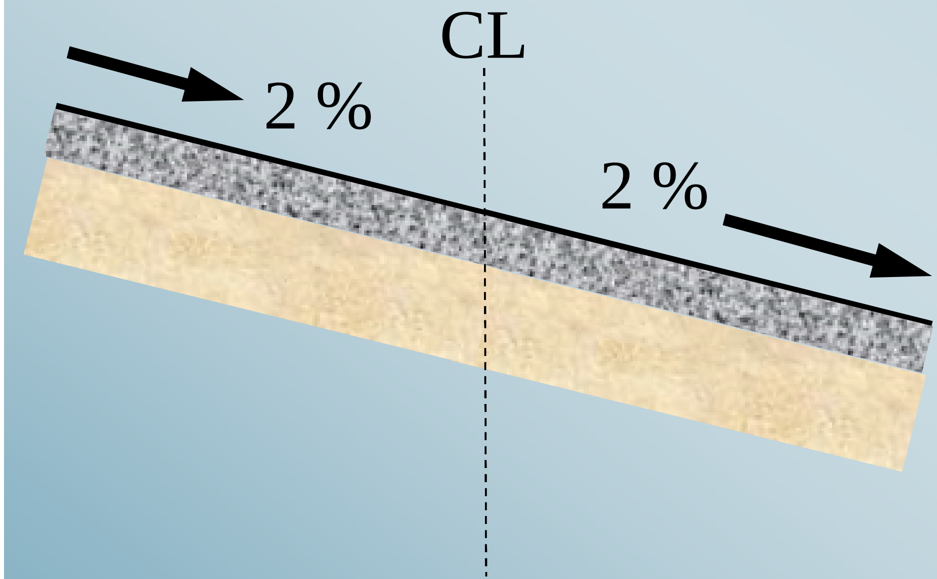

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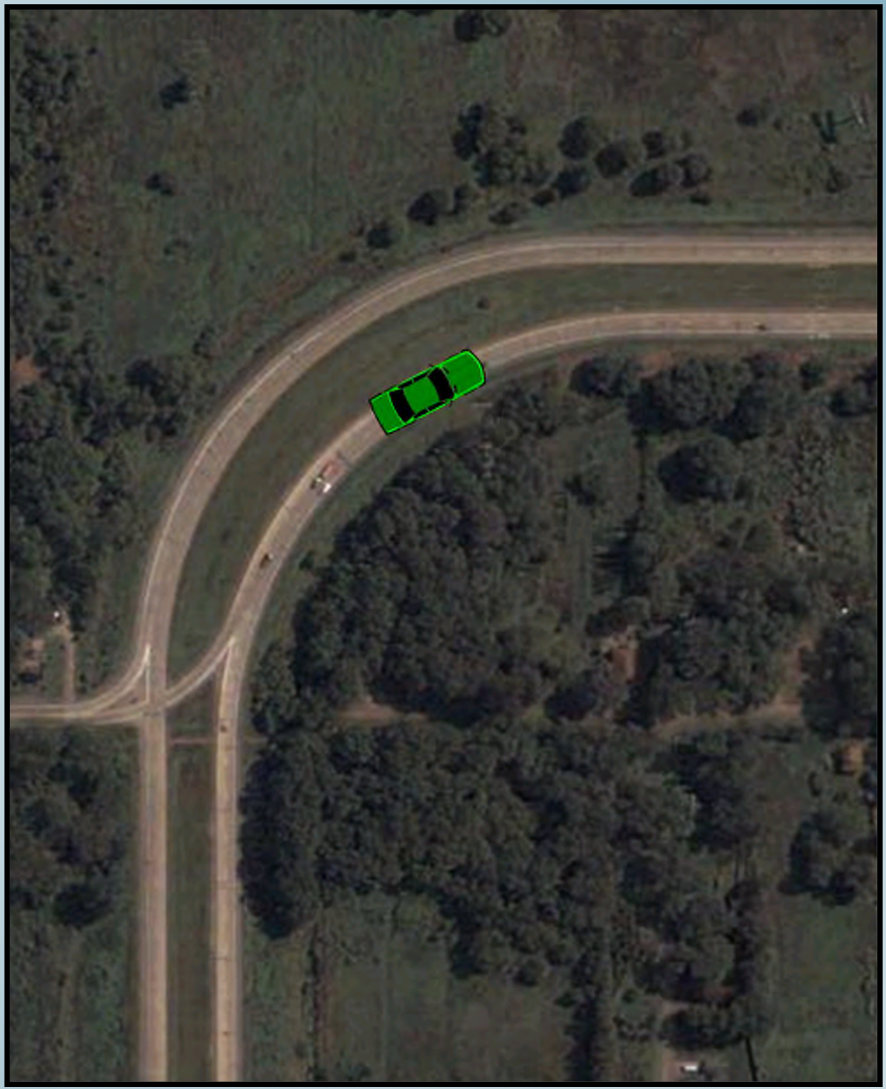

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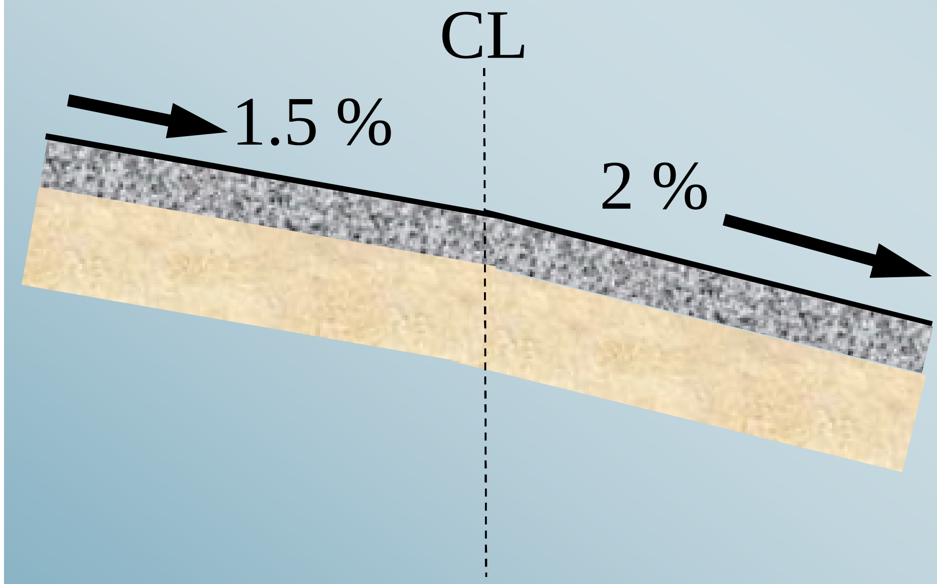
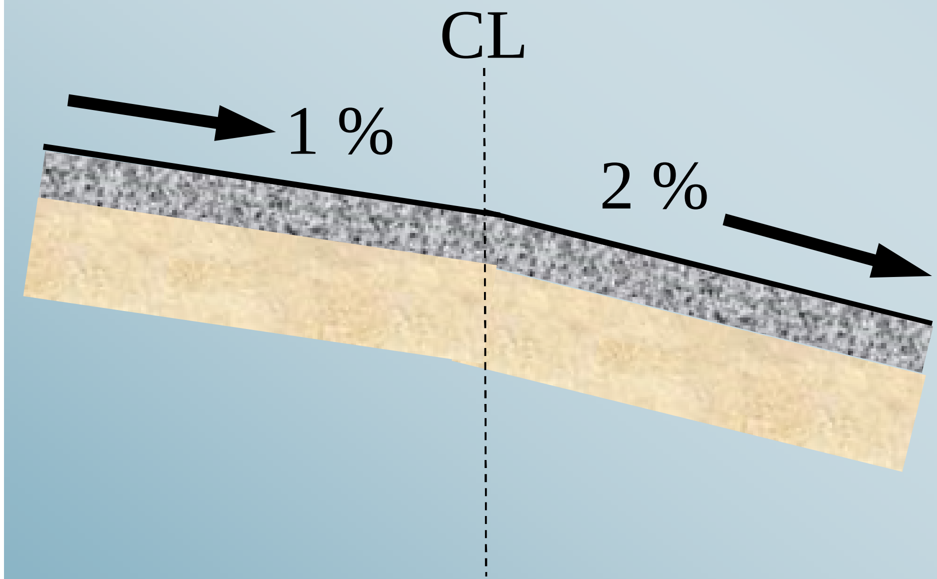


Road Cross Section

SUPERELEVATION



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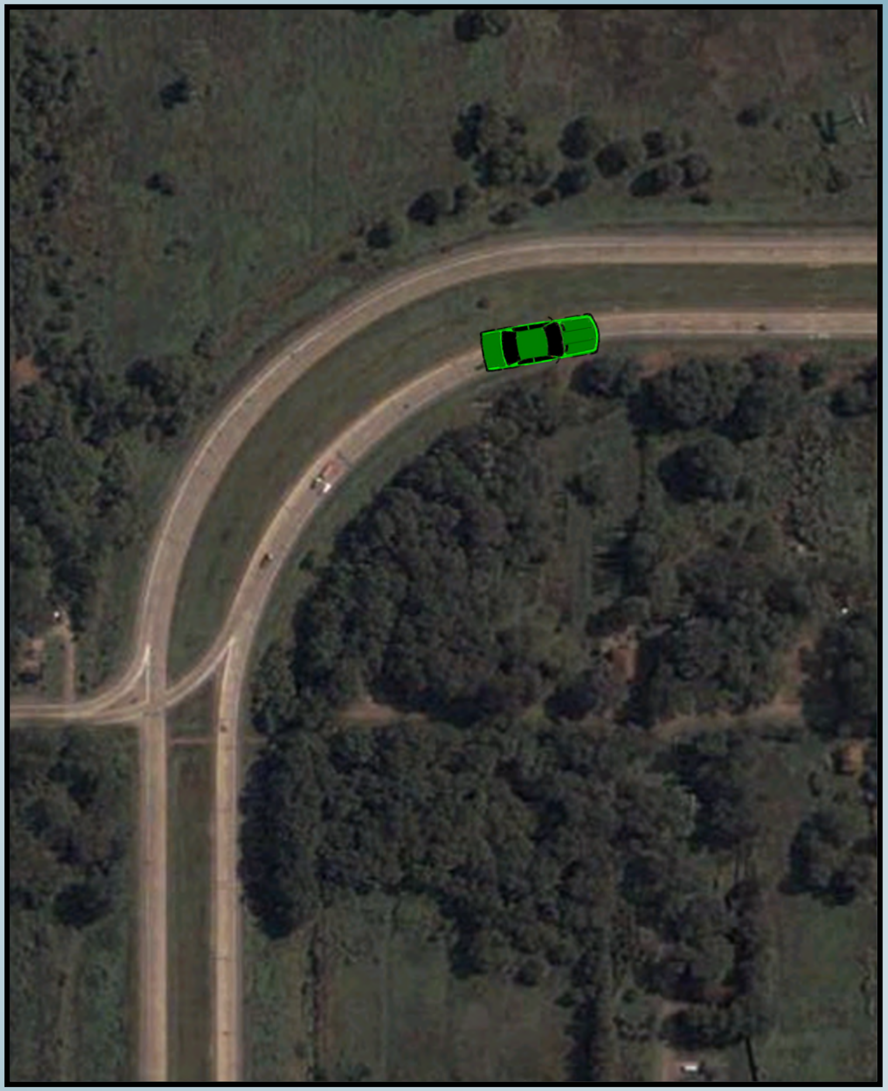

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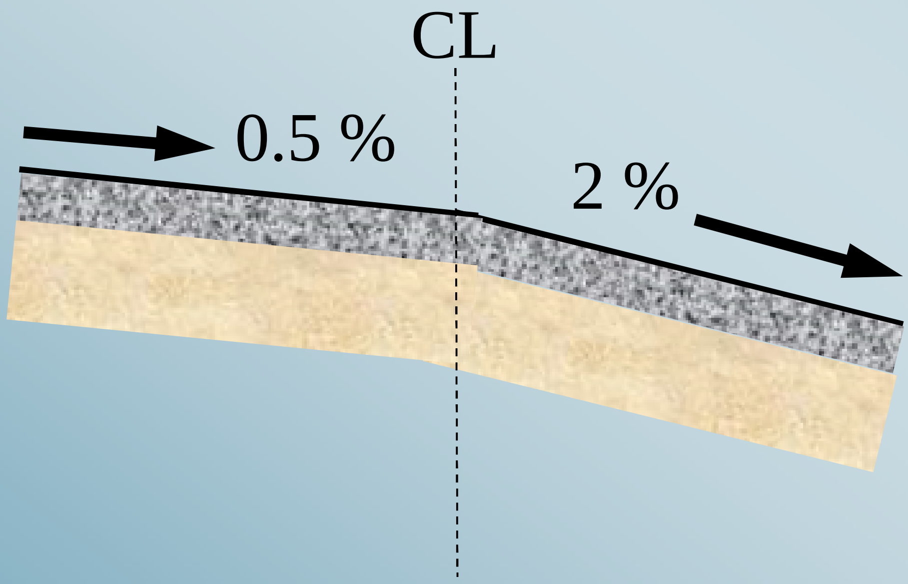

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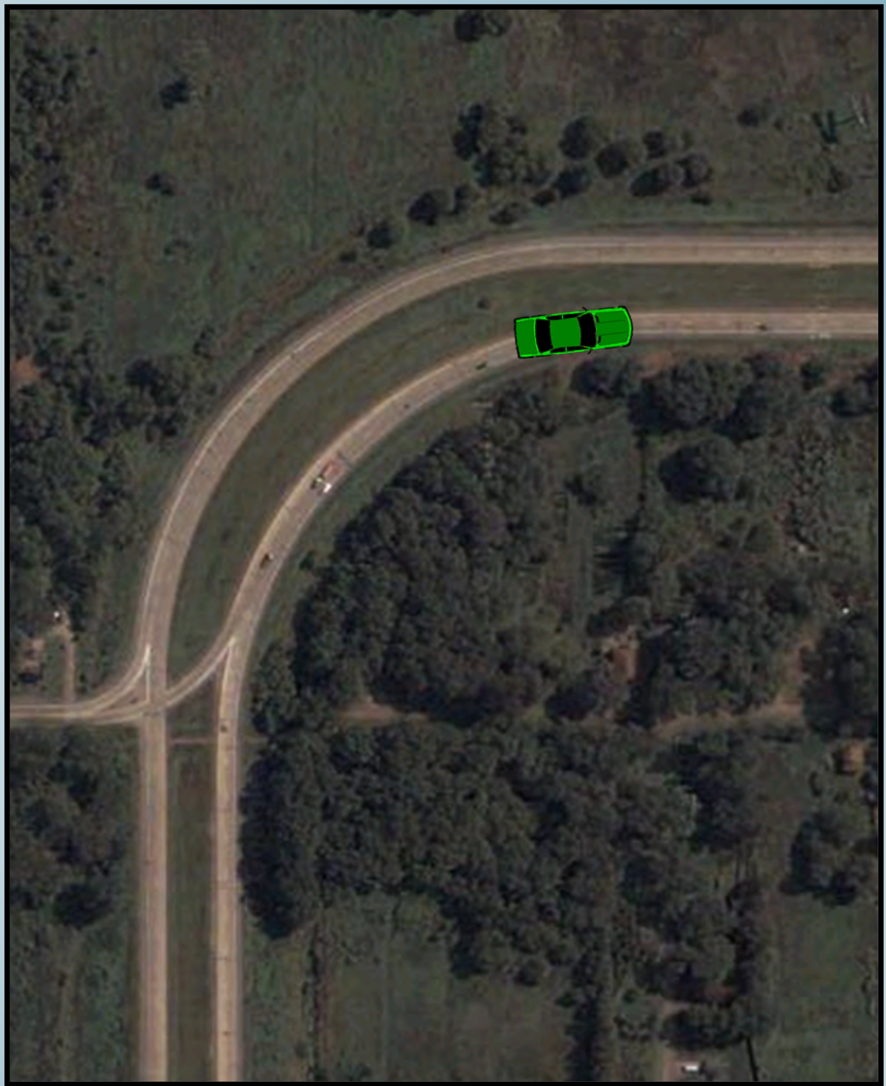

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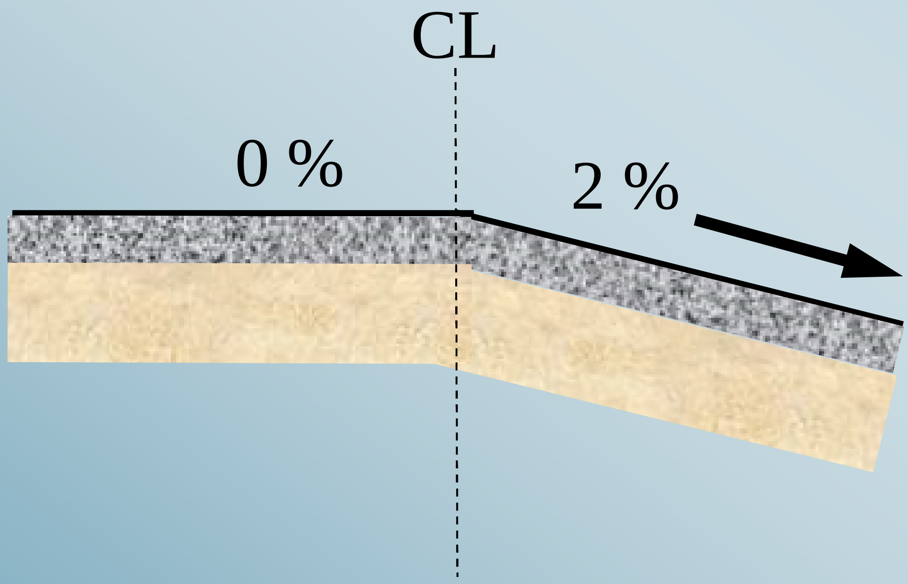
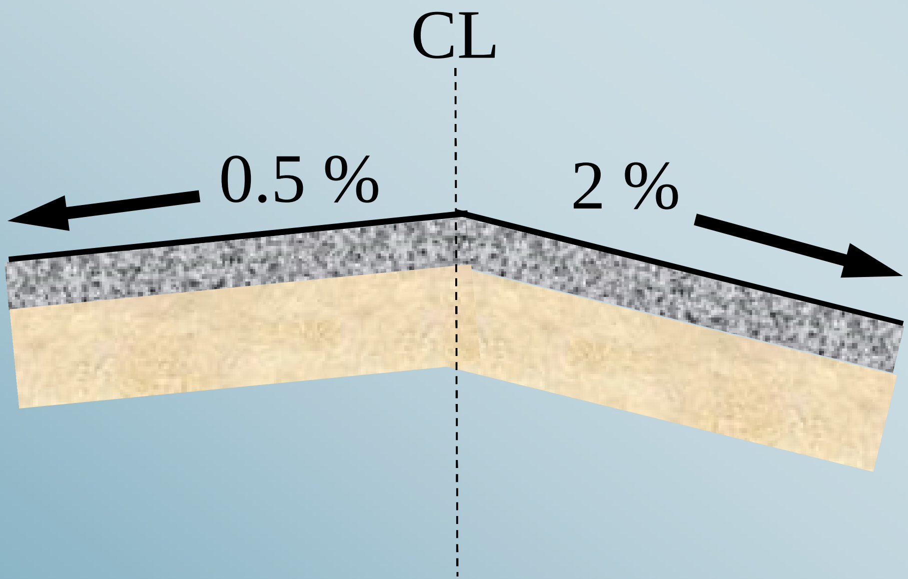


Road Cross Section

SUPERELEVATION



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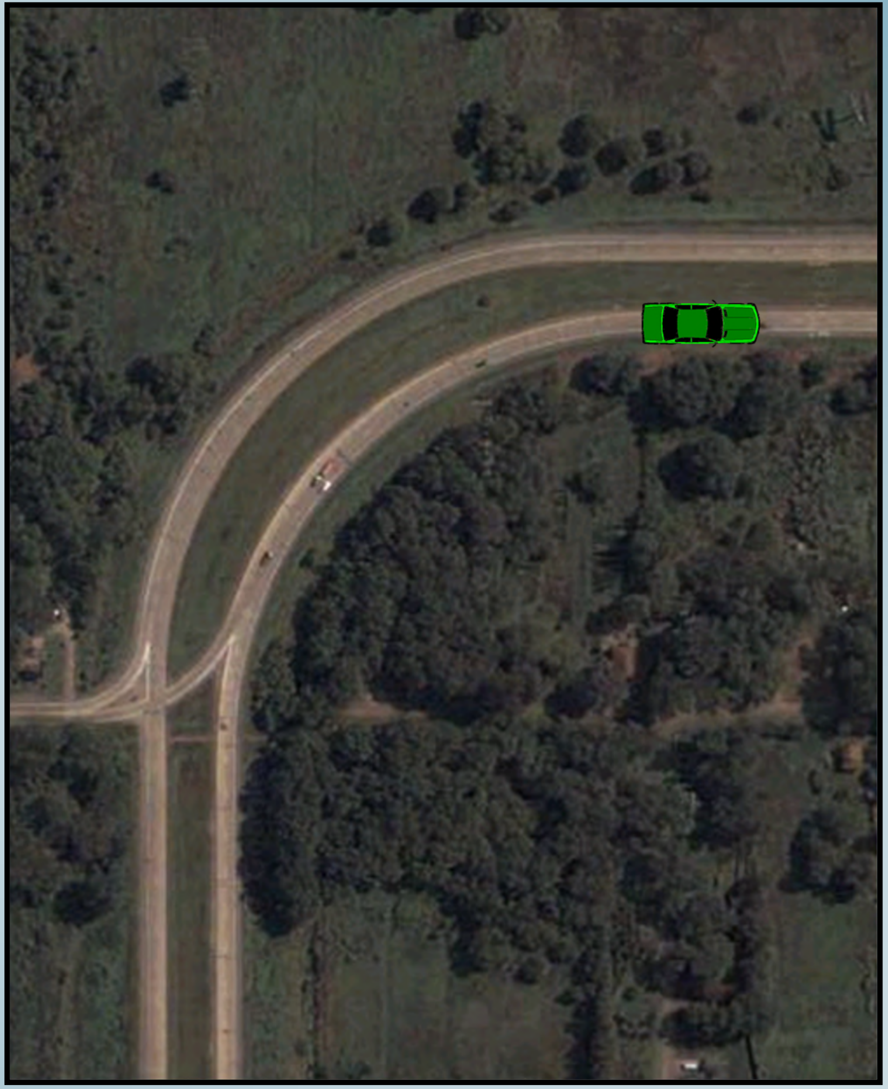

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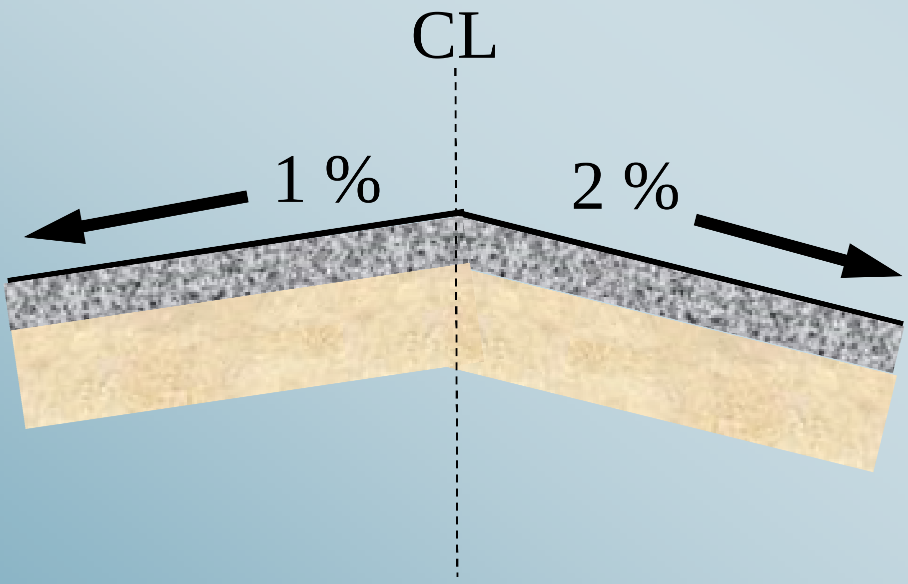
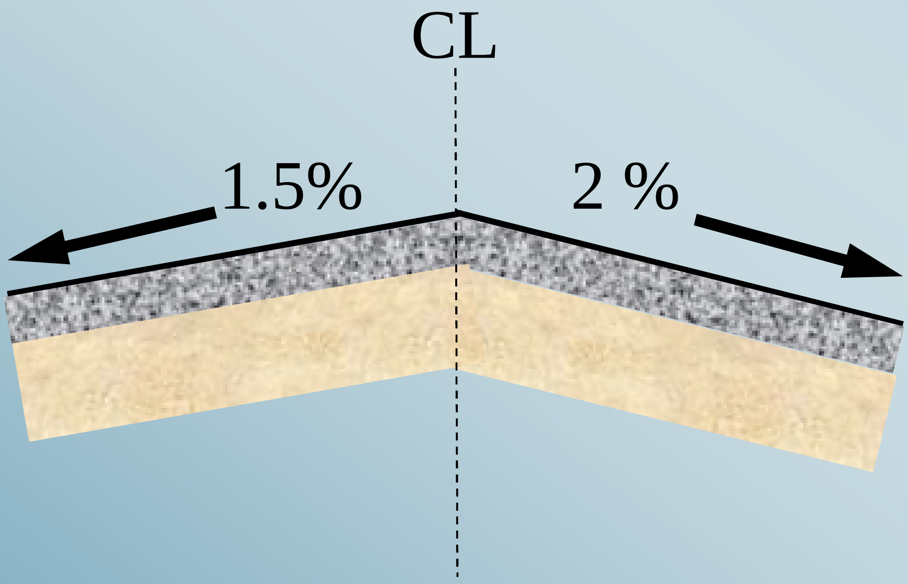


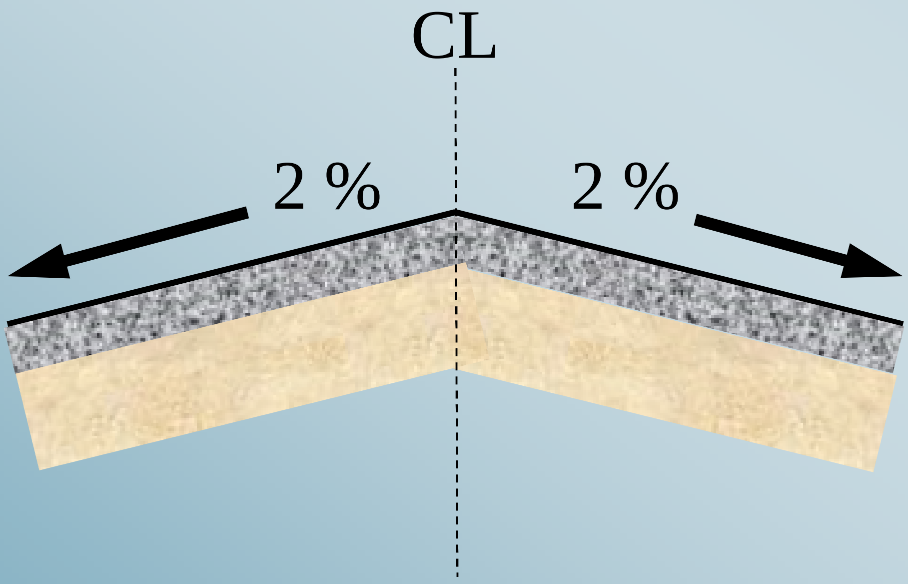
Road Cross Section

SUPERELEVATION

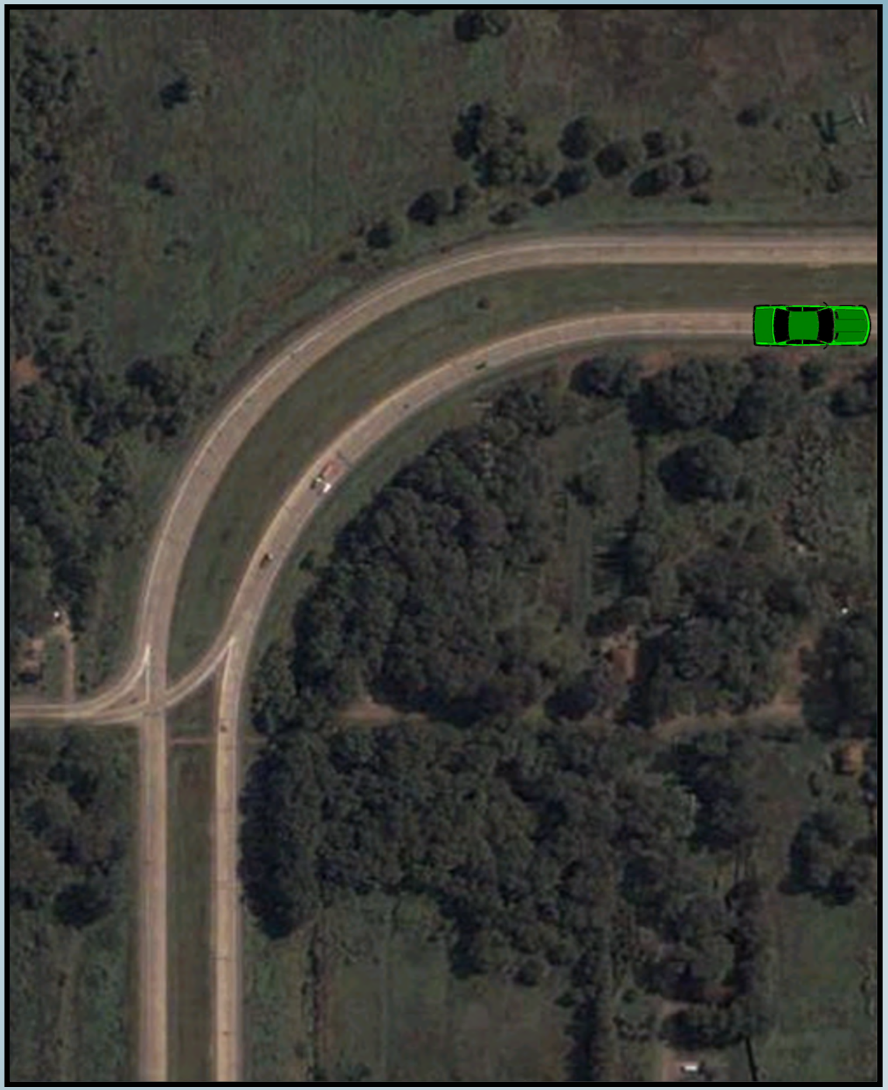


Road Cross Section

SUPERELEVATION

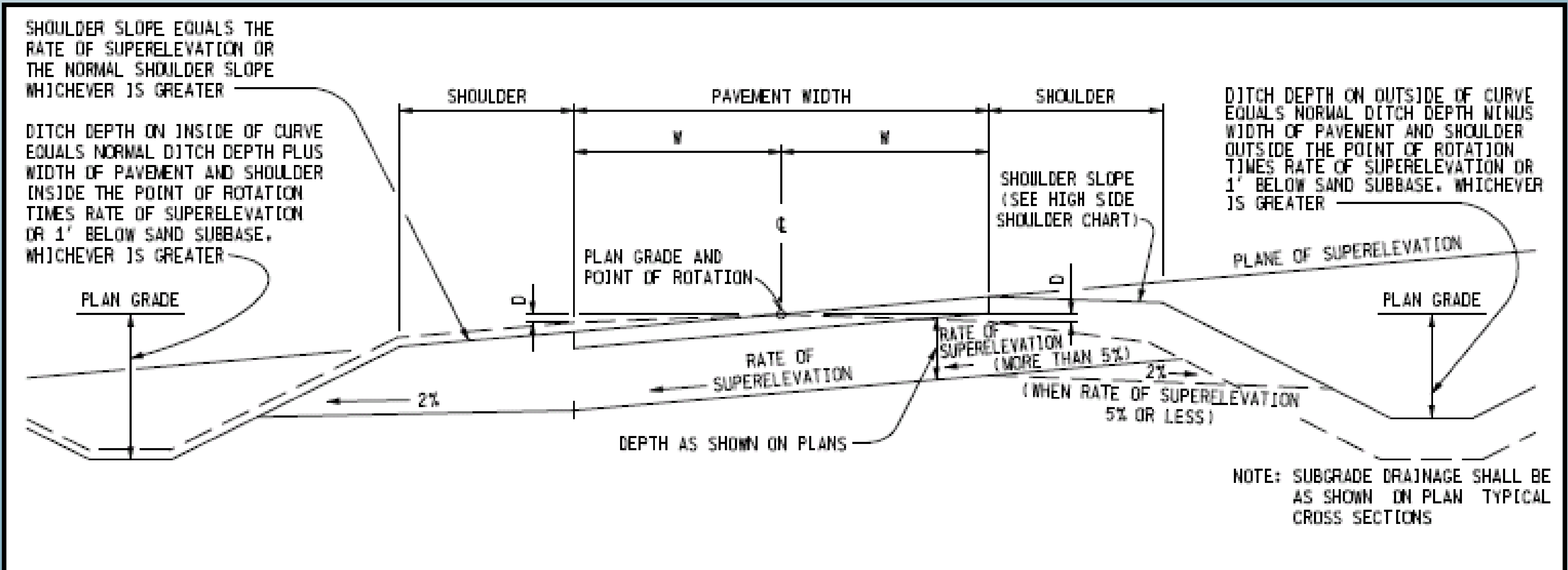


Road Cross Section



SUPERELEVATION

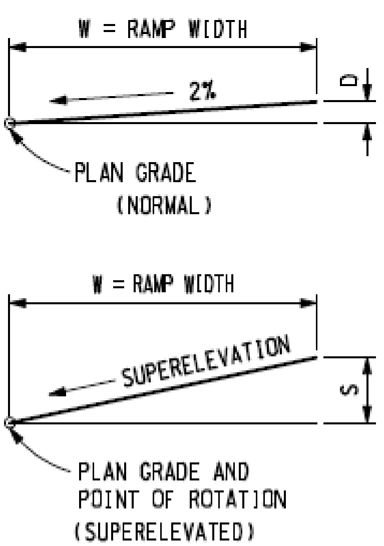
MDOT Standard Plan R-107



SUPERELEVATED FINISHED SECTION
(TWO-WAY SHOWN)

SUPERELEVATION

MDOT Standard Plan R-107



RAMPS

LEGEND

NC = NORMAL CROWN RATE

W = DISTANCE IN FEET FROM POINT OF ROTATION TO FARTHEST OUTSIDE EDGE

D = W x NC

e = RATE OF SUPERELEVATION

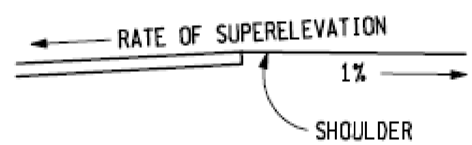
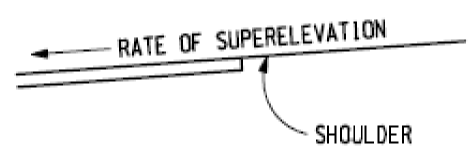
S = W x e

C = CROWN RUNOUT / TANGENT RUNOUT (ADVERSE CROWN REMOVED)

L = TRANSITION LENGTH OR SUPERELEVATION RUNOFF OF INSIDE OR OUTSIDE EDGE OF PAVEMENT

Δ% = SUPERELEVATION TRANSITION SLOPE OF PAVEMENT EDGES

HIGH SIDE SHOULDER CHART

WHEN RATE OF FULL SUPERELEVATION IS	SHOULDER SLOPE AT FULL SUPERELEVATION EQUALS
FROM 2% TO 3%	RATE OF SUPERELEVATION MINUS NORMAL SHOULDER SLOPE
3% TO AND INCLUDING 5%	
OVER 5%	

SUPERELEVATION

MDOT Standard Plan R-107

RATE OF SUPERELEVATION AND SUPERELEVATION TRANSITION SLOPE

RADIUS (FEET)	30 MPH		35 MPH		40 MPH		45 MPH		50 MPH		55 MPH		60 MPH		65 MPH		FREEWAYS 70 MPH		FREEWAYS 75 MPH		URBAN FREEWAYS AND URBAN RAMPS 60 MPH	
	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%	e %	Δ%
23000	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---
20000	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---
17000	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---
14000	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	2.0	0.31	2.0	0.30	NC	---
12000	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	2.0	0.32	2.0	0.31	2.0	0.30	NC	---
10000	NC	---	NC	---	NC	---	NC	---	NC	---	NC	---	2.0	0.36	2.0	0.32	2.1	0.31	2.3	0.31	2.0	0.34
8000	NC	---	NC	---	NC	---	NC	---	2.0	0.40	2.0	0.38	2.1	0.36	2.3	0.33	2.6	0.32	2.9	0.31	2.0	0.34
6000	NC	---	NC	---	NC	---	2.0	0.40	2.0	0.40	2.3	0.39	2.7	0.37	3.0	0.34	3.3	0.33	3.7	0.33	2.4	0.36
5000	NC	---	NC	---	2.0	0.40	2.0	0.40	2.3	0.41	2.7	0.39	3.1	0.38	3.5	0.35	3.9	0.34	4.4	0.34	2.8	0.37
4000	NC	---	2.0	0.45	2.0	0.40	2.4	0.41	2.8	0.42	3.3	0.40	3.8	0.39	4.2	0.37	4.7	0.36	5.3	0.35	3.3	0.39
3500	NC	---	2.0	0.45	2.2	0.41	2.6	0.42	3.1	0.42	3.6	0.41	4.2	0.40	4.7	0.38	5.2	0.37	5.9	0.36	3.5	0.40
3000	2.0	0.50	2.0	0.45	2.5	0.42	3.0	0.43	3.5	0.43	4.1	0.42	4.7	0.41	5.2	0.39	5.9	0.38	6.5	0.37	3.8	0.41
2500	2.0	0.50	2.4	0.46	2.9	0.43	3.5	0.44	4.1	0.44	4.7	0.43	5.3	0.42	5.9	0.41	6.5	0.39	7.0	0.38	4.2	0.42
2000	2.3	0.51	2.9	0.48	3.5	0.45	4.1	0.46	4.7	0.45	5.4	0.44	6.1	0.43	6.6	0.42	7.0	0.40	R MIN.= 2344'		4.6	0.44
1800	2.5	0.52	3.1	0.49	3.8	0.46	4.4	0.47	5.1	0.46	5.7	0.45	6.4	0.44	6.9	0.43	R MIN.= 1922'				4.8	0.44
1600	2.7	0.52	3.4	0.50	4.1	0.48	4.8	0.48	5.4	0.47	6.1	0.45	6.7	0.44	7.0	0.43					4.9	0.45
1400	3.0	0.53	3.7	0.51	4.5	0.49	5.1	0.49	5.8	0.48	6.5	0.46	6.9	0.45	R MIN.= 1565'						R MIN.= 1412'	
1200	3.4	0.54	4.1	0.52	4.9	0.50	5.6	0.50	6.3	0.49	6.8	0.47	R MIN.= 1263'									
1150	3.5	0.55	4.3	0.53	5.0	0.51	5.7	0.50	6.4	0.49	6.9	0.47										
1000	3.8	0.56	4.6	0.54	5.4	0.52	6.1	0.52	6.7	0.49	R MIN.= 1008'											
900	4.1	0.57	4.8	0.55	5.7	0.53	6.4	0.52	6.9	0.50												
820	4.3	0.57	5.1	0.55	5.9	0.54	6.6	0.53	7.0	0.50												
800	4.4	0.58	5.1	0.56	6.0	0.54	6.7	0.53	7.0	0.50												
720	4.6	0.58	5.4	0.57	6.3	0.55	6.9	0.54	R MIN.= 794'													
700	4.7	0.59	5.5	0.57	6.3	0.56	6.9	0.54														
600	5.0	0.60	5.9	0.58	6.7	0.57	R MIN.= 614'															
500	5.4	0.61	6.4	0.60	7.0	0.58																
450	5.7	0.62	6.6	0.61	R MIN.= 464'																	
400	6.0	0.63	6.8	0.61																		
350	6.3	0.64	7.0	0.62																		
300	6.7	0.65	R MIN.= 327'																			
265	6.9	0.66																				
225	7.0	0.66																				
	R MIN.= 222'																					

NOTES:

LOOP RAMPS SHALL HAVE A 7% RATE OF SUPERELEVATION.

THE RATE OF SUPERELEVATION FOR CURVES APPROACHING RAMP TERMINALS (STOPPING CONDITION) SHOULD BE LIMITED TO 5% MAX.

IF DELTA VALUES FROM THE CHART CANNOT BE OBTAINED FOR THE DESIGN RADIUS, USE THE MAXIMUM DELTA VALUE FOR THE CORRESPONDING SPEED.

FOR RADII LESS THAN THOSE TABULATED, (BUT NOT LESS THAN R MIN.), USE e_{max}. MAXIMUM SUPERELEVATION FOR URBAN FREEWAYS AND URBAN RAMPS (WITH A 60 MPH DESIGN SPEED) IS 5%. OTHERWISE e_{max} = 7% .

SUPERELEVATION

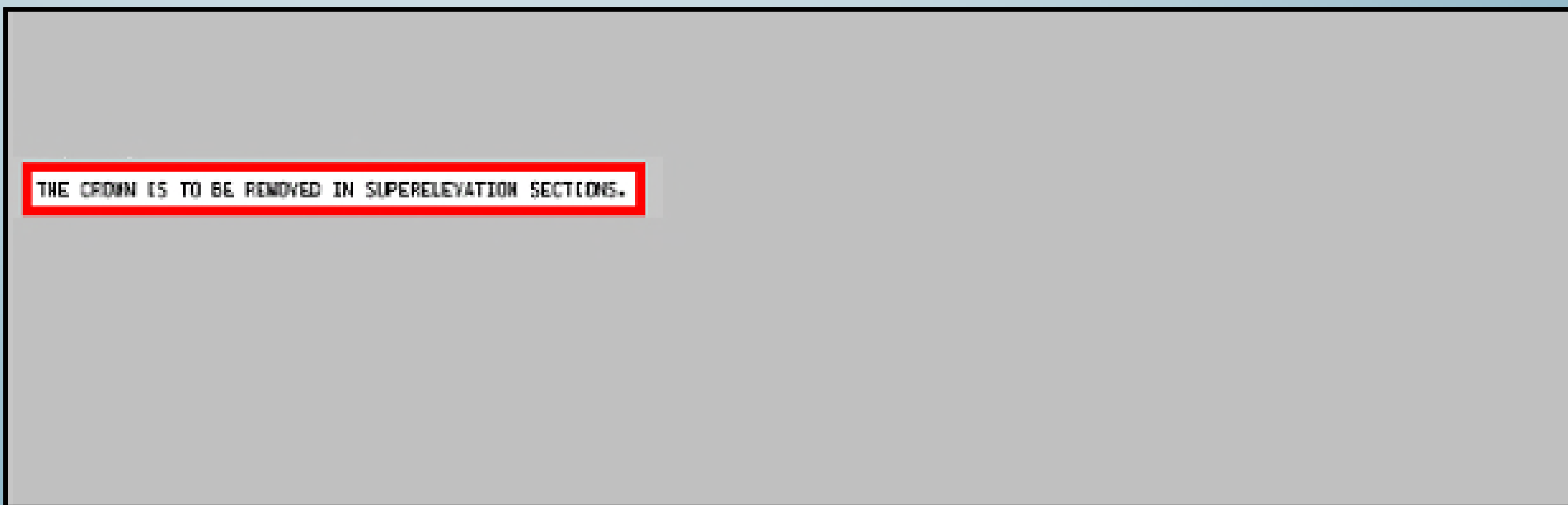
MDOT Standard Plan R-107

THE CROWN POINT AND POINT OF ROTATION WILL NORMALLY BE AT THE CENTER OF TWO-LANE AND FOUR-LANE UNDIVIDED PAVEMENTS AND AT THE EDGE OF AN INSIDE LANE OF FIVE-LANE UNDIVIDED PAVEMENTS. THE POINT OF ROTATION WILL NORMALLY BE AT THE INSIDE EDGES OF DIVIDED PAVEMENTS.

