

Chapter Five presents guidance for the design of New and Reconstructed projects; design guidance for 3R projects is provided in Chapter Seventeen.

Chapter Five

Interstates, Grade Separations, and Interchanges

Primary sources for design guidance for Interstates are the **American Association of State Highway and Transportation Officials (AASHTO)** publications *A Policy on Design Standards – Interstate System* (Ref. 5.1) and *A Policy on Geometric Design of Highways and Streets* (the *Green Book*) (Ref. 5.2). Design details specific to the design of Interstates by the **Nebraska Department of Transportation (NDOT)** are presented in this chapter. Refer to the design details and information presented in the remaining chapters of this manual for **NDOT** guidance not presented here.

The primary guide for grade separation and interchange design for **NDOT** is the *Green Book* (Ref. 5.2). This chapter presents a general overview of and **NDOT** variations on the *Green Book* guidance.

Additional resources used by **NDOT** include the **Transportation Research Board's (TRB's) Highway Capacity Manual** (Ref. 5.3) and the **Federal Highway Administration's (FHWA's) Manual on Uniform Traffic Control Devices (MUTCD)**, Ref. 5.4) (<http://dot.nebraska.gov/business-center/contractor/mutcd/>).

1. **INTERSTATE SYSTEM**
(<https://www.fhwa.dot.gov/programadmin/interstate.cfm>)

The Dwight D. Eisenhower National System of Interstate and Defense Highways (Interstate System) is a national defense system of highways consisting of routes built to uniform geometric and construction standards. This system connects the principal metropolitan areas, cities, and industrial centers of the United States and, to the greatest extent possible, connects the border routes of continental importance with Canada and Mexico. A map showing the Interstate routes in Nebraska is available on the internet at https://dot.nebraska.gov/media/2741/nat_hwy_sys.pdf.

1.A. **Interstate Design Values**

The **NDOT** minimum design values for use on the Interstate System are in Chapter 2 of the Nebraska Administrative Code, Title 428 (MDS) (Ref. 5.5) (<http://dot.nebraska.gov/media/5593/nac-428-rules-regs-nbcs.pdf>). *Green Book* (Ref. 5.2) minimum design values are in Appendix H, “AASHTO Minimum Design Guidance”, of this manual.

1.B **Design Controls**

1.B.1 **Design Year**

The design year for New and Reconstructed projects and for 3R projects is the year of initial construction plus 20 years.

1.B.2 **Design Speed**

The desirable design speed is five mph greater than the anticipated posted speed limit for the roadway. For 3R projects the design speed to be used is the speed limit determined by the **Traffic Engineering Division (Traffic Engineering)** to be posted at the completion of construction.

1.B.3 **Design Vehicle**

The design vehicle for Interstate and ramp terminals is the WB-67. See Chapter Four: Intersections, Driveways, and Channelization, Section 1.C.5, “Design Vehicle”, of this manual for additional information.

1.C **Alignment**

For design guidance regarding horizontal and vertical alignment, see Chapter Three: Roadway Alignment, of this manual.

1.D The Typical Interstate Cross-Section

Typical Rural Interstate cross-sections are shown in EXHIBITS 5.1 THROUGH 5.3. The desirable depressed median width for an Interstate is 64 feet (See Chapter Four: Intersections, Driveways, and Channelization, Section 5.B.3, “Median Width” of this manual for additional information). A beveled edge will be installed on the inside (median) shoulders which are less than six feet in width (See Chapter Six: The Typical Roadway Cross-Section, Section 2.C, “Beveled Edge” of this manual for additional information). There are no typical cross-sections for Suburban, Urban, and Urban Core Interstates due to the greater variety in the number of lanes. For additional information, see Chapter Six: The Typical Roadway Cross-Section of this manual.

1.E Earthwork

Earthwork for Interstates, freeways, and expressways should be calculated based on the phased construction of the directional lanes; see Chapter Seven: Earthwork, Section 2, “Staged Construction/ Phasing”, of this manual for guidance.

1.F Interstate Surfacing

The minimum pavement thickness of Portland Cement Concrete Pavement on the Interstate System is 12 inches. Shoulders will be built at full depth. Rumble strips will be constructed on the shoulders, including the median shoulders, for all Rural Interstate projects, either New, Reconstructed, or 3R. See Chapter Eight: Surfacing of this manual for additional information.