THE CROWN POINT AND POINT OF ROTATION WILL NORMALLY BE AT THE CENTER OF TWO-LANE AND FOUR-LANE UNDIVIDED PAVEMENTS AND AT THE EDGE OF AN INSIDE LANE OF FIVE-LANE UNDIVIDED PAVEMENTS. THE POINT OF ROTATION WILL NORMALLY BE A THE INSIDE EDGES OF DIVIDED PAVEMENTS.

SUPERELEVATION

MDOT Standard Plan R-107



THE CROWN IS TO BE REMOVED IN SUPERELEVATED SECTIONS.

SUPERELEVATION

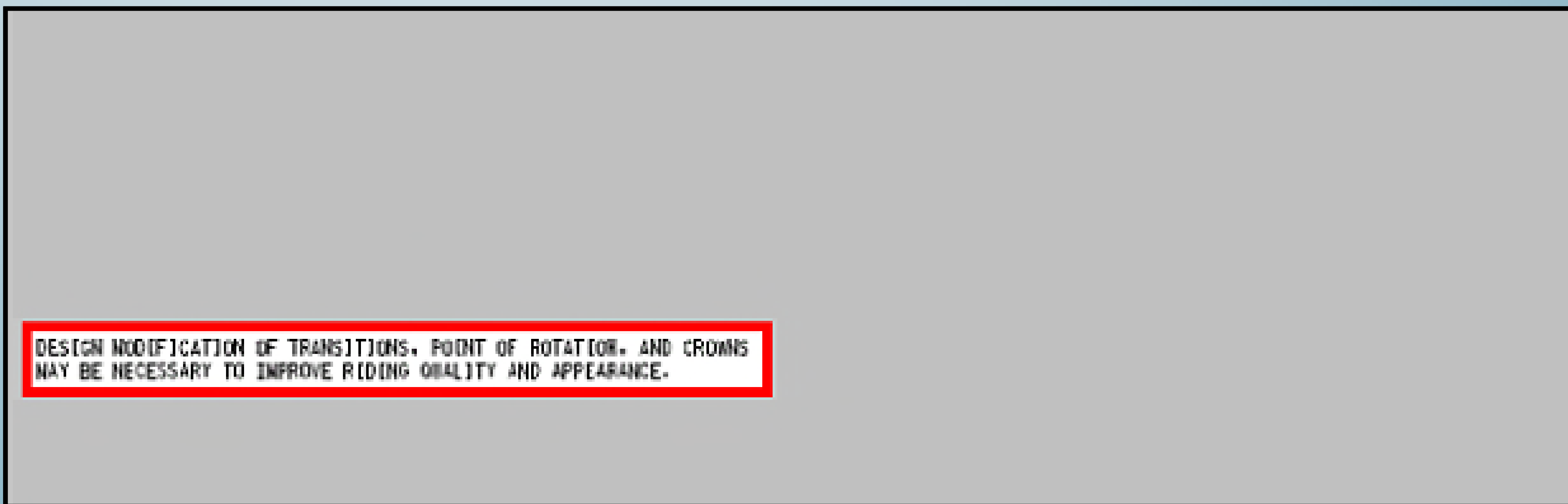
MDOT Standard Plan R-107

ON URBAN SERVICE ROADS AND URBAN FREE ACCESS TRUNKLINE CURVES WHERE DRIVEWAYS ARE PREVALENT, AND WHERE NORMAL SUPERELEVATION CANNOT BE OBTAINED, A MINIMUM OF 1% TO 2% SUPERELEVATION IN THE DIRECTION OF THE CURVE MAY BE USED TO REMOVE THE ADVERSE CROWN.

ON URBAN SERVICE ROADS AND URBAN FREE ACCESS TRUNKLINE CURVES WHERE DRIVEWAYS ARE PREVALENT, AND WHERE NORMAL SUPERELEVATION CANNOT BE OBTAINED, A MINIMUM OF 1.5% TO 2% SUPERELEVATION IN THE DIRECTION OF THE CURVE MAY BE USED TO REMOVE THE ADVERSE CROWN.

SUPERELEVATION

MDOT Standard Plan R-107



DESIGN MODIFICATION OF TRANSITIONS, POINT OF ROTATION, AND CROWNS MAY BE NECESSARY TO IMPROVE RIDING QUALITY AND APPEARANCE.

SUPERELEVATION

MDOT Standard Plan R-107

THE LOCATION, LENGTH OF SUPERELEVATION TRANSITIONS, CROWN RUNOFF LENGTHS, SUPERELEVATION RATES, AND POINT OF ROTATION WILL BE AS SPECIFIED ON THE PLANS.

THE LOCATION, LENGTH OF SUPERELEVATION TRANSITIONS, CROWN RUNOFF LENTGHS, SUPERELEVATION RATES, AND POINT OF ROTATION WILL BE AS SPECIFIED ON THE PLANS.

SUPERELEVATION

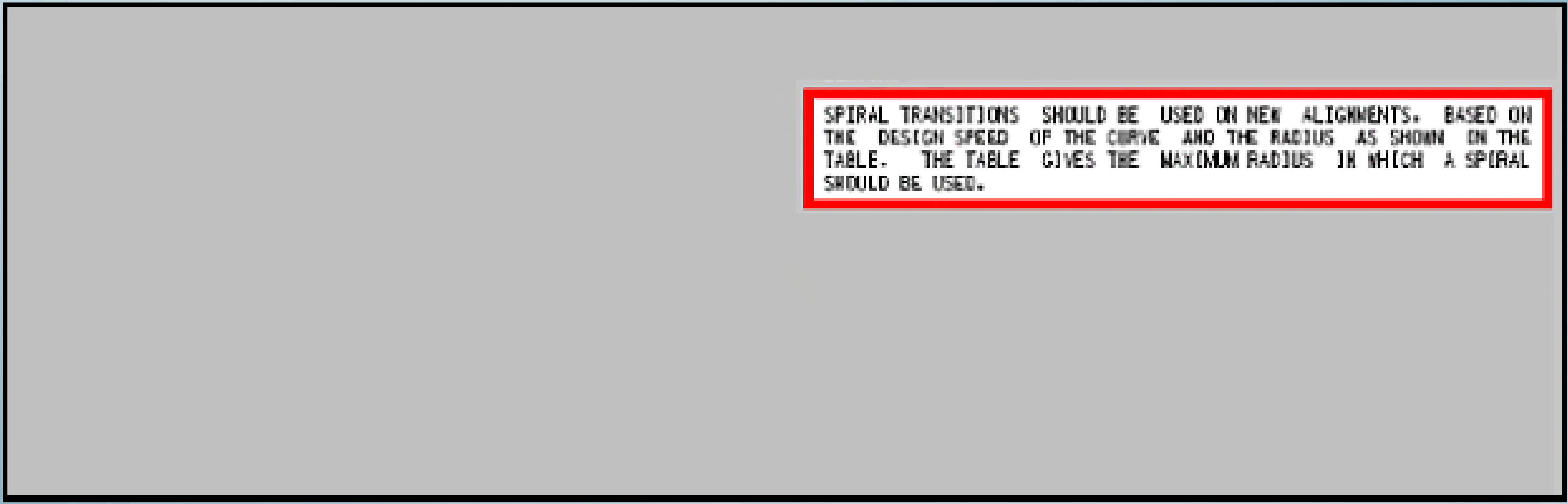
MDOT Standard Plan R-107

SPIRAL LENGTHS WILL BE EQUAL TO OR LONGER THAN TRANSITION SLOPE LENGTHS.

SPRIAL LENGTHS WILL BE EQUAL TO OR LONGER THAN TRANSITION SLOPE LENGTHS.

SUPERELEVATION

MDOT Standard Plan R-107



SPIRAL TRANSITIONS SHOULD BE USED ON NEW ALIGNMENTS. BASED ON THE DESIGN SPEED OF THE CURVE AND THE RADIUS AS SHOWN ON THE TABLE. THE TABLE GIVES THE MAXIMUM RADIUS IN WHICH A SPIRAL SHOULD BE USED.

SPIRAL TRANSITIONS SHOULD BE USED ON NEW ALIGNMENTS, BASED ON THE DESIGN SPEED OF THE CURVE AND THE RADIUS AS SHOWN IN THE TABLE. THE TABLE GIVES THE MAXIMUM RADIUS IN WHICH A SPIRAL SHOULD BE USED.

SUPERELEVATION

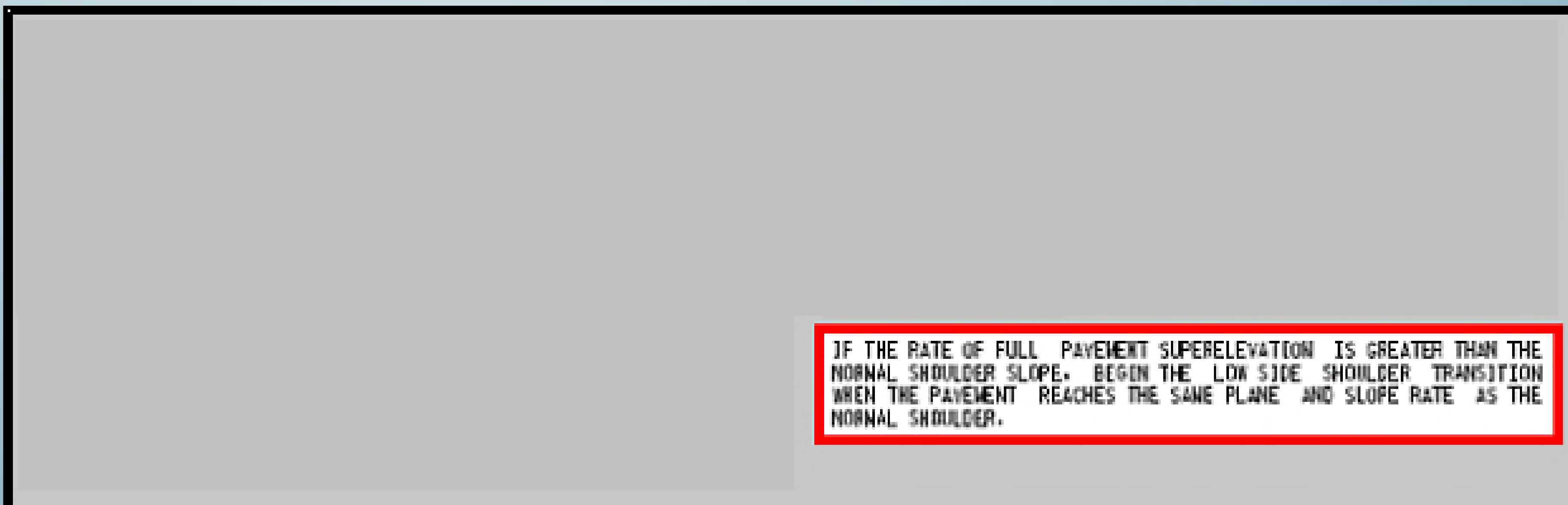
MDOT Standard Plan R-107


BEGIN THE HIGH SIDE SHOULDER TRANSITION AT THE PAVEMENT CROWN RUN OUT POINT (CROWN REMOVED). TRANSITION THE SHOULDER IN THE DISTANCE "L" TO THE SHOULDER SLOPE RATE REQUIRED AT FULL PAVEMENT SUPERELEVATION.

BEGIN THE HIGH SIDE SHOULDER TRANSITION AT THE PAVEMENT CROWN RUN OUT POINT (CROWN REMOVED). TRANSITION THE SHOULDER IN THE DISTANCE "L" TO THE SHOULDER SLOPE RATE REQUIRED AT FULL PAVEMENT SUPERELEVATION.

SUPERELEVATION

MDOT Standard Plan R-107



IF THE RATE OF FULL PAVEMENT SUPERELEVATIONS IS GREATER THAN THE NORMAL SHOULDER SLOPE, BEGIN THE LOW SIDE SHOULDER TRANSITION WHEN THE PAVEMENT REACHES THE SAME PLANE AND SLOPE RATE AS THE NORMAL SHOULDER.

SUPERELEVATION

MDOT Standard Plan R-107

WHEN TRANSITIONING THE SHOULDER SLOPE TO/FROM A BRIDGE SECTION, CALCULATE THE TRANSITION DISTANCE USING THE SUPERELEVATION TRANSITION SLOPE (Δ%) REQUIRED FOR THE CURVE, OR IN TANGENT SECTIONS, USE THE MINIMUM VALUE FOR SUPERELEVATION TRANSITION SLOPE (Δ%) GIVEN IN THE TABLE, IN THE COLUMN FOR THE SPEED OF THE ROADWAY. (TRANSITION DISTANCE = SHOULDER WIDTH x (RATE OF BRIDGE SHOULDER SUPERELEVATION MINUS RATE OF ROAD SHOULDER SUPERELEVATION) x 100 / Δ%)

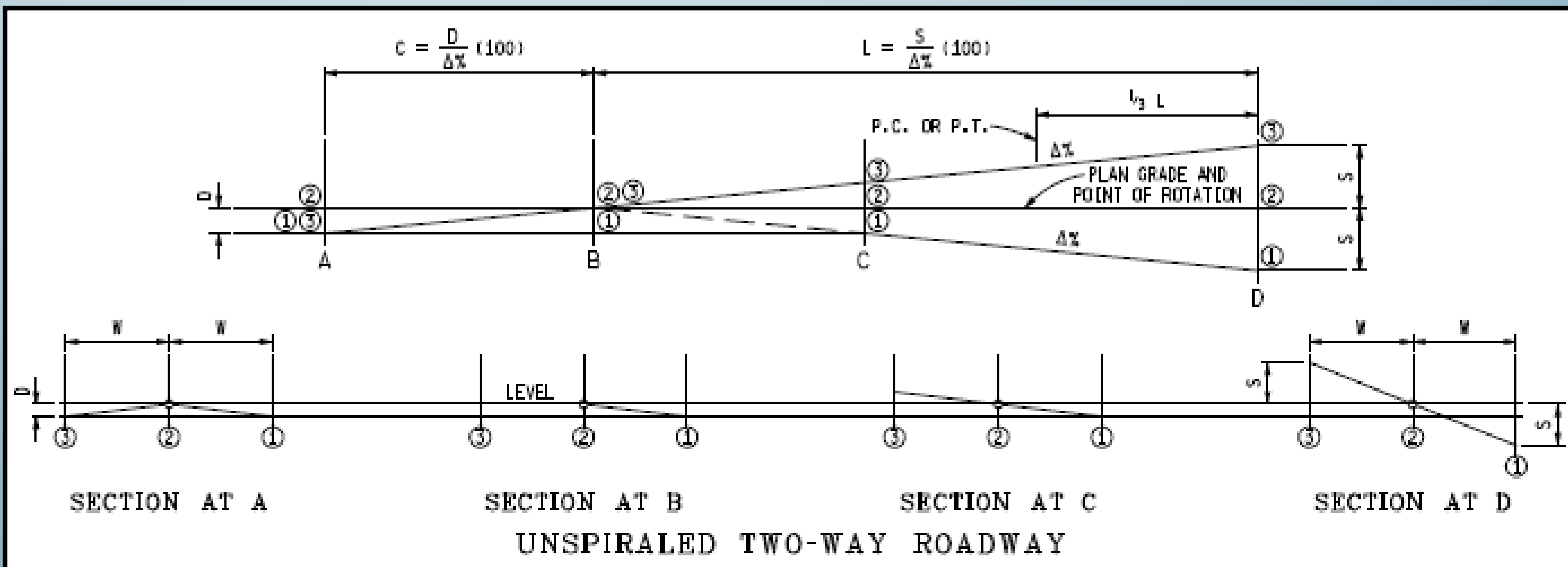
SUPERELEVATION

MDOT Standard Plan R-107

SPIRAL CURVE TRANSITIONS			
DESIGN SPEED (MPH)	MAXIMUM RADIUS (FEET)	DESIGN SPEED (MPH)	MAXIMUM RADIUS (FEET)
30	456	60	1822
35	620	65	2138
40	810	70	2479
45	1025	75	2846
50	1265	80	3238
55	1531		

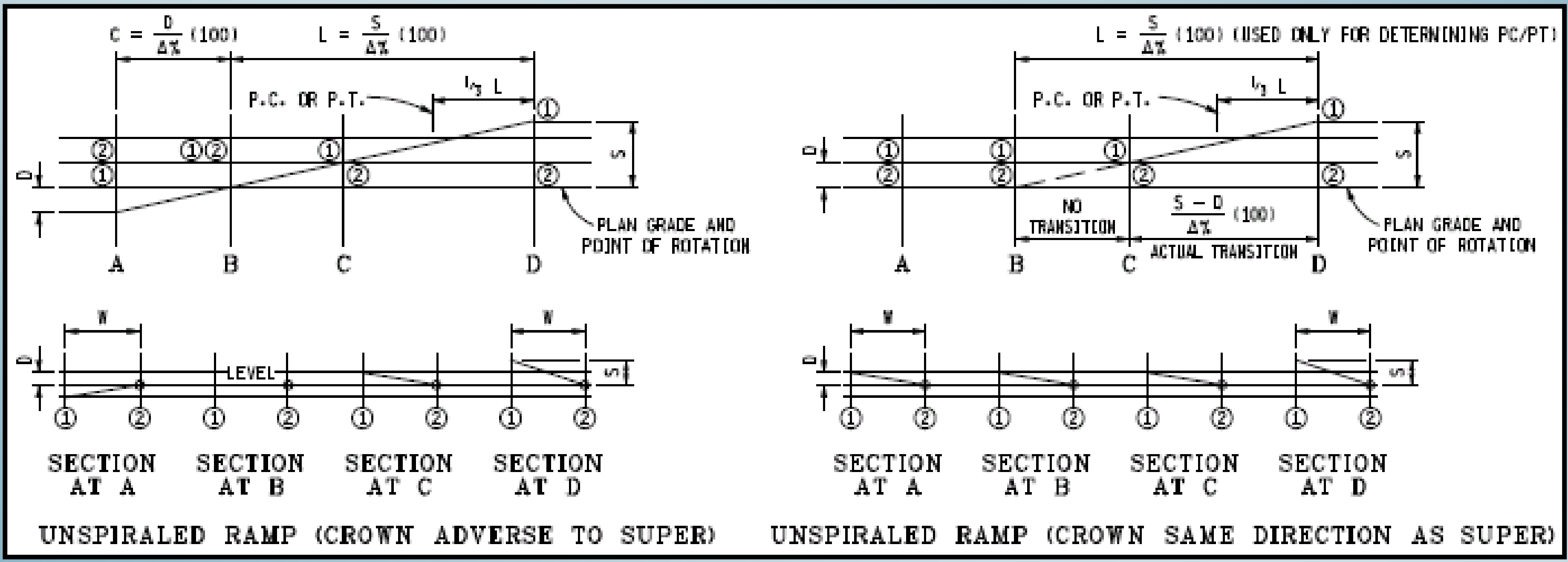
SUPERELEVATION

MDOT Standard Plan R-107



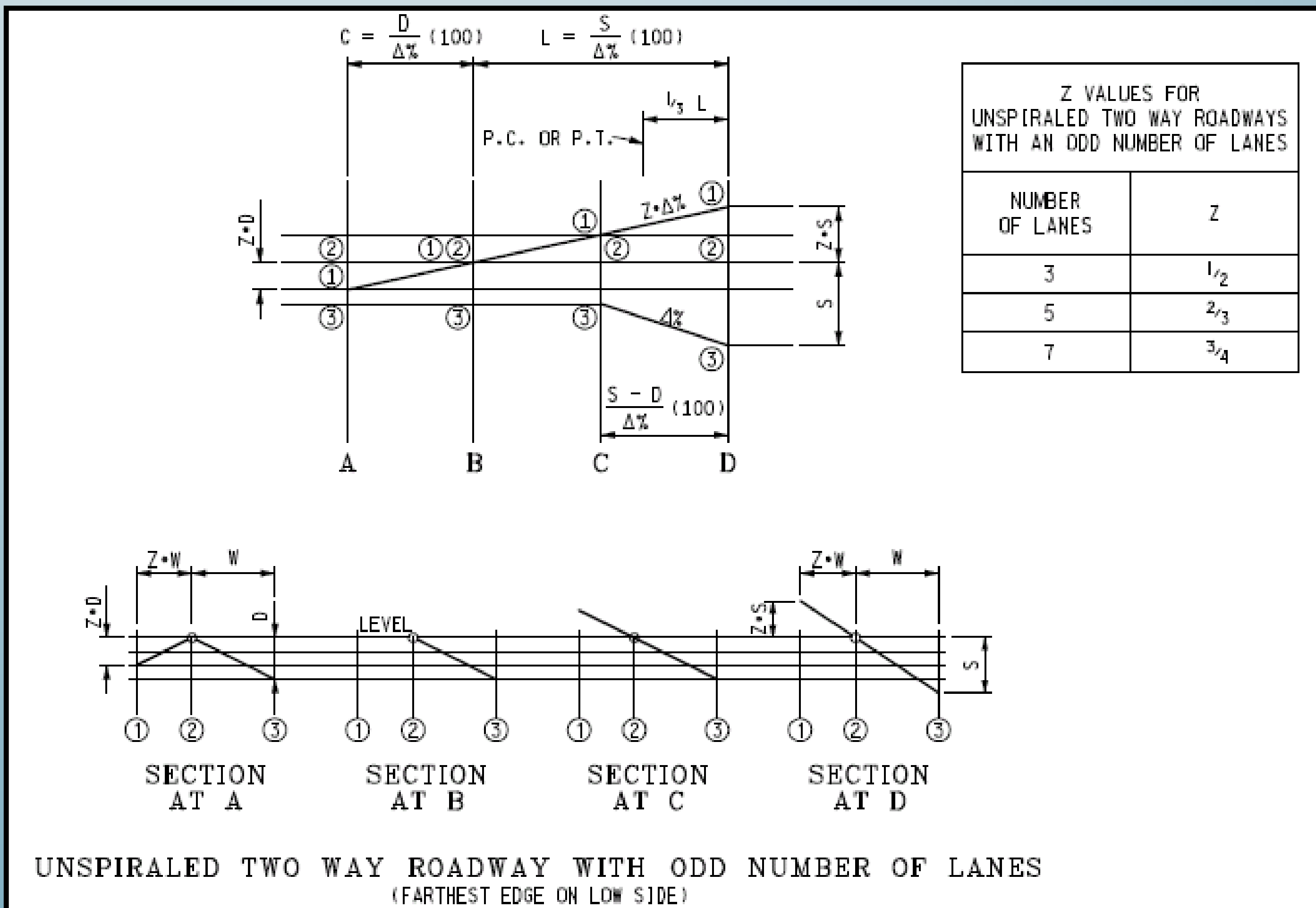
SUPERELEVATION

MDOT Standard Plan R-107



SUPERELEVATION

MDOT Standard Plan R-107

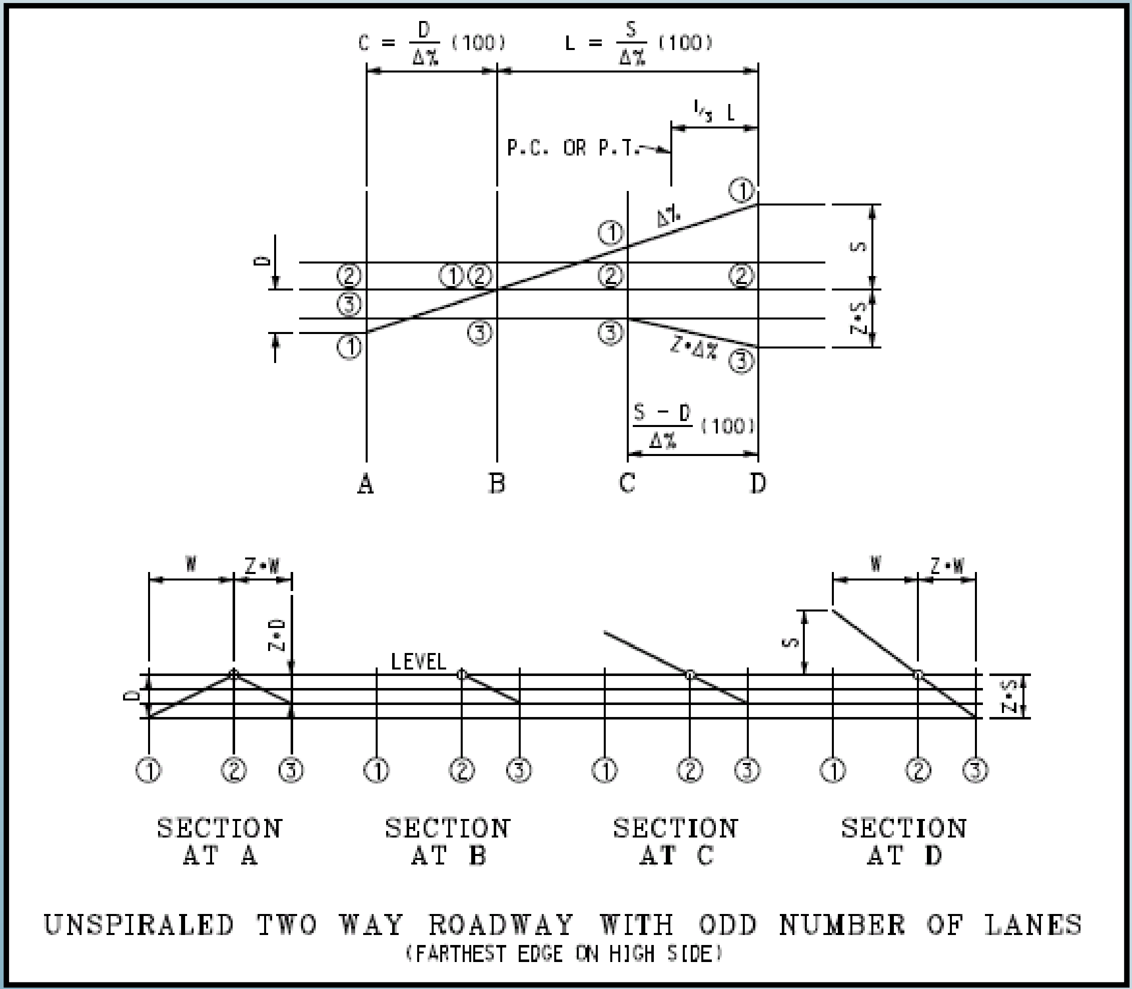


Z VALUES FOR UNSPIRALED TWO WAY ROADWAYS WITH AN ODD NUMBER OF LANES

NUMBER OF LANES	Z
3	1/2
5	2/3
7	3/4

SUPERELEVATION

MDOT Standard Plan R-107



SUPERELEVATION

Straight Line Method

(RDM 3.04.03)

STRAIGHT LINE SUPERELEVATION

RADIUS Feet	30 mph		35 mph		40 mph		45 mph		50 mph		55 mph		60 mph		65 mph		Freeways				Urban Freeways and Urban Ramps	
																	70 mph		75 mph		60 mph	
	e	Δ%	e	Δ%	e	Δ%	e	Δ%	e	Δ%	e	Δ%	e	Δ%	e	Δ%	e	Δ%	e	Δ%	e	Δ%
20000	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--
17000	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	2.0	0.30	N.C.	--
14000	[illegible]	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	2.0	0.32	2.0	0.31	2.0	0.30	N.C.	--
12000	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	2.0	0.36	2.0	0.32	2.0	0.31	2.0	0.30	2.0	0.36
10000	N.C.	--	N.C.	--	N.C.	--	N.C.	--	N.C.	--	2.0	0.38	2.0	0.36	2.0	0.32	2.0	0.31	2.0	0.30	2.0	0.36
8000	N.C.	--	N.C.	--	N.C.	--	N.C.	--	2.0	0.40	2.0	0.38	2.0	0.36	2.0	0.32	2.0	0.31	2.0	0.30	2.0	0.36
6000	N.C.	--	N.C.	--	N.C.	--	2.0	0.40	2.0	0.40	2.0	0.38	2.0	0.36	2.0	0.32	2.0	0.31	2.5	0.31	2.0	0.36
5000	N.C.	--	N.C.	--	2.0	0.40	2.0	0.40	2.0	0.40	2.0	0.38	2.0	0.36	2.0	0.32	2.5	0.32	3.0	0.32	2.0	0.36
4000	N.C.	--	2.0	0.45	2.0	0.40	2.0	0.40	2.0	0.40	2.0	0.38	2.0	0.36	2.5	0.33	3.1	0.33	3.8	0.34	2.0	0.36
3500	N.C.	--	2.0	0.45	2.0	0.40	2.0	0.40	2.0	0.40	2.0	0.38	2.3	0.37	2.8	0.34	3.5	0.34	4.3	0.35	2.0	0.36
3000	2.0	0.50	2.0	0.45	2.0	0.40	2.0	0.40	2.0	0.40	2.1	0.38	2.7	0.38	3.3	0.36	4.1	0.36	5.0	0.36	2.4	0.37
2500	2.0	0.50	2.0	0.45	2.0	0.40	2.0	0.40	2.0	0.40	2.5	0.39	3.2	0.39	4.0	0.37	4.9	0.38	6.0	0.38	2.8	0.38
2050	2.0	0.50	2.0	0.45	2.0	0.40	2.0	0.40	2.4	0.41	3.1	0.40	3.9	0.40	4.8	0.40	6.0	0.40			3.4	0.39
1800	2.0	0.50	2.0	0.45	2.0	0.40	2.1	0.41	2.8	0.42	3.5	0.41	4.4	0.42	5.5	0.42					3.9	0.40
1675	2.0	0.50	2.0	0.45	2.0	0.40	2.3	0.41	3.0	0.42	3.8	0.42	4.8	0.42	5.9	0.43					4.2	0.41
1425	2.0	0.50	2.0	0.45	2.0	0.40	2.7	0.42	3.5	0.44	4.5	0.44	5.6	0.44							5.0	0.43
1350	2.0	0.50	2.0	0.45	2.2	0.41	2.9	0.43	3.7	0.44	4.7	0.44	5.9	0.45								
1150	2.0	0.50	2.0	0.45	2.5	0.42	3.4	0.45	4.3	0.46	5.5	0.46										
1075	2.0	0.50	2.0	0.45	2.7	0.43	3.6	0.46	4.7	0.47	5.9	0.47										
850	2.0	0.50	2.4	0.47	3.4	0.46	4.5	0.49	5.9	0.50												
820	2.0	0.50	2.5	0.47	3.5	0.47	4.7	0.49														
800	2.0	0.50	2.6	0.47	3.6	0.47	4.8	0.50														
720	2.0	0.50	2.8	0.49	4.0	0.49	5.4	0.52														
650	2.1	0.51	3.1	0.50	4.5	0.51	5.9	0.54														
600	2.3	0.51	3.4	0.51	4.8	0.53																
500	2.8	0.53	4.1	0.54	5.8	0.57																
450	3.1	0.54	4.5	0.56																		
400	3.5	0.56	5.1	0.58																		
345	4.0	0.58	5.9	0.62																		
300	4.6	0.61																				
232	6.0	0.66																				
$\Delta\%_{max}$		0.66		0.62		0.58		0.54		0.50		0.47		0.45		0.43		0.40		0.38		0.45
Rmin	232		340		485		643		833		1061		1333		1657		2042		2500		1412	

Use 7% superelevation for loop ramps (see Standard Plan R-107-Series). However, special consideration should be given to curves which approach a ramp terminal (stopping condition). If relative gradient (Δ%) values from the tables cannot be obtained for the design radius, use $\Delta\%_{max}$ for the corresponding design speed.

For radii less than those tabulated (but not less than Rmin) use e_{max} and $\Delta\%_{max}$.

Maximum superelevation for urban freeways and urban ramps (with 60 mph design speed) is 5%, otherwise e_{max} = 6%.

QUESTIONS

Problem 5:

Non-Freeway, NHS Corridor (4R Work Type)
Divided Arterial, Three lanes in each direction
ADT = 15,000
Level terrain
Posted speed 50 mph

a. What is the design speed?

b. What is the lane width?

c. Paved shoulder width – left and right?

d. Stopping sight distance?

e. Maximum grade %?

f. Cross-slope for the traveled way and shoulders in a normal crown section?

g. Minimum required superelevation rate for a horizontal curve with R=1800'?

h. Superelevation rate for a horizontal curve with R=1800' using Standard Plan R-107?

Problem 5:

(Solutions)

Non-Freeway, NHS Corridor (4R Work Type)
Divided Arterial, Three lanes in each direction
ADT = 15,000
Level terrain
Posted speed 50 mph

a. What is the design speed?

55 mph / 50 mph ***(RDM 3.06 / RDM Appendix 3A)***

b. What is the lane width?

Rural or Urban: 12' ***(RDM Appendix 3A)***

c. Paved shoulder width – left and right?

Rural: ***8' Right and 8' Left***

(RDM Appendix 3A)

Urban: ***8' Right and 8' Left – If Not Constrained by ROW.***
Where ROW is Not Sufficient, No shoulders are required.

d. Stopping sight distance?

495' (55 mph) / 425' (50 mph) ***(MDOT Sight Distance Guidelines)***

e. Maximum grade %?

Rural: 4% (50 mph or 55mph design speed)

(RDM Appendix 3A)

Urban: 5% (55 mph design speed) / 6% (50 mph design speed)

f. Cross-slope for the traveled way and shoulders in a normal crown section?

Traveled Way: ***2.0%***

(RDM Appendix 3A)

Shoulders: ***4.0%***

g. Minimum required superelevation rate for a horizontal curve with R=1800'?

3.5% (55 mph)

(Straight-Line Superelevation Rate - RDM 3.04.03)

2.8% (50 mph)

h. Superelevation rate for a horizontal curve with R=1800' using Standard Plan R-107?

5.7% (55 mph)

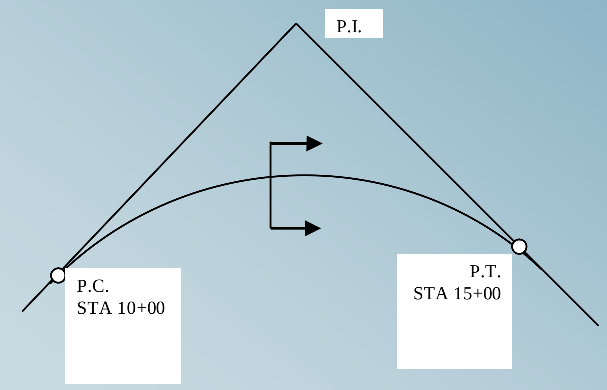
(R-107 Superelevation Rate - Standard Plan R-107)

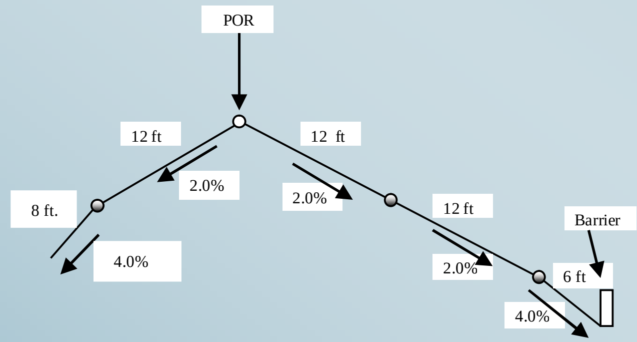
5.1% (50 mph)

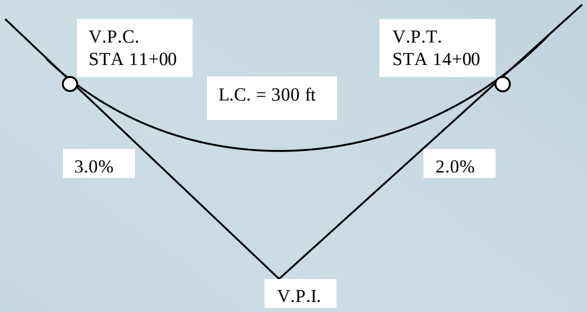
Problem 6:

Given the following information:

Design Speed = 50 mph
R = 2500 feet
Straight Line Superelevation Chart







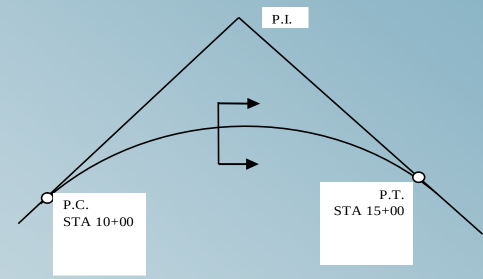
Calculate the following:

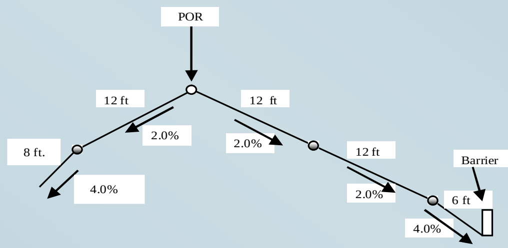
a. Superelevation Rate
b. Delta Percent Value
c. Crown Runout Length (C)
d. Superelevation Transition Length (L)
e. Superelevation Transition Distribution/Placement Inside and Outside of the Curve.
f. Determine the Required Horizontal Sightline Offset (HSO) to Ensure Adequate Stopping Sight Distance. Is the Required HSO Provided in this Case?
g. Determine the K Value Based on the Proposed Vertical Alignment. Does this K Value Meet for the Design Speed of the Roadway?

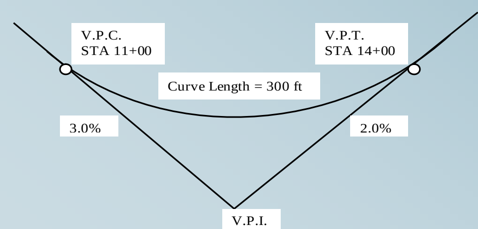
Problem 6:
(Solutions)

Given the following information:

Design Speed = 50 mph
R = 2500 feet
Straight Line Superelevation Chart







Determine/Calculate the following:

a. Superelevation Rate: ***2.0%*** ***(RDM 3.04.03)***

b. Delta Percent Value: ***0.40*** ***(RDM 3.04.03)***

c. Crown Runout Length (C): ***(2%)(12')/0.40 = 60'*** ***(MDOT Standard Plan R-107)***

d. Superelevation Transition Length (L): ***(2%)(12')/0.40 = 60'; (20' into curve/40' out of curve).***

e. Superelevation Transition Distribution/Placement Inside and Outside of the Curve.

At PC: L = Sta. 10+00 + 20' = Sta. 10+20 - 60' = 9+60. ***L: 9+60 to 10+20.***
C = Sta. 9+60 - 60' = Sta. 9+00. ***C: 9+00 to 9+60.***

At PT: L = Sta. 15+00 - 20' = Sta. 14+80 + 60' = 15+40. ***L: 14+80 to 15+40.***
C = Sta. 15+40 + 60' = Sta. 16+00. ***C: 15+40 to 16+00.***

f. Determine the required Horizontal Sightline Offset (HSO) to Ensure Adequate Stopping Sight Distance. Is the Required HSO Provided in this Case?

D.S. = 50 mph, R = 2500': Required HSO = 9.0'. Yes; 12.0' of HSO is Provided.

g. Determine the K Value Based on the Proposed Vertical Alignment. Does this K Value Meet for the Design Speed of the Roadway?

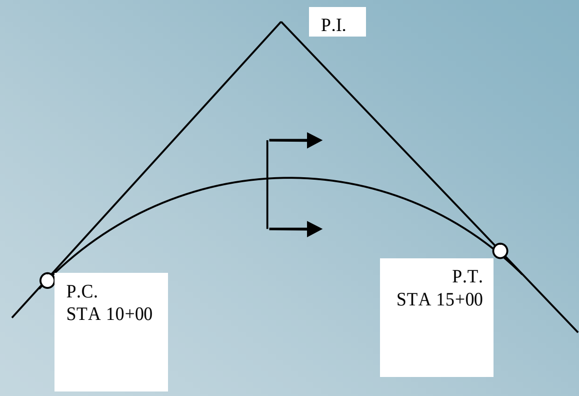
K = L/A = 300/5 = 60. No; $K_{(sag)}$ = 60 Does Not Meet for 50 mph; it Meets for 35 mph.

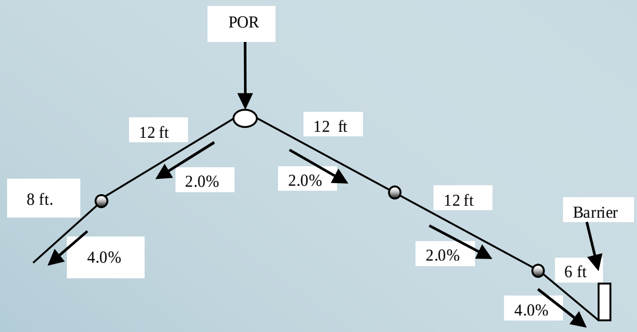
(NOTE: This Would be an Allowable Vertical Alignment for a 3R Non-Freeway Project).