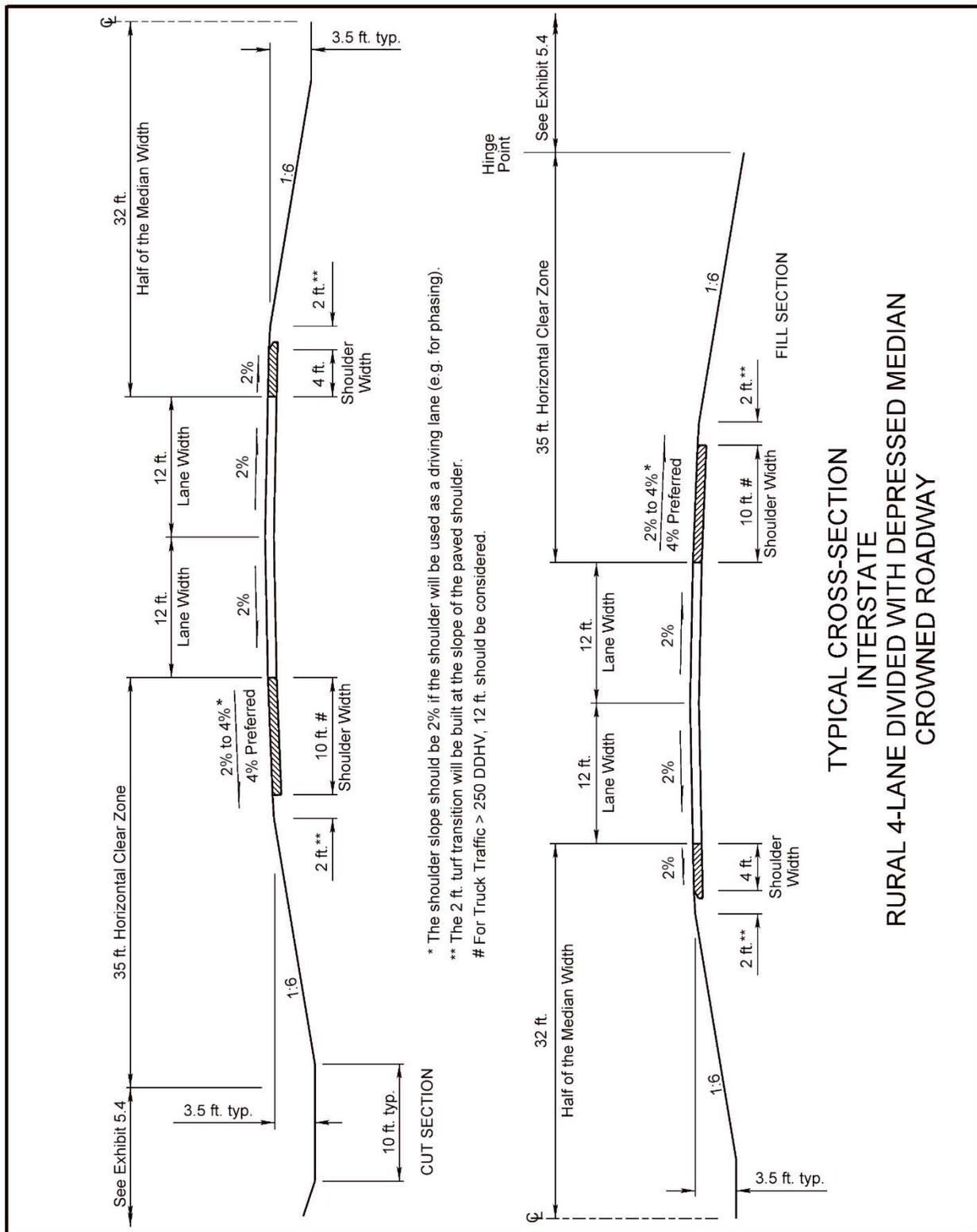


Exhibit 5.1 Typical Section – Rural Four-Lane Divided Interstate with Depressed Median (Crowned Roadway)

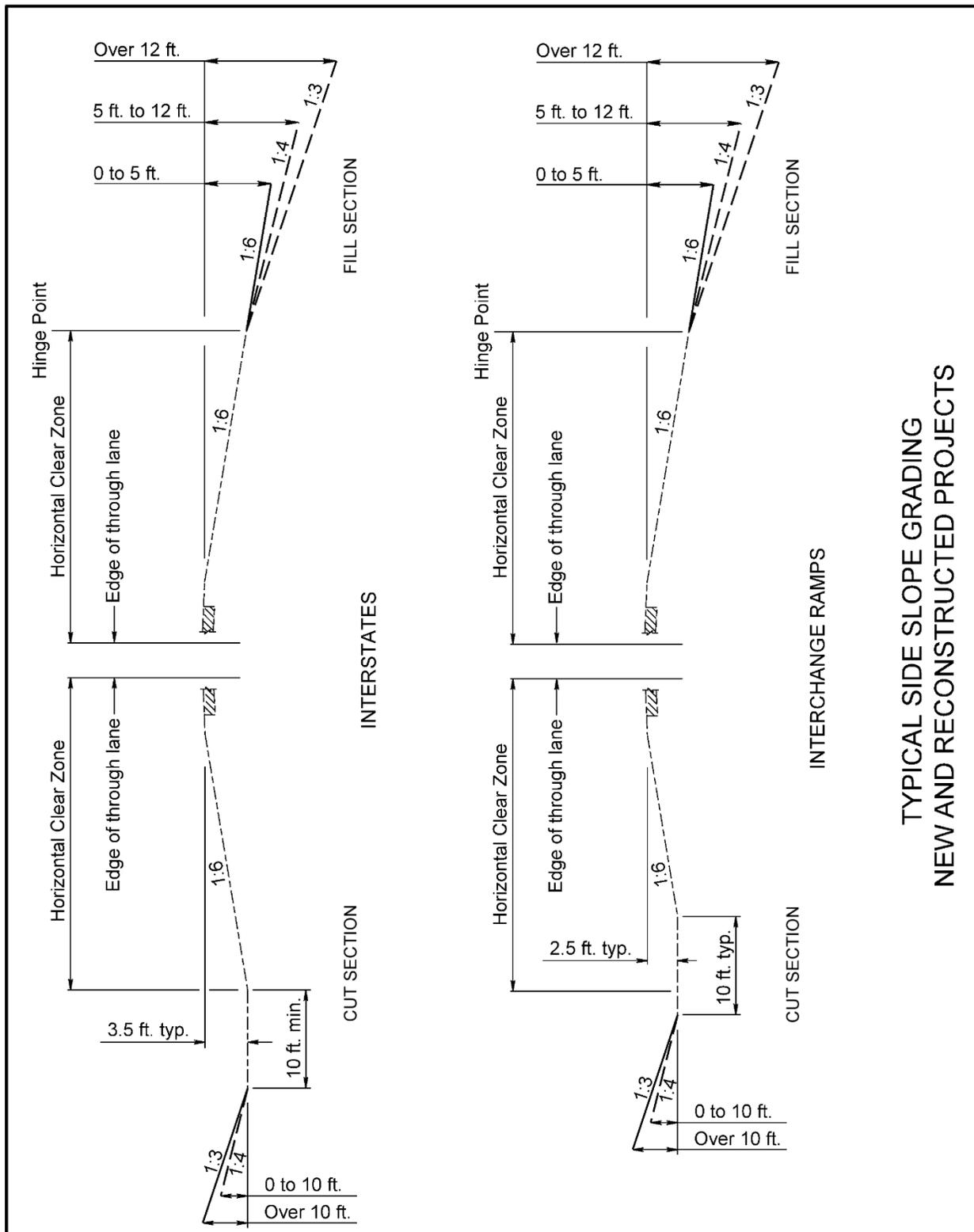


Exhibit 5.4 Typical Side Slopes for New and Reconstructed Interstates and Interchange Ramps

1.G Guardrail and Roadside Barriers

A Guardrail End Treatment, Type I is Test Level 3 approved and shall be used on Interstate projects. See Chapter Nine: Guardrail and Roadside Barriers of this manual for additional information.

1.H Miscellaneous Interstate Design Issues

1.H.1 **Fencing**

Interstates shall be fenced. The fencing is run along the right-of-way line according to the Standard Specifications for Highway Construction (Spec Book), Section 9.10 (Ref. 5.6) (<http://dot.nebraska.gov/media/10343/2017-specbook.pdf>). At rural interchanges, fencing should extend 500 feet along the cross road from the ramp terminal. Interstate fencing shall be included in the construction items; the roadway designer shall include this fencing in the **Roadway Design PS&E Estimate** (Status Code 50, "Plan Package Phase"). See Chapter Ten: Miscellaneous Design Issues, Section 6, "Fencing" and Chapter Twelve: Cost Estimating & Funding, EXHIBIT 12.1 and Section 7.G, "Construction Items", of this manual for additional information.