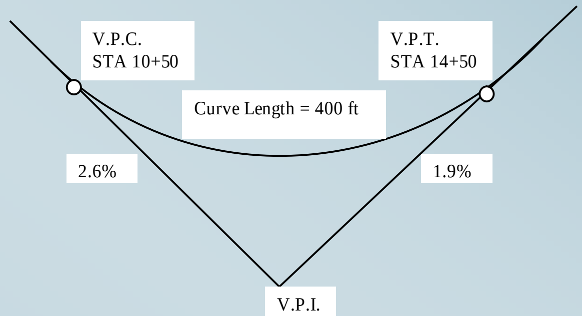
Problem 7:

Given the following information:

Design Speed = 60 mph
R = 2050’
Straight Line Superelevation Chart







Determine/Calculate the following:

a. Superelevation Rate:
b. Delta Percent Value:
c. Crown Runout Length (C):
d. Superelevation Transition Length (L):
e. Superelevation Transition Distribution/Placement Inside/Outside of the Curve:

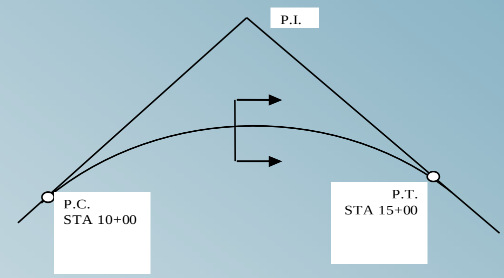
f. Determine the Required Horizontal Sightline Offset (HSO) to Ensure Adequate Stopping Sight Distance. Is the Required HSO Provided in this Case?

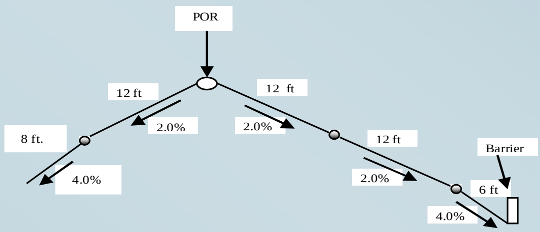
g. Determine the K Value Based on the Proposed Vertical Alignment. Does this K Value Meet for the Design Speed of the Roadway?

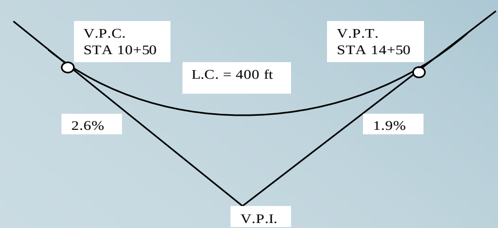
Problem 7:

Given the following information:

Design Speed = 60 mph
R = 2050’
Straight Line Superelevation Chart







Calculate the following:

a. Superelevation Rate: ***3.9%*** ***(RDM 3.04.03)***

b. Delta Percent Value: ***0.40*** ***(RDM 3.04.03)***

c. Crown Runout Length (C): C = (24’)(2%)/0.40 = **120’**.

d. Superelevation Transition Length (L): L = (24’)(3.9%)/0.40 = **234’**. **(78’ in / 156’ out)**.

e. Superelevation Transition Distribution/Placement Inside/Outside of the Curve:

PC: L = Sta. 10+00 + 78’ = Sta. 10+78 - 234’ = Sta. 8+44. C = Sta. 8+44 – 120’ = Sta. 7+24.

Crown Runout: Sta. 7+24 to Sta. 8+44. Super Transition: Sta. 8+44 to Sta. 10+78.

PT: L = Sta. 15+00 - 78’=Sta. 14+22 + 234’=Sta. 16+56. C = Sta. 16+56 + 120’=Sta. 17+76.

Super Transition: Sta. 14+22 to Sta. 16+56. Crown Runout: Sta. 16+56 to Sta. 17+76.

f. Determine the Required Horizontal Sightline Offset (HSO) to Ensure Adequate Stopping Sight Distance. Is the Required HSO Provided in this Case?

D.S. = 60 mph, R = 2050’: Required HSO = 19.8’. No; the Proposed HSO is Only 12.0’.

g. Determine the K Value Based on the Proposed Vertical Alignment. Does this K Value Meet for the Design Speed of the Roadway?

K = L/A = 400/4.5 = 88.9. No; $K_{(sag)}$ = 88 Does Not Meet for 60 mph; it Meets for 45 mph.

(NOTE: This Would be an Allowable Vertical Alignment for a 3R, Non-Freeway Project).

INTERCHANGE DESIGN

INTERCHANGE - GENERAL

- **Interchange** – A system of interconnecting roadways in conjunction with grade separations providing for the interchange of traffic between two or more intersecting roadways

INTERCHANGE - GENERAL

- Two Types
  - System
  - Service
- Configuration Based on Service Demand
- Spacing
  - Rural
  - Urban
- Approach to Structures
- Sight Distance

INTERCHANGE

Design Principles

- Interchanges Should be Designed to Best Serve the Projected Design Hourly Volume Safely and Efficiently

Operational Uniformity Concept

- Interchange Design Should Reinforce Driver Expectancies that Conform with (or Reinforce) a Prior Experience

INTERCHANGE LAYOUT

Road Design Manual (3.07.02 B)

- Adequate Visibility on Ramps
  - Sight Distance at Least as Long as SSD
  - Clear View of Entire Exit Terminal
    - Exit Nose
    - Section of Ramp Roadway Beyond Gore
- Exit Ramps Should Begin Where the Freeway is on a Tangent
- Exit in Advance of Structure
  - Loop Ramps Beyond a Structure Usually Need a Parallel Deceleration Lane

INTERCHANGE LAYOUT

Road Design Manual (3.07.02 B)

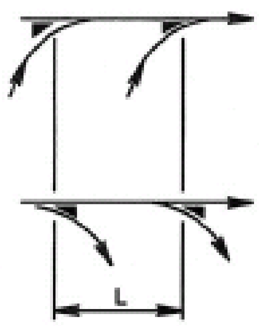
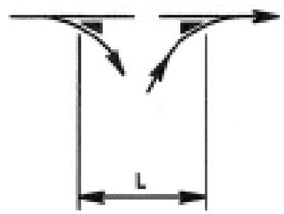
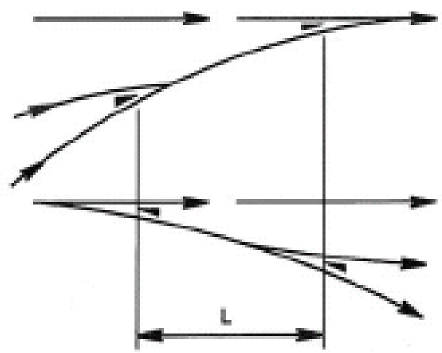
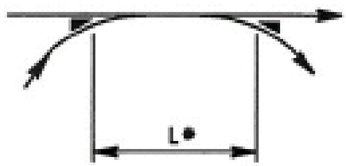
- Extreme Care Exercised to Avoid Left-Hand Entrances and Exits
- Avoid Lane Drops between Closely Spaced Interchanges
- Loop Ramps should be Designed with a Minimum Radius of 260’ If Possible
- Gore Areas Should be Designed as Flat as Possible
- Consistency Should be Provided in Interchange and Ramp Design and Utilization

INTERCHANGE

Spacing

- Impacts Freeway Operations
- Capacity/Congestion
- Urban Areas
  - Difficult to Get Spacing - 1 Mile Spacing Desirable
- Rural Areas
  - 2 Mile Spacing Desirable

INTERCHANGE

EN-EN OR EX-EX		EX-EN		TURNING ROADWAYS		EN-EX (WEAVING)			
						 * NOT APPLICABLE TO CLOVERLEAF LOOP RAMPS			
FULL FREEWAY	CDR OR FDR	FULL FREEWAY	CDR OR FDR	SYSTEM INTER-CHANGE	SERVICE INTER-CHANGE	SYSTEM TO SERVICE INTERCHANGE		SERVICE TO SERVICE INTERCHANGE	
						FULL FWY.	CDR OR FDR	FULL FWY.	CDR OR FDR
MINIMUM LENGTHS MEASURED BETWEEN SUCCESSIVE RAMP TERMINALS									
300 m [1000 ft]	240 m [800 ft]	150 m [500 ft]	120 m [400 ft]	240 m [800 ft]	180 m [600 ft]	600 m [2000 ft]	480 m [1600 ft]	480 m [1600 ft]	300 m [1000 ft]

NOTES:

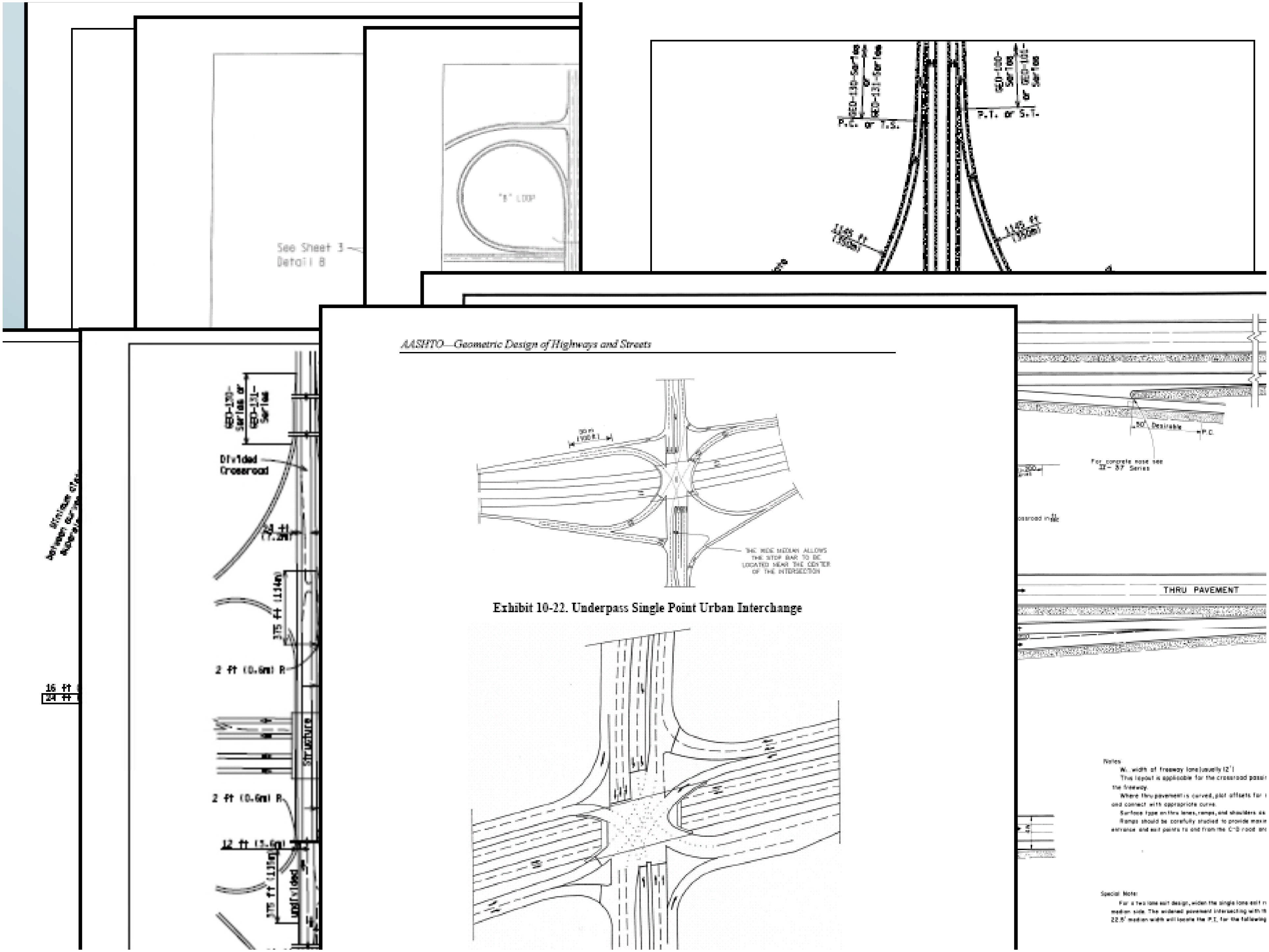
FDR - FREEWAY DISTRIBUTOR ROAD

CDR - COLLECTOR DISTRIBUTOR ROAD

EN - ENTRANCE

EX - EXIT

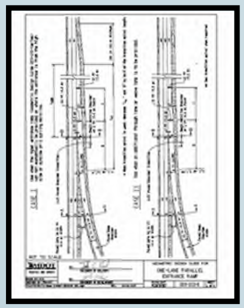
THE RECOMMENDATIONS ARE BASED ON OPERATIONAL EXPERIENCE AND NEED FOR FLEXIBILITY AND ADEQUATE SIGNING. THEY SHOULD BE CHECKED IN ACCORDANCE WITH THE PROCEDURE OUTLINED IN THE HIGHWAY CAPACITY MANUAL (4) AND THE LARGER OF THE VALUES IS SUGGESTED FOR USE.
THE "L" DISTANCES NOTED IN THE FIGURES ABOVE ARE BETWEEN LIKE POINTS, NOT NECESSARILY "PHYSICAL" GORES.
A MINIMUM DISTANCE OF 90 m [270 ft] IS RECOMMENDED BETWEEN THE END OF THE TAPER FOR THE FIRST ON RAMP AND THE THEROETICAL GORE FOR THE SUCCEDING ON RAMP FOR THE EN-EN (SIMILIAR FOR EX-EN).


See Sheet 3 —
Detail B
"B" LOOP
P.C. or T.S.
P.T. or S.T.
AASHTO—Geometric Design of Highways and Streets
THE WIDE MEDIAN ALLOWS THE STOP BAR TO BE LOCATED NEAR THE CENTER OF THE INTERSECTION
Exhibit 10-22. Underpass Single Point Urban Interchange
Divided Crossroad
2 ft (0.6m) R
Structure
undivided
THRU PAVEMENT
Desirable
Notes
Special Note:

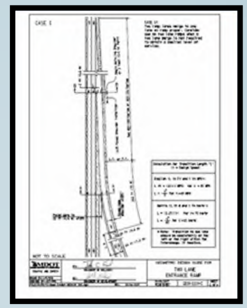
RAMP TYPES

GEO-100-F
One Lane
Tapered Entrance

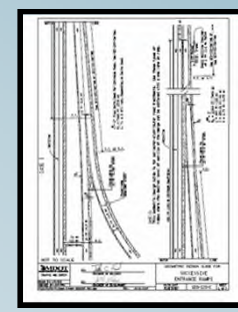
GEO-101-F
One Lane
Parallel Entrance



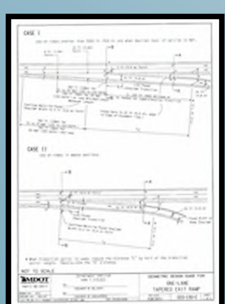
GEO-110-C
Two Lane
Entrance



GEO-120-C
Successive
Entrance

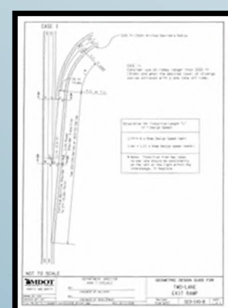


GEO-130-D
One Lane
Tapered Exit

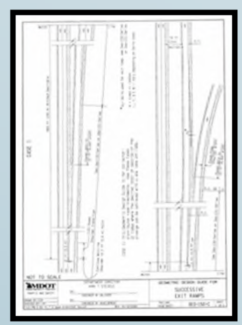


GEO-131-D
One Lane
Parallel Exit

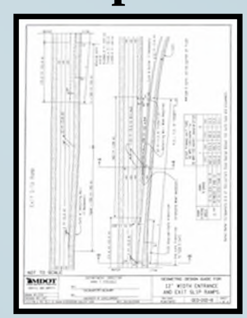
GEO-140-B
Two Lane
Exit



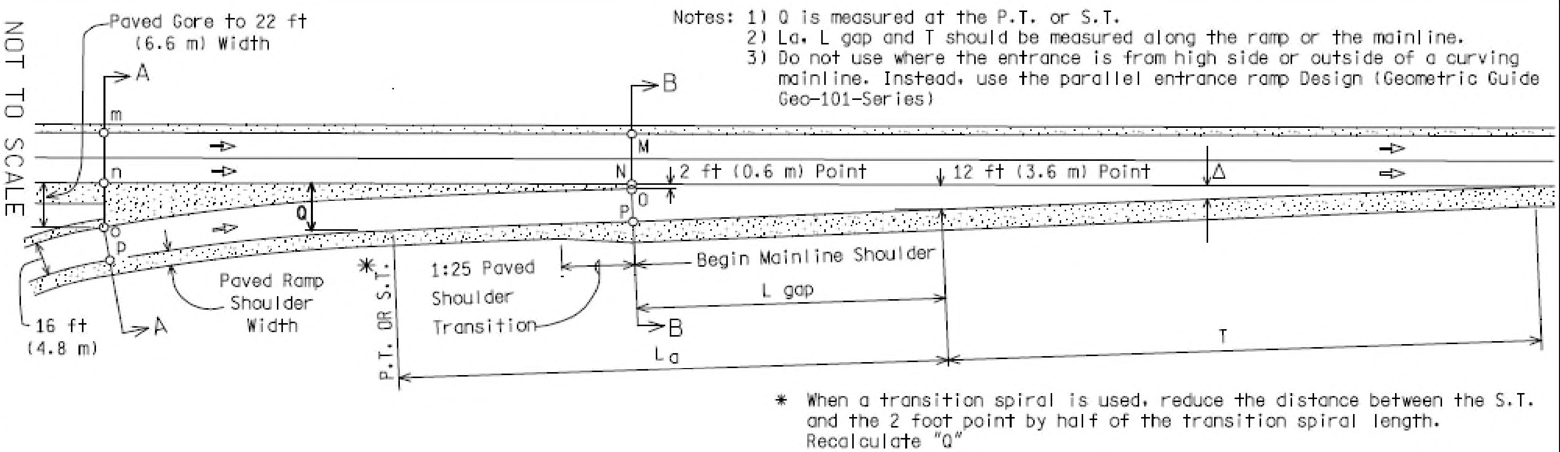
GEO-150-C
Successive
Exit



GEO-202-B
12’ Width
Entrance & Exit
Slip



INTERCHANGE



EDGE OF PAVEMENT ELEVATION RELATIONSHIPS

WHEN THE THROUGH LANES ARE NOT SUPERELEVATED	WHEN THE THROUGH LANES ARE SUPERELEVATED AND N IS LOWER THAN M	WHEN THE THROUGH LANES ARE SUPERELEVATED AND N IS HIGHER THAN M	
		RAMP AND THROUGH LANE SUPERELEVATED IN SAME DIRECTION	RAMP AND THROUGH LANE SUPERELEVATED IN OPPOSITE DIRECTION
SECTION A-A			
POINTS n, o & p SHOULD BE PROGRESSIVELY LOWER.	POINTS m, n, o & p SHOULD BE PROGRESSIVELY LOWER.	POINT o SHOULD BE HIGHER THAN POINT n.	POINT o SHOULD BE EQUAL TO OR LOWER THAN POINT n.
SECTION B-B			
POINTS N, O & P SHOULD BE IN THE SAME PLANE.	POINTS M, N, O & P SHOULD BE IN THE SAME PLANE.	POINTS M, N, O & P SHOULD BE IN THE SAME PLANE.	POINTS M, N, O & P SHOULD BE IN THE SAME PLANE.

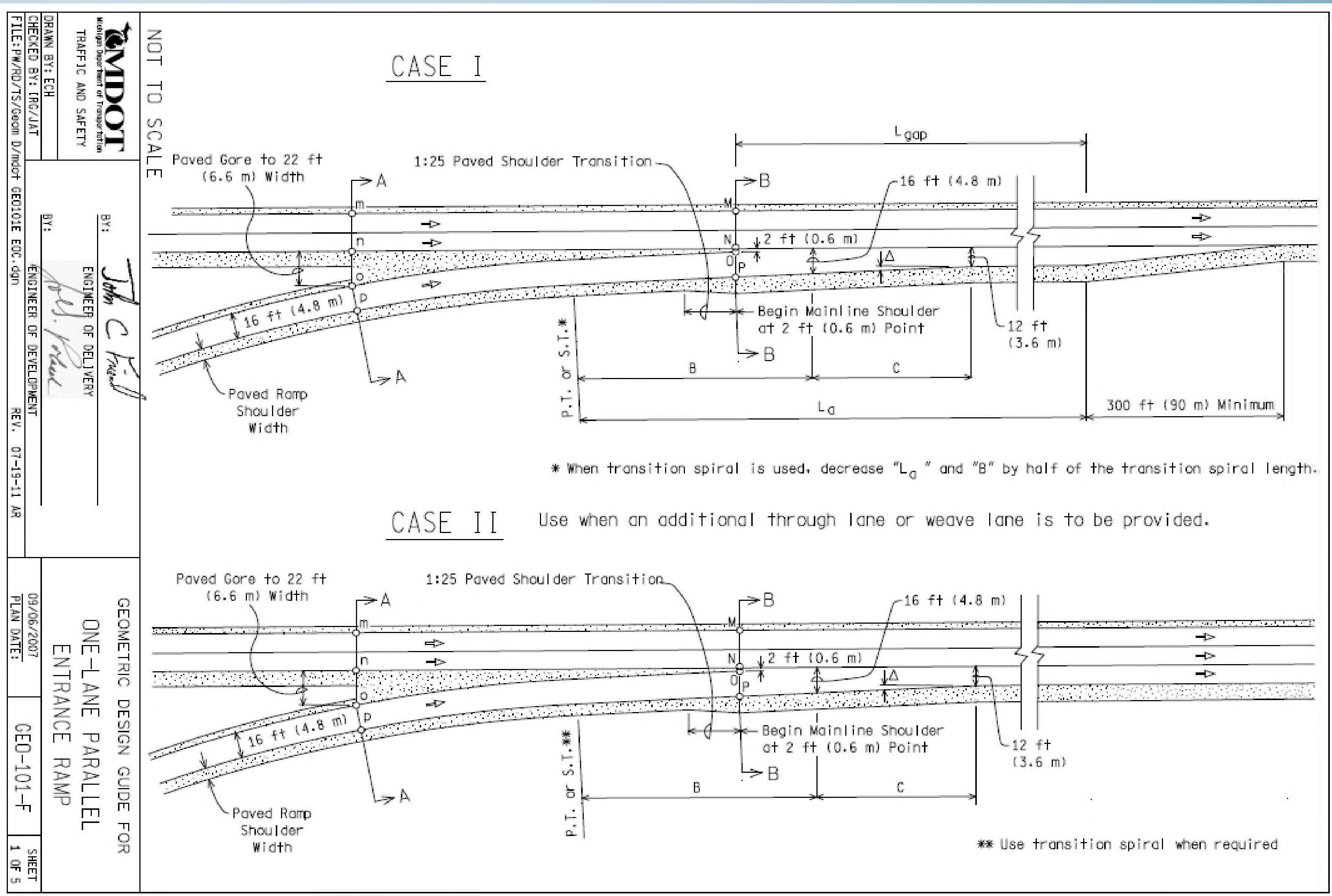
Note:
Maximum algebraic difference in pavement cross slope between mainline and ramp auxiliary lane should not exceed 5%.

MDOT Michigan Department of Transportation
TRAFFIC AND SAFETY
DRAWN BY: ECH
CHECKED BY: IRG/JAT
FILE:PW/RD/TS/Geom D/mdot GEO100E EOC.dgn
BY: ENGINEER OF DELIVERY
BY: ENGINEER OF DEVELOPMENT
REV. 05/24/2011 jt
GEOMETRIC DESIGN GUIDE FOR ONE LANE TAPERED ENTRANCE RAMP
PLAN DATE: 09/06/2007
GEO-100-F
SHEET 1 OF 4

MINIMUM ENGLISH LENGTHS FOR TAPERED ENTRANCE RAMPS

RAMP DESIGN SPEED (MPH)	PERCENT GRADE OF THROUGH ROADWAY	TAPER=65:1 Δ=0°52′53″ ROADWAY DESIGN SPEED = 75 MPH T = 780 FT Lgap = 390 FT		TAPER=60:1 Δ=0°57′17″ ROADWAY DESIGN SPEED = 70 MPH T = 720 FT Lgap = 360 FT		TAPER=55:1 Δ=1°02′30″ ROADWAY DESIGN SPEED = 60 MPH T = 660 FT Lgap = 330 FT		TAPER=50:1 Δ=1°08′45″ ROADWAY DESIGN SPEED = 55 to 50 MPH T = 600 FT Lgap = 300 FT		TAPER=45:1 Δ=1°16′23″ ROADWAY DESIGN SPEED = 45 or less MPH T = 540 FT Lgap = 270 FT	
		L_a (FT)	Q (FT)	L_a (FT)	Q (FT)	L_a (FT)	Q (FT)	L_a (FT)	Q (FT)	L_a (FT)	Q (FT)
20	-3 TO LESS THAN -5	978	27.1	912	27.2	660	24.0	506	22.2	450	22.0
	BETWEEN -3 AND +3	1630	37.1	1520	37.4	1100	32.0	810	28.2	450	22.0
	+3 TO LESS THAN +5	2528	50.9	2280	50.0	1540	40.0	1094	33.9	608	25.5
25	-3 TO LESS THAN -5	948	26.6	852	26.2	612	23.2	500	22.0	450	22.0
	BETWEEN -3 AND +3	1580	36.4	1420	35.7	1020	30.6	780	27.6	450	22.0
	+3 TO LESS THAN +5	2528	50.9	2201	48.7	1479	38.9	1092	33.9	608	25.5
30	-3 TO LESS THAN -5	906	26.0	810	25.5	555	22.0	500	22.0	450	22.0
	BETWEEN -3 AND +3	1510	35.3	1350	34.5	910	28.6	670	25.4	450	22.0
	+3 TO LESS THAN +5	2492	50.4	2160	48.0	1365	36.9	972	31.5	608	25.5
35	-3 TO LESS THAN -5	852	25.2	738	24.3	550	22.0	500	22.0	450	22.0
	BETWEEN -3 AND +3	1420	33.9	1230	32.5	800	26.6	550	23.0	450	22.0
	+3 TO LESS THAN +5	2450	49.7	2030	45.9	1200	33.9	798	28.0	608	25.5
40	-3 TO LESS THAN -5	696	22.8	600	22.0	550	22.0	500	22.0	450	22.0
	BETWEEN -3 AND +3	1160	29.9	1000	28.7	550	22.0	500	22.0	450	22.0
	+3 TO LESS THAN +5	2088	44.2	1700	40.4	825	27.0	725	26.5	608	25.5
45	-3 TO LESS THAN -5	650	22.0	600	22.0	550	22.0	500	22.0	450	22.0
	BETWEEN -3 AND +3	1040	28.0	820	25.7	550	22.0	500	22.0	450	22.0
	+3 TO LESS THAN +5	1924	41.6	1435	36.0	825	27.0	725	26.5	608	25.5
50	-3 TO LESS THAN -5	650	22.0	600	22.0	550	22.0	500	22.0		
	BETWEEN -3 AND +3	780	24.0	600	22.0	550	22.0	500	22.0		
	+3 TO LESS THAN +5	1482	34.8	1080	30.0	825	27.0	725	26.5		
55	-3 TO LESS THAN -5	650	22.0	600	22.0	550	22.0	500	22.0		
	BETWEEN -3 AND +3	650	22.0	600	22.0	550	22.0	500	22.0		
	+3 TO LESS THAN +5	1268	31.5	1080	30.0	825	27.0	725	26.5		
60	-3 TO LESS THAN -5	650	22.0	600	22.0	550	22.0				
	BETWEEN -3 AND +3	650	22.0	600	22.0	550	22.0				
	+3 TO LESS THAN +5	1268	31.5	1080	30.0	825	27.0				
65	-3 TO LESS THAN -5	650	22.0	600	22.0						
	BETWEEN -3 AND +3	650	22.0	600	22.0						
	+3 TO LESS THAN +5	1268	31.5	1080	30.0						
70	-3 TO LESS THAN -5	650	22.0	600	22.0						
	BETWEEN -3 AND +3	650	22.0	600	22.0						
	+3 TO LESS THAN +5	1268	31.5	1080	30.0						
75	-3 TO LESS THAN -5	650	22.0								
	BETWEEN -3 AND +3	650	22.0								
	+3 TO LESS THAN +5	1268	31.5								

INTERCHANGE



INTERCHANGE

MINIMUM ENGLISH LENGTHS FOR PARALLEL ENTRANCE

RAMP DESIGN SPEED (MPH)	PERCENT GRADE OF THROUGH ROADWAY	TAPER=65:1 Δ=0°52′53″ ROADWAY DESIGN SPEED = 75 MPH B = 390 FT C = 260 FT Lgap = 390 FT	TAPER=60:1 Δ=0°57′17″ ROADWAY DESIGN SPEED = 70 MPH B = 360 FT C = 240 FT Lgap = 360 FT	TAPER=55:1 Δ=1°02′30″ ROADWAY DESIGN SPEED = 60 MPH B = 330 FT C = 220 FT Lgap = 330 FT	TAPER=50:1 Δ=1°08′45″ ROADWAY DESIGN SPEED = 55 to 50 MPH B = 300 FT C = 200 FT Lgap = 300 FT	TAPER=45:1 Δ=1°16′23″ ROADWAY DESIGN SPEED = 45 or less MPH B = 270 FT C = 180 FT Lgap = 270 FT
		L_a (FT)	L_a (FT)	L_a (FT)	L_a (FT)	L_a (FT)
20	-3 TO LESS THAN -5	978	912	660	506	450
	BETWEEN -3 AND +3	1630	1520	1100	810	450
	+3 TO LESS THAN +5	2528	2280	1540	1094	608
25	-3 TO LESS THAN -5	948	852	612	500	450
	BETWEEN -3 AND +3	1580	1420	1020	780	450
	+3 TO LESS THAN +5	2528	2201	1479	1092	608
30	-3 TO LESS THAN -5	906	810	550	500	450
	BETWEEN -3 AND +3	1510	1350	910	670	450
	+3 TO LESS THAN +5	2492	2160	1365	972	608
35	-3 TO LESS THAN -5	852	738	550	500	450
	BETWEEN -3 AND +3	1420	1230	800	550	450
	+3 TO LESS THAN +5	2450	2030	1200	798	608
40	-3 TO LESS THAN -5	696	600	550	500	450
	BETWEEN -3 AND +3	1160	1000	550	500	450
	+3 TO LESS THAN +5	2088	1700	825	725	608
45	-3 TO LESS THAN -5	650	600	550	500	450
	BETWEEN -3 AND +3	1040	820	550	500	450
	+3 TO LESS THAN +5	1924	1435	825	725	608
50	-3 TO LESS THAN -5	650	600	550	500	
	BETWEEN -3 AND +3	780	600	550	500	
	+3 TO LESS THAN +5	1482	1080	825	725	
55	-3 TO LESS THAN -5	650	600	550	500	
	BETWEEN -3 AND +3	650	600	550	500	
	+3 TO LESS THAN +5	1268	1080	825	725	
60	-3 TO LESS THAN -5	650	600	550		
	BETWEEN -3 AND +3	650	600	550		
	+3 TO LESS THAN +5	1268	1080	825		
65	-3 TO LESS THAN -5	650	600			
	BETWEEN -3 AND +3	650	600			
	+3 TO LESS THAN +5	1268	1080			
70	-3 TO LESS THAN -5	650	600			
	BETWEEN -3 AND +3	650	600			
	+3 TO LESS THAN +5	1268	1080			
75	-3 TO LESS THAN -5	650				
	BETWEEN -3 AND +3	650				
	+3 TO LESS THAN +5	1268				

NOTES:

1. The designer has the flexibility to choose either the taper type ramp or the parallel type ramp. However, the same type of entrance and exit ramp should be used within an interchange and corridor. Uniformity in design is needed to aid driver expectancy. On sharp curves, it may be preferable to use parallel type ramps.

2. Select design speed based on a combination of the superelevation rate and the radius of the curve. See also chapter 3 of the MDOT Road Design Manual.

3. If an additional through lane is provided or the entrance ramp joins the mainline on the high side (outside) of the curve, use GEO-101-Series.

4. If the through pavement is curved, plot offsets for taper and connect with appropriate curve.

5. Prepare detail grades and profiles from Section A-A to section B-B.

6. The value of La or Lgap, whichever produces the greater distance downstream from the 2 ft (0.6 m) point, is suggested for use in the design of the ramp entrance. La is the acceleration distance. Lgap is the minimum distance required to find a gap in traffic and merge onto the mainline.

7. Spirals transitions should be used on new ramp alignments based on the design speed of the curve and the radius as shown in the table of the Road Standard Plan R-107-Series. The table gives the maximum radius in which a spiral should be used.

8. The maximum algebraic difference in pavement cross slope between the mainline and the ramp auxiliary lane should not exceed 5%.

9. The cross slope in the gore area between the 2 ft (0.6 m) point and the 22 ft (6.6 m) point should not exceed 8%, with a 6% maximum algebraic difference in cross slope between the gore and the adjacent paved lane. This algrebraic difference also applies within crowned gores.

10. The design speed of the ramp vertical alignment should meet or exceed the design speed of the ramp horizontal alignment.

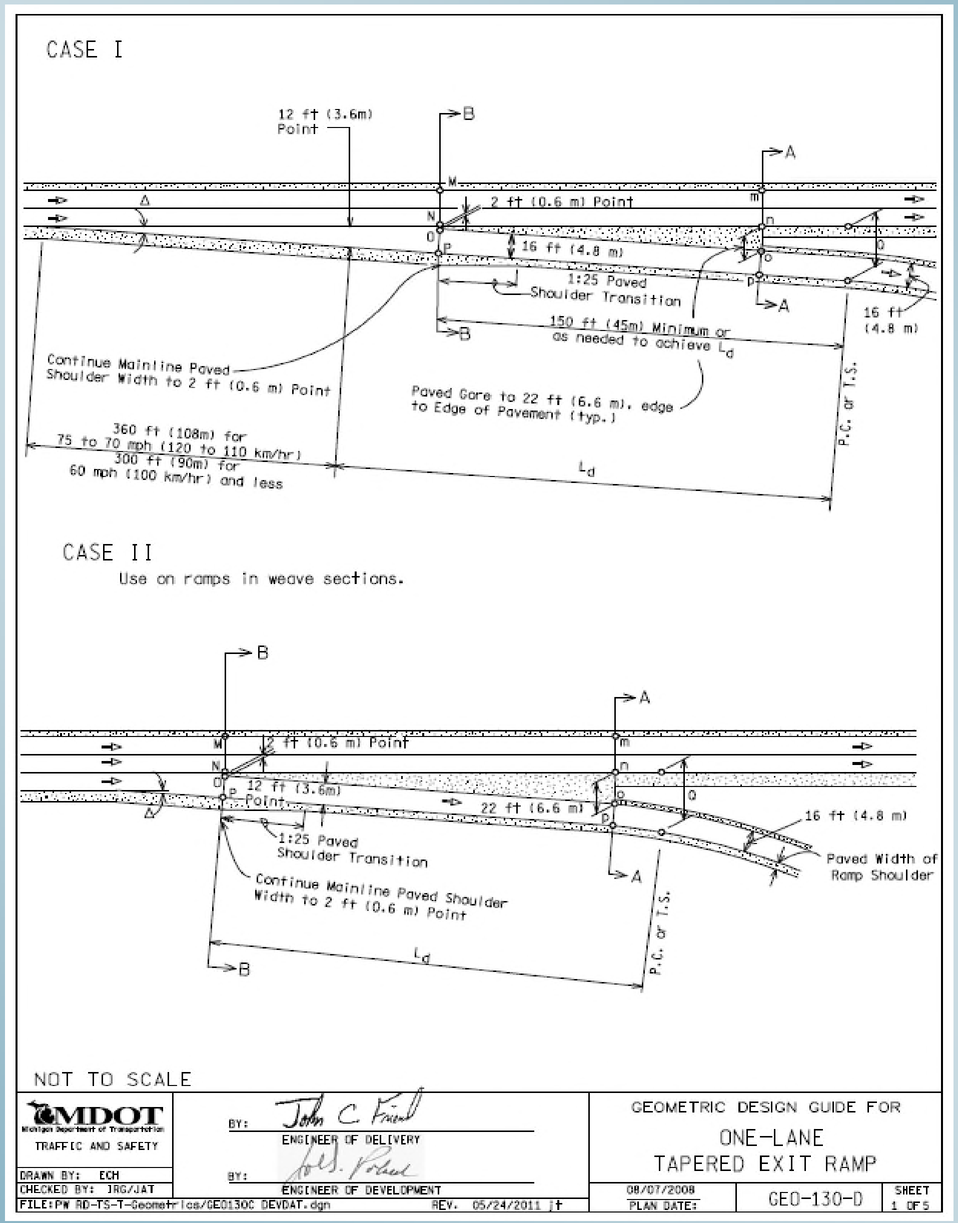
11. The mainline shoulder width should extend along the ramp to where the gore is 2 ft (0.6 m) wide. Use a 1:25 taper transition where it joins the ramp shoulder paving.

12. Each ramp should be carefully studied to provide maximum vision at its merge points. See Geometric Design Guide GEO-300-Series.

13. These design concepts are for new construction. Where modification may be needed for retrofitting to existing road features, consult the Geometric Design Unit of Lansing Traffic and Safety.

NOT TO SCALE

INTERCHANGE

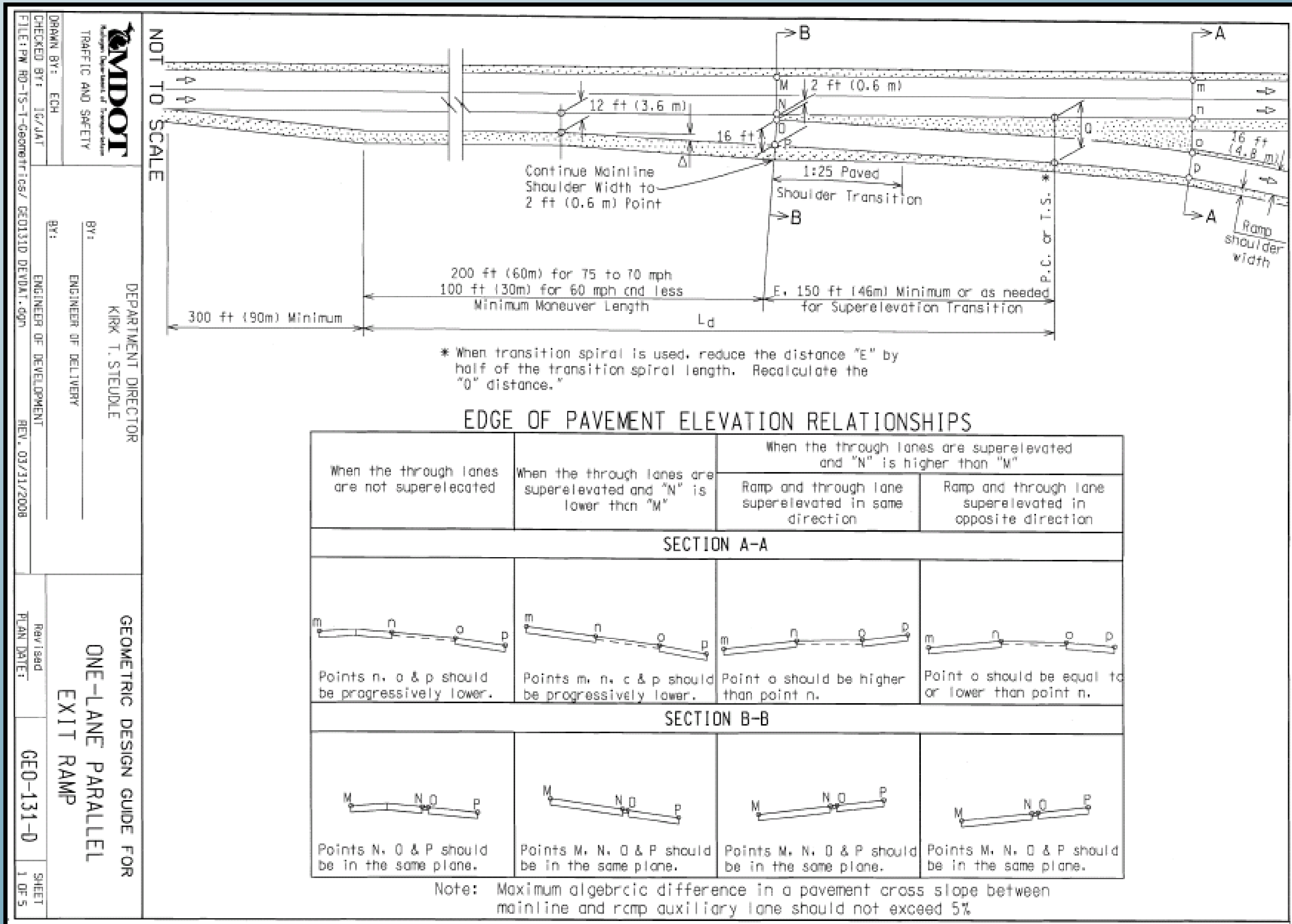


MINIMUM ENGLISH LENGTHS FOR TAPERED EXIT RAMPS

RAMP DESIGN SPEED (MPH)	PERCENT GRADE OF THROUGH ROADWAY	TAPER=30:1 Δ=1°54'33" ROADWAY DESIGN SPEED = 75 MPH L_d min = 330		TAPER=30:1 Δ=1°54'33" ROADWAY DESIGN SPEED = 70 MPH L_d min = 330		TAPER=25:1 Δ=2°17'26" ROADWAY DESIGN SPEED = 60 MPH L_d min = 300		TAPER=25:1 Δ=2°17'26" ROADWAY DESIGN SPEED = 55 MPH TO 50 MPH L_d min = 300		TAPER=25:1 Δ=2°17'26" ROADWAY DESIGN SPEED = 45 MPH OR LESS L_d min = 300	
		L_d (FT)	Q (FT)	L_d (FT)	Q (FT)	L_d (FT)	Q (FT)	L_d (FT)	Q (FT)	L_d (FT)	Q (FT)
20	-3 TO LESS THAN -5	744	36.8	684	34.8	576	35.1	528	33.2	390	27.6
	BETWEEN -3 AND +3	620	32.7	570	31.0	480	31.2	440	29.6	325	25.0
	+3 TO LESS THAN +5	558	30.6	513	29.1	432	29.3	396	27.9	300	24.0
25	-3 TO LESS THAN -5	720	36.0	660	34.0	552	34.1	492	31.7	354	26.2
	BETWEEN -3 AND +3	600	32.0	550	30.4	460	30.4	410	28.4	300	24.0
	+3 TO LESS THAN +5	540	30.0	495	28.5	414	28.6	369	26.8	300	24.0
30	-3 TO LESS THAN -5	690	35.0	624	32.8	516	32.7	456	30.3	300	24.0
	BETWEEN -3 AND +3	575	31.2	520	29.4	430	29.2	380	27.2	300	24.0
	+3 TO LESS THAN +5	518	29.3	468	27.6	387	27.5	342	25.7	300	24.0
35	-3 TO LESS THAN -5	642	33.4	588	31.6	486	31.5	420	28.8	300	24.0
	BETWEEN -3 AND +3	535	29.9	490	28.4	405	28.2	350	26.0	300	24.0
	+3 TO LESS THAN +5	482	28.1	441	26.7	365	26.6	315	24.6	300	24.0
40	-3 TO LESS THAN -5	588	31.6	528	29.6	420	28.8	342	25.7	300	24.0
	BETWEEN -3 AND +3	490	28.4	440	26.7	350	26.0	300	24.0	300	24.0
	+3 TO LESS THAN +5	441	26.7	396	25.2	315	24.6	300	24.0	300	24.0
45	-3 TO LESS THAN -5	528	29.6	468	27.6	360	26.4	300	24.0	300	24.0
	BETWEEN -3 AND +3	440	26.7	390	25.0	300	24.0	300	24.0	300	24.0
	+3 TO LESS THAN +5	396	25.2	351	23.7	300	24.0	300	24.0	300	24.0
50	-3 TO LESS THAN -5	468	27.6	432	26.4	300	24.0	300	24.0		
	BETWEEN -3 AND +3	390	25.0	360	24.0	300	24.0	300	24.0		
	+3 TO LESS THAN +5	351	23.7	330	23.0	300	24.0	300	24.0		
55	-3 TO LESS THAN -5	468	27.6	432	26.4	300	24.0	300	24.0		
	BETWEEN -3 AND +3	390	25.0	360	24.0	300	24.0	300	24.0		
	+3 TO LESS THAN +5	351	23.7	330	23.0	300	24.0	300	24.0		
60	-3 TO LESS THAN -5	468	27.6	432	26.4	300	24.0				
	BETWEEN -3 AND +3	390	25.0	360	24.0	300	24.0				
	+3 TO LESS THAN +5	351	23.7	330	23.0	300	24.0				
65	-3 TO LESS THAN -5	468	27.6	432	26.4						
	BETWEEN -3 AND +3	390	25.0	360	24.0						
	+3 TO LESS THAN +5	351	23.7	330	23.0						
70	-3 TO LESS THAN -5	468	27.6	432	26.4						
	BETWEEN -3 AND +3	390	25.0	360	24.0						
	+3 TO LESS THAN +5	351	23.7	330	23.0						
75	-3 TO LESS THAN -5	468	27.6								
	BETWEEN -3 AND +3	390	25.0								
	+3 TO LESS THAN +5	351	23.7								

NOT TO SCALE

INTERCHANGE



MINIMUM ENGLISH LENGTHS FOR PARALLEL EXIT RAMPS

RAMP DESIGN SPEED (MPH)	PERCENT GRADE OF THROUGH ROADWAY	TAPER=30:1 Δ=1°54′33″ ROADWAY DESIGN SPEED = 75 MPH Q = 23′ L_d min = 350′	TAPER=30:1 Δ=1°54′33″ ROADWAY DESIGN SPEED = 70 MPH Q = 23′ L_d min = 350′	TAPER=25:1 Δ=2°17′26″ ROADWAY DESIGN SPEED = 60 MPH Q = 24′ L_d min = 300′	TAPER=25:1 Δ=2°17′26″ ROADWAY DESIGN SPEED = 55 MPH TO 50 MPH Q = 24′ L_d min = 300′	TAPER=25:1 Δ=2°17′26″ ROADWAY DESIGN SPEED = 45 MPH OR LESS Q = 24′ L_d min = 300′
		L_d (FT)	L_d (FT)	L_d (FT)	L_d (FT)	L_d (FT)
20	-3 TO LESS THAN -5	744	684	576	528	390
	BETWEEN -3 AND +3	620	570	480	440	325
	+3 TO LESS THAN +5	558	513	432	396	300
25	-3 TO LESS THAN -5	720	660	552	492	354
	BETWEEN -3 AND +3	600	550	460	410	300
	+3 TO LESS THAN +5	540	495	414	369	300
30	-3 TO LESS THAN -5	690	624	516	456	300
	BETWEEN -3 AND +3	575	520	430	380	300
	+3 TO LESS THAN +5	518	468	387	342	300
35	-3 TO LESS THAN -5	642	588	486	420	300
	BETWEEN -3 AND +3	535	490	405	350	300
	+3 TO LESS THAN +5	482	441	365	315	300
40	-3 TO LESS THAN -5	588	528	420	342	300
	BETWEEN -3 AND +3	490	440	350	300	300
	+3 TO LESS THAN +5	441	396	315	300	300
45	-3 TO LESS THAN -5	528	468	360	300	300
	BETWEEN -3 AND +3	440	390	300	300	300
	+3 TO LESS THAN +5	396	351	300	300	300
50	-3 TO LESS THAN -5	468	432	300	300	
	BETWEEN -3 AND +3	390	360	300	300	
	+3 TO LESS THAN +5	351	350	300	300	
55	-3 TO LESS THAN -5	468	432	300	300	
	BETWEEN -3 AND +3	390	360	300	300	
	+3 TO LESS THAN +5	351	350	300	300	
60	-3 TO LESS THAN -5	468	432	300		
	BETWEEN -3 AND +3	390	360	300		
	+3 TO LESS THAN +5	351	350	300		
65	-3 TO LESS THAN -5	468	432			
	BETWEEN -3 AND +3	390	360			
	+3 TO LESS THAN +5	351	350			
70	-3 TO LESS THAN -5	468	432			
	BETWEEN -3 AND +3	390	360			
	+3 TO LESS THAN +5	351	350			
75	-3 TO LESS THAN -5	468				
	BETWEEN -3 AND +3	390				
	+3 TO LESS THAN +5	351				

Note: When an L_d value of 300′ is used for mainline design speeds of 60 mph and less, the parallel portion of the ramp is omitted, and the ramp taper connects directly with the mainline taper to form a uniform deflection (Δ).

NOT TO SCALE

NOTES:

1. The designer has the flexibility to choose the taper type ramp or the parallel type ramp. However, the same type of entrance and exit ramp should be used within an interchange and corridor. Uniformity in design is needed to aid driver expectancy. On sharp curves, it may be preferable to use parallel type ramp.

2. Select design speed based on a combination of the superelevation rate and the radius of the curve. See also chapter 3 of the MDOT Road Design Manual.

3. If an additional through lane is provided or the exit ramp leaves the mainline on the high side (outside) of the curve, use GEO-131-Series.

4. If the through pavement is curved, plot offsets for taper and connect with the appropriate curve.

5. Prepared detail grades and profiles from Section B-B through Section A-A.

6. Spirals transitions should be used on new ramp alignments based on the design speed of the curve and the radius as shown in the table of the Road Standard Plan R-107-Series. The table gives the maximum radius in which a spiral should be used.

7. The maximum algebraic difference in pavement cross slope between the mainline and the ramp auxiliary lane should not exceed 5%.

8. The cross slope in the gore area between the 2 ft (0.6m) point and the 22 ft (6.6 m) point should not exceed 8%, with a 6% maximum algebraic difference in cross slope between the gore and the adjacent paved lane. This algebraic difference also applies within crowned gores.

9. The design speed of the ramp vertical alignment should meet or exceed the design speed of the ramp horizontal alignment.

10. The mainline shoulder width should extend along the ramp to where the gore is 2 ft (0.6 m) wide. Use a 1:25 taper transition where it joins the ramp shoulder paving.

11. Each ramp will be carefully studied to provide maximum vision at its merge points. See Geometric Design Guide Geo-300-Series.

12. Caution must be used in positioning a taper type deceleration lane on a left turning highway. The exit should begin before or after the P.C. or S.T. to avoid having the appearance of an extension of the mainline to the motorist. Consider using a parallel type deceleration lane.

13. The sight distance in advance of the exit ramp gore should be at least 25% longer than the minimum stopping sight distance for the design speed of the mainline.

14. These design concepts are for new construction. Where modification may be needed for retrofitting to existing road features, consult with the Geometric Design Unit of Lansing Traffic and Safety.

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION TRAFFIC AND SAFETY GEOMETRIC DESIGN GUIDE		08/07/2008	GEO-130-D	SHEET
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INTERCHANGE

Upgrading Existing One-Lane ENTRANCE Ramps on "3R" Freeway Projects

Tapered GEO-100

(Meet L_a and L_{gap})

Locate 12' Width Point

Stub on Length of Parallel 12' Lane as Needed to Achieve Required L_a and L_{gap} Distances

Add 300' Closing Taper

Parallel GEO-101

(Meet L_a and L_{gap})

Locate End of 12' Parallel Lane

Stub on Length of Parallel 12' Lane as Needed to Achieve Required L_a and L_{gap} Distances

Add 300' Closing Taper

INTERCHANGE

Upgrading Existing One-Lane EXIT Ramps on "3R" Freeway Projects

Tapered GEO-130

(Meet L_d)

Locate 12' Width Point

Stub on Length of Parallel 12' Lane as Needed to Achieve Required L_d Distance

Add 300' Opening Taper

Parallel GEO-131

(Meet L_d)

Locate End of 12' Parallel Lane

Stub on Length of Parallel 12' Lane as Needed to Achieve Required L_d Distance

Add 300' Opening Taper

INTERCHANGE

US Customary										
Highway design speed (mph)	30	35	40	45	50	55	60	65	70	75
Ramp design speed (mph)										
Upper range (85%)	25	30	35	40	45	48	50	55	60	65
Middle range (70%)	20	25	30	33	35	40	45	45	50	55
Lower range (50%)	15	18	20	23	25	28	30	30	35	40
Corresponding minimum radius (ft)	To Determine Minimum Radius and Design Speed of Ramp See Standard Plan R-107 or Straight Line Chart									

Exhibit 10-56. Guide Values for Ramp Design Speed as Related to Highway Design Speed

INTERCHANGE

12’ Width Entrance and Exit Slip Ramps

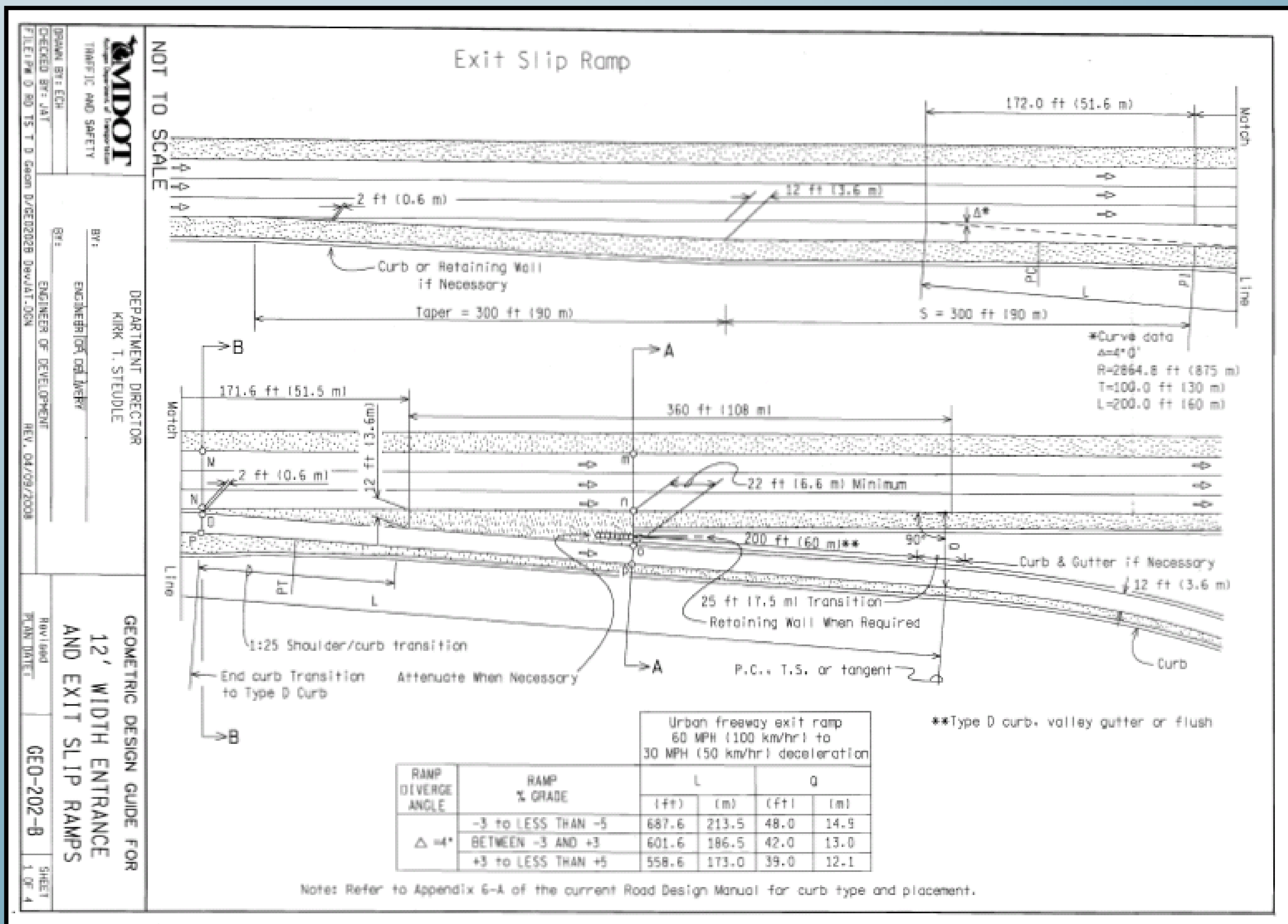
Slip Ramps Connect a Freeway to a Parallel Service Road Not a Perpendicular Crossroad

Only for Use on True “Urban” Freeways

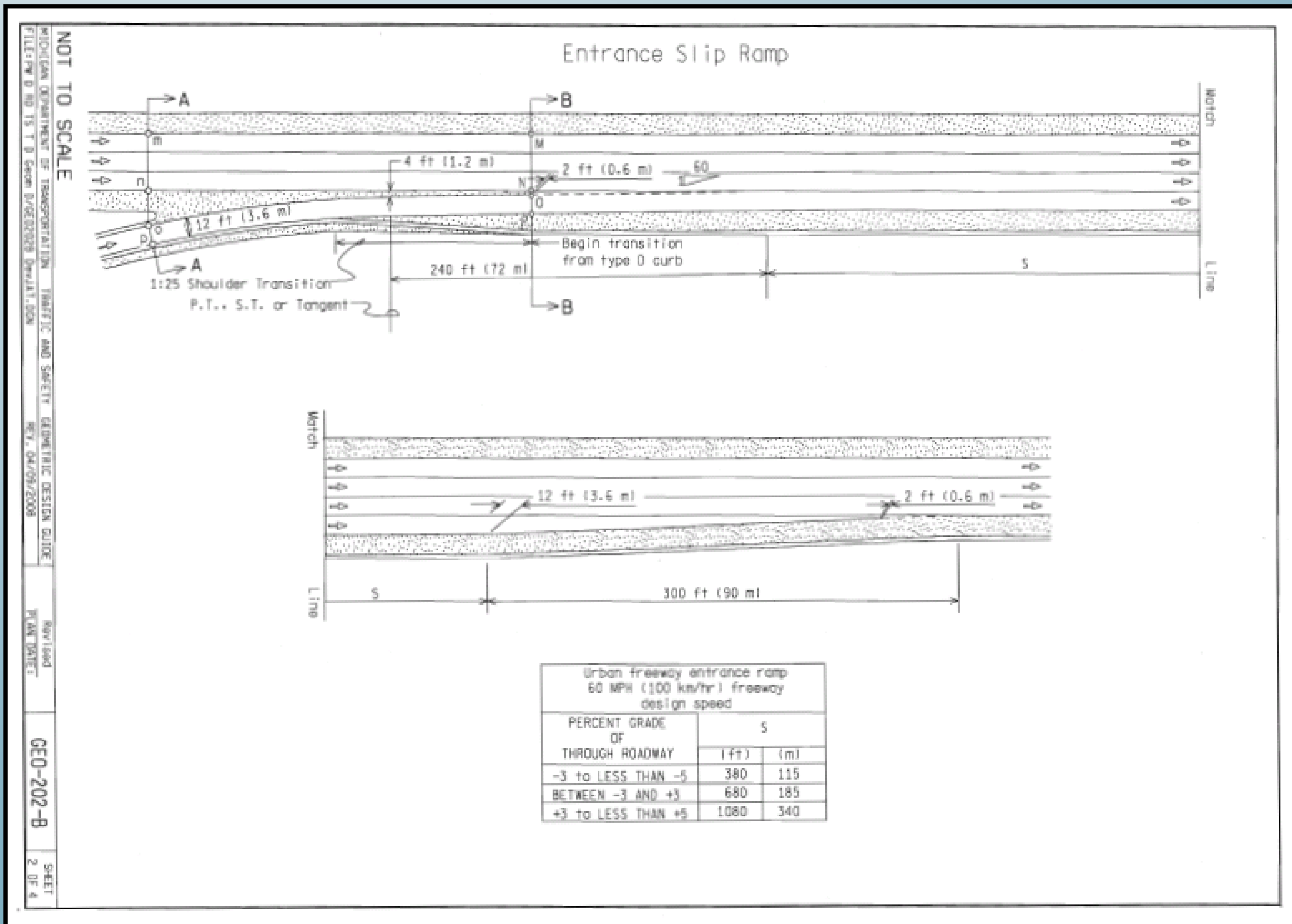
Maximum Design Speed 60 mph

Minimum Radii of 1145’ (Maximum Curvature of 5°) for Any Horizontal Curves

INTERCHANGE



INTERCHANGE



PERCENT GRADE OF THROUGH ROADWAY	S (ft)	S (m)
-3 to LESS THAN -5	380	115
BETWEEN -3 AND +3	680	185
+3 to LESS THAN +5	1080	340

NOTES:

1. Select design speed based on a combination of the superelevation rate and the radius of the curve. See also chapter 3 of the MDOT Road Design Manual.

2. If an additional through lane is provided or the entrance ramp joins the mainline on the high side (outside) of the curve, use GEO-101-Series.

3. If the through pavement is curve, plot offsets for taper and connect with appropriate curve.

4. Prepare detail grades and profiles from Section A-A to Section B-B.

5. A curve on the exit ramp beyond the gore may be introduced when necessary but should have a 1145 ft (350m) minimum radius for slip exit ramps.

6. A parallel entrance acceleration lane length "S" of at least 1080' (324 m), plus taper, is desirable wherever it is anticipated that the ramp and freeway will carry traffic volumes approximately equal to the design capacity of the merging area.

7. Spirals transition should be used on new ramp alignments based on the design speed of the curve and the radius as shown in the table of the Road Standard Plan R-107-Series. The table gives the Maxium radius in which a spiral should be used.

8. The maximum algebraic difference in pavement cross slope between the mainline and the ramp auxiliary lane should not exceed 5%.

9. Superelevation should conform to Standard Plan R-107-Series. The maximum rate of superelevation for ramp curves should be 5%.

10. The cross slope in the gore area between the 2 ft (0.6m) point and the 22 ft (6.6 m) point should not exceed 8%, with a 6% maximum algebraic difference in cross slope between the gore and the adjacent paved lane. The algebraic difference also applies within crowned gores.

11. The design speed of the ramp vertical alignment should meet or exceed the design speed of the ramp horizontal alignment.

12. The mainline shoulder width should extend along the ramp to where the gore is 2 ft (0.6 m) wide. Use a 1:25 taper transition where it joins the ramp shoulder paving.

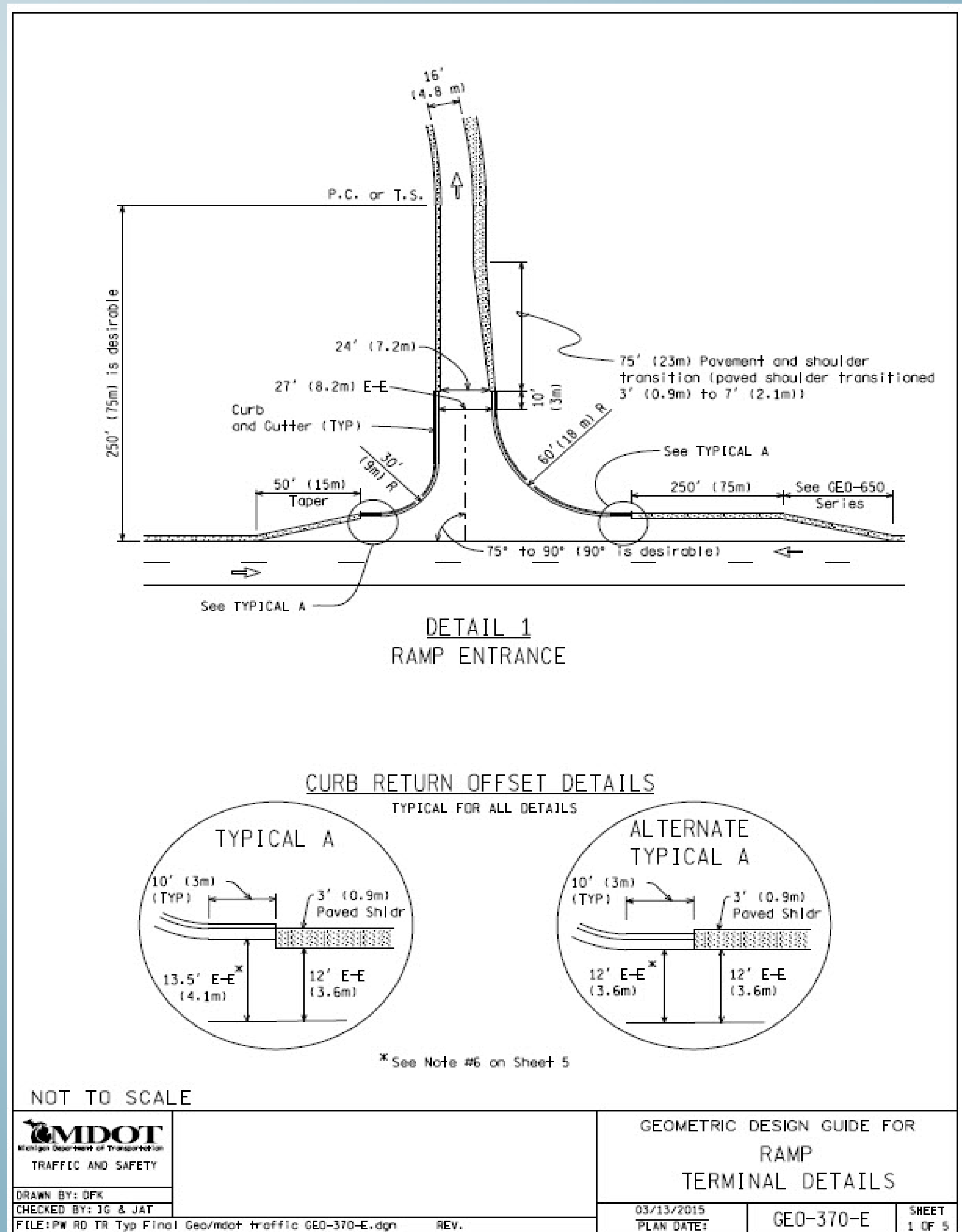
13. Each ramp should be carefully studied to provide maximum vision at their merge points. See Geometric Design Guide GEO-300-Series.

14. The sight distance in advance of the exit ramp gore should be at least 25% longer than the minimum stopping sight distance for the design speed of the mainline.

15. These design concepts are for new construction. Where modifications are needed for retrofitting to existing road features, consult the Geometric Design Unit of Lansing Traffic and Safety.

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION TRAFFIC AND SAFETY GEOMETRIC DESIGN GUIDE	Revised	GEO-202-B	SHEET
FILE:PW D RD TS T D Geom D/GEO202B DevJAT.DGN REV. 04/29/2008	PLAN DATE:		4 OF 4


16'
(4.8 m)
P.C. or T.S.
250' (75m) is desirable
24' (7.2m)
27' (8.2m) E-E
Curb
and Gutter (TYP)
75' (23m) Pavement and shoulder
transition (paved shoulder transitioned
3' (0.9m) to 7' (2.1m))
10'
(3m)
60' (18 m) R
30'
(9m) R
See TYPICAL A
50' (15m)
Taper
250' (75m)
See GEO-650
Series
75° to 90° (90° is desirable)
See TYPICAL A
DETAIL 1
RAMP ENTRANCE
CURB RETURN OFFSET DETAILS
TYPICAL FOR ALL DETAILS
TYPICAL A
10' (3m)
(TYP)
3' (0.9m)
Paved Shldr
13.5' E-E*
(4.1m)
12' E-E
(3.6m)
ALTERNATE
TYPICAL A
10' (3m)
(TYP)
3' (0.9m)
Paved Shldr
12' E-E*
(3.6m)
12' E-E
(3.6m)
* See Note #6 on Sheet 5
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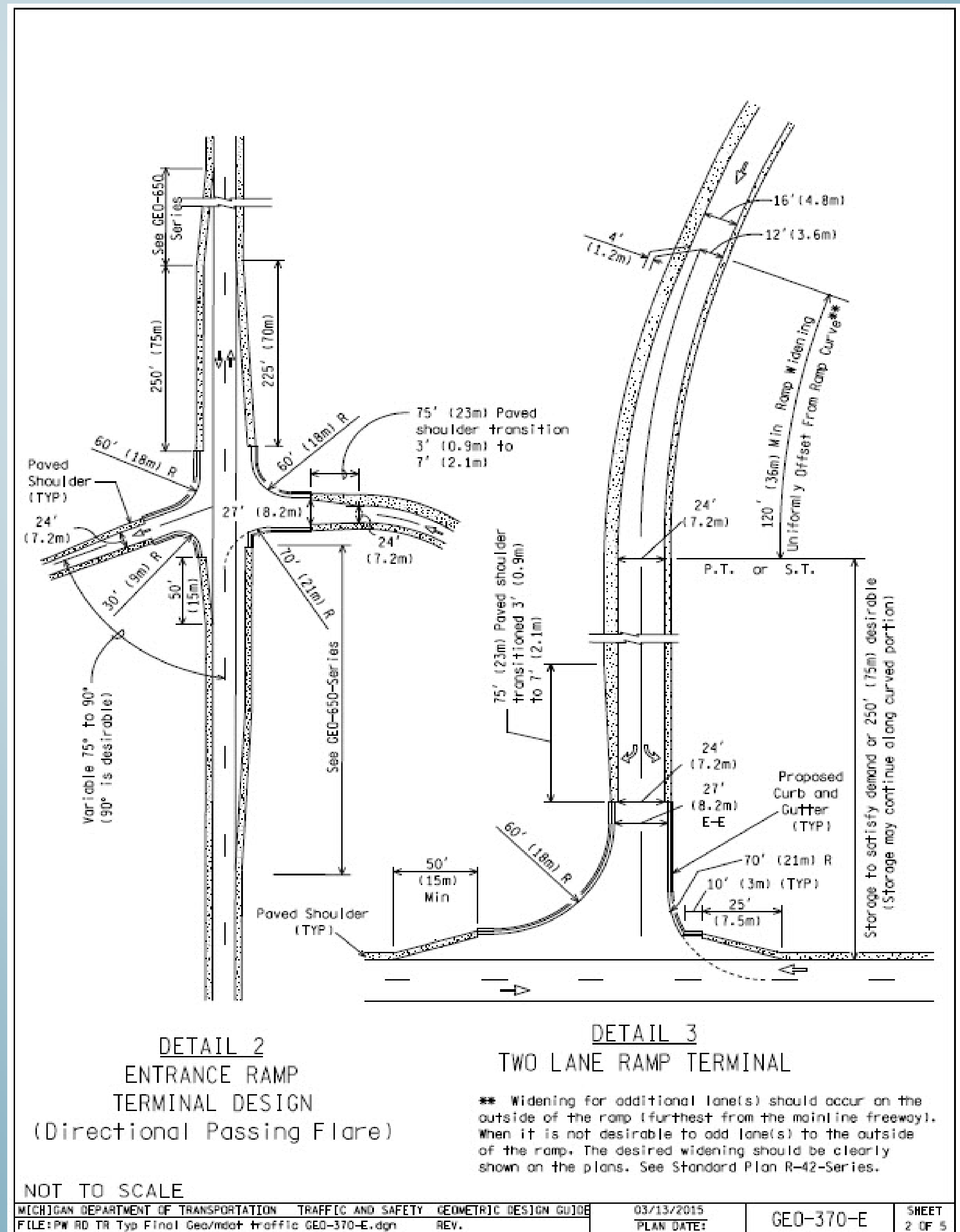
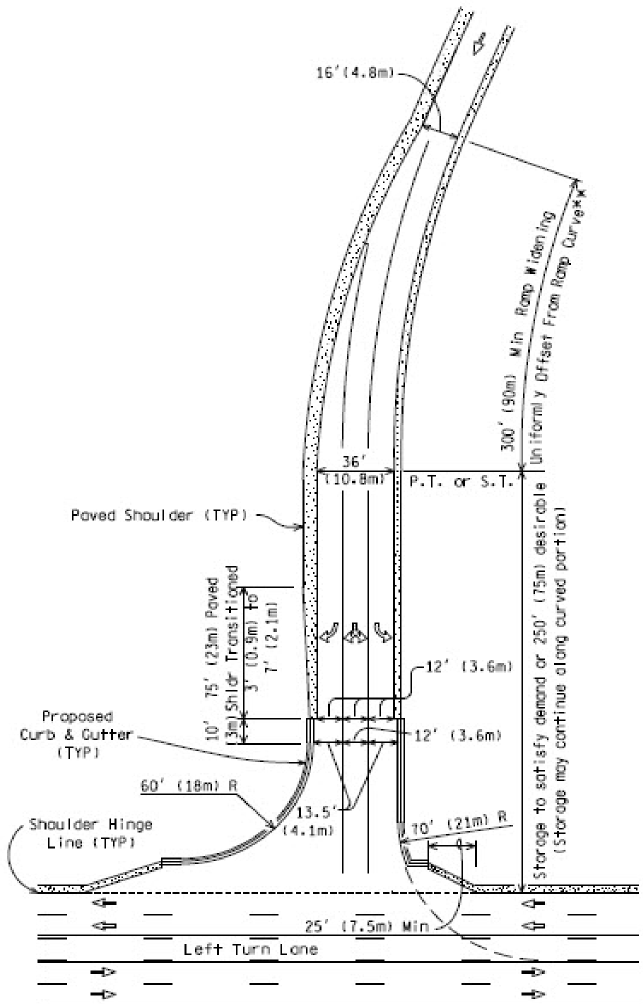
MDOT
Michigan Department of Transportation
TRAFFIC AND SAFETY
DRAWN BY: DFK
CHECKED BY: JG & JAT
FILE: PW RD TR Typ Final Geo/mdot traffic GEO-370-E.dgn
REV.
GEOMETRIC DESIGN GUIDE FOR
RAMP
TERMINAL DETAILS
03/13/2015
PLAN DATE:
GEO-370-E
SHEET
1 OF 5


See GEO-650 Series
250' (75m)
225' (70m)
60' (18m) R
Paved Shoulder (TYP)
24' (7.2m)
27' (8.2m)
75' (23m) Paved shoulder transition 3' (0.9m) to 7' (2.1m)
24' (7.2m)
30' (9m) R
50' (15m)
70' (21m) R
See GEO-650-Series
Variable 75° to 90° (90° is desirable)
16' (4.8m)
12' (3.6m)
4' (1.2m)
120' (36m) Min Ramp Widening Uniformly Offset From Ramp Curve**
24' (7.2m)
P.T. or S.T.
75' (23m) Paved shoulder transitioned 3' (0.9m) to 7' (2.1m)
Storage to satisfy demand or 250' (75m) desirable (Storage may continue along curved portion)
24' (7.2m)
27' (8.2m) E-E
Proposed Curb and Gutter (TYP)
70' (21m) R
10' (3m) (TYP)
25' (7.5m)
60' (18m) R
50' (15m) Min
Paved Shoulder (TYP)
DETAIL 2
ENTRANCE RAMP TERMINAL DESIGN
(Directional Passing Flare)
DETAIL 3
TWO LANE RAMP TERMINAL
** Widening for additional lane(s) should occur on the outside of the ramp (furthest from the mainline freeway). When it is not desirable to add lane(s) to the outside of the ramp. The desired widening should be clearly shown on the plans. See Standard Plan R-42-Series.
NOT TO SCALE
MICHIGAN DEPARTMENT OF TRANSPORTATION TRAFFIC AND SAFETY GEOMETRIC DESIGN GUIDE
FILE: PW RD TR Typ Final Geo/mdot traffic GEO-370-E.dgn
REV.
03/13/2015
PLAN DATE:
GEO-370-E
SHEET 2 OF 5



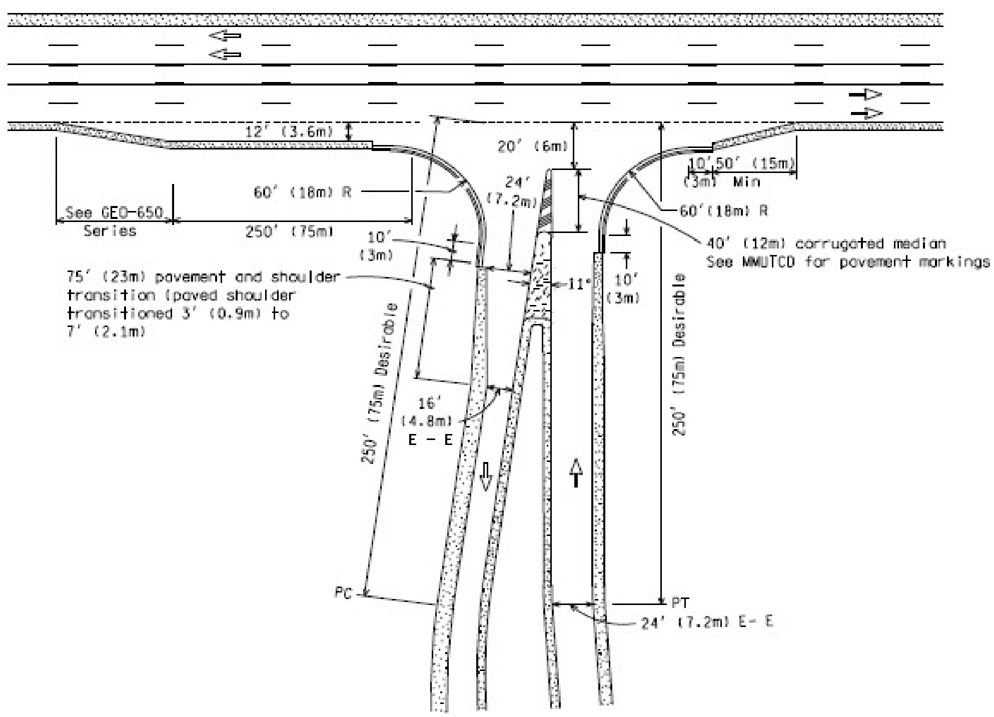
DETAIL 4

THREE LANE RAMP TERMINAL

** Widening for additional lane(s) should occur on the outside of the ramp (furthest from the mainline freeway). When it is not desirable to add lane(s) to the outside of the ramp, the desired widening should be clearly shown on the plans. See also Standard Plan R-42-Series.

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION TRAFFIC AND SAFETY GEOMETRIC DESIGN GUIDE	03/13/2015	GEO-370-E	SHEET
FILE: PW RD TR Typ Final Geo/mdot traffic GEO-370-E.dgn REV.	PLAN DATE:		3 OF 5



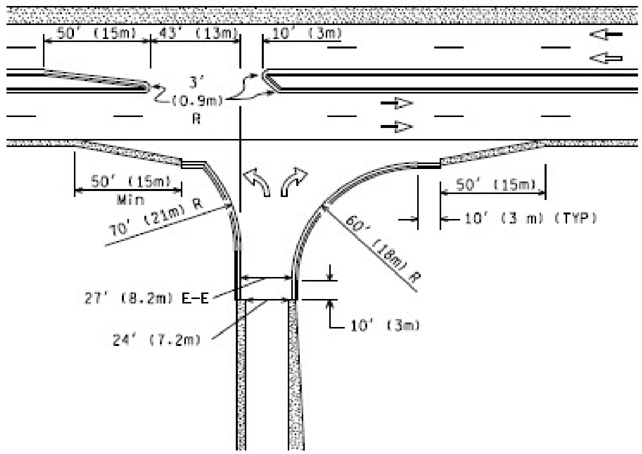
At unsignalized ramp terminals, it is desirable to redirect the left turns right from the ramp to an adjacent directional crossover when the median width can accommodate truck traffic (WB-65).

DETAIL 5

PARCLO ENTRANCE AND EXIT TERMINAL

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION TRAFFIC AND SAFETY GEOMETRIC DESIGN GUIDE	03/13/2015	GEO-370-E	SHEET
FILE: PW RD TR Typ Final Geo/mdot traffic GEO-370-E.dgn REV.	PLAN DATE:		4 OF 5



DETAIL 6

CURBED MEDIAN DETAIL

NOTES:

1. The dimensions used on this Geometric Design Guide are typical.

2. Where feasible, joint line and lane line markings shall coincide.

3. See Standard Plan R-42-Series for joint layout.

4. Clear vision areas and sight distance along the ramp and its terminals must be according to current MDOT practice. No hidden ramp or disappearing crossroad grades will be permitted.

5. Provide intersection sight distance at all exit ramp terminals.

6. Alternate Typical A may be used when construction and maintenance issues make the 13.5' (4.1m) curb setback undesirable or the crossroad is curbed.

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION TRAFFIC AND SAFETY GEOMETRIC DESIGN GUIDE	03/13/2015	GEO-370-E	SHEET
FILE:PW RD TR Typ Final Geo/mdot traffic GEO-370-E.dgn REV.	PLAN DATE:		5 OF 5

CLEAR VISION AREAS

- Geometric Design Guidance 1.1.3
- Geometric Design Guide GEO-300-D
- Ramps
- Crossroad
- Terminals
- Merge/Diverge Areas

1.1.3 Clear Vision Areas

In order to enhance the safe and efficient movement of traffic, the acquisition of certain properties (or portions thereof) at intersections sometimes is necessary. The following guidelines should be followed.

Clear vision areas will be obtained at all at-grade intersections of trunklines with other roads or streets in rural areas including freeway ramps. Interchange ramps are considered trunkline.

Clear vision areas will not be obtained within urban areas as determined by the Bureau of Transportation Planning's urban area boundary description and map. Clear vision areas will not be obtained within rural areas contiguous to sections of trunkline where urban conditions exist to the extent that 50 percent or more of the trunkline frontage is occupied by residential, business, or industrial development.

The Region/TSC Traffic and Safety Representative reviews each case from a traffic operational and safety standpoint and recommends one of the following courses of action: acquire all or part of area, defer acquisition in particular quadrant to future date, or eliminate all clear vision.

For additional information and guidance regarding clear vison areas, please refer to MDOT Geometric Design Guide GEO-300 and the Michigan Road Design Manual, Chapter 5, Right Of Way.

CLEAR VISION AREAS

1.1.3 Clear Vision Areas

In order to enhance the safe and efficient movement of traffic, the acquisition of certain properties (or portions thereof) at intersections sometimes is necessary. The following guidelines should be followed.

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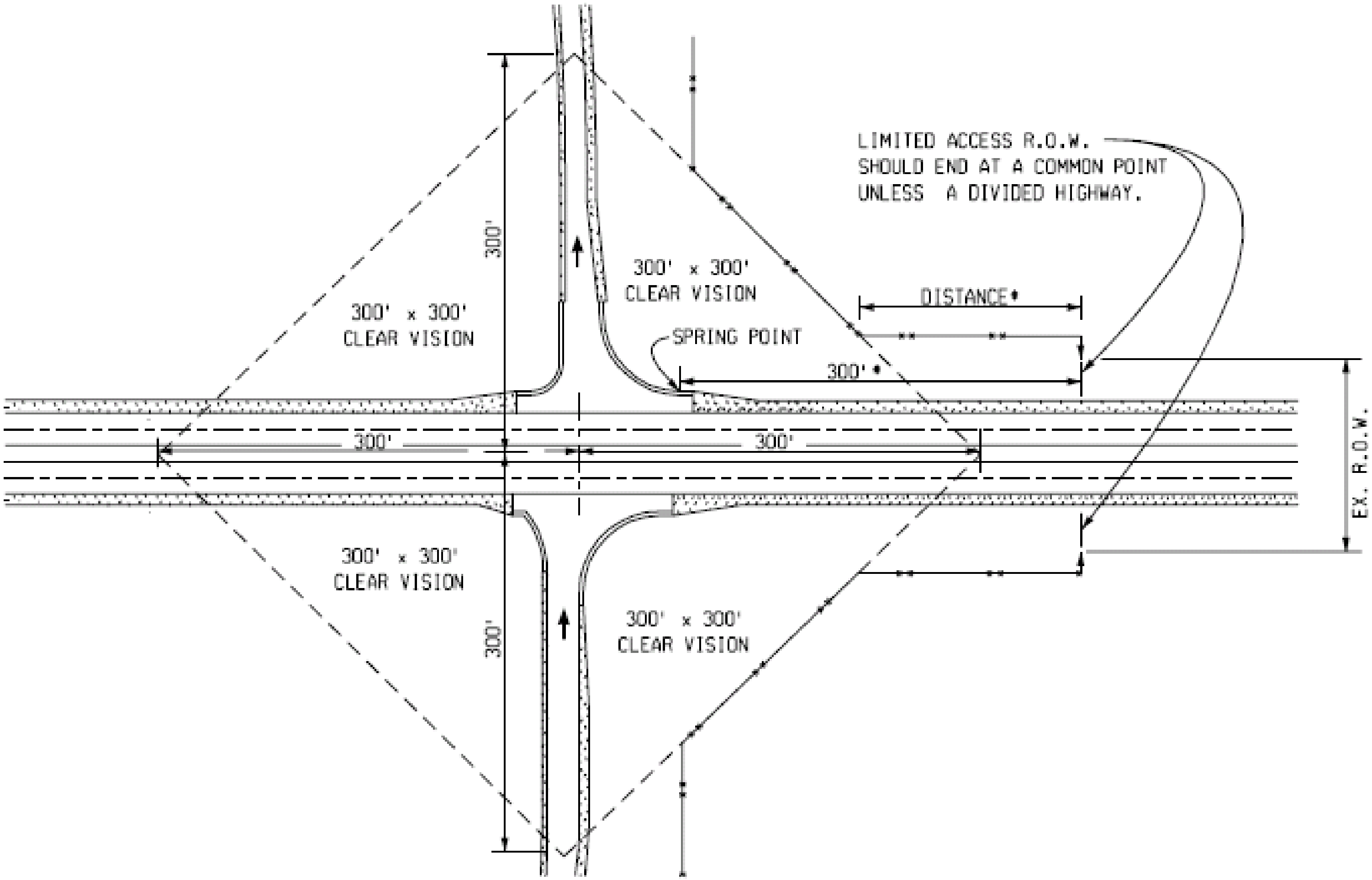
L.A. ROW & CLEAR VISION AREAS



* LIMITED ACCESS RIGHT-OF-WAY TO THE END OF THE RIGHT TURN TAPER OR 300' MINIMUM FROM THE SPRINGPOINT, IF THERE IS NO DECELERATION LANE.