1.H.2 **Utilities**

Longitudinal utility occupancy inside the fenced right-of-way of an Interstate is considered only as a "last resort" when no other feasible route can be followed by the utility facility or when such utility facility exclusively serves a highway facility. Specific details for each installation will be determined at the time the utility occupancy is authorized. See Chapter Ten: Miscellaneous Design Issues, Section 11.D, "Utility Accommodation on State Highway Right-of-Way", of this manual for additional information.

1.H.3 **Water Quality**

NDOT is responsible for maintaining the Stormwater Treatment Facilities (STFs) on Interstate and freeway projects (See Chapter Three: Stormwater Treatment of the Drainage Design and Erosion Control Manual, Ref. 5.8) (<http://dot.nebraska.gov/business-center/design-consultant/rd-manuals/>).

1.H.4 **Left-in-Place Median Crossovers**

Selected Interstate median crossovers will be retained following an improvement. These crossovers will be available for traffic phasing on future projects, first responder access, detouring traffic around closed lanes (e.g. accidents, flooded lanes), etc. The median crossovers to be left-in-place will be determined on a case-by-case basis, taking into consideration such items as scope of work, traffic control, and traffic volumes.

Design guidance for a left-in-place median crossover includes:

- A desirable design speed of 65 mph
- A paved width of 14 feet per lane
- A concrete pavement depth of 10 inches
- Drainage patterns and structures designed for the retention of the crossover

1.H.5 Rest Areas and Weigh Stations

Roadway Design is not responsible for the design of rest areas or weigh stations but a designer may be called upon for assistance in the design of the ramps, parking areas, and scale platform. The designer will coordinate the design with the **Capital Facilities Section** of the **Operations Division, Traffic Engineering**, and other **Divisions/ Sections** or consultants as required by the project.

1.I Interstate Plans

Large Scale Plan (J) Sheets are normally used for Interstate projects. See Chapter Eleven: Highway Plans Assembly, Section 4.J, of this manual for additional information.

1.J Right-Of-Way/ Access Control

Access control is a restriction of the number and location of access points along a highway. The Interstate, freeway and expressway (access only at interchanges) systems are multi-lane highways for through traffic with full control of access and no at-grade intersections. Access to the facility is allowed only at interchange locations. Access control along intercepting roads should be acquired a minimum of 660 feet beyond the interchange ramp terminal (See EXHIBIT 5.5). See Chapter Fifteen: Right-of-Way, Section 3, "Access Control" of this manual for additional information.

1.K Interstate Pedestrian and Bicycle Facilities

By statute, the **State of Nebraska** does not allow bicycles and pedestrians on the Interstate System or on freeways. For additional information, see the Reissue Revised Statutes of Nebraska 60-6,142 (<https://nebraskalegislature.gov/laws/statutes.php?statute=60-6,142>) and 60-6,144 (<https://nebraskalegislature.gov/laws/statutes.php?statute=60-6,144>). Section 2.G of this chapter addresses pedestrian access at interchanges.

1.L Drainage Design

Interstate drainage structures (culverts, storm sewers, and median drainage structures) will be designed to a 50 year Design Storm Frequency except for Intercepting Dike/ Backslope Drop Pipes (25 year) and Temporary Structures (duration \leq 2 years, 2 year design storm). For additional information, see Chapter One: Drainage of the **NDOT Drainage Design and Erosion Control Manual** (Ref. 5.8).

1.M 3R Interstate Projects

See Chapter Seventeen: Resurfacing, Restoration and Rehabilitation (3R) Projects, Section 1.D, of this manual.

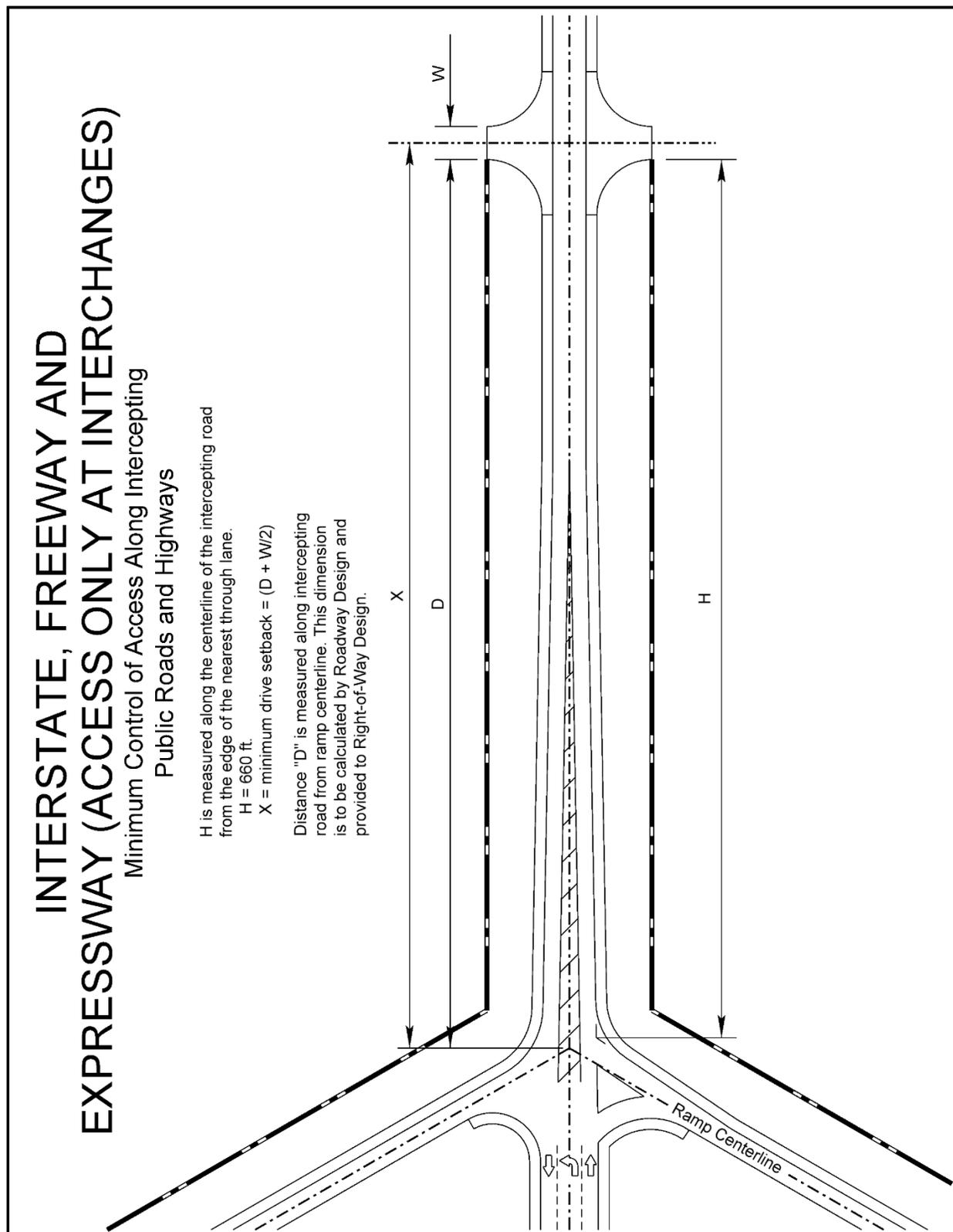


Exhibit 5.5 Control of Access Along Intercepting Public Roads and Highways Interstate, Freeway and Expressway (Access only at Interchanges)

2. GRADE SEPARATIONS AND INTERCHANGES

A grade separation is by definition a crossing of two highways (or a highway and a railroad line) at different levels, separating the through traffic movements of intersecting roadways while not providing access for turning traffic. To facilitate design and construction of possible future interchanges, the designer of a grade separation should consider including the interchange criteria for grade, alignment, and sight distance into the design of the grade separation.

An interchange is a system of interconnected roadways, consisting of one or more grade separations with connecting ramps, designed to increase highway capacity and to reduce or eliminate traffic conflicts. Interchanges separate through traffic movements and provide for turning traffic movements. An interchange may be a “System Interchange”, used to connect two or more freeways, or a “Service Interchange”, used to connect a freeway to a lower classification roadway. Interchanges are built on roadways with complete control of access (See Section 1.J, “Right-of-Way/ Access Control”, of this chapter).