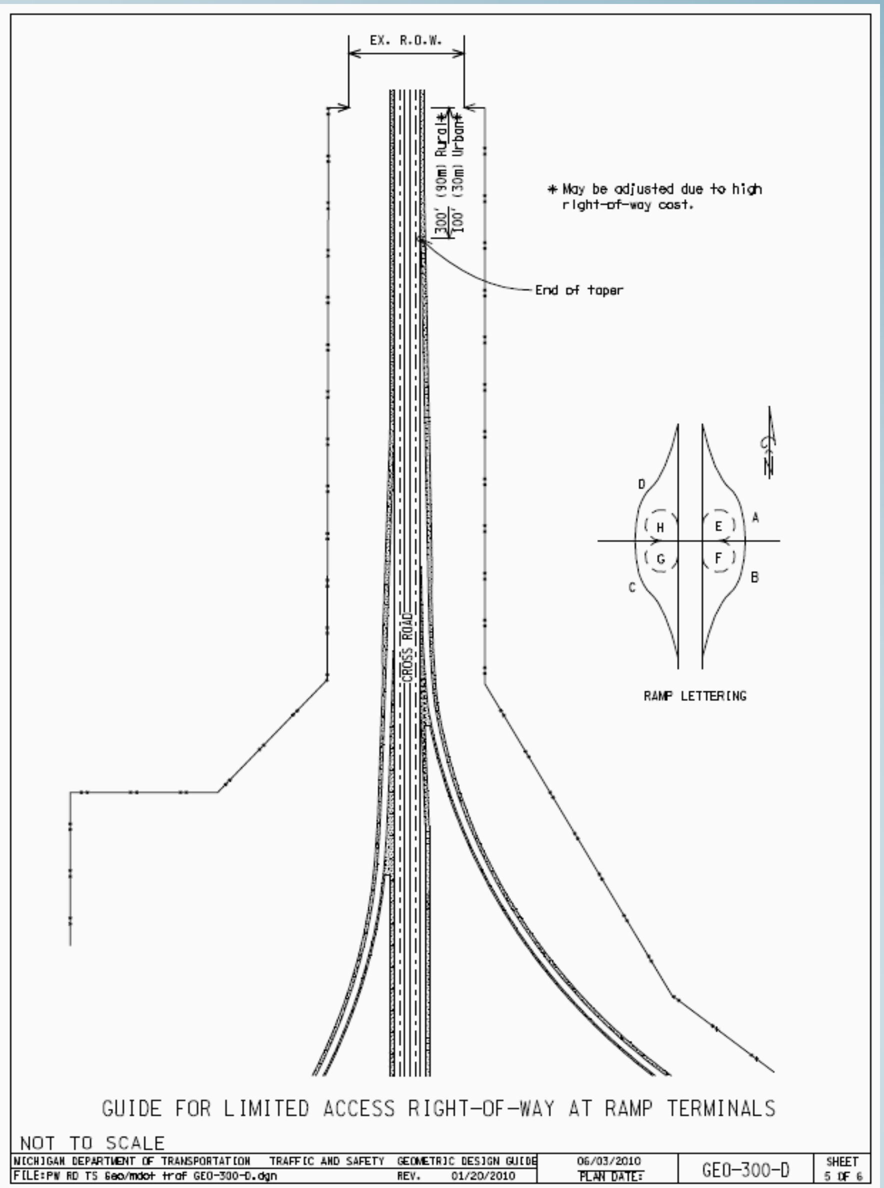
MAY BE ADJUSTED DUE TO HIGH RIGHT-OF-WAY COST. CONSULT THE GEOMETRIC DESIGN UNIT OF TRAFFIC AND SAFETY IF ADJUSTMENTS ARE NECESSARY.

SEE GEOMETRIC DESIGN GUIDE VII-370 SERIES FOR GUIDANCE ON INTERSECTION SIGHT DISTANCE.

L.A. ROW & CLEAR VISION AREAS

GEO-300-D

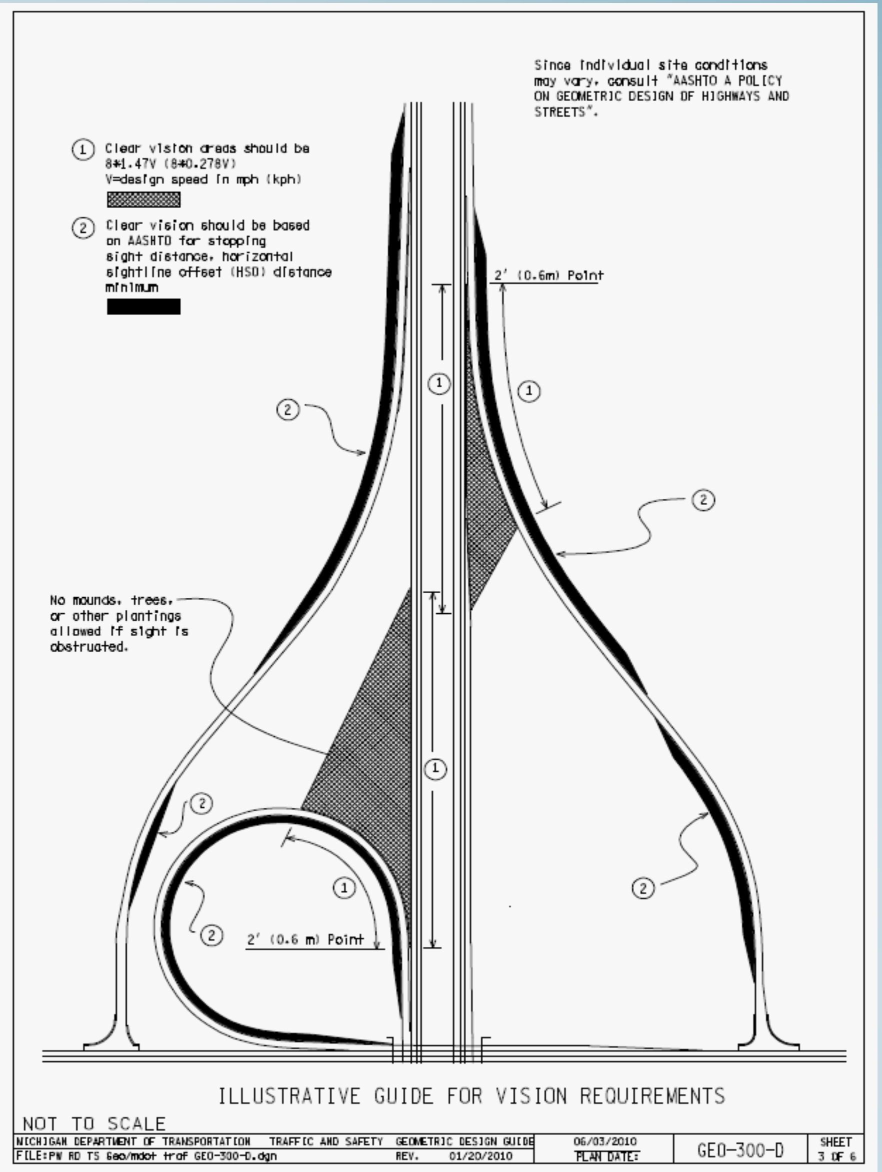
(Sheet 5 of 6)



L.A. ROW & CLEAR VISION AREAS

GEO-300-D

(Sheet 3 of 6)



QUESTIONS

INTERSECTION DESIGN

INTERSECTIONS

- **Intersection** – The general area where two or more roadways join or cross, including the roadway and roadside facilities for traffic movements within the area.

INTERSECTIONS

Types

T - Three Leg

4 – Leg

Multi-Leg

INTERSECTIONS

Provide Ease/Control of Access Consistent with the Function of Intersecting Roadways

The…

Efficiency
Safety
Speed
Delay
Capacity

…of the Facility Depend on the Design

INTERSECTION DESIGN ELEMENTS

Human Factors

Traffic Considerations

Physical Elements

Economic Factors

Functional Areas

Number of Conflict Points

INTERSECTIONS

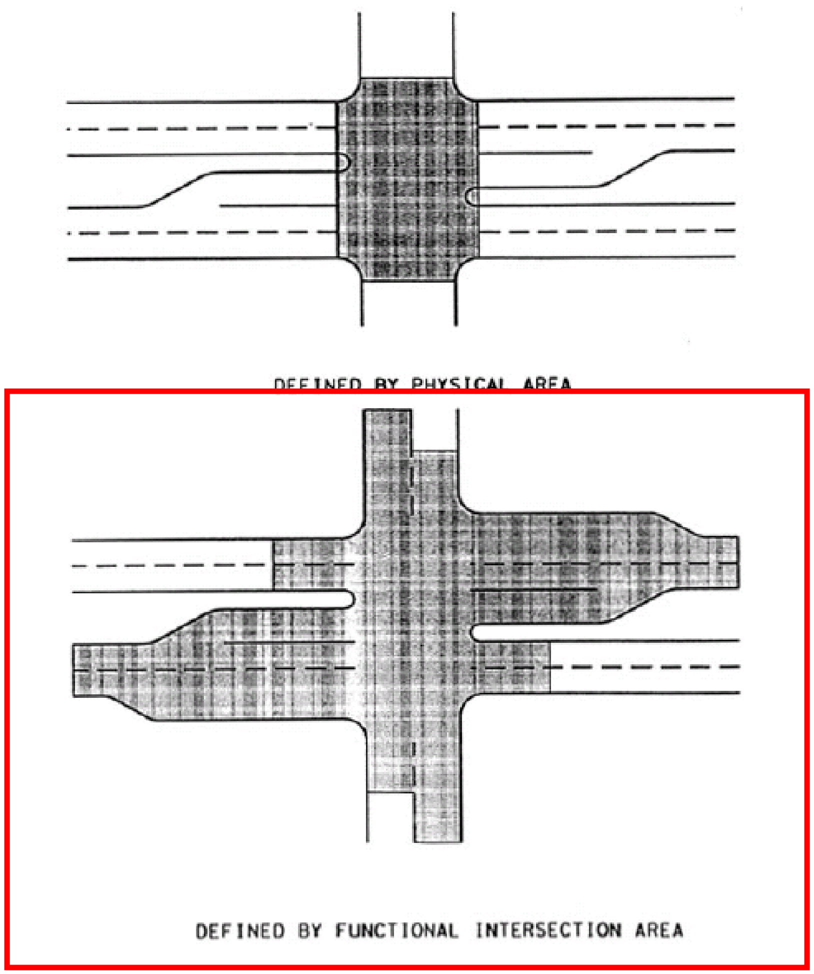


Exhibit 9-1. Physical and Functional Intersection Area

Keep

Access Points

Out of

Functional

Intersection

Area

INTERSECTIONS

Intersecting Roads Should Meet At Right Angles

75° to 105° Desirable

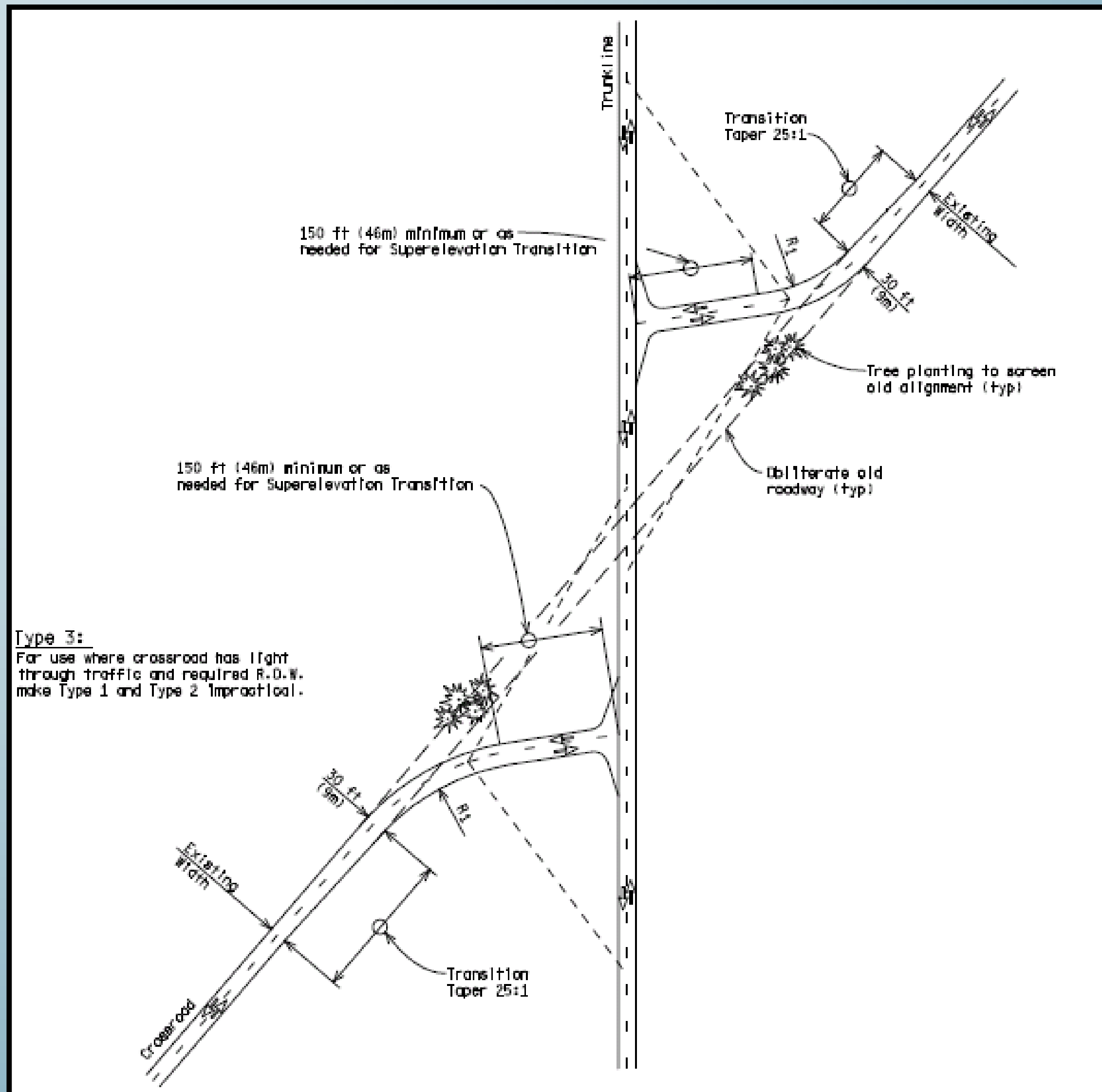
Side Roads

Landings ≤ 2%

Adequate ISD & Clear Vision Corners Should be Provided

TURNED IN ROADWAYS

GEO-640



TRAFFIC AND SAFETY NOTE 612A

SUBJECT: **Clear Vision Areas**

PURPOSE: **Provide Guidance on When to Obtain Clear Vision Areas**

COORDINATING UNIT: **Geometric Design Unit**

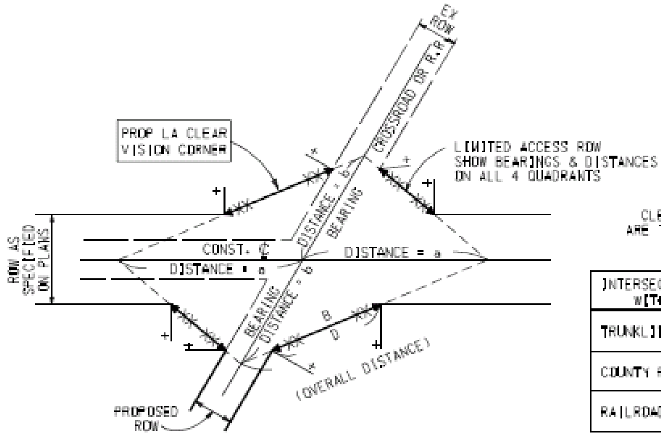
INFORMATION: In order to enhance the safe and efficient movement of traffic, the acquisition of certain properties, or portions thereof, at intersections sometimes is necessary. The following guidelines should be followed.

Clear vision areas will be obtained at all at-grade intersections of trunklines with other roads or streets in rural areas including freeway ramps. Interchange ramps are considered trunkline.

Clear vision areas will not be obtained within urban areas as determined by the Bureau of Transportation Planning's urban area boundary description and map. Clear vision areas will not be obtained within rural areas contiguous to sections of trunkline where urban conditions exist to the extent that 50 percent or more of the trunkline frontage is occupied by residential, business, or industrial development.

The Region/TSC Traffic and Safety Representative reviews each case from a traffic operational and safety standpoint and recommends one of the following courses of action: acquire all or part of area, defer acquisition in particular quadrant to future date, or eliminate all clear vision.

INTERSECTIONS



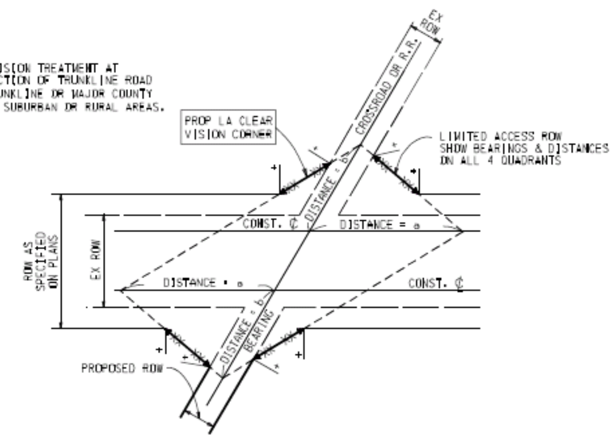
FOR SINGLE ROADWAY

CLEAR VISION CORNERS ARE TO BE LIMITED ACCESS

INTERSECTION WITH	LOCATION	a	b
TRUNKLINE	RURAL	300'	300'
COUNTY ROAD	RURAL	300'	200'
RAILROAD	RURAL	*	*

* REFER TO THE TRUNKLINE RAILROAD CROSSING UNIT OF THE DESIGN DIVISION

CLEAR VISION TREATMENT AT INTERSECTION OF TRUNKLINE ROAD WITH TRUNKLINE OR MAJOR COUNTY ROAD IN SUBURBAN OR RURAL AREAS.

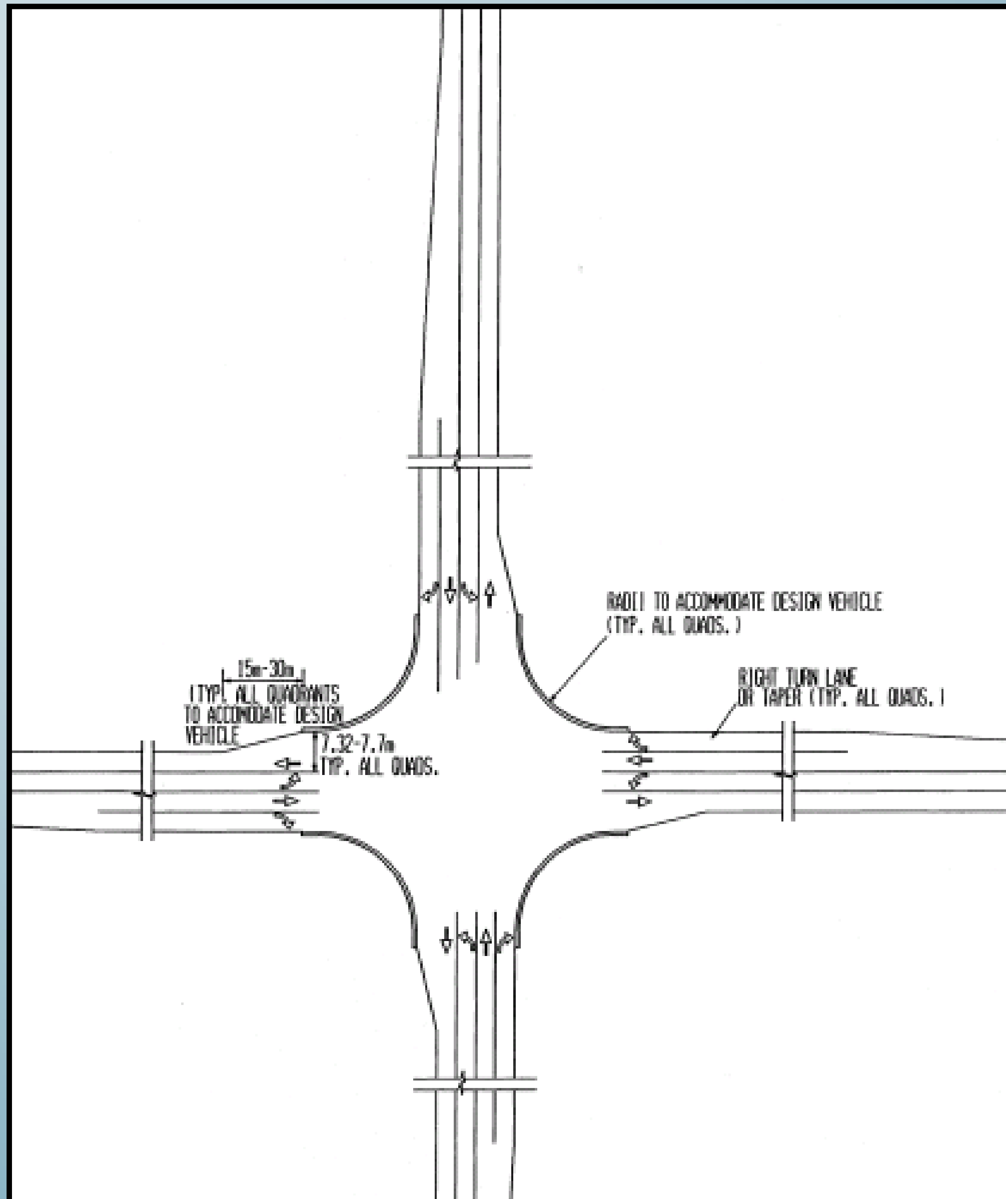


FOR DUAL ROADWAY

SKETCHES SHOWING DIMENSIONS FOR CLEAR VISION AREAS

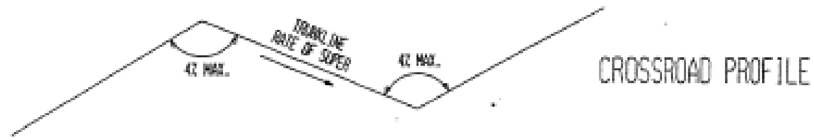
Figure 5.24.03

INTERSECTIONS

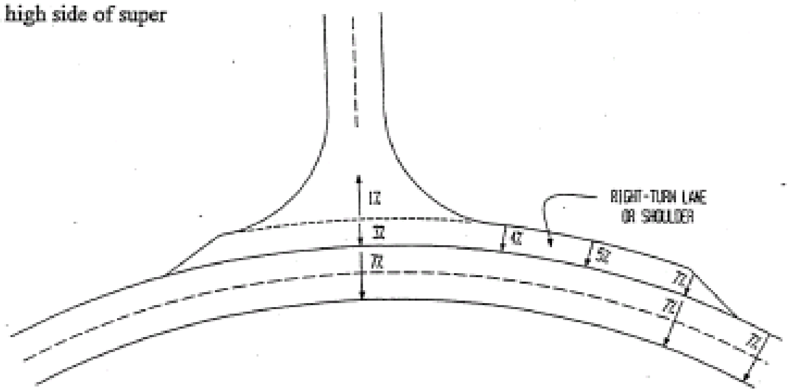


Treating superelevation/intersection conflicts:

Assuming it is unfeasible to include proper crossroad work per G-650 by using vertical curves, the maximum algebraic difference in cross-slope at a crossroad should be 4%, to prevent vehicle snagging or bottoming out.



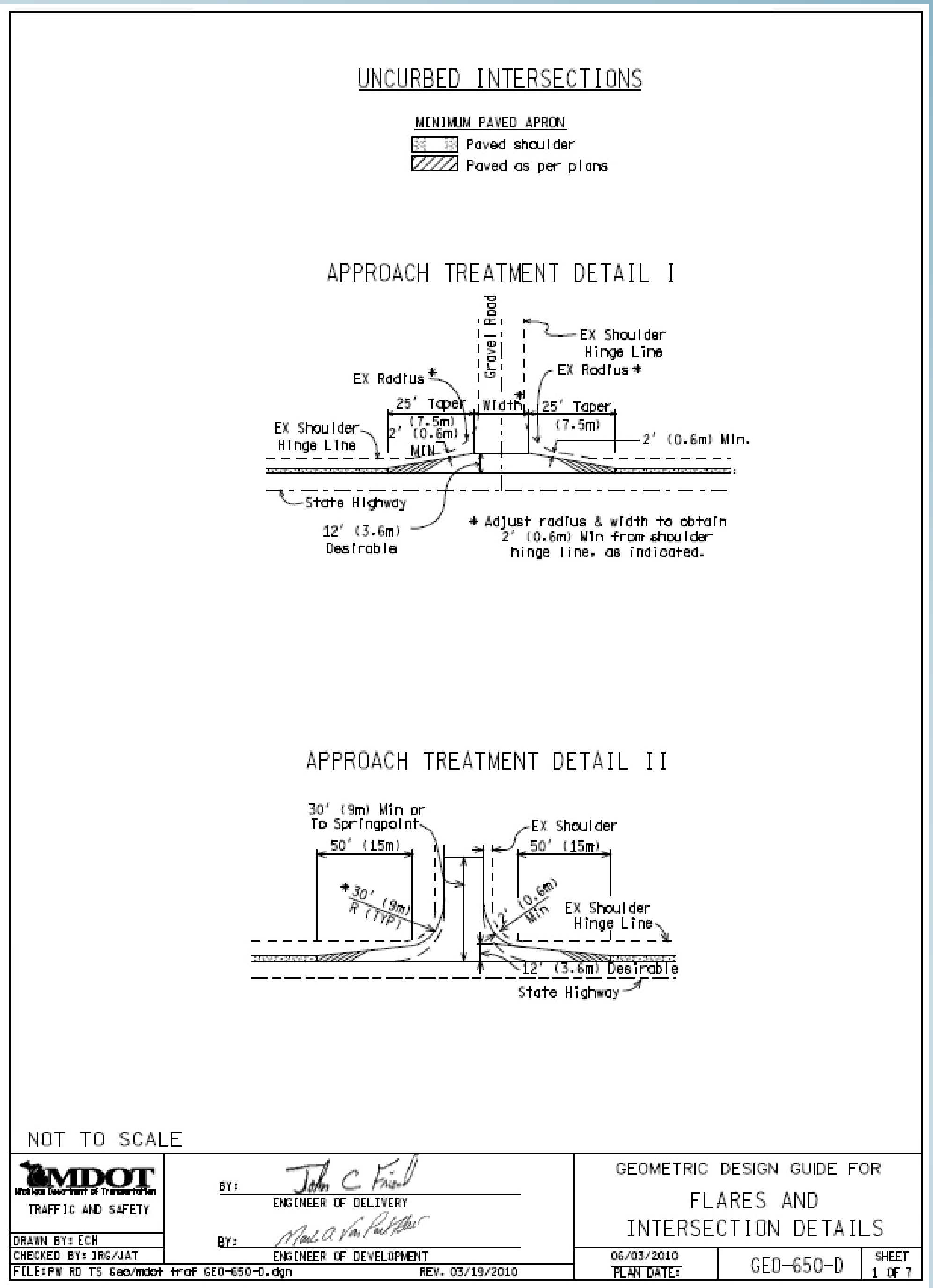
Example:
Trunkline superelevation = 7%
T-intersection
Crossroad on high side of super



1. Prior to the intersection, transition down the right turn lane or shoulder at the same delta % as the trunkline.
2. Reverse the process beyond the intersection.

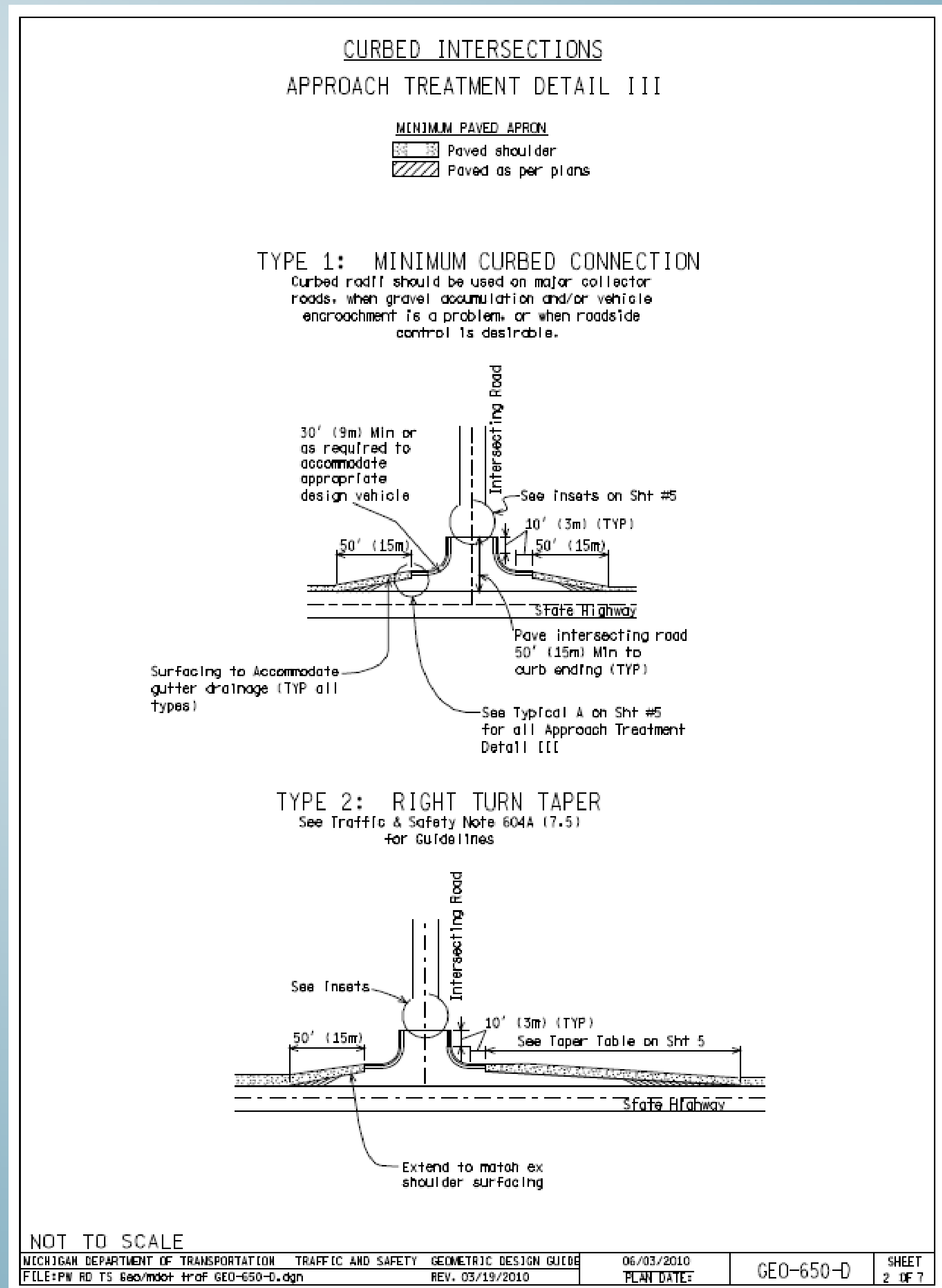
Points of consideration:
1. Is the existing super on the trunkline parabolic?
2. How much of a grade raise is expected on the high side to upgrade the super to R-107 or the Straight Line chart?
3. How far down will work have to occur on the crossroad in order to tie-in to the mainline properly?
4. Are excessive intersection breaks (>4% on both the high side and low side) being created due to the super upgrade?
5. What impact will a large grade raise have on nearby ditches, sidewalks, or sideslopes?
6. Four leg intersection - ensure adequate sight distance is available over the high side of super for vehicles turning left out of either side of the crossroad and for thru vehicles on the trunkline to see approaching crossroad vehicles. *This is especially critical at intersections that are signalized or will have future signalization.*

GEO-650



UNCURBED INTERSECTIONS
MINIMUM PAVED APRON
Paved shoulder
Paved as per plans
APPROACH TREATMENT DETAIL I
Gravel Road
EX Shoulder Hinge Line
EX Radius *
EX Radius *
25' Taper (7.5m)
Width *
25' Taper (7.5m)
EX Shoulder Hinge Line
2' (0.6m) MIN
2' (0.6m) Min.
State Highway
12' (3.6m) Desirable
* Adjust radius & width to obtain 2' (0.6m) Min from shoulder hinge line, as indicated.
APPROACH TREATMENT DETAIL II
30' (9m) Min or To Springpoint
EX Shoulder
50' (15m)
50' (15m)
* 30' (9m) R (TYP)
2' (0.6m) Min
EX Shoulder Hinge Line
12' (3.6m) Desirable
State Highway
NOT TO SCALE
MDOT
Michigan Department of Transportation
TRAFFIC AND SAFETY
BY:
ENGINEER OF DELIVERY
BY:
ENGINEER OF DEVELOPMENT
DRAWN BY: ECH
CHECKED BY: JRG/JAT
FILE: PW RD TS Geo/mdot traf GEO-650-D.dgn
REV. 03/19/2010
GEOMETRIC DESIGN GUIDE FOR
FLARES AND INTERSECTION DETAILS
06/03/2010
PLAN DATE:
GEO-650-D
SHEET 1 OF 7

GEO-650


CURBED INTERSECTIONS
APPROACH TREATMENT DETAIL III
MINIMUM PAVED APRON
Paved shoulder
Paved as per plans
TYPE 1: MINIMUM CURBED CONNECTION
Curbed radii should be used on major collector roads, when gravel accumulation and/or vehicle encroachment is a problem, or when roadside control is desirable.
Intersecting Road
30' (9m) Min or as required to accommodate appropriate design vehicle
See insets on Sht #5
10' (3m) (TYP)
50' (15m)
50' (15m)
State Highway
Pave intersecting road 50' (15m) Min to curb ending (TYP)
Surfacing to Accommodate gutter drainage (TYP all types)
See Typical A on Sht #5 for all Approach Treatment Detail III
TYPE 2: RIGHT TURN TAPER
See Traffic & Safety Note 604A (7.5) for Guidelines
Intersecting Road
See Insets
10' (3m) (TYP)
50' (15m)
See Taper Table on Sht 5
State Highway
Extend to match ex shoulder surfacing
NOT TO SCALE
MICHIGAN DEPARTMENT OF TRANSPORTATION TRAFFIC AND SAFETY GEOMETRIC DESIGN GUIDE
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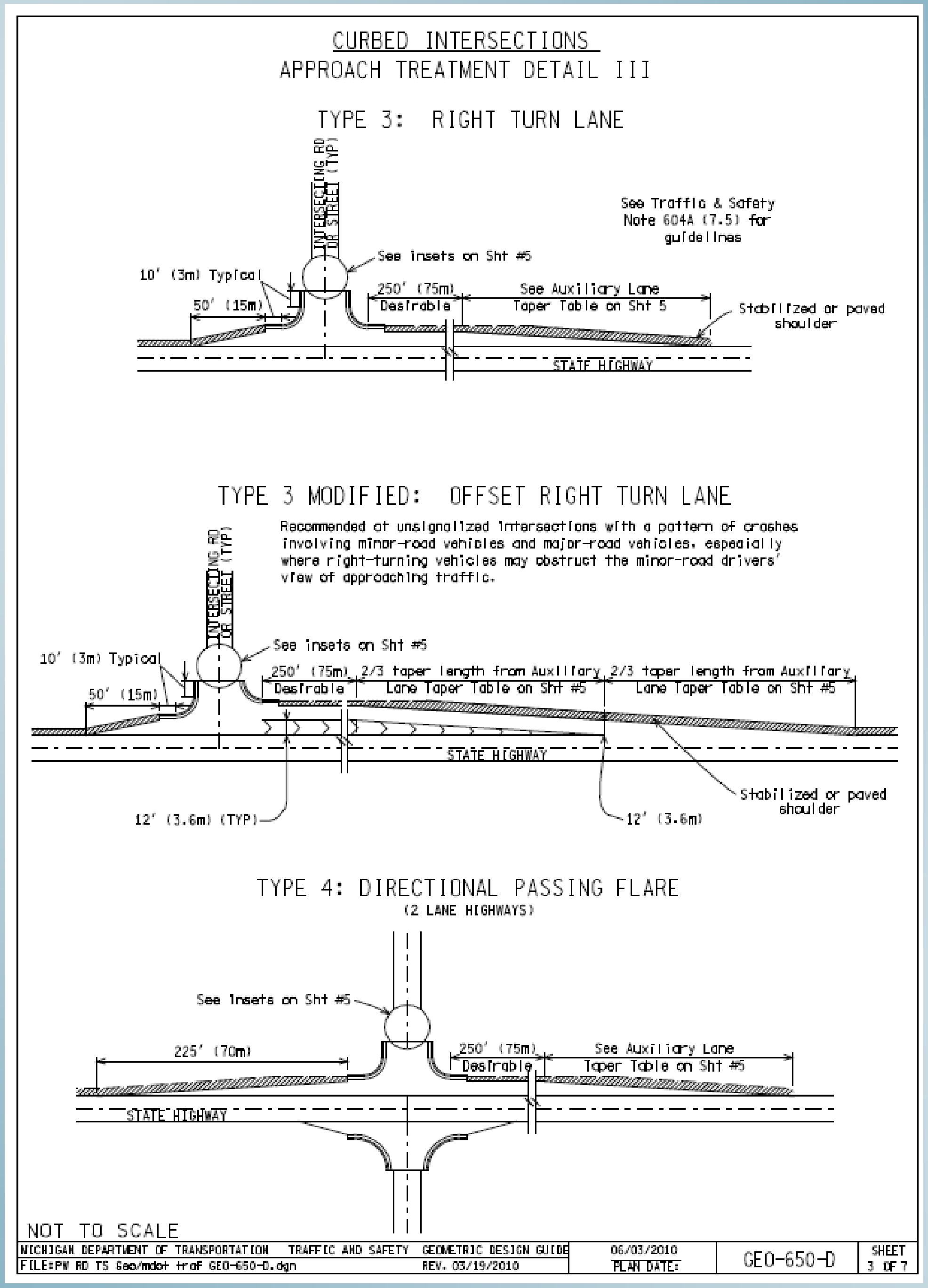
06/03/2010
PLAN DATE:
GEO-650-D
SHEET 2 OF 7

GEO-650



CURBED INTERSECTIONS
APPROACH TREATMENT DETAIL III
TYPE 3: RIGHT TURN LANE
INTERSECTING RD OR STREET (TYP)
See Traffic & Safety Note 604A (7.5) for guidelines
See Insets on Sht #5
10' (3m) Typical
50' (15m)
250' (75m) Desirable
See Auxiliary Lane Taper Table on Sht 5
Stabilized or paved shoulder
STATE HIGHWAY
TYPE 3 MODIFIED: OFFSET RIGHT TURN LANE
Recommended at unsignalized intersections with a pattern of crashes involving minor-road vehicles and major-road vehicles, especially where right-turning vehicles may obstruct the minor-road drivers' view of approaching traffic.
INTERSECTING RD OR STREET (TYP)
See Insets on Sht #5
10' (3m) Typical
50' (15m)
250' (75m) Desirable
2/3 taper length from Auxiliary Lane Taper Table on Sht #5
2/3 taper length from Auxiliary Lane Taper Table on Sht #5
STATE HIGHWAY
12' (3.6m) (TYP)
12' (3.6m)
Stabilized or paved shoulder
TYPE 4: DIRECTIONAL PASSING FLARE
(2 LANE HIGHWAYS)
See Insets on Sht #5
225' (70m)
250' (75m) Desirable
See Auxiliary Lane Taper Table on Sht #5
STATE HIGHWAY
NOT TO SCALE
MICHIGAN DEPARTMENT OF TRANSPORTATION TRAFFIC AND SAFETY GEOMETRIC DESIGN GUIDE
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REV. 03/19/2010
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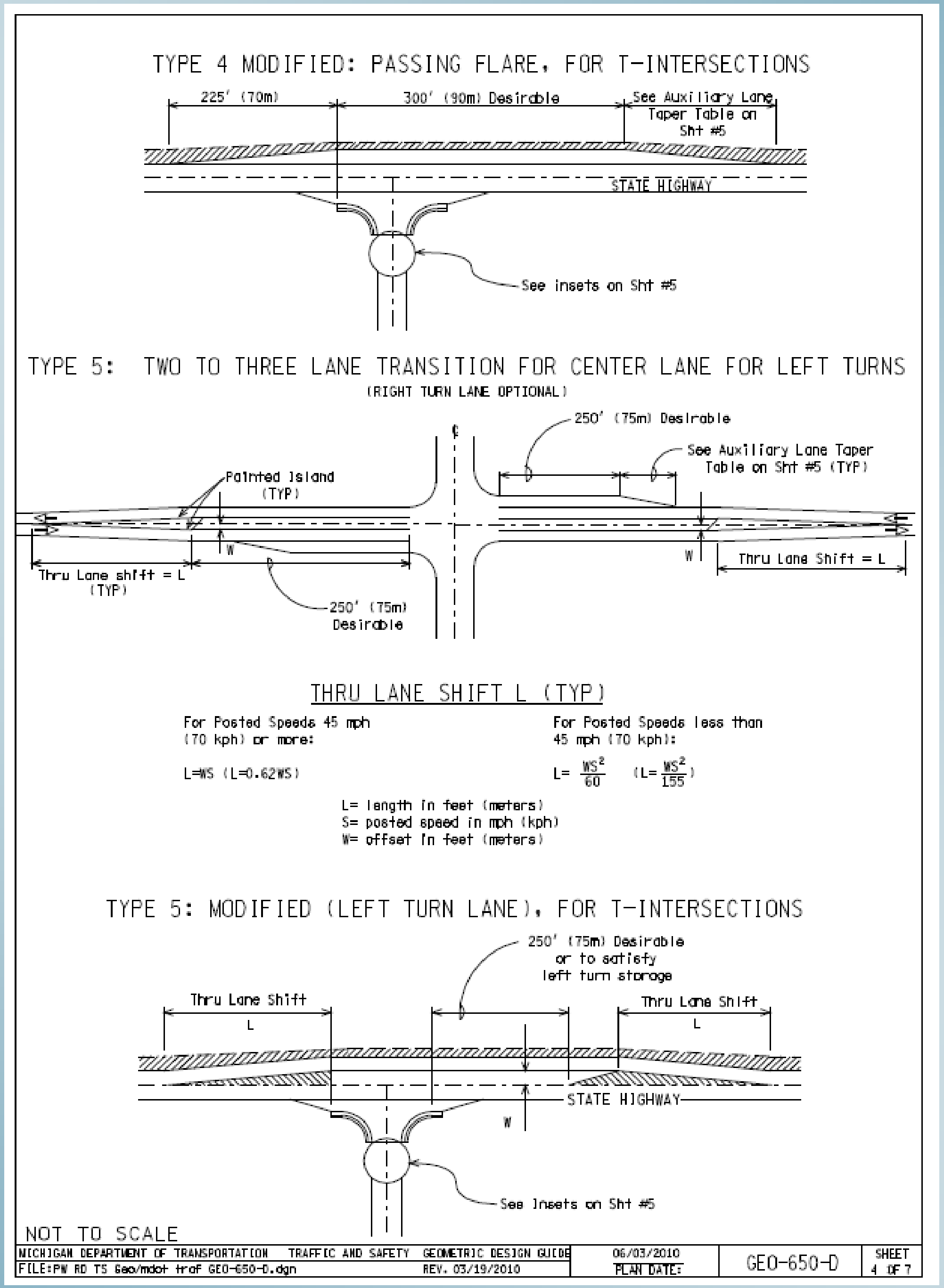
PLAN DATE:
GEO-650-D
SHEET 3 OF 7