The **Traffic Engineering Division (Traffic Engineering)** assists in the development of interchange type and design. The types and design of grade separations and interchanges is a function of many factors including, but not limited to:

- Highway classification
- Location (Suburban, urban, urban core, rural, or rural town)
- Design year forecast traffic volumes (for the initial year of construction of the project plus 20 years)
- Traffic composition
- Design vehicle
- Design speed
- The number of intersection legs
- Driver expectancy
- Pedestrian/ bicycle access
- Right-of-way
- Access control
- Terrain
- Environmental concerns
- Economics

The **Project Development Division (PDD)** submits recommendations for the construction of a grade separation or an interchange. **Traffic Engineering**, the **District Engineer (DE)**, the **Roadway Design Engineer** and/ or the **Assistant Design Engineer (ADE)** may also make a recommendation. When a new interchange for an Interstate is recommended, an Interchange Justification Report (IJR) may be required and **Federal Highway Administration (FHWA)** approval is necessary. An Interchange Modification Report (IMR) may be required, with **FHWA** approval, when changes are proposed to an existing access to the Interstate. These reports will focus on the technical and operational feasibility of the proposed access; the social, economic, and environmental impacts will be addressed in the NEPA review (reconstruction or major modifications to existing interchanges that do not involve adding roadway capacity may be eligible for classification as a CE). Guidance for **FHWA** procedures/ requirements for Interstate access are in the **FHWA Policy on Access to the Interstate** (May 22, 2017) (<https://www.fhwa.dot.gov/design/interstate/170522.cfm>).

2.A FHWA Design Discipline Support Tool for Interchanges

The FHWA Design Discipline Support Tool contains additional discussion on and a convenient prompt-list for the elements of interchange design for New and Reconstructed projects. This document may be found at (<https://www.fhwa.dot.gov/modiv/programs/intersta/idp.cfm>).

2.B General Interchange Design Considerations

Detailed discussion of the following general considerations for the design of interchanges are in Chapter 10, Section 10.9.5, of the *Green Book* (Ref. 5.2).

- Determination of Interchange Configuration
- Approaches to the Structure
- Sight Distance
- Interchange Spacing
- Uniformity of Interchange Patterns
- Route Continuity
- Overlapping Routes
- Signing and Marking
- Basic Number of Lanes
- Coordination of Lane Balance and Basic Number of Lanes
- Auxiliary Lanes
- Lane Reductions
- Weaving Sections
- Collector-Distributor Roads
- Two-Exit versus Single Exit Interchange Design
- Wrong-Way Entry

Additional considerations to be aware of include:

- Cost: Interchanges are the most expensive type of roadway intersection.
- Constructability: Phasing and traffic accommodation during construction must be addressed. Closing an entrance to the Interstate during construction is allowable but exits from the Interstate should be kept open. The design speed for phasing is 10 mph below the posted speed limit.
- Drainage: Considerations include bridge deck drainage, erosion control of slopes, drainage of the low point of the roadway under an overpass, and erosion control during construction.
- Crossroad Intersection Sight Distance: Sight distance requirements for at-grade intersections apply at the ramp/ crossroad intersections of interchanges. An added sight distance element at interchange intersections involves the bridge structure supporting the secondary facility over or under the major highway.
- ROW constraints
- Environmental impacts

2.C Interchange Warrants

An interchange is an effective, but expensive, means of reducing intersection capacity problems. Warrants for interchange use at individual locations will vary due to such factors as site condition, design year traffic volume, highway classification, and interchange layout. Six warrants in particular should be considered when determining the applicability of a grade separation or an interchange for a given location:

1. Design designation: full access control will necessitate the use of grade separations and/or interchanges. All Interstate access points will be interchanges.
2. Reduction of bottlenecks or spot congestion: the inability to provide intersection capacity may make the construction of an interchange a viable option.
3. Reduction of crash frequency and severity: intersections with high accident rates may warrant interchanges.
4. Site topography: topographic conditions may preclude cost effective provision of at-grade intersections.
5. Road-user benefits: an interchange may be advisable due to the attendant costs of traffic delays (e.g. user delay, fuel consumption, engine wear).
6. Traffic volumes: volumes too great for an at-grade intersection to handle efficiently may warrant an interchange.

These warrants are expanded on in Chapter 10, Section 10.2, of the *Green Book* (Ref. 5.2).

2.D Adaptability of Highway Grade Separations and Interchanges

The three basic types of intersections are at-grade intersections, grade separations without ramps, and interchanges. Each type is a feasible solution for a range of situations but there is no demarcation line denoting when one type becomes preferable over another. Some overlapping exists between these ranges, the ultimate design may be a compromise based on consideration of the following factors:

- Traffic and operation (See Chapter 10, Section 10.3.1, of the *Green Book*, Ref. 5.2)
- Site conditions (See Chapter 10, Section 10.3.2, of the *Green Book*, Ref. 5.2)
- Type of highway and intersecting facility (See Chapter 10, Section 10.3.3, of the *Green Book*, Ref. 5.2)
- Access separations and control on the crossroad at interchanges (See Chapter 10, Section 10.4, of the *Green Book*, Ref. 5.2)
- Safety (See Chapter 10, Section 10.5, of the *Green Book*, Ref. 5.2)
- Stage Development (See Chapter 10, Section 10.6, of the *Green Book*, Ref. 5.2)
- Economic factors (See Chapter 10, Section 10.7, of the *Green Book*, Ref. 5.2)

2.E Grade Separation Structures

See Chapter 10, Section 10.8 of the *Green Book* (Ref. 5.2) for a detailed discussion.