GEO-650



TYPE 4 MODIFIED: PASSING FLARE, FOR T-INTERSECTIONS
225' (70m)
300' (90m) Desirable
See Auxiliary Lane Taper Table on Sht #5
STATE HIGHWAY
See insets on Sht #5
TYPE 5: TWO TO THREE LANE TRANSITION FOR CENTER LANE FOR LEFT TURNS
(RIGHT TURN LANE OPTIONAL)
250' (75m) Desirable
See Auxiliary Lane Taper Table on Sht #5 (TYP)
Painted Island (TYP)
Thru Lane shift = L (TYP)
W
250' (75m) Desirable
Thru Lane Shift = L
THRU LANE SHIFT L (TYP)
For Posted Speeds 45 mph (70 kph) or more:
L=WS (L=0.62WS)
For Posted Speeds less than 45 mph (70 kph):
L= WS²/60 (L= WS²/155)
L= length in feet (meters)
S= posted speed in mph (kph)
W= offset in feet (meters)
TYPE 5: MODIFIED (LEFT TURN LANE), FOR T-INTERSECTIONS
250' (75m) Desirable or to satisfy left turn storage
Thru Lane Shift
L
Thru Lane Shift
L
STATE HIGHWAY
W
See Insets on Sht #5
NOT TO SCALE
MICHIGAN DEPARTMENT OF TRANSPORTATION TRAFFIC AND SAFETY GEOMETRIC DESIGN GUIDE
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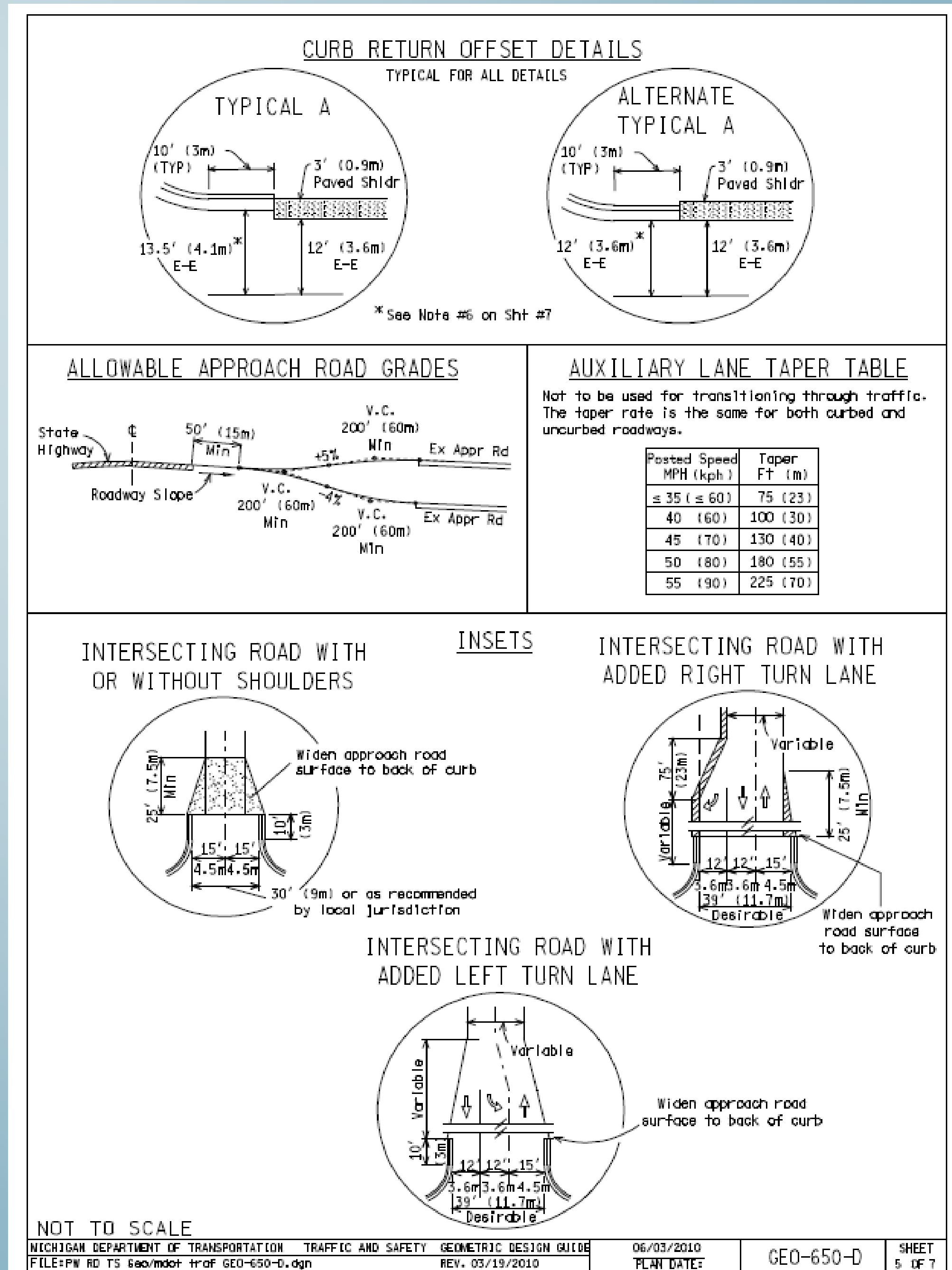
SHEET 4 OF 7

GEO-650



Posted Speed MPH (kph)	Taper Ft (m)
≤ 35 (≤ 60)	75 (23)
40 (60)	100 (30)
45 (70)	130 (40)
50 (80)	180 (55)
55 (90)	225 (70)

GEO-650

TABLE OF RADII FOR DESIGN VEHICLES

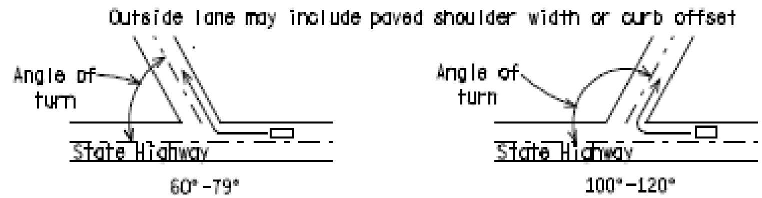
SEE NOTE 4

TABLE 1 (R*)

TURN FROM 12' (3.6m) OUTSIDE LANE TO 12' (3.6m) OUTSIDE LANE			
DESIGN VEHICLES	ANGLES OF TURN		
	60°-79°	80°-99°	100°-120°
P	30' (9m)R	30' (9m)R	30' (9m)R
SU	50' (15m)R	50' (15m)R	40' (12m)R
WB-50	90' (27m)R	80' (24m)R	60' (18m)R
WB-65	170' (51m)R	110' (33m)R	80' (24m)R

TABLE 2 (R**)

TURN FROM 12' (3.6m) OUTSIDE LANE TO 20' (6m) OUTSIDE LANE			
DESIGN VEHICLES	ANGLES OF TURN		
	60°-79°	80°-99°	100°-120°
P	30' (9m)R	30' (9m)R	30' (9m)R
SU	30' (9m)R	30' (9m)R	30' (9m)R
WB-50	50' (15m)R	50' (15m)R	40' (12m)R
WB-65	70' (21m)R	60' (18m)R	50' (15m)R



1. Design vehicles: P=Passenger Car, SU=Single Unit Truck (30' (9m) overall), WB-50=Tractor-Trailer Combination (50' (15m) wheelbase), WB-65=Interstate Semi-Trailer (65' (19.8m) wheelbase).

2. Angle of intersection of approach road and state highway should not be less than 60 degrees or more than 120 degrees.

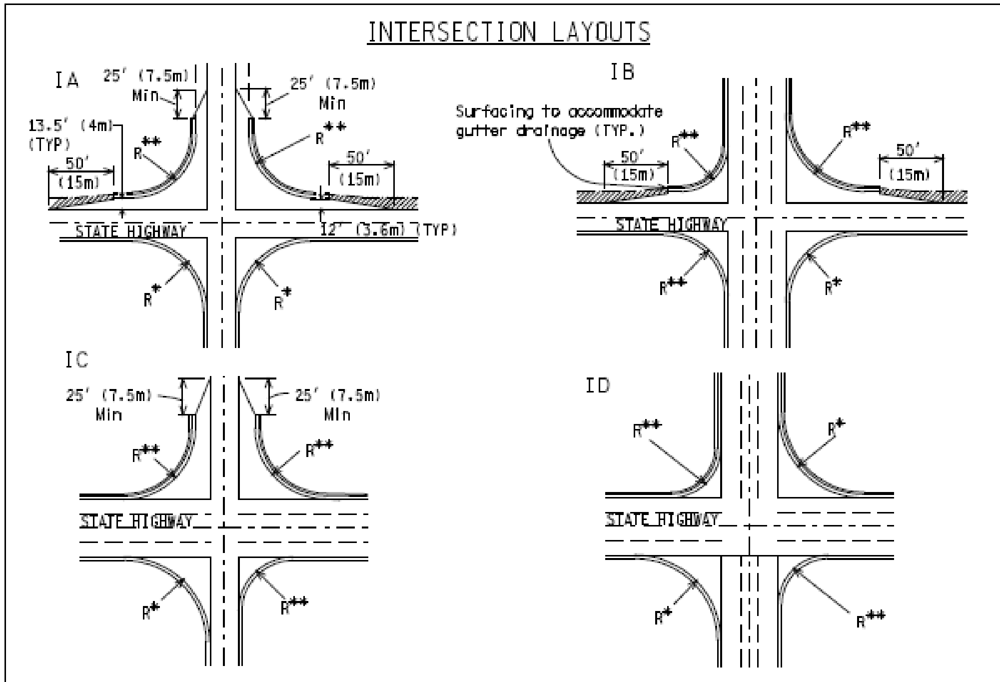
3. The above tables are to be used as a guide, turning vehicle templates or AutoTurn should be used for verification.

4. When a state highway intersects a one way approach, in non-turning quadrants the radius shall be a maximum of 10' (3m).

5. On the National Truck Network and Green Route Intersections where trucks turn, a WB-65 Interstate Semi-Trailer is the design vehicle.

6. For dual turns - consult the Geometric Review and Congestion Analysis Unit, Division of Operations.

GEO-650



NOTES:

1. An intersecting road as herein defined may be a city street, county road or state highway.

2. 12′ (3.6m) wide lanes are to be used unless conditions require narrower lanes.

3. On horizontal curves, the cross slope on turn lanes should be the same as the through pavement. Where physical constraints do not make this practical the maximum allowable algebraic difference in cross-slope between the turn lane and mainline is 5%, with a desirable maximum of 4%.

4. See Standard Plan R-30-Series for curb and gutter details.

5. Clear vision areas should be considered at all intersections.

6. Alternate Typical A may be used when construction and maintenance make the 13.5′ (4.1m) curb setback undesirable or the crossroad is curbed.

7. Current AASHTO "A Policy on Geometric Design of Highways and Streets" and MDOT Guidelines should be used for sight distance requirements.

8. See Traffic & Safety Note 614A for guidance on nearside and farside lane drops at intersections.

9. These design concepts are for new construction. Where modification may be needed for retrofitting to existing road features, consult the Geometric Review and Congestion Analysis Unit, Division of Operations.

ROUNDABOUTS

Potential Benefits:

- **Reduced Delay**
- **Reduced Conflict Points**
- **Reduced Crash Severity**
- **Reduced Bridge Width**
- **Reduced Design Requirements**

ROUNDABOUTS

Yield at Entry

Deflected at Entry

Flared at Entry

Traffic Calming

ROUNDABOUTS

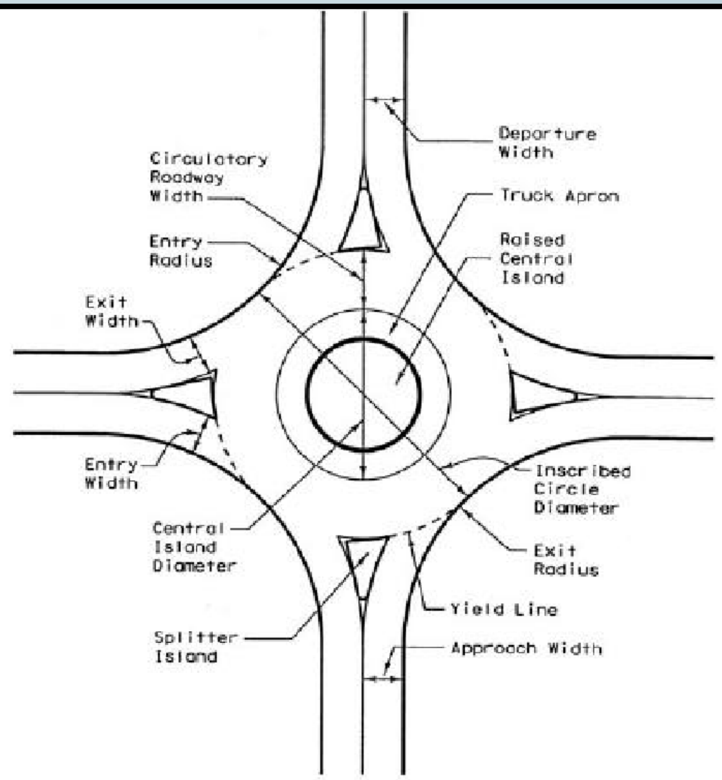


Exhibit 9-15. Geometric Elements of a Single-Lane Modern Roundabout

Exhibit 9-16. Typical Modern Roundabout

ROUNDABOUTS

Common Misconceptions:

- Do Not Accommodate Large Trucks
- Difficult to Navigate/Confusing to Motorists

ROUNDABOUTS IN MICHIGAN

Number of Roundabouts (Existing/Constructed)	Location	County	Time of Construction
3 (2 trunkline)	US-23/8 Mile Road Interchange 8 Mile Road and Whitmore Lake Road	Washtenaw/ Livingston	
2	US-23/N. Territorial Road Interchange	Washtenaw	
1	M-52 at Church/Broad Street	Lenawee	
1	US-41 at Grove Street	Marquette	
1	US-41 at Marquette Hospital Drive	Marquette	
2	I-94 at Sprinkle Rd. interchange	Kalamazoo	
1	US-12 at old M-205 and Five Points Road	Cass	
2	M-72 near US-31, Acme	Grand Traverse	
1	US-131 at Fife Lake Road	Grand Traverse	
1	M-52 at Werkner Rd.	Washtenaw	
1	US-41/M-28 at 2nd St.	Marquette	
1	M-11 at Remembrance Rd., Walker	Kent	September 2015
1	M-30 at WB US-10 Ramps, Sanford	Midland	June, 2015
1	US-10 BR/ M-20 at Patrick Road, Midland	Midland	2014
1	M-37/M-115 east junction near Mesick	Wexford	September 2013
2	US-23/US-223 interchange	Monroe	August 2013
1	M-93 at Camp Grayling/ Howe Road, Grayling Township	Crawford	2012
1	M-5 at Pontiac Trail, Commerce Township	Oakland	2012
2	the I-94 at Main Street interchange, Mattawan	Van Buren	September 2011
2	US-23 at Geddes Road interchange, Ann Arbor and Ann Arbor Township	Washtenaw	October 2010
1	US-41/M-28 at Front Street, Marquette	Marquette	September 2010
2	I-94 Business Loop/Main Street at Riverview Drive and at 5th Street, Benton Harbor	Berrien	November 2009
1	M-46 at M-37/ Newaygo Rd	Muskegon	October 2009
1	US-127 Business Route at Mission Road, Clare	Isabella	June 2009
2	M-53 at 26 Mile Road interchange	Macomb	July 2009
1	M-43 at the intersection of 72nd St. / County Road (CR) 689 and 12th Avenue CR 384, South Haven	Van Buren	November 2008
2	M-14 at Maple Road interchange, Ann Arbor	Washtenaw	July 2007
2	I-75/M-81 interchange	Saginaw	December 2006
3 (2 trunkline)	US-23 at Lee Rd. Interchange (US-23/Lee Rd./ Whitmore Lake Rd.)	Livingston	2006
1	M-53 at 18 ½ Mile (Van Dyke) Road, Sterling Heights	Macomb	June 2005
Total:			
44	**30**		

Number of Roundabouts (Planned/Proposed)	Location	County	Time of Construction
1	I-75BL/Mackinac Trail/3 Mile Road		February 2018 Letting
2	I-94/Cooper Street Interchange		June 2018 Letting
1	NB I-75 Ramps at Bristol Rd.		
2	US-23/US-12 Interchange		
1	M-343 at G Avenue	Kalamazoo	
Total:			
7	**5**		

Roundabout in Saginaw County at I-75@M-81

ROUNDABOUT DESIGN GUIDANCE

Roundabout Design Aid

Michigan Department of Transportation

PREPARED BY

TRAFFIC AND SAFETY

October 2019

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 672

Roundabouts:
An Informational Guide

Second Edition

Lee Rodegerdts, Justin Bansen, Christopher Tiesler, Julia Knudsen, and Edward Myers
KITTELSON & ASSOCIATES, INC.
Portland, OR

Mark Johnson
MTJ ENGINEERING, INC.
Madison, WI

Michael Moule
LIVABLE STREETS INC.
Tampa, FL

Bhagwant Persaud and Craig Lyon
PERSAUD AND LYON
Toronto, ON, Canada

Shauna Hallmark and Hillary Isebrands
CENTER FOR TRANSPORTATION RESEARCH AND EDUCATION
IOWA STATE UNIVERSITY
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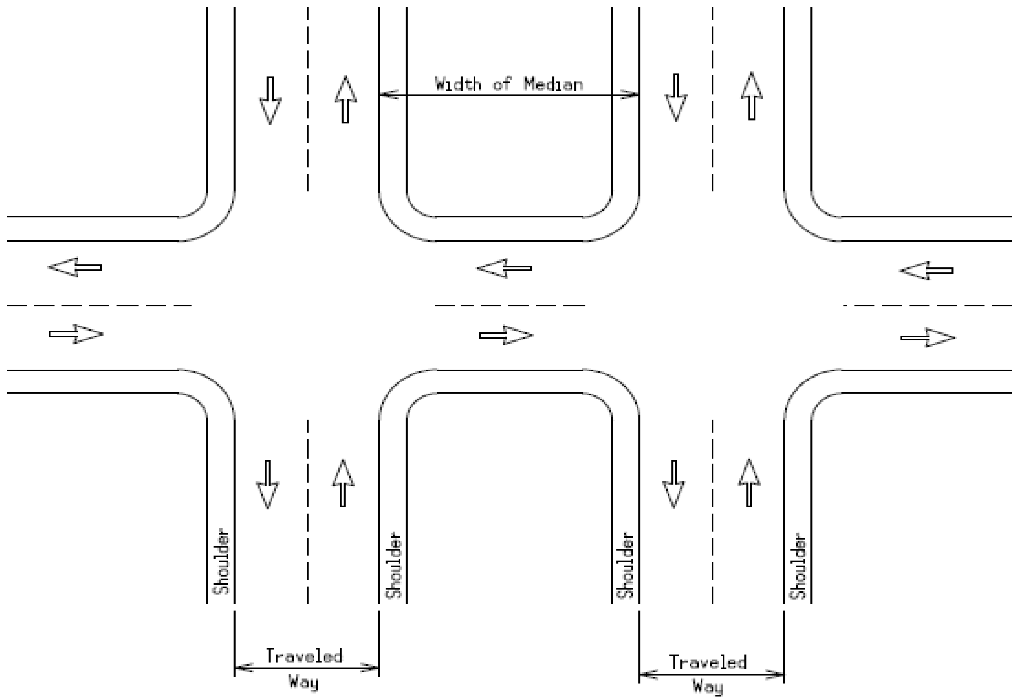
DIVIDED ROADWAY INTERSECTIONS

Michigan Vehicle Code

"…where a highway includes two roadways 30 feet or more apart, then every crossing of each such divided highway by an intersecting highway shall be regarded as a separate intersection…"

MMUTCD

Provides direction for use and placement of TCD's at divided highway intersections



Example of Median Width Measurement on an Uncurbed Divided Roadway

MDOT TRAFFIC AND SAFETY NOTE	DIVIDED ROADWAY INTERSECTIONS		
DRAWN BY: MTS CHECKED BY: JAT	09/15/2005 PLAN DATE:	504B	SHEET 3 OF 3
FILE: K:/DGN/ts notes/Note504B tsn.dgn		REV. 09/15/2005	

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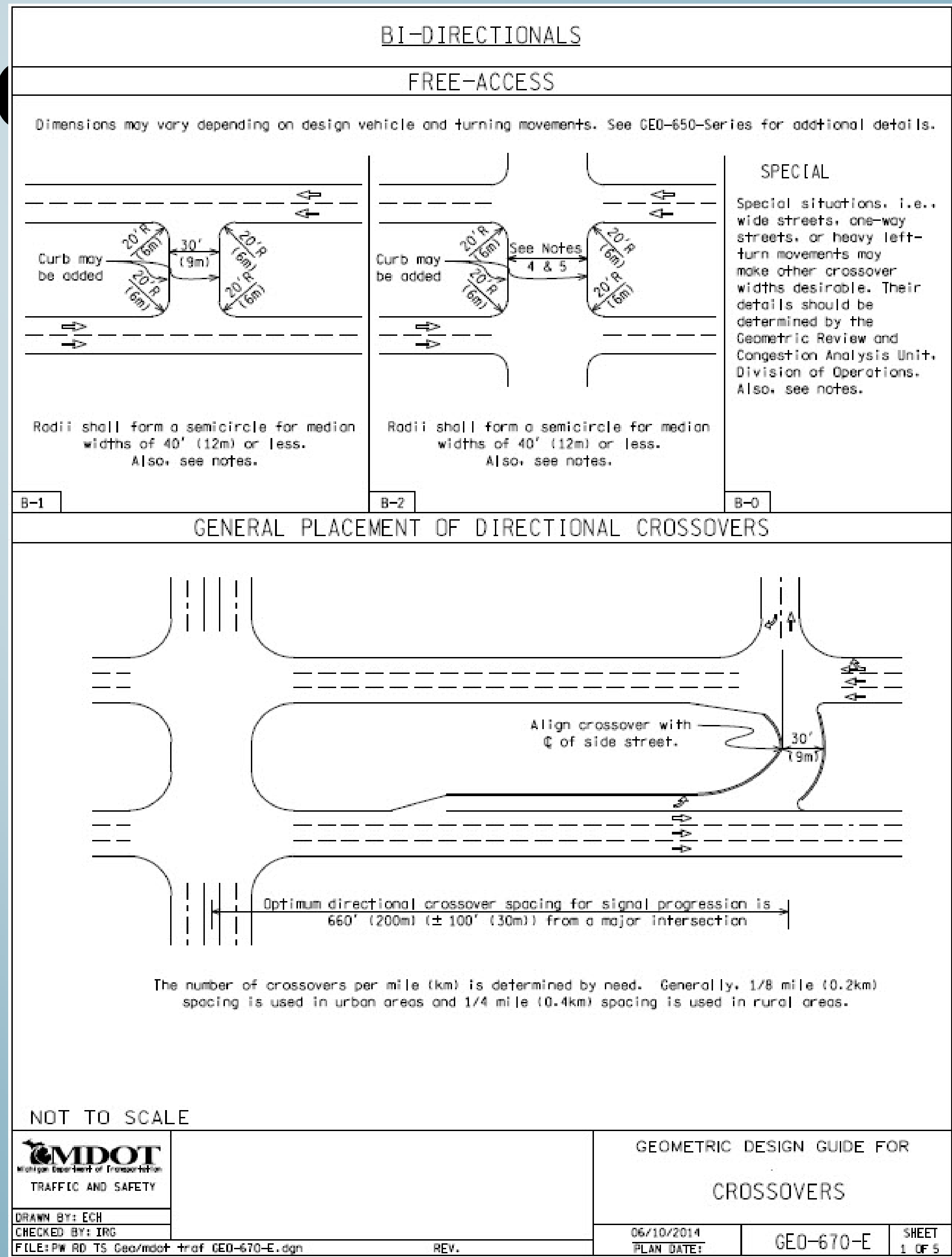
BI-DIRECTIONALS
FREE-ACCESS
Dimensions may vary depending on design vehicle and turning movements. See GEO-650-Series for additional details.
Curb may be added
20' R (6m)
30' (9m)
Radii shall form a semicircle for median widths of 40' (12m) or less. Also, see notes.
B-1
See Notes 4 & 5
B-2
SPECIAL
Special situations, i.e., wide streets, one-way streets, or heavy left-turn movements may make other crossover widths desirable. Their details should be determined by the Geometric Review and Congestion Analysis Unit, Division of Operations. Also, see notes.
B-0
GENERAL PLACEMENT OF DIRECTIONAL CROSSOVERS
Align crossover with ℄ of side street.
30' (9m)
Optimum directional crossover spacing for signal progression is 660' (200m) (± 100' (30m)) from a major intersection
The number of crossovers per mile (km) is determined by need. Generally, 1/8 mile (0.2km) spacing is used in urban areas and 1/4 mile (0.4km) spacing is used in rural areas.
NOT TO SCALE
MDOT
TRAFFIC AND SAFETY
DRAWN BY: ECH
CHECKED BY: IRG
FILE: PW RD TS Geo/mdot traf GEO-670-E.dgn
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GEOMETRIC DESIGN GUIDE FOR
CROSSOVERS
06/10/2014
PLAN DATE:
GEO-670-E
SHEET 1 OF 5

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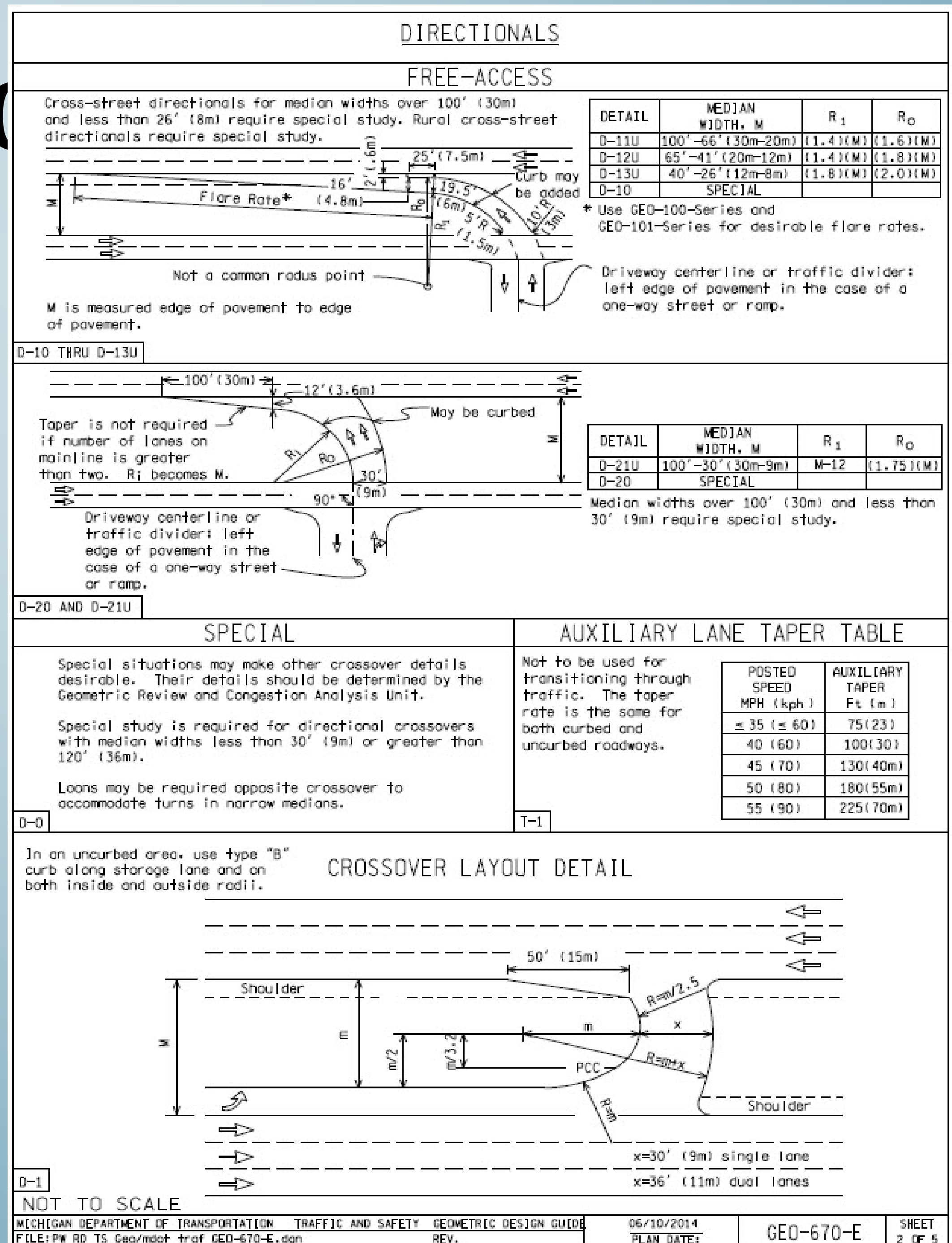

DIRECTIONALS

FREE-ACCESS

Cross-street directionals for median widths over 100' (30m) and less than 26' (8m) require special study. Rural cross-street directionals require special study.

DETAIL	MEDIAN WIDTH, M	R_1	R_o
D-11U	100'-66' (30m-20m)	(1.4)(M)	(1.6)(M)
D-12U	65'-41' (20m-12m)	(1.4)(M)	(1.8)(M)
D-13U	40'-26' (12m-8m)	(1.8)(M)	(2.0)(M)
D-10	SPECIAL		

* Use GEO-100-Series and GEO-101-Series for desirable flare rates.

Curb may be added

Not a common radius point

Driveway centerline or traffic divider: left edge of pavement in the case of a one-way street or ramp.

M is measured edge of pavement to edge of pavement.

D-10 THRU D-13U

Taper is not required if number of lanes on mainline is greater than two. R_i becomes M.

May be curbed

Driveway centerline or traffic divider: left edge of pavement in the case of a one-way street or ramp.

DETAIL	MEDIAN WIDTH, M	R_1	R_o
D-21U	100'-30' (30m-9m)	M-12	(1.75)(M)
D-20	SPECIAL		

Median widths over 100' (30m) and less than 30' (9m) require special study.

D-20 AND D-21U

SPECIAL

Special situations may make other crossover details desirable. Their details should be determined by the Geometric Review and Congestion Analysis Unit.

Special study is required for directional crossovers with median widths less than 30' (9m) or greater than 120' (36m).

Loons may be required opposite crossover to accommodate turns in narrow medians.

D-0

AUXILIARY LANE TAPER TABLE

Not to be used for transitioning through traffic. The taper rate is the same for both curbed and uncurbed roadways.

POSTED SPEED MPH (kph)	AUXILIARY TAPER Ft (m)
≤ 35 (≤ 60)	75(23)
40 (60)	100(30)
45 (70)	130(40m)
50 (80)	180(55m)
55 (90)	225(70m)

T-1

In an uncurbed area, use type "B" curb along storage lane and on both inside and outside radii.

CROSSOVER LAYOUT DETAIL

x=30' (9m) single lane

x=36' (11m) dual lanes

D-1

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION TRAFFIC AND SAFETY GEOMETRIC DESIGN GUIDE | 06/10/2014 PLAN DATE: | GEO-670-E | SHEET 2 OF 5

FILE: PW RD TS Geo/mdot traf GEO-670-E.dgn REV.

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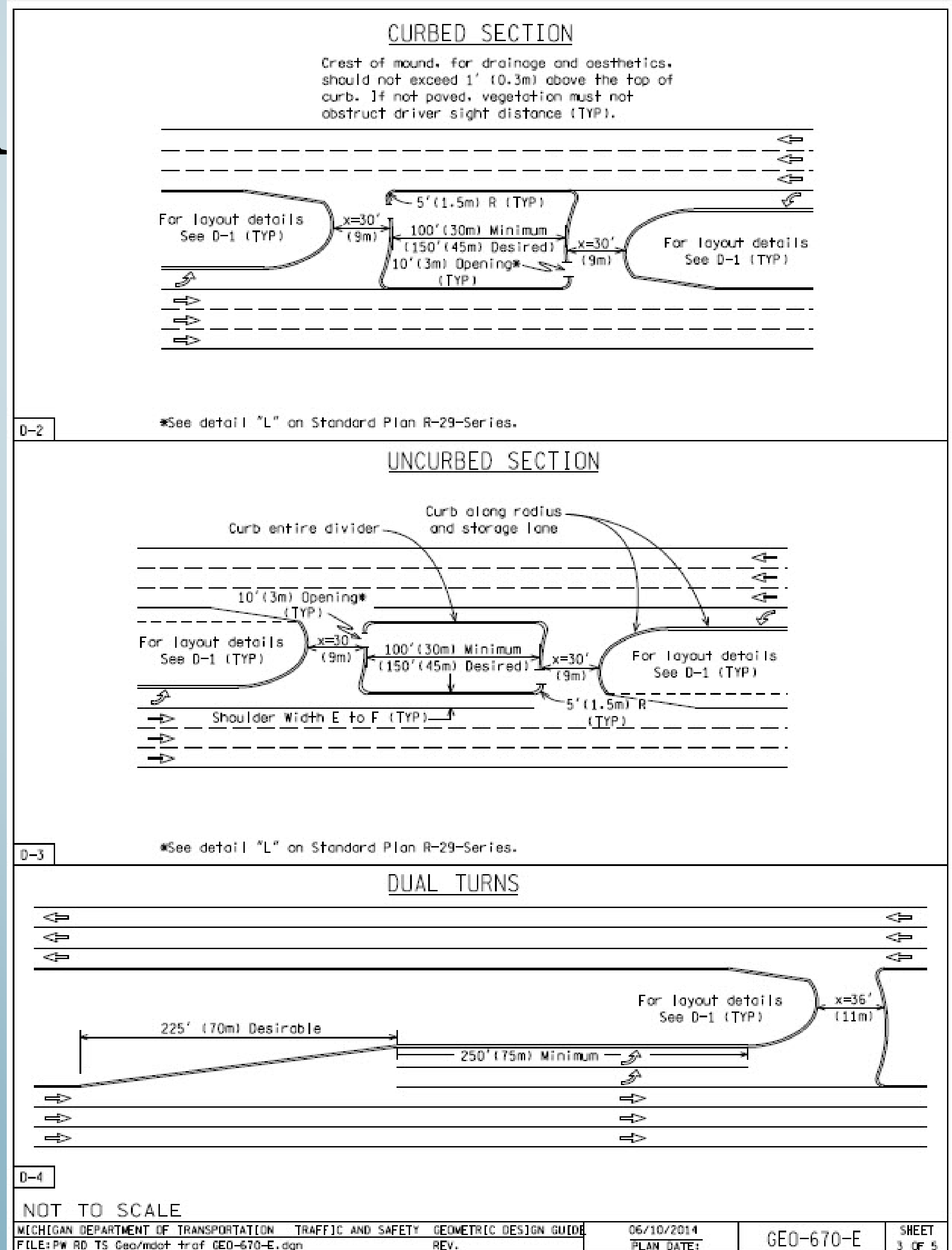
CURBED SECTION
Crest of mound, for drainage and aesthetics, should not exceed 1' (0.3m) above the top of curb. If not paved, vegetation must not obstruct driver sight distance (TYP).
For layout details See D-1 (TYP)
x=30' (9m)
5'(1.5m) R (TYP)
100'(30m) Minimum (150'(45m) Desired)
10'(3m) Opening* (TYP)
*See detail "L" on Standard Plan R-29-Series.
D-2
UNCURBED SECTION
Curb entire divider
Curb along radius and storage lane
10'(3m) Opening* (TYP)
Shoulder Width E to F (TYP)
5'(1.5m) R (TYP)
D-3
DUAL TURNS
225' (70m) Desirable
250'(75m) Minimum
x=36' (11m)
D-4
NOT TO SCALE
MICHIGAN DEPARTMENT OF TRANSPORTATION TRAFFIC AND SAFETY GEOMETRIC DESIGN GUIDE
FILE: PW RD TS Geo/mdot traf GEO-670-E.dgn
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PLAN DATE:
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GEO-670-E
SHEET 3 OF 5

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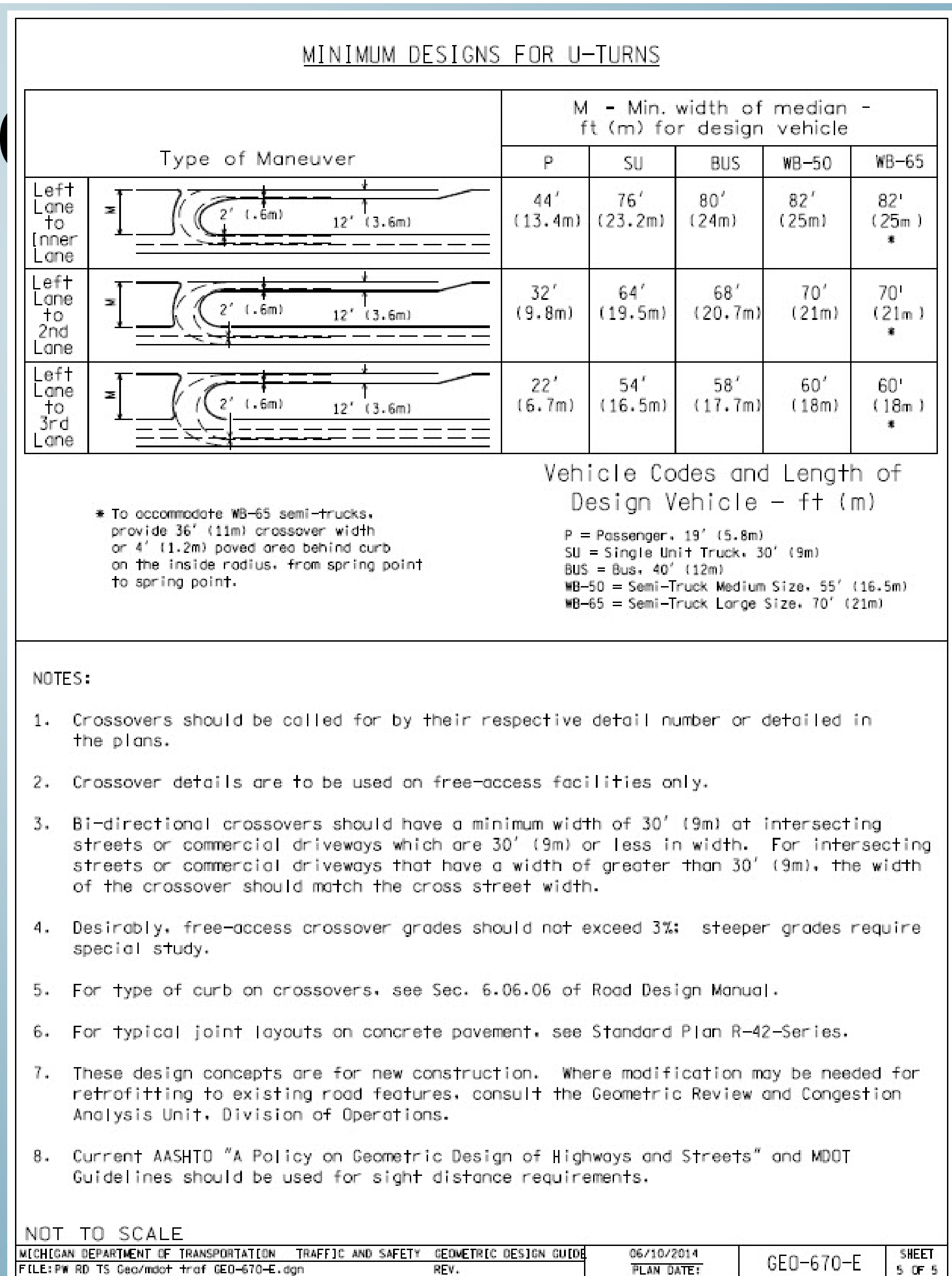


MINIMUM DESIGNS FOR U-TURNS

Type of Maneuver	M - Min. width of median - ft (m) for design vehicle				
	P	SU	BUS	WB-50	WB-65
Left Lane to Inner Lane (M; 2' (.6m); 12' (3.6m))	44' (13.4m)	76' (23.2m)	80' (24m)	82' (25m)	82' (25m) *
Left Lane to 2nd Lane (M; 2' (.6m); 12' (3.6m))	32' (9.8m)	64' (19.5m)	68' (20.7m)	70' (21m)	70' (21m) *
Left Lane to 3rd Lane (M; 2' (.6m); 12' (3.6m))	22' (6.7m)	54' (16.5m)	58' (17.7m)	60' (18m)	60' (18m) *

* To accommodate WB-65 semi-trucks, provide 36' (11m) crossover width or 4' (1.2m) paved area behind curb on the inside radius, from spring point to spring point.

Vehicle Codes and Length of Design Vehicle - ft (m)

P = Passenger, 19' (5.8m)
SU = Single Unit Truck, 30' (9m)
BUS = Bus, 40' (12m)
WB-50 = Semi-Truck Medium Size, 55' (16.5m)
WB-65 = Semi-Truck Large Size, 70' (21m)

NOTES:

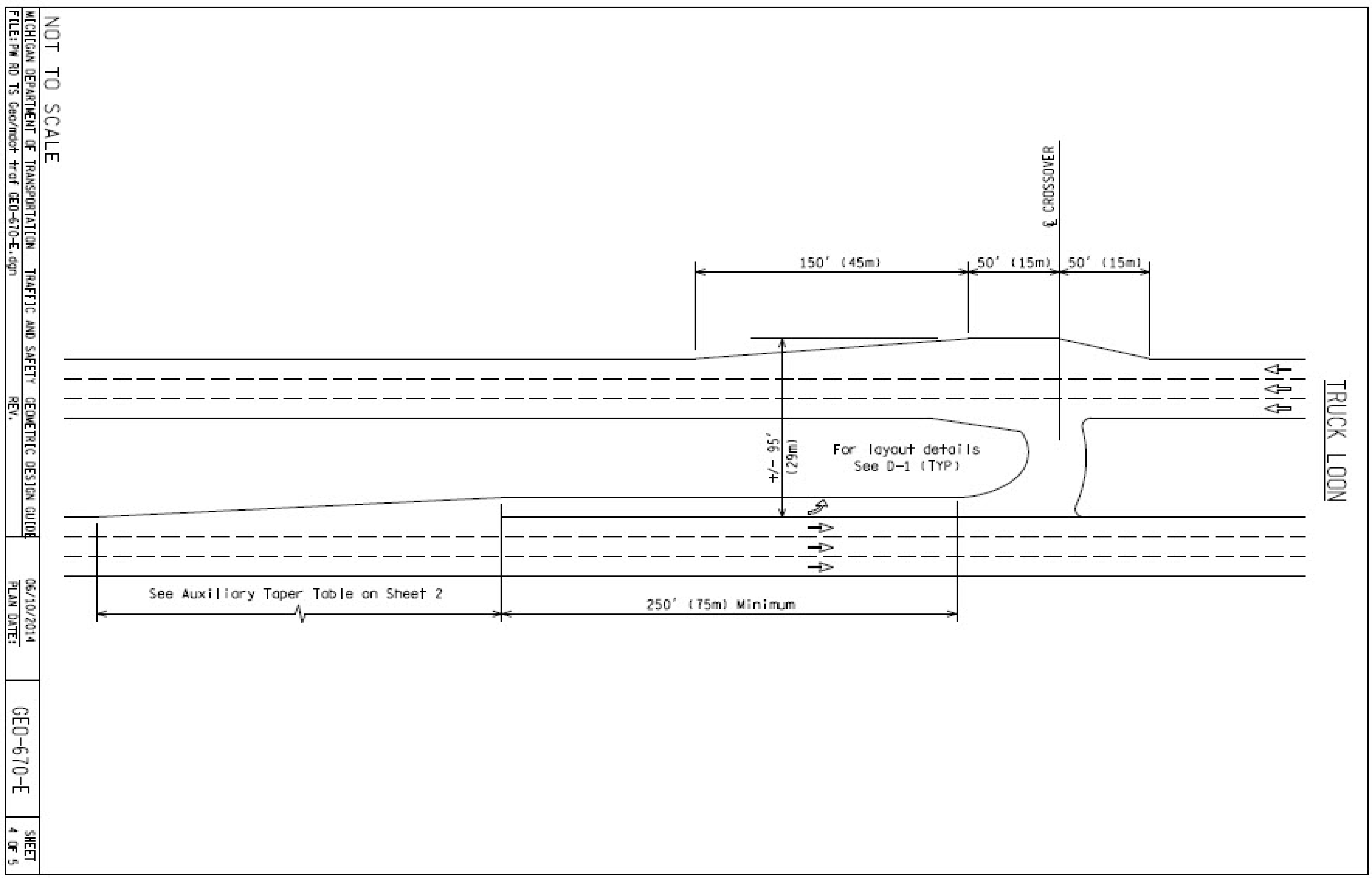
1. Crossovers should be called for by their respective detail number or detailed in the plans.
2. Crossover details are to be used on free-access facilities only.
3. Bi-directional crossovers should have a minimum width of 30' (9m) at intersecting streets or commercial driveways which are 30' (9m) or less in width. For intersecting streets or commercial driveways that have a width of greater than 30' (9m), the width of the crossover should match the cross street width.
4. Desirably, free-access crossover grades should not exceed 3%; steeper grades require special study.
5. For type of curb on crossovers, see Sec. 6.06.06 of Road Design Manual.
6. For typical joint layouts on concrete pavement, see Standard Plan R-42-Series.
7. These design concepts are for new construction. Where modification may be needed for retrofitting to existing road features, consult the Geometric Review and Congestion Analysis Unit, Division of Operations.
8. Current AASHTO "A Policy on Geometric Design of Highways and Streets" and MDOT Guidelines should be used for sight distance requirements.

NOT TO SCALE

MICHIGAN DEPARTMENT OF TRANSPORTATION TRAFFIC AND SAFETY GEOMETRIC DESIGN GUIDE	06/10/2014	GEO-670-E	SHEET
FILE: PW RD TS Geo/mdot traf GEO-670-E.dgn REV.	PLAN DATE:		5 OF 5

CROSSOVERS

Truck Loon Detail



INDIRECT LEFT TURNS

Advantages

Safety

Capacity

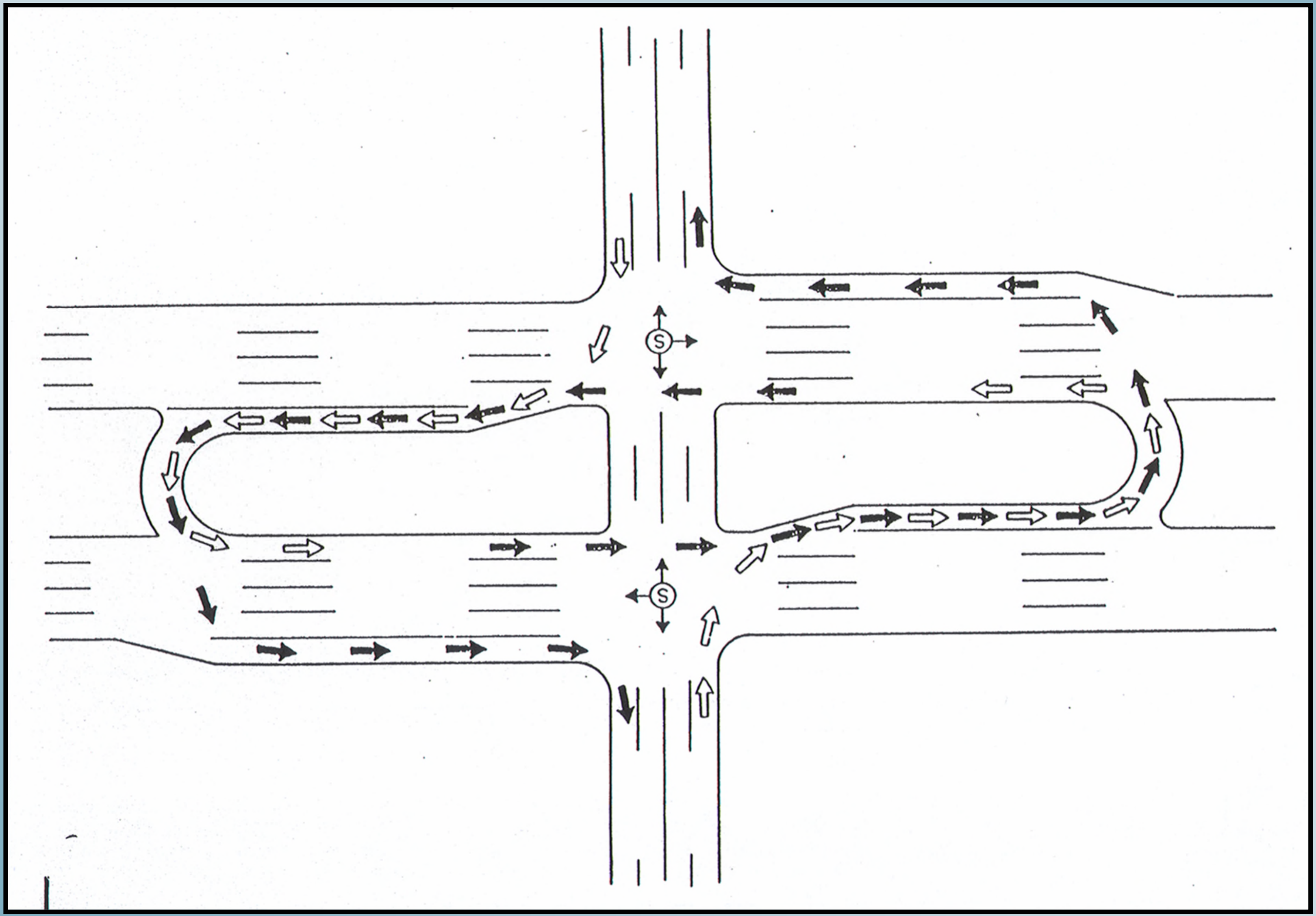
Efficiency

Disadvantages

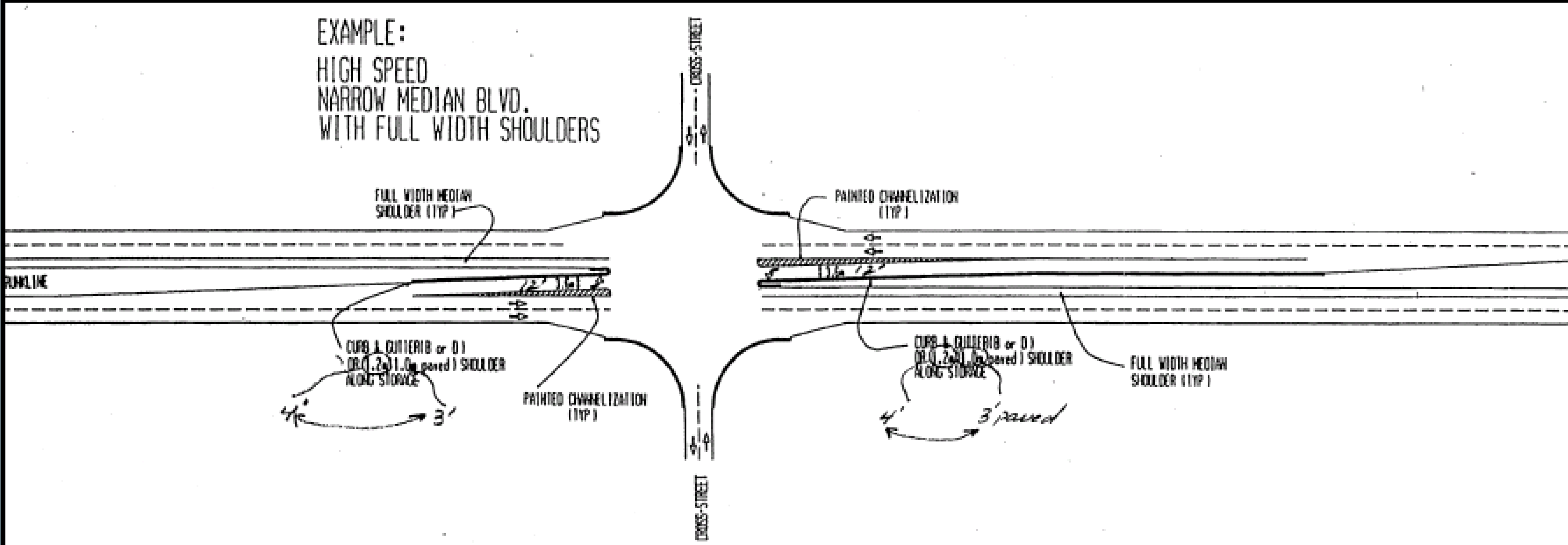
Adverse Distance

Weaving

INDIRECT LEFT TURNS



DIRECT LEFT TURNS



1. Ensure design vehicle can turn opposite another design vehicle without encroaching. This can be verified with turning templates. Widen the median opening as needed.

2. Ensure (in high speed areas) that the left turn bay is placed such that a median shoulder can still be provided.

3. Ensure that there is adequate storage length for left-turning vehicles.

4. Ensure that once the design vehicle completes the left-turn that it does not encroach into the crossroad traffic's outbound lanes. This can be verified with turning templates.

RIGHT TURN LANES AND TAPERS

(Geometric Design Guidance Document 1.1.4)
(Formerly Traffic and Safety Note 604A)

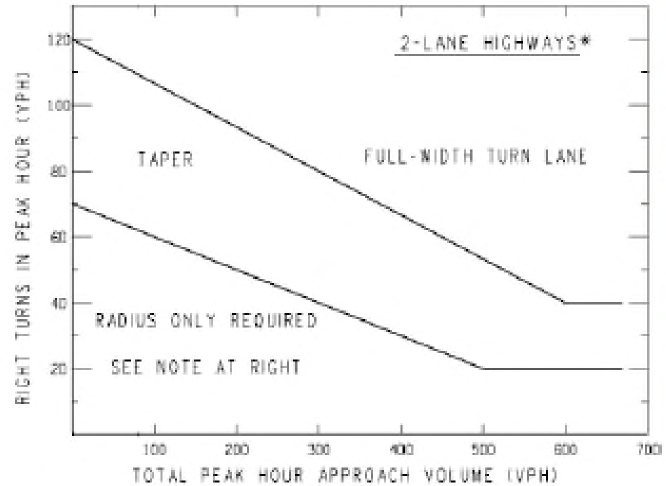
- At Any Intersection Where a Capacity Analysis Determines a Right Turn Lane is Required for a Desired LOS

- Crash Experience, Engineering Judgment, Indicates a Right Turn Lane will Improve Operations

- Any Unsignalized Intersection which Satisfies the Criteria on the Following Charts…

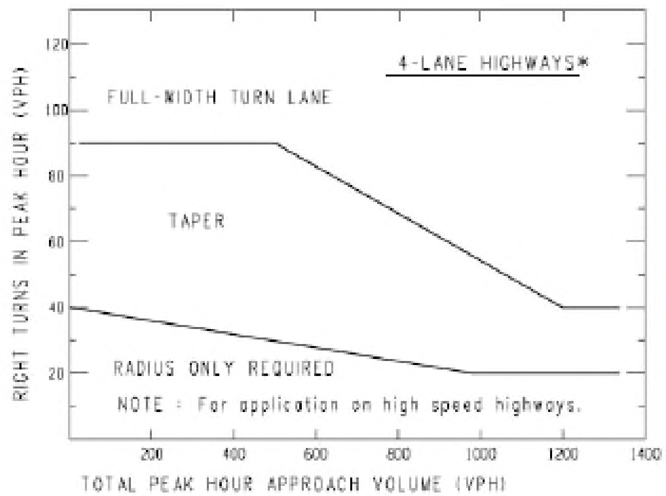
RIGHT APERS

(Geomet nt 1.1.4)
(Form 604A)



NOTE: For posted speeds at or under 45 mph, peak hour right turns greater than 40 vph, and total peak hour approach less than 300 vph, adjust right turn volumes.

Adjust peak hour Right turns = Peak hour Right turns – 20



*If a center left-turn lane exists (ie 3 or 5 lane roadway), subtract the number of left turns in approach volume form the total approach volume to get an adjusted total approach volume.

Sample Problem: The Design Speed is 55 mph. The Peak Hour Approach Volume is 300 vph. The Number of Right Turns in the Peak Hous is 100 vph. Determine if a right turn lane is recommended.

Solution: Figure indicates that the intersection of 300 vph and 100 vph is located above the upper trend line; thus, a right-turn lane may be recommended.

LEFT TURN LANES AND FLARES

(Geometric Design Guidance Document 1.1.5)
(Formerly Traffic and Safety Note 605A)

- Unsignalized Intersections on Two-Lane Highways: Charts for 35 mph, 45 mph, and 55 mph
- Unsignalized Intersections on Four-Lane Highways: Chart for any/all speeds
- Any Intersection where…
  - Crash Experience
  - Traffic Operations
  - Sight Distance Concerns

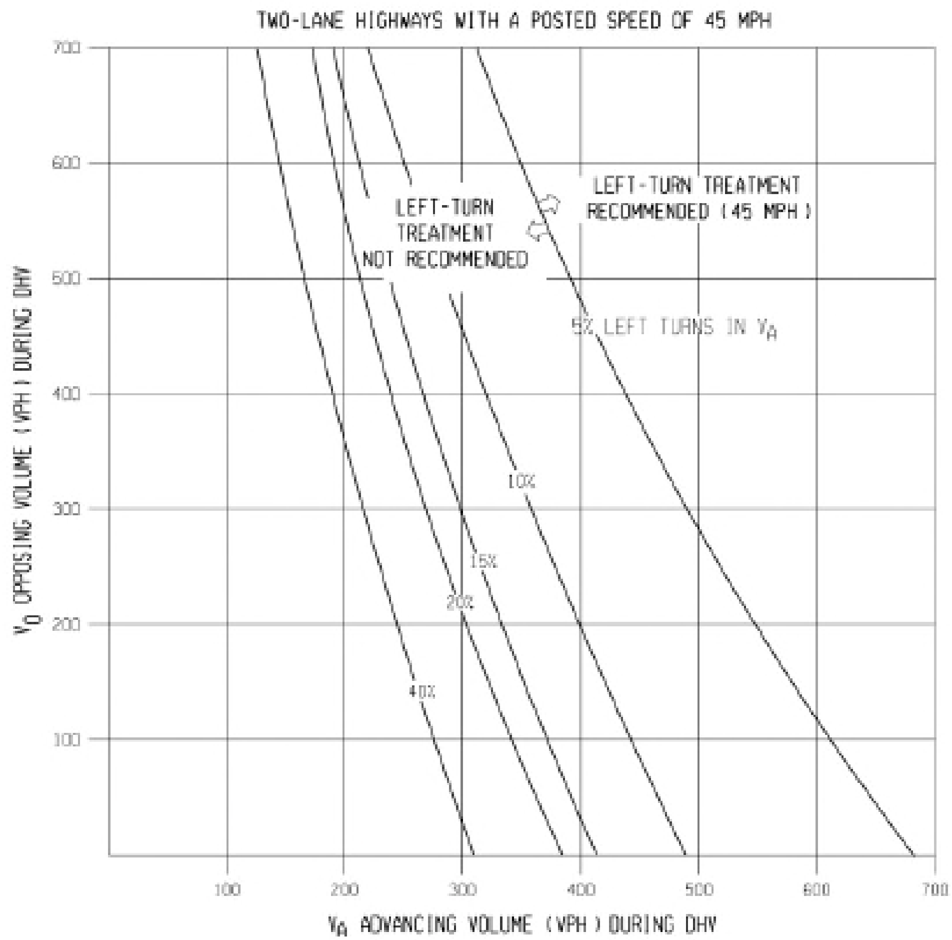
…Indicate that a Left Turn would Improve Operations

LEFT T… …LARES

(Geomet… …nt 1.1.5)

(Form… …605A)

Two-Lane Highways



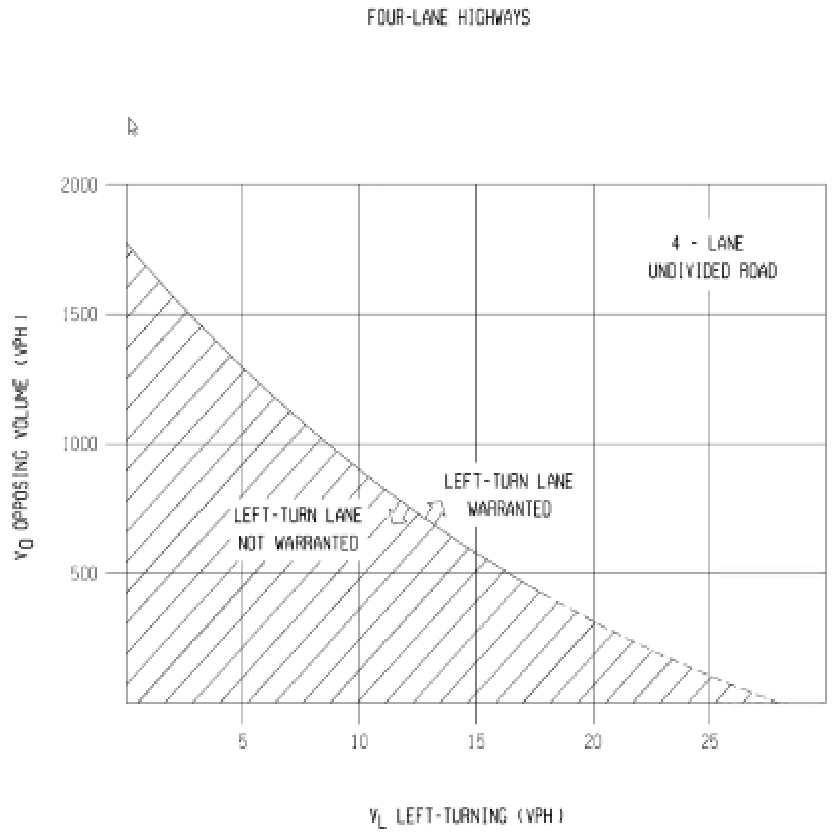
<u>Instructions:</u>

1. The family of curves represent the percentage of left turns in advancing volume (V_A). The designer should locate the curve for the actual percentage of left turns. When this is not an even increment of 5, the designer should estimate where the curve lies.
2. Read V_A and V_O into the chart and locate the intersection of the two volumes.
3. Note the location of the point in #2 relative to the line in #1. If the point is to the right of the line, then a left-turn lane is recommended. If the point is to the left of the line, then a left-turn is not recommended based on traffic volumes.

LEFT T LARES

(Geometr ent 1.1.5)
(Forme e 605A)

Four-Lane Highways



NOTE:

When V_O <400 vph (dashed line), a Left-Turn Lane is Not Normally Warranted Unless The Advancing Volume (V_A) in The Same Direction as the Left-Turning Traffic Exceeds 400 vph (V_A > 400 vph).

DRIVEWAY PASSING FLARES

(Geometric Design Guidance Document 1.2.3)
(Formerly Traffic and Safety Note 603A)

- Function of Peak Hour Left Turn Volume and 24 Hour Two-Way Volume
- Prohibit Left Turns
- Provide Driveway Passing Flare
- Cost Should be Borne by Developer
- See GEO-650-D for Design Considerations

DRIV RES

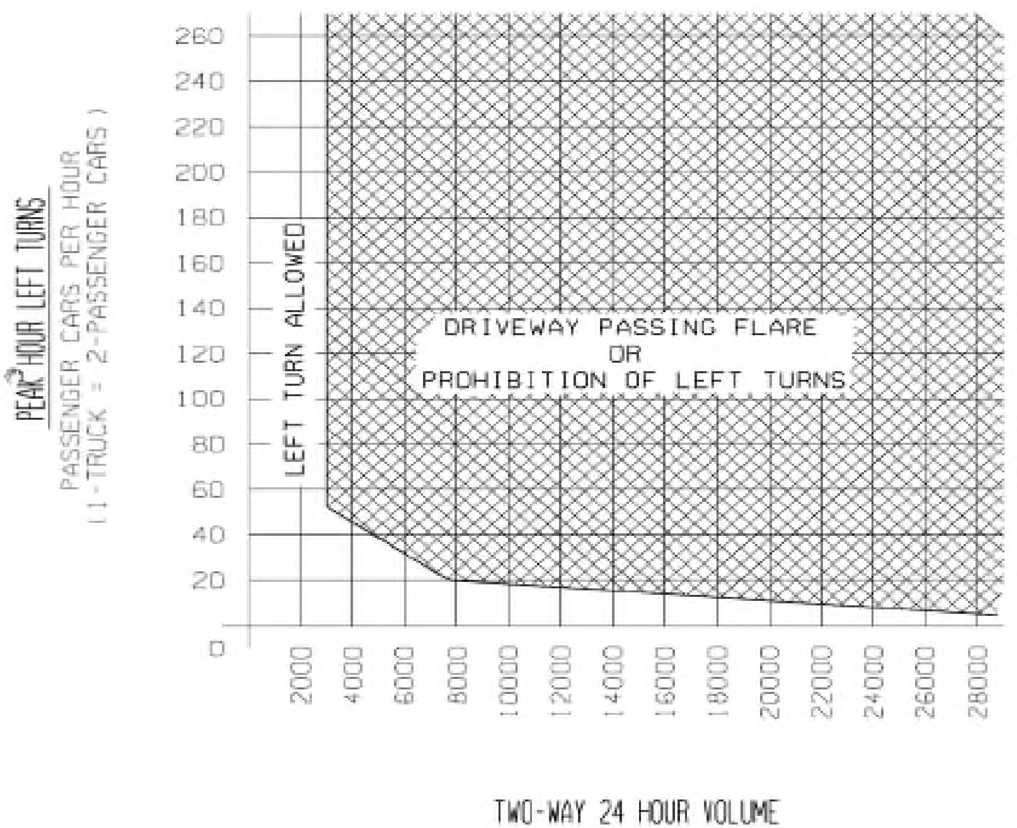
(Geome nt 1.2.3)

(For 03A)

1.2.3 Traffic Volume Guidelines for Driveway Passing Flares

Driveways serving large developments along state trunkline highways frequently generate large numbers of left-turns. On two-lane, two-way roadways, this situation can aggravate the efficiency of traffic operations and often make shoulder maintenance difficult. In such situations, prohibition of left-turns at driveways to large developments or construction of driveway passing flares should be considered.

In an attempt to alleviate the types of problems outlined above, the following chart is provided showing the relationship between peak hour left-turns and 24-hour volumes. When peak hour left-turns and 24-hour volumes fall within the area above and to the right of the trend line, left-turns should be prohibited or a driveway passing flare be installed. If a driveway passing flare is constructed, the entire cost should be borne by the developer. For additional information and geometric design guidance regarding driveway passing flares, please refer to Geometric Design Guide GEO-650.



NOTE: This chart is based on Total Development and is for Two-Way Roadways.

SPACING STREETS

(Ge 2.2)

( )

1.2.2 Spacing for Commercial Drives and Streets

The spacing of access for commercial driveways and streets is an important element in the planning, design, and operation of roadways. Access points are the main location of crashes and congestion. Their location and spacing directly affect the safety and functional integrity of the roadway.

Region Review: The Region/TSC Utility and Permit Engineer shall forward the site plan and the access request to the Region/TSC Traffic and Safety Representative for review. In general, one access point is adequate for a single business. When one-way pair driveways (In-Out) are requested and the inside traffic circulation promotes such operation, these driveways may be considered as a single access point. In some cases multiple access points are requested. In this case, the Region/TSC Traffic and Safety Representative may require a traffic impact study from the business owner/property owner to justify the need for the multiple accesses. A copy of the following information may be sent to the business owner/property owner to outline the traffic analysis needed.

Unsignalized Access Spacing: Adjacent accesses should be spaced as far apart as on-site circulation allows. In some cases the Region/TSC Traffic and Safety Representative may require that the business owner/property owner redesign his site plan, and relocate the access point to meet the desirable spacing distance. Table 1 shows the desirable unsignalized access spacing as a function of posted speed. These distances are based on average acceleration and deceleration considered adequate to maintain good traffic operations. The sight distance at the access points must also be investigated.

Posted Speed mph (km/hr)	Center-to-Center of Access feet (meters)
25 (40)	130 (40)
30 (50)	185 (55)
35 (60)	245 (75)
40 (60)	300 (90)
45 (70)	350 (105)
50 (80) and above	455 (140)

Table 1

Lack of Sufficient Frontage to Maintain Adjacent Spacing: In the event that a particular parcel lacks sufficient frontage to maintain adequate spacing, the Region/TSC Traffic and Safety and Utility and Permit Engineers have the following options.

1. Choose the next lowest spacing from Table 1. For example, on 30 mph (50 km/hr) roadway requiring 185 ft (56 m) spacing, the distance may be reduced to no less than 130 ft (40 m) which is the spacing from 25 mph (40 km/hr) speed.

SPACING … STREETS

(Ge… 2.2)

(…)

2. Encourage a shared driveway with the adjacent owners. In such case the driveway midpoint may be located at the property line between two parcels. However, all parties must agree to the joint driveway in writing.

3. Provide an access point to the side street when it is possible.

4. In areas where frontage roads or service drives exist or can be constructed, individual properties shall be provided access to these drives rather than directly to the main highway.

5. After all the above options are exhausted, an access point may be allowed within the property limits as determined by the Region/TSC Traffic and Safety and the Utility and Permit Engineers.

Intersection Corner Clearance: AASHTO specifically states that driveways should not be situated within the functional boundary of at-grade intersections. This boundary includes the longitudinal limits of auxiliary lanes. An access point may be allowed within the above boundary if the entire property frontage is located within this boundary. In all quadrants of an intersection access points should be located according to the dimensions shown in Figure 1.

Conflict Reductions: Restricting or prohibiting left turns at unsignalized access points aligned across from each other can greatly reduce safety and operational problems. A typical four-legged intersection, such as where two accesses line up across a four-lane roadway, has 36 conflict points. By prohibiting left turns and through movements the number of conflicts can be reduced from 36 to four, as illustrated in Figure 2.

In cases where these movements cannot be prohibited, the Region/TSC Traffic and Safety Representative may choose to offset the access points. Table 2 provides the desirable distances between two access points on the opposite side of the roadway.

Posted Speed mph (km/hr)	Desirable Offset Between Access Points on Opposite Sides of the Roadway Center-to-Center of Access On Undivided Highways feet (meters)
25 (40)	255 (80)
30 (50)	325 (100)
35 (60)	425 (130)
40 (60)	525 (160)
45 (70)	630 (190)
50 (80) and above	750 (230)

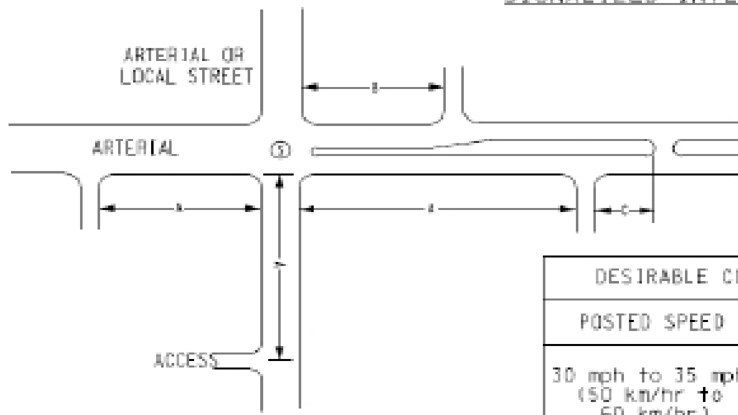
Table 2

SPACING … STREETS

(Ge… 2.2)

(…)

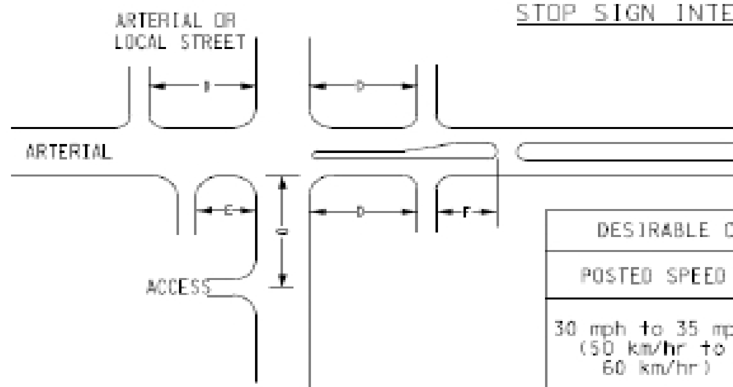
SIGNALIZED INTERSECTION CONTROL



- Coordinate with the Local Government Agency Regarding the Local Street Clearances.

DESIRABLE CORNER CLEARANCES		
POSTED SPEED	ITEM	ft (m)
30 mph to 35 mph (50 km/hr to 60 km/hr)	A	230 (70)
	B	115 (35)
	C	75 (22)
40 mph to 65 mph (60 km/hr to 105 km/hr)	A	460 (140)
	B	230 (70)
	C	150 (44)

STOP SIGN INTERSECTION CONTROL



- Coordinate with the Local Government Agency Regarding the Local Street Clearances.

DESIRABLE CORNER CLEARANCES		
POSTED SPEED	ITEM	ft (m)
30 mph to 35 mph (50 km/hr to 60 km/hr)	D	115 (35)
	E	85 (25)
	F	75 (22)
40 mph to 65 mph (60 km/hr to 105 km/hr)	D	230 (70)
	E	170 (50)
	F	150 (44)

SPACING FOR
COMMERCIAL DRIVES AND STREETS

Figure 1

INT OPS

(Geom t 1.1.6)

(For 14A)

1.1.6 Near Side/Far Side Lane Drops

The following guidelines, based on an ITE report, are qualitative in order to encourage the evaluation of lane drops at intersections on an individual basis:

General

1. Engineering judgment is the primary basis for determining the appropriate intersection lane drop, near-side or far-side. Additionally, engineering judgment should prevail when applying the distances recommended in these guidelines to specific traffic conditions.

2. Intersection capacity, intersection turning volumes (especially right turns), parking and right of way restrictions, design speed, lighting, and safety are significant considerations in the evaluation of the appropriate intersection lane drop, either near-side or far-side.

3. The Decision Sight Distance concept is applicable to the geometric design and placement of traffic control devices for both near-side and far-side intersection lane drops.

4. Intersection lane drops present the driver with a high judgment, complex driving situation and, therefore, the most effective signing and pavement marking is recommended (please refer to the appropriate figures).

5. Far-side intersection lane drops are preferred over near-side. To some extent both types of lane drops have been used for different purposes (far-side for capacity; near-side for operations).

6. Intersection lane drops can be associated with an interim condition before a highway widening is extended at a future date. If it is planned to continue the widening, a far-side lane drop has the advantage of placing the beginning of the new construction well beyond the intersection (please refer to the appropriate figures).

Near-Side Intersection Lane Drop

1. A near-side intersection lane drop is applicable at an urban area intersection with a heavy right turn volume and is not recommended for use in a high speed, unlighted rural area. The "trap lane" should be avoided except where extenuating circumstances such as a heavy right turn volume and/or where a far-side intersection lane drop is not feasible due to constraints (e.g. prohibitive right of way costs).

2. The Decision Sight Distance concept can be applied to the placement of traffic control devices for near-side intersection lane drops. The distances traveled during the reaction time (detection, recognition, decision, response) plus the vehicle maneuver time will produce the total Decision Sight Distance values required for various posted speeds (please refer to Table 1). These Decision Sight Distance values, in addition to allowances for queue lengths (assumed signalized intersection), will establish reasonable sign and pavement marking locations (please refer to the top figure).

INTI ROPS

(Geom nt 1.1.6)

(For 14A)

3. The signing and pavement markings for near-side intersection lane drops need special emphasis. An advance warning sign, THRU TRAFFIC MERGE LEFT (W4-7), is recommended. Advance street name signs and special pavement markings in the dropped lane will also reinforce the advance warning sign and provide motorists with the necessary guidance to react and maneuver the vehicle safely and effectively to avoid the "trap lane" (please refer to the top figure). In addition, lane control signs (R3-7 series) or RIGHT LANE MUST TURN RIGHT (R3-7R) support the use of the right turn lane. The same sign should be used at both locations.

Far-Side Intersection Lane Drop

1. A far-side intersection lane drop is applicable to both an urban and rural areas, and is considered to be the preferred intersection lane drop treatment (please refer to the bottom figure).

2. At unsignalized intersections, Decision Sight Distance can be utilized to determine the length beyond the intersection at which the lane should be dropped using the values indicated in Table 1.

3. At signalized intersections, a two part analysis is required. Adequate vehicle storage beyond the intersection, brought about by the release of vehicles from the traffic signal, must be considered in addition to the Decision Sight Distance requirement. The larger of the values calculated using these analyses will provide the required length beyond the intersection as measured from the stop bar.

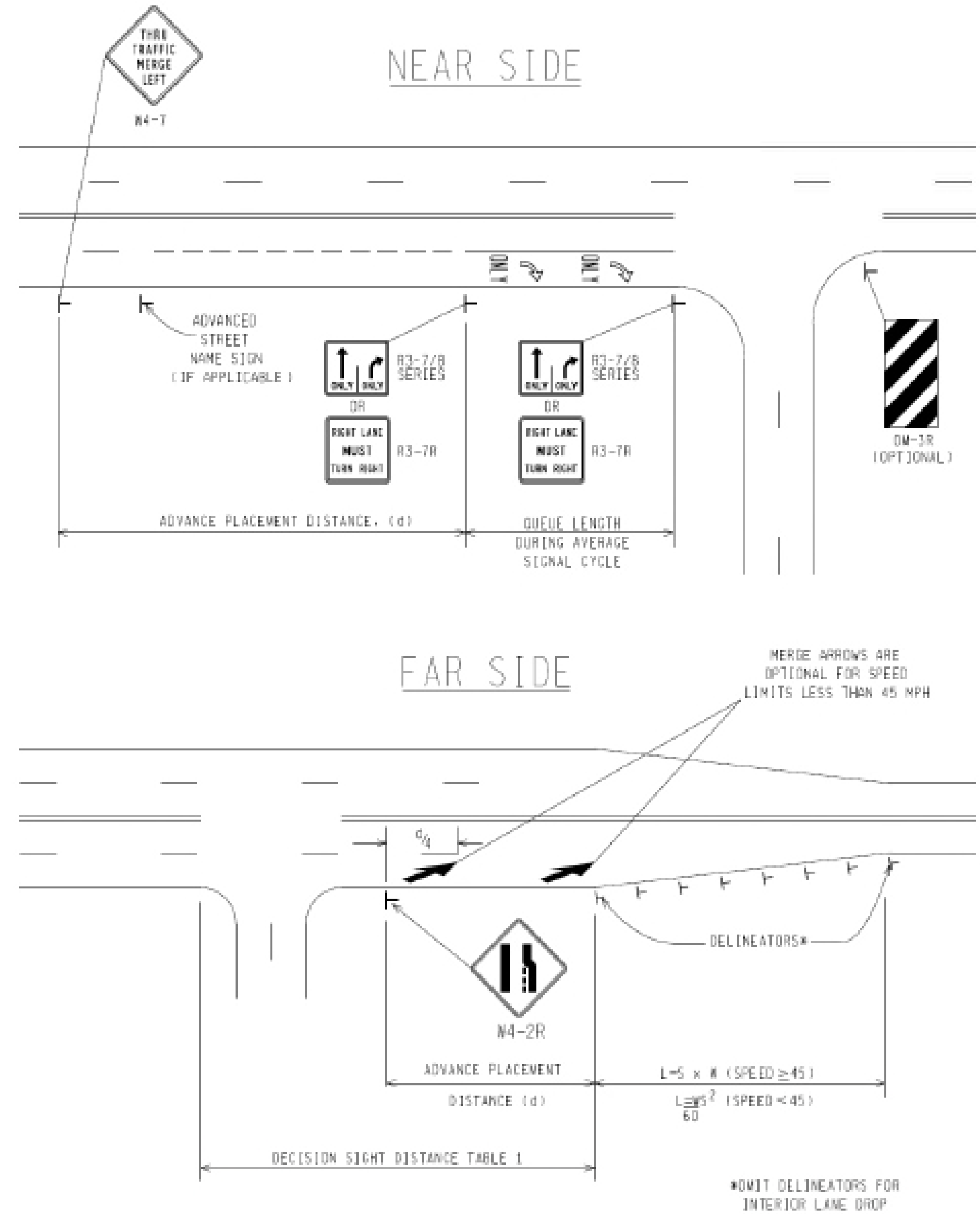
4. Proper taper lengths (L) are calculated from the following formulas:
$L = W \times S$, for S greater than or equal to 45 mph, or, $L = WS^2/60$, for S less than 45 mph (where W = width in feet and S = speed in mph).

5. Effective signing and pavement markings are necessary components to ensure a successful lane drop operation. The signing and pavement markings shown in the bottom sketch are recommended for far-side intersection lane drops.

INTE … ROPS

(Geome … nt 1.1.6)

(Forn … 614A)



Advance placement distance (d): See Traffic Sign Design Placement, and Application Guidelines (TSDPAG) Table 3: Condition A. See PAVE Standards for pavement marking details.