The **Bridge Division (Bridge)** is responsible for the design of grade separation structures; the designer will coordinate with **Bridge** on grade separation/ interchange design and on railroad overpass designs. For projects involving the construction of an overpass or of a viaduct over a railroad line, the **Highway Liaison Manager** in the **Rail Unit** in the **Local Assistance Division** and the railroad company will need to be involved in discussions early in the design process. Minimum bridge widths are given in the *MDS* (Ref. 5.5). See Chapter Ten: Miscellaneous Design Issues, Section 1, “Railroads”, and Section 2, “Bridge Structures”, of this manual for additional information.

2.E.1 **Underpass Roadways**

See Chapter 10, Section 10.8.4, of the *Green Book* (Ref. 5.2).

2.E.1.a **Roadway Cross-Section**

The cross-section through an underpass should be the same as the approach roadway cross-section, including the clear zone or roadside barriers. Future widening of the roadway should be considered if significant traffic volume increases are anticipated in the near future (provide sufficient additional width for an additional lane in each direction to be added later).

2.E.1.b **Underpass Sight Distance**

The designer should verify that when sag vertical curves are used on underpasses the overhead structure does not obstruct driver visibility. Equations 3-53 and 3-54 of the *Green Book* (Ref. 5.2) should be used to calculate the appropriate overhead clearance to provide stopping sight distance. See Chapter Three: Roadway Alignment, Section 3.D, “Sag Vertical Curves”, of this manual for additional information.

2.E.1.c **Vertical Clearance**

The allowable vertical clearances for overhead structures are in the *MDS* (Ref. 5.5). See Chapter Ten: Miscellaneous Design Issues, Section 2.E, “Vertical Clearances”, of this manual for additional information. An additional 0.50 foot allowance should be included in the minimum vertical clearance for future resurfacing of the underpass.

2.E.2 **Overpass Roadways**

See Chapter 10, Section 10.8.5, of the *Green Book* (Ref. 5.2).

2.E.2.a **Roadway Cross-Section**

It is desirable to carry the full width of the approach roadway across the overpass.

2.E.3 Local Roads Crossing Freeways and Expressways

When **NDOT** is constructing or upgrading an off-system crossroad over or under a freeway or expressway as part of a New or Reconstructed project, **NDOT** will fund the crossroad construction to match the existing section. Maintenance of the structure and road over the mainline is the responsibility of the **State**. The designer will coordinate all necessary agreements with the **Agreements and Consultant Services Section** of **PDD** as early in the project as possible. For additional information, see *NDOT Operating Instructions 45-5, "Agreements"* and *60-12, "Cost Sharing for Local Roads Crossing Freeways and Expressways"* in Appendix B, "Selected *NDOT Operating Instructions*" of this manual.

2.F Interchange Configurations

Interchange configurations generally take one of three types: three-leg designs, four-leg designs, and special interchange designs involving two or more structures. The type and configuration of an interchange is site dependent, based on such factors as the number of legs, design year forecast traffic, traffic composition (through volumes and turning movements), truck traffic, topography, right-of-way, environmental concerns, etc. Chapter 10, Section 10.9, of the *Green Book* (Ref. 5.2) discusses interchange types and configuration in detail. EXHIBIT 5.6 shows some commonly used interchange configurations.

Interchange types are many, varied, and evolving. One helpful reference, in addition to the *Green Book* (Ref. 5.2), is the **FHWA** publication Alternative Intersections/Interchanges: Informational Report (AIR) (<https://www.fhwa.dot.gov/publications/research/safety/09060/>).

2.F.1 Single Point Urban Interchange

The Single Point Urban Interchange (SPUI) (EXHIBIT 5.7) is a variation of the Compressed Diamond Interchange (See EXHIBIT 5.6), requiring less right-of-way than the Diamond Interchange. The turning movements of the major road ramps and the movements of the minor road occur in the central area of the interchange, at one signalized intersection. SPUIs increase highway capacity and accommodate more vehicles than conventional diamond interchanges.