IN… PS

(Geo… .1.6)

(F… A)

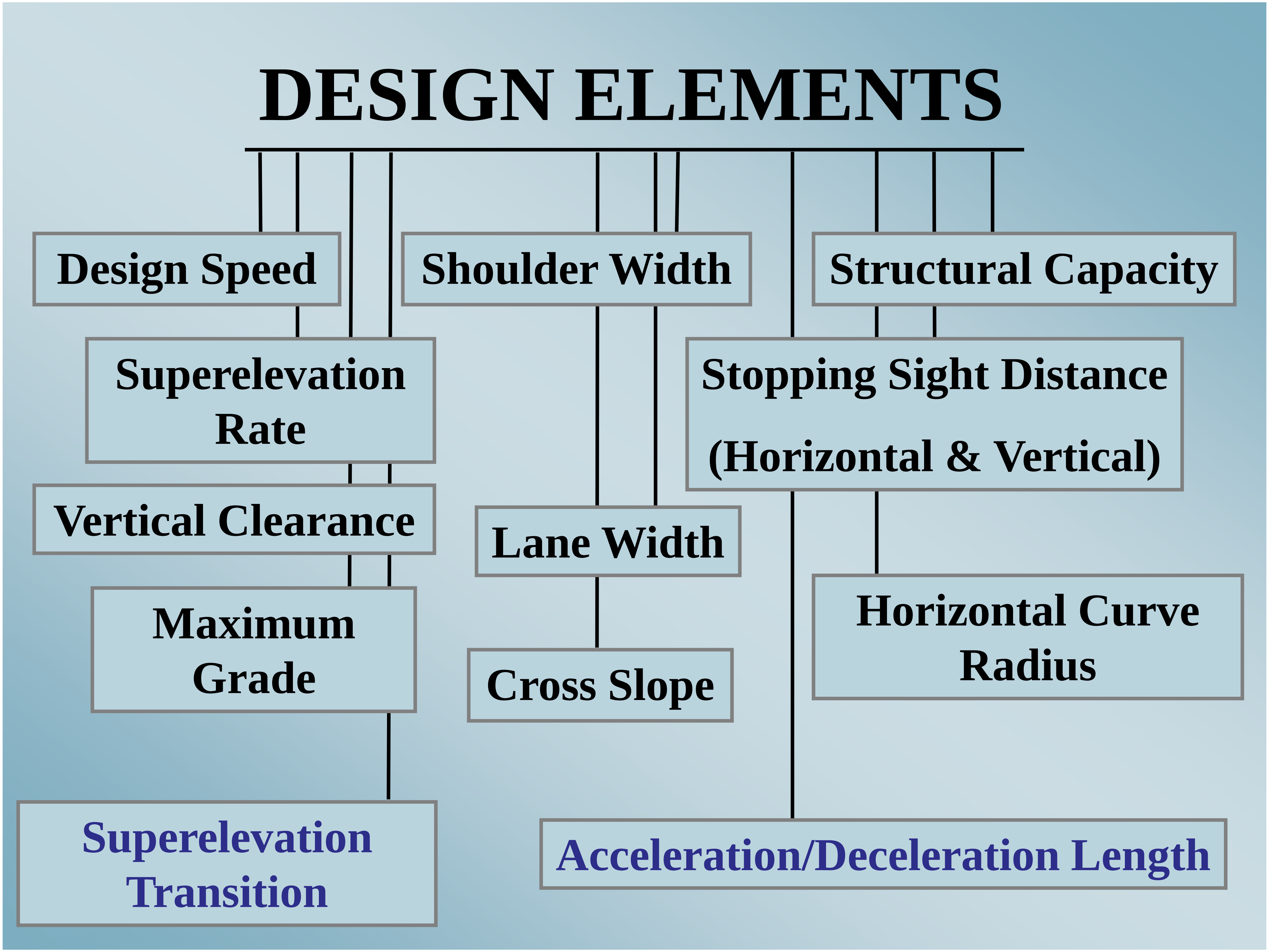
Posted speed (mph)	Decision sight distance (ft)				
	Avoidance maneuver				
	A	B	C	D	E
30	220	490	450	535	620
35	275	590	525	625	720
40	330	690	600	715	825
45	395	800	675	800	930
50	465	910	750	890	1030
55	535	1030	865	980	1135
60	610	1150	990	1125	1280
65	695	1275	1050	1220	1365
70	780	1410	1105	1275	1445
75	875	1545	1180	1365	1545
80	970	1685	1260	1455	1650

Avoidance Manuever A: Stop on rural road – $t = 3.0$ s
Avoidance Manuever B: Stop on urban road – $t = 9.1$ s
Avoidance Manuever C: Speed/path/direction change on rural road – t varies between 10.2 and 11.2 s
Avoidance Manuever D: Speed/path/direction change on suburban road – t varies between 12.1 and 12.9 s
Avoidance Manuever E: Speed/path/direction change on urban road – t varies between 14.0 and 14.5 s

Decision Sight Distance
TABLE 1

QUESTIONS

DESIGN EXCEPTIONS
DESIGN VARIANCES


DESIGN ELEMENTS
Design Speed
Shoulder Width
Structural Capacity
Superelevation Rate
Stopping Sight Distance (Horizontal & Vertical)
Vertical Clearance
Lane Width
Horizontal Curve Radius
Maximum Grade
Cross Slope
Superelevation Transition
Acceleration/Deceleration Length

DESIGN EXCEPTIONS / VARIANCES

(RDM 3.08.01E)

Non-Standard Design Element (NHS and Non-NHS) (See Section 3.11.01 for DE Criteria for 3R freeway work)	Applicability of Design Exception (DE) Design Variance (DV)	
	Design Speed	
	≥ 50 MPH	< 50 MPH
Design Speed < Posted Speed	DE	DE
Lane Width*	DE	DV
Shoulder Width	DE	DV
Horizontal Curve Radius*	DE	DV
Superelevation Rate*	DE	DV
Superelevation Transition*	DV	DV
Maximum Grade*	DE	DV
Stopping Sight Distance (Horizontal and Vertical)*	DE	DV
Cross Slope	DE	DV
Vertical Clearance	DE	DE
Design Loading Structural Capacity	DE	DE
Ramp Acceleration / Deceleration Length*	DV	DV

**Values based on design speeds less than posted.*

DESIGN CRITERIA

3R PROJECTS

Road Design Manual 3.09 & 3.11.01

NHS

Road Design Manual 3.09.02A

Non-NHS

Road Design Manual 3.09.02B

4R PROJECTS

Road Design Manual 3.11

Freeway

Road Design Manual Appendix 3A

Non-Freeway

Road Design Manual Appendix 3A

RDM 3.09.02A

MICHIGAN DESIGN MANUAL
ROAD DESIGN

3.09.02 (continued)

A. Non-Freeway, NHS

Geometric Elements	Non-Freeway, NHS 3R Minimum Guidelines			
Design Speed (see Section 3.06)	Posted Speed Minimum			
Shoulder Width	Current ADT Two-Way		Inside Shoulder	Outside Shoulder
	Two Lane (and three lane when the center lane is a left turn lane)	<750		3'-0" Gravel
		750 - 5000		6'-0" (3'-0" Paved)
		>5000 - 10,000		8'-0" (3'-0" Paved)
		>10,000		8'-0" (7'-0" Paved)
	Multi-Lane Undivided	≤ 10,000 > 10,000		6'-0" (3'-0" Paved) 8'-0" (3'-0" Paved)
	Multi-Lane Divided	≤ 10,000 > 10,000	3'-0" Paved 3'-0" Paved	6'-0" (3'-0" Paved) 8'-0" (3'-0" Paved)
NOTE: Minimum shoulder widths apply for posted speeds greater than 45 mph. Restrictions such as right of way and roadside context sensitivity issues may preclude the use of minimum shoulders within city, village or township limits with posted speeds of 45 mph and less.	See Bridge Design Manual Appendix 12.02 for Bridge Widths			
Lane Width	ADT	Lane Width		
	≤750	10'-0"		
	>750	11'-0"		
		10'-0" lanes may be considered in urban areas for multi-lane un-divided (regardless of ADT) and multi-lane divided (ADT < 10,000). 12'-0" lanes are desirable on the Priority Commercial Network (PCN). 12'-0" lanes are required on the National Network (also known as the National Truck Network). Design Exceptions / Design Variances to maintain existing narrower lanes generally receive favorable consideration but a high burden of justification is placed on requests to reduce lane widths to less than 12'-0".		
Design Loading Structural Capacity	Rural		Urban	
	Minimum Design Loading HS20.		Minimum Design Loading HS20.	
	(See Bridge Design Manual Appendix 12.02 for other trunkline classifications)			
Horizontal Curve Radius and Stopping Sight Distance	Existing curve radius and stopping sight distance may be retained if the design speed of the existing curve is not more than 15 mph below the project design speed and there is no crash concentration. Otherwise standards for new construction apply. See 2011 6th Edition AASHTO Green Book or MDOT Sight Distance Guidelines.			
Maximum Grade	Review crash data. Existing grade may be retained without crash concentration.			
Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05			
Superelevation Rate	Standard Plan R-107-Series or reduced maximum (6%) Straight Line Superelevation Chart using the project design speed.			
Vertical Clearance	See Section 3.12.			

RDM 3.09.02B

3.09.02 (continued)

B. Non-Freeway, Non-NHS

Geometric Elements	Non-Freeway, Non-NHS 3R Minimum Guidelines		
Design Speed	Posted Speed Minimum		
Shoulder Width	Current ADT Two-Way	Inside and Outside Shoulder Width	
NOTE: Minimum shoulder widths apply for posted speeds greater than 45 mph. Restrictions such as right of way and roadside context sensitivity issues may preclude the use of minimum shoulders within city, village or township limits with posted speeds of 45 mph and less.	≤750	2'-0" (Gravel)	
	750 - 2000	3'-0" (Paved)	
	> 2000	6'-0" (3'-0" Paved)	
	Multi-Lane (Divided & Undivided)	Inside (Divided)	Outside (Both sides for un-divided)
		3'-0" Paved	6'-0" (3'-0" Paved)
	See Bridge Design Manual Appendix 12.02 for Bridge Widths		
Lane Width	ADT	Lane Width	
	≤750	10'-0"	
	>750	11'-0"	
		10'-0" lanes may be considered in urban areas for multi-lane un-divided (regardless of ADT) and multi-lane divided (ADT < 10,000).	
		12'-0" lanes are desirable on the Priority Commercial Network (PCN) and the National Network (also known as the National Truck Network). Existing narrower lanes may be retained without Design Exceptions / Design Variances. Reduction of existing lane widths on the National Network to less than 12-0" require a Design Exceptions / Design Variances request having a high burden of justification.	
Design Loading Structural Capacity **(Existing Bridges to remain in place)**	ADT (Design Year)	Minimum Design Loading	
	0 - 750	H15	
	> 750	HS15	
Horizontal Curve Radius and Stopping Sight Distance	Existing curve radius and stopping sight distance may be retained if the design speed of the existing curve is not more than 15 mph (horizontal) or 20 mph (vertical) below the project design speed and there is no crash concentration. Otherwise standards for new construction apply. See 2011 6[th] Edition AASHTO Green Book or MDOT Sight Distance Guidelines.		
Maximum Grade	Review crash data. Existing grade may be retained without crash concentration.		
Cross Slopes	Traveled way 1.5% - 2%, Shoulder see Section 6.05.05		
Superelevation Rate	Standard Plan R-107-Series or reduced maximum (6%) Straight Line Superelevation Chart using the project design speed.		
Vertical Clearance	See Section 3.12.		

3R FREEWAY ALLOWANCES

GEOMETRIC REQUIREMENTS FOR FREEWAY PROJECTS INVOLVING 3R WORK TYPES

Geometric Design Element		Minimum Required Standard *	Compliance Determination
Design Speed		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Horizontal Curve Radius (Rmin.)		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Longitudinal Grade (Min./Max.)		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Stopping Sight Distance (Horizontal and/or Vertical))		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Lane Width		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Shoulder Width		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Superelevation		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Cross-Slope	***(Excluding parabolic – Parabolic cross-slopes still require a DE/DV)***	Standard at the time of construction or the most recent 4R project ***(Unless parabolic; Parabolic cross-slopes must be removed or a DE/DV is required)***	Compliance Assumed ***(Unless parabolic; Parabolic cross-slopes must be removed or a DE/DV is required)***
Structural Capacity		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Vertical Clearance		Standard at the time of construction or the most recent 4R project	Compliance Assumed
Acceleration/Deceleration Length		Existing Length	Compliance Assumed

*** If the project-wide Safety Review identifies a pattern of crashes associated with a particular design element (or elements), then that design element (or those elements) <u>must</u> be bought up to <u>current</u> standards (i.e. the existing design values may <u>not</u> be retained if they do not meet current standards).**

RDM APPENDIX 3A

Appendix 3A
GEOMETRIC DESIGN ELEMENTS
New Construction / Reconstruction

<table>
<tr><th>Element</th><th></th><th>Urban</th><th>Rural</th></tr>
<tr><td rowspan="3">Design Speed</td><td>Freeway</td><td>The greater of posted speed, or 60 mph.</td><td>The greater of posted speed, or 70 mph.</td></tr>
<tr><td>Non Freeway (Arterial)</td><td>The greater of posted speed, or 30 mph.</td><td>The greater of posted speed, or 40 mph..</td></tr>
<tr><td>Collector Roads</td><td>Posted speed (minimum).</td><td>Posted speed (minimum)..</td></tr>
<tr><td rowspan="4">Lane Width</td><td>Freeway</td><td>12 ft.</td><td>12 ft.</td></tr>
<tr><td>Non Freeway (Arterial)</td><td>12 ft, lanes are most desirable and should be used where practical. 11 ft. lanes are often used for low speed (45 mph design)

Lane widths of 10 ft. may be used in more constrained areas where truck and bus volumes are relatively low and speeds are less than 35 mph.

12 ft. lanes on the National Network (NN). Design exceptions / variances are required to maintain existing narrower lanes. A high burden of justification is required in a design exception / variance to reduce existing lane widths less than or equal to 12'-0".</td><td>
<table>
<tr><th rowspan="3">Design Speed, (mph)</th><th colspan="4">Minimum Lane Width, ft.</th></tr>
<tr><th colspan="4">ADT, vehicles/day</th></tr>
<tr><th>Under 400</th><th>400 to 1500</th><th>1500 to 2000</th><th>Over 2000</th></tr>
<tr><td>40</td><td>11*</td><td>11*</td><td>11*</td><td>12</td></tr>
<tr><td>45</td><td>11*</td><td>11*</td><td>11*</td><td>12</td></tr>
<tr><td>50</td><td>11*</td><td>11*</td><td>12</td><td>12</td></tr>
<tr><td>55</td><td>11*</td><td>11*</td><td>12</td><td>12</td></tr>
<tr><td>60</td><td>12</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td>65</td><td>12</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td>70</td><td>12</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td>75</td><td>12</td><td>12</td><td>12</td><td>12</td></tr>
<tr><td colspan="5">*12 ft. desirable</td></tr>
</table>
</td></tr>
<tr><td rowspan="2">Collector Roads</td><td>Added turn lanes at intersections 10-12 ft.
Where right-of-way is restricted. 11 ft.
Industrial Areas 12 ft.</td><td rowspan="2">
<table>
<tr><th rowspan="3">Design Speed, (mph)</th><th colspan="4">Minimum Lane Width, ft.</th></tr>
<tr><th colspan="4">ADT, vehicles/day</th></tr>
<tr><th>Under 400</th><th>400 to 1500</th><th>1500 to 2000</th><th>Over 2000</th></tr>
<tr><td>20</td><td>10*</td><td>10*</td><td>11*</td><td>12</td></tr>
<tr><td>25</td><td>10*</td><td>10*</td><td>11*</td><td>12</td></tr>
<tr><td>30</td><td>10*</td><td>10*</td><td>11*</td><td>12</td></tr>
<tr><td>35</td><td>10*</td><td>11*</td><td>11*</td><td>12</td></tr>
<tr><td>40</td><td>10*</td><td>11*</td><td>11*</td><td>12</td></tr>
<tr><td>45</td><td>10*</td><td>11*</td><td>11*</td><td>12</td></tr>
<tr><td>50</td><td>10*</td><td>11*</td><td>11*</td><td>12</td></tr>
<tr><td>55</td><td>11*</td><td>11*</td><td>12</td><td>12</td></tr>
<tr><td>60</td><td>11*</td><td>11*</td><td>12</td><td>12</td></tr>
<tr><td colspan="5">*12 ft. desirable</td></tr>
</table>
</td></tr>
<tr><td>Where shoulders are used, see guidelines for Rural Collectors</td></tr>
</table>

RDM APPENDIX 3A

Appendix 3A
GEOMETRIC DESIGN ELEMENTS
New Construction / Reconstruction

<table>
<tr><th>Element</th><th></th><th colspan="5">Urban & Rural</th></tr>
<tr><td rowspan="14">Shoulder Width</td><td rowspan="4">Freeway</td><td colspan="3">Mainline</td><td colspan="2">Ramp (one lane and two lanes)</td></tr>
<tr><td colspan="2">Median</td><td>Outside</td><td>Left</td><td>Right</td></tr>
<tr><td colspan="2">8 ft. (4ft. paved)
(8 ft. paved at bridge and barrier sections)

For 6 or more lane sections (3 or more lanes directional) use 10 ft. paved min and consider 12 ft. paved where truck traffic exceeds 250 DDHV.</td><td>10 ft. min (paved)

For non-interstate freeways, use 12 ft. paved where truck traffic exceeds 250 DDHV.

For interstate freeways consider using 12 ft. paved where truck traffic exceeds 250 DDHV.</td><td>6 ft. (4 ft. paved)</td><td>8 ft. (7ft. paved)</td></tr>
<tr><td colspan="5">For new construction and reconstruction, the mainline outside paved shoulder is extended with 1 ft. of aggregate to the shoulder hinge for stabilization.
When widening existing paved shoulders to meet current standard widths, it is desirable to provide the additional foot of aggregate when feasible.</td></tr>
<tr><td rowspan="6">Non Freeway (Arterial)</td><td>Urban</td><td colspan="4">Rural</td></tr>
<tr><td rowspan="4">In those instances where sufficient right-of-way exists to include shoulders, refer to the guidance for non freeway rural shoulders.*</td><td colspan="4">Min paved shoulder, ft. for specified ADT, veh/day
Undivided Roadways*</td></tr>
<tr><td>Under 400</td><td>400 to 1500</td><td>1500 to 2000</td><td>Over 2000</td></tr>
<tr><td>4</td><td>6</td><td>6</td><td>8</td></tr>
<tr><td colspan="4">Use 8ft. right and 4 ft. left for divided arterials.
Use full width (8 ft.) on both sides of divided arterials with 3 lanes in each direction.

For new construction and reconstruction and when feasible on shoulder widening, the paved shoulder is extended with 1 ft. of aggregate to the shoulder hinge for stabilization.</td></tr>
<tr><td colspan="5">A minimum 4 ft. (3 ft. paved) shoulder is acceptable adjacent to right turn lanes.
* Minimum shoulder widths apply for posted speeds greater than 45 mph. At lower speeds, minimum shoulders are desirable.</td></tr>
<tr><td rowspan="4">Collector Roads</td><td rowspan="4">Where shoulders are used, refer to requirements for rural arterials.</td><td colspan="4">Min shoulder, ft. for specified ADT, veh/day</td></tr>
<tr><td>Under 400</td><td>400 to 1500</td><td>1500 to 2000</td><td>Over 2000</td></tr>
<tr><td>2</td><td>5</td><td>6</td><td>8</td></tr>
<tr><td colspan="4">The above ranges apply on uncurbed roads and when shoulders are feasible on curbed roads. A minimum paved width of 1 ft. is desirable.</td></tr>
</table>

RDM APPENDIX 3A

Appendix 3A
GEOMETRIC DESIGN ELEMENTS
New Construction / Reconstruction

Element		Urban & Rural	
Design Loading Structural Capacity (Also see Bridge Design Manual)	Freeway	HS-25/HL93	
	Non Freeway	State Trunkline	HS-25/HL93
		Local Roads Over Freeways and State Trunkline	HS-25/HL93
		Local Roads and Streets	Design according to county or city standards, HS20/HL93 min.
		Use HS-25/HL93 for all structures in an interchange regardless of route type	
Horizontal Curve Radius	Freeway	*See Standard Plan R-107-Series and Section 3.04.03*	
	Non Freeway (Arterial)		
	Collector Roads		
	Non Freeway (Arterial)		
	Collector Roads		

RDM APPENDIX 3A

Appendix 3A
GEOMETRIC DESIGN ELEMENTS
New Construction / Reconstruction

Maximum Grade

Maximum Grade (%) for specified design speed (mph)

Freeway – Type of Terrain	50	55	60	65	70	75
Level	4	4	3	3	3	3
Rolling	5	5	4	4	4	4

Grades 1% steeper may be provided in urban areas.

Non Freeway (Arterial) – Type of Terrain	Urban							Rural				
	30	35	40	45	50	55	60	40	45	50	55	60
Level	8	7	7	6	6	5	5	5	5	4	4	3
Rolling	9	8	8	7	7	6	6	6	6	5	5	4

Collector Roads – Type of Terrain	Urban									Rural								
	20	25	30	35	40	45	50	55	60	20	25	30	35	40	45	50	55	60
Level	9	9	9	9	9	8	7	7	6	7	7	7	7	7	7	6	6	5
Rolling	12	12	11	10	10	9	8	8	7	10	10	9	9	8	8	7	7	6

Element	Requirement
Stopping Sight Distance	Follow 2011 6th Edition of AASHTO "A Policy on Geometric Design of Highways and Streets" (AKA AASHTO Green Book). The MDOT Sight Distance Guidelines also provide detailed information on sight distance calculation.
Cross Slope	Traveled way cross slope = 2.0%, Paved shoulder cross slope = 4.0% (Also see Section 6.05.05)
Superelevation Rate	AASHTO Method 5 "Curvilinear Relation" is used for new construction/reconstruction. Maximum rate of 7%. (See Standard Plan R-107-Series.)
	AASHTO Method 1 "Straight Line Relation" is allowed when Method 5 is not feasible. Maximum rate of 6%. (See Section 3.04.03)
	The above methods also apply to urban freeways and urban ramps, except the maximum rate is 5% for 60 mph design speed.

Vertical Clearance

	NHS	Non NHS
Freeway	16'-0"	14'-6"
Non Freeway (Arterial)	16'-0"	14'-6"
Collectors & "Special Routes"	14'-6" (1 ft. greater than Michigan legal vehicle height.)	14'-6"

For pedestrian bridges provide 1 ft. additional clearance over non-freeway and 17 ft. minimum under clearance over freeways. A vertical clearance of 23'-0" is required for grade separations over railroads. *(See Bridge Design Manual 7.01.08 and Bridge Design Guides 5.24.03-04.)*

FORM DE26

Clear Form

Michigan Department of Transportation
DE26 (03/19)

DESIGN EXCEPTION REQUEST - TRUNKLINE

This Information Fulfills Requirements of the Federal Highway Administration.

I. PROJECT DESCRIPTION (FILL IN PROJECT INFORMATION AND PROVIDE A BRIEF WRITE-UP OF PROJECT AND LIMITS)

CONTROL SECTION(S)	JOB NUMBER(S)	PHYSICAL REFERENCE NUMBER(S)

CONSTRUCTION GUIDELINE	NATIONAL HIGHWAY SYSTEM	OVERSIGHT APPROVAL
☐ 3R ☐ 4R	☐ YES ☐ NO	☐ MDOT ☐ FHWA PoDI

LOCATION

DESCRIPTION OF WORK

PLAN REVIEW DATE	PLAN COMPLETION DATE	APPROVED LETTING DATE

II. LEGAL SPEED AND EXISTING AND FUTURE TRAFFIC VOLUMES

POSTED SPEED	DESIGN SPEED	Ex ADT	PROJECTED ADT	Ex % COMM.	Ex COMM. DDHV (Fwy only)
mph	mph				

FIX LIFE	YEAR PROJECTED *(FIX YEAR + FIX LIFE)*	PROJECTED % COMMERCIAL	PROJECTED COMMERCIAL DDHV (Fwy only)
Years			

III. DESIGN EXCEPTION FOR THE FOLLOWING ELEMENT (IDENTIFY LOCATION BELOW)

ELEMENT: Select from drop down menu

Describe existing roadway/bridge geometric features including element values for each exception location (identify locations by station and mile point).

Design criteria for these features (provide the appropriate references, including document to the chapter, page and design values):

MDOT CRITERIA	AASHTO CRITERIA

Proposed design values for the exception element (identify what design speed and appropriate dimensions this treatment meets if applicable).

All Design Exceptions must have a site specific Crash Analysis attached. The crashes must be analyzed for the requested Geometric element utilizing the most recent 4 years of crash data available on RoadSoft. Fatalities (K) and Serious Injuries (A) must be reviewed and commented on in the review and analysis. Access High Load Hits database (maintenance) and include with analysis for vertical clearance design exceptions. A crash analysis may be POB-POE if the geometric element in question is also POB-POE (e.g., shoulder width). The project scoping "Safety Review and Crash Analysis" document is not applicable for design exceptions.

See attached site specific crash analysis (and approval memo if a consultant performed the crash analysis).

Impacts other than costs of bringing the features up to standard as specified under Design Criteria (e.g., impacts to other design features, ROW, environmental effects, preservation of historical feature, construction issues, social concerns, reduction of design life...)

PROGRAMMED CONSTRUCTION COST OF PROJECT	INCREASED COST TO MEET MINIMUM DESIGN CRITERIA FOR REQUESTED DESIGN EXCEPTION

List the proposed and/or existing mitigation measures to address design exception feature if applicable (advisory signs, lighting of curves, future work to address design exception, incremental improvements. . .)

ADDITIONAL COMMENTS

SIGNATURES REQUIRED

RECOMMENDED BY	MDOT APPROVED/REVIEWED BY

* APPROVED BY (FHWA Area Engineer)

* Note: Reviewed and/or approved by FHWA in Accordance with the PoDI Project Stewardship & Oversight Agreement (SOA).

FORM DV26

Clear Form

Michigan Department
of Transportation
DV26 (03/19)

DESIGN VARIANCE REQUEST - TRUNKLINE

Page 1 of 1

I. PROJECT DESCRIPTION			
CONTROL SECTION(S) or PR NUMBERS(S)		JOB NUMBER(S)	
CONSTRUCTION GUIDELINE ☐ 3R ☐ 4R	NATIONAL HIGHWAY SYSTEM ☐ YES ☐ NO	POSTED SPEED mph	DESIGN SPEED mph
LOCATION			
DESCRIPTION OF WORK			
II. DESIGN VARIANCE CRITERIA			
ELEMENT: Select from drop down menu			
Describe existing features including element values for each variance location (include stationing).			
MDOT CRITERIA		AASHTO CRITERIA	
Proposed design values for the variance			

All Design Variances must have a site specific Crash Analysis attached. The crashes must be analyzed for the requested Geometric element utilizing the most recent 4 years of crash data available on RoadSoft. Fatalities (K) and Serious injuries (A) must be reviewed and commented on in the review and analysis. A crash analysis may be POB-POE if the geometric element in question is also POB-POE (e.g., shoulder width). The project scoping "Safety Review and Crash Analysis" document is not applicable for design variance.

See attached site specific crash analysis (and approval memo if a consultant performed the crash analysis).

Justification for not meeting the standard (Cost, Environmental, Historical, ROW, etc.)

ADDITIONAL COMMENTS

Does a bridge exist within the limits of the DV that influences/affects the DV element? ☐ YES ☐ NO

Have variances affected by bridges been coordinated with the Bridge Design Supervising Engineer? ☐ YES ☐ Not Applicable

SIGNATURES REQUIRED	
APPROVED BY : Associate Region Engineer of Development	RECOMMENDED BY: Project Manager

Design Exception Crash Analysis Instructions

REQUIRED ELEMENTS OF A COMPREHENSIVE DESIGN EXCEPTION REQUEST CRASH ANALYSIS

1) Subject heading which includes a description of the project (route number, control section, P.R. number, control section and P.R. beginning and ending mile points, and job number).

2) A statement that the crash analysis is in relation to a specific design exception request (as opposed to a project wide analysis).

3) A statement indicating which geometric feature the design exception has been requested for, and the location to which it applies (Control Section or P.R. number and mile points).

4) A description of the existing condition or value of the geometric feature in question.

5) A description of the proposed condition or value of the geometric feature in question.

6) A statement detailing what the standard value is for the geometric feature in question, and a reference to the appropriate governing Standard or Guide.

7) A description of the crash data used in the analysis (time span and mile point limits of the data query). This should be the most recent four years for which crash data is available, using the Safety Management System in TMS.

8) A summary of the total numbers and types of crashes found in the analysis.

9) A statement that the crash types associated with the geometric feature in question were specifically investigated in detail. Refer to Table A to determine which crash types are associated with which geometric features. This detailed investigation shall include a review of all crash reports (UD-10's) for these crash types. If there are a large number of crashes of the associated types, a representative sample of UD-10's may be selected for review (as opposed to all of them).

10) A statement that the analysis did not (or conversely, did) find a pattern or concentration of crashes associated with the geometric feature for which the design exception has been requested.

Design Exception Crash Analysis Instructions

TABLE A

GEOMETRIC FEATURE TO WHICH DESIGN EXCEPTION APPLIES	ASSOCIATED CRASH TYPES
Design Speed	All Crash Types
Lane Width	Sideswipe, Fixed-Object, Run-Off, Overturn
Shoulder Width	Sideswipe, Fixed-Object, Run-Off, Overturn
Bridge Width	Sideswipe, Fixed-Object
Structural Capacity	N/A
Horizontal Alignment	Fixed-Object, Run-Off, Overturn, Sideswipe, Head-On
Vertical Alignment	Rear-End, Sideswipe, Head-On, Fixed-Object, Run-Off, Overturn, Angle
Longitudinal Grade	Rear-End, Sideswipe, Head-On
Stopping Sight Distance *	Rear-End, Sideswipe, Head-On, Fixed-Object, Run-Off, Overturn, Angle
Cross-Slope/Roll-Over	Too Little: Rear-End, Percent Wet, Percent Icy
	Too Great: Fixed-Object, Run-Off, Overturn
Superelevation	Fixed-Object, Run-Off, Overturn, Sideswipe, Head-On
Vertical Clearance	High-Load Hits
Horizontal Clearance (Excluding Clear Zone)	Sideswipe, Rear-End, Head-On, Fixed-Object
Ramp Acceleration or Deceleration Length	Sideswipe, Rear-End, Fixed-Object, Run-Off, Overturn

* At night, the available sight distance through sag vertical curves is largely determined by headlight illumination distance. Therefore, when reviewing crashes in relation to sag vertical curves, particular attention should be paid to night-time crashes, including animal collisions. A high percentage of night-time crashes could indicate a crash pattern related to insufficient stopping sight distance. While animal collisions are not generally included in crash analyses due to the large uncertainty as to their causes and/or exact locations, they should not be summarily dismissed, either. Animal crashes can be taken with together with the crash data set as a whole, and can sometimes help identify crash patterns specifically related to restricted sight distance.

When performing a crash analysis as part of a design exception request, focus the review on the crash types which are associated with the geometric feature in question. Use the table above to determine which crash types are associated with each geometric feature. Also, consider only the crashes which have occurred in the vicinity of the subject geometric feature (not necessarily project wide). It is usually sufficient to set the mile point limits of the crash data query to a few hundred feet on either side of the geometric feature in question.

Crash analysis is, by its nature, an inexact and subjective exercise. There will often times be uncertainty as to whether or not a particular geometric feature contributed towards a given crash. The information provided in the UD-10's, along with engineering judgement, can usually resolve any questions adequately.

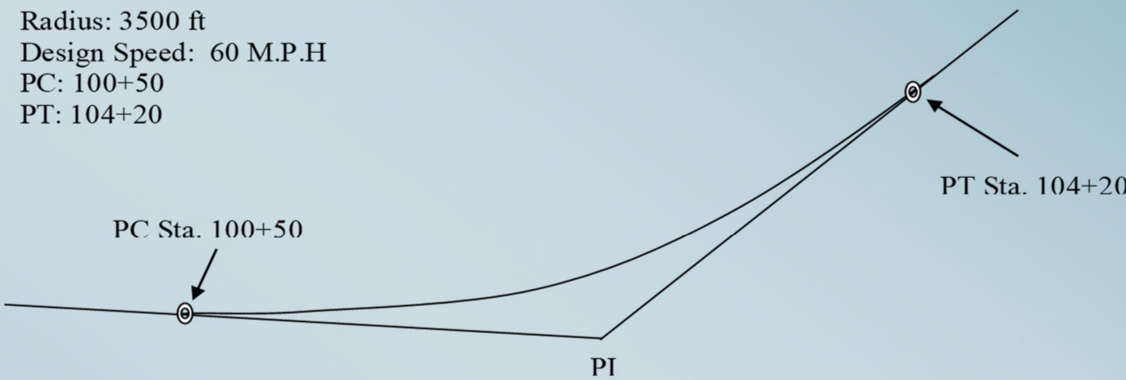
QUESTIONS

Superelevation Transitions for 2 Lane 2 Way
(Reference R-107 sheet 3 of 7)

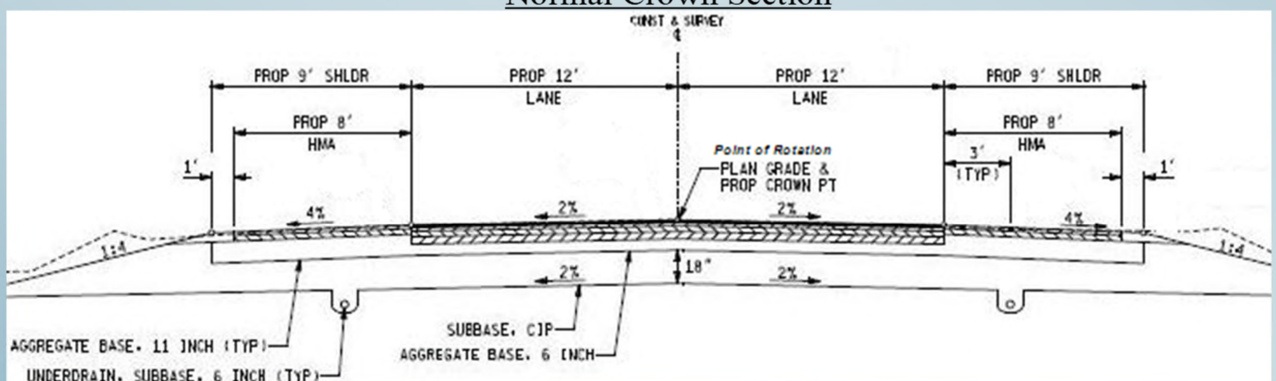
Problem 8:

Given the following information:

Radius: 3500 ft
Design Speed: 60 M.P.H
PC: 100+50
PT: 104+20



Normal Crown Section



Given the following curve information, determine the following design criteria using R-107:

- Proposed Superelevation Rate
- Delta Percent Value
- Shoulder Cross-Slopes in Superelevated Section (High-Side and Low-Side)
- Crown Runout Length (C) and Superelevation Transition Length (L)
- Placement of Superelevation Transition with Respect to the PC and PT

Answers:

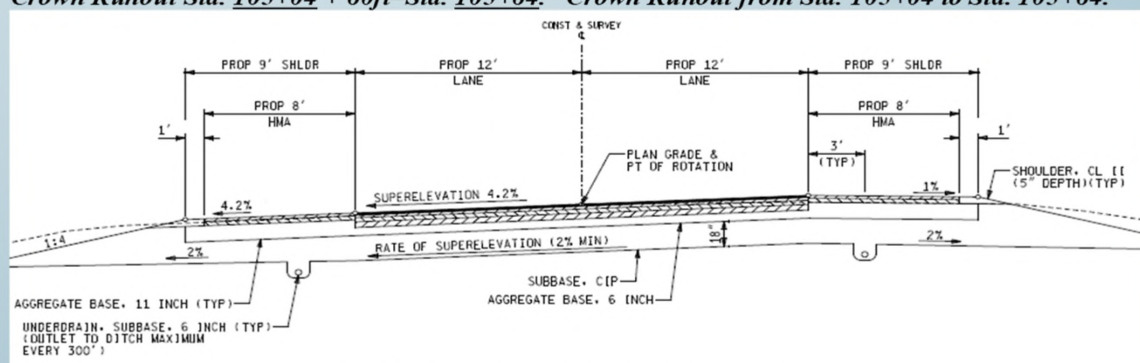
Superelevation = 4.2%
Delta = 0.40
Shoulder Cross-slopes = Same as Super (4.2%) on Low-Side and -1.0% on High-Side

Super Transition Length = (12' x 4.2%) / 0.40 = **126ft**
126ft / 3 = 42ft
PC Station 100+50 + 42ft = Sta. 100+92 - 126 ft = Sta. 99+66
PT Station 104+20 - 42ft = Sta. 103+78 + 126ft = Sta. 105+04

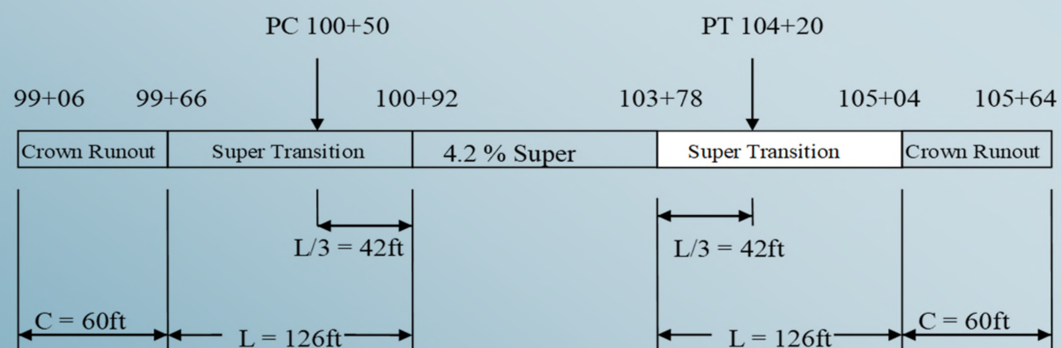
Super Transition from Station 99+66 to Station 100+92 (PC)
Super Transition from Station 103+78 to 105+04 (PT)

Crown Runout = (12' x 2%) / 0.40 = **60ft**
PC Station 100+50:
Crown Runout Sta. 99+66 – 60ft = Sta. 99+06. Crown Runout from Sta. 99+06 to Sta. 99+66.

PT Station 104+20:
Crown Runout Sta. 105+04 + 60ft=Sta. 105+64. Crown Runout from Sta. 105+04 to Sta. 105+64.



PROPOSED SUPERELEVATED SECTION

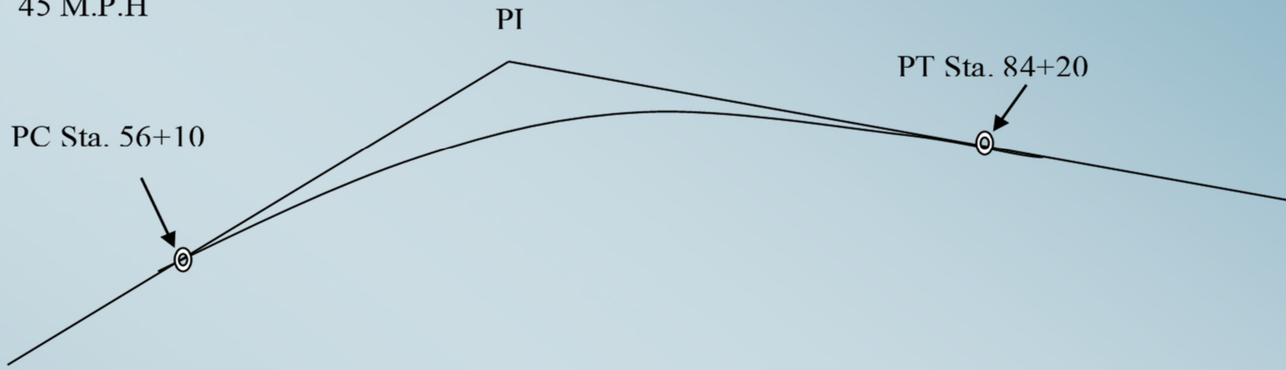


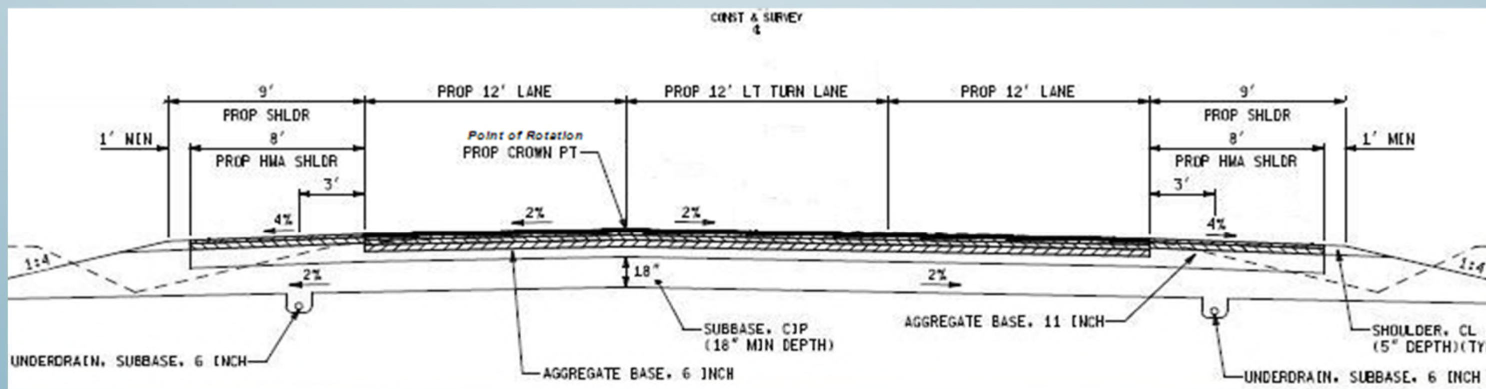
Superelevation Transitions for Odd Number of Lanes
(Reference R-107 sheet 7 of 7)

’roblem 9:

Given the following information:

Radius: 2500 ft
Design Speed: 45 M.P.H
PC: 56+10
PT: 84+20





Given the following curve information, determine the following design criteria using R-107:

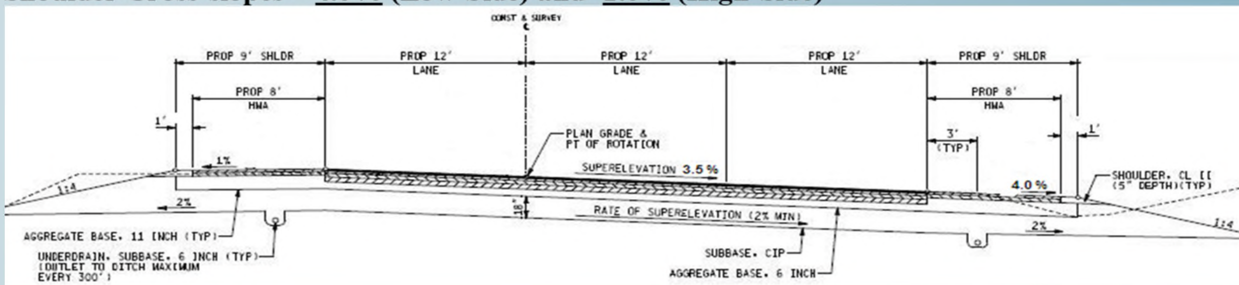
- Proposed Superelevation Rate
- Delta Percent Value
- Shoulder Cross-Slopes in Superelevated Section (High-Side and Low-Side)
- Crown Runout Length (C) and Superelevation Transition Length (L)
- Placement of Superelevation Transition with Respect to the PC and PT

Answers:

Superelevation = 3.5%

Delta = 0.44

Shoulder Cross-slopes = 4.0% (Low-Side) and -1.0% (High-Side)



Super Transition = L1 + L2

L1 = (12' x 2.0%) / (0.5 x 0.44) = 109ft

L2 = [24' x (3.5% - 2%)] / (0.44) = 82ft

L = L1 + L2 = 109ft +90ft = **191ft**

191ft / 3 = **64ft**

PC Station 56+10 + 64ft = Sta. 56+74 - 191 ft = Sta. 54+83

PT Station 84+20 - 64ft = Sta. 83+56 + 191ft = Sta. 85+47

Super Transition from Station 54+83 to Station 56+74 (PC)

Super Transition from Station 83+56 to 85+47 (PT)

Crown Runout = (12' x 2%) / (0.5 x 0.44) = **109ft**

PC Station 56+10 Sta. 54+83 – 109ft = Sta. 53+74

PT Station 84+20 Sta. 85+47 + 109ft = Stat 86+56

Crown Runout at station 53+74 to 54+83

Crown Runout at station 85+47 to 86+56