2.F.2 Diverging Diamond Interchange

The Diverging Diamond Interchange (DDI) (EXHIBIT 5.8) shifts the left-turning traffic to the opposite side of the roadway at two signalized intersections. This reduces the conflict between left-turning vehicles and on-coming traffic common to conventional interchanges, enhancing the safety and operational capacity of the interchange. For additional information see NCHRP Research Report 959 "Diverging Diamond Interchange, Informational Guide, Second Edition" (2021) (<https://www.trb.org/Main/Blurbs/181562.aspx>).

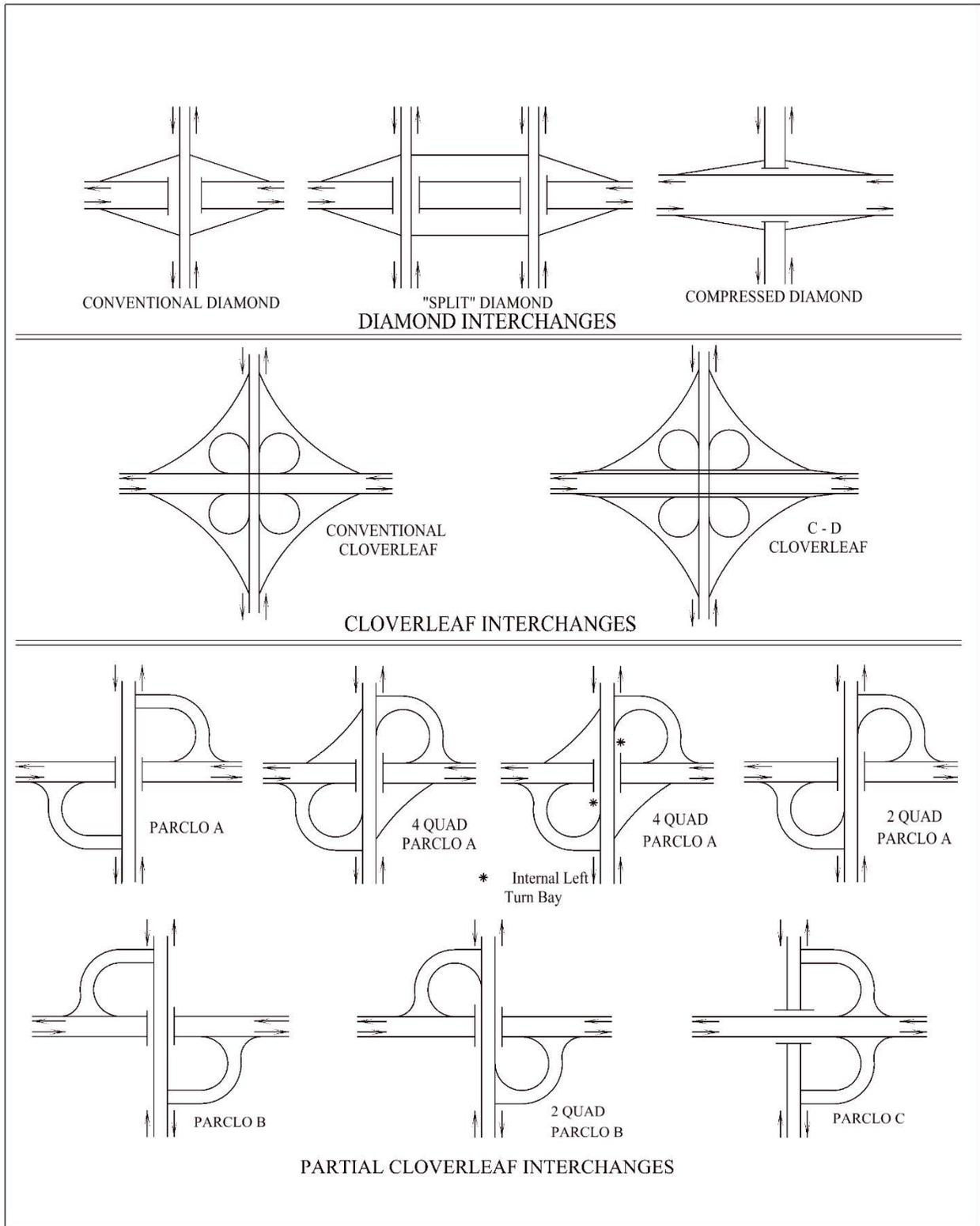


Exhibit 5.6 Common Interchange Configurations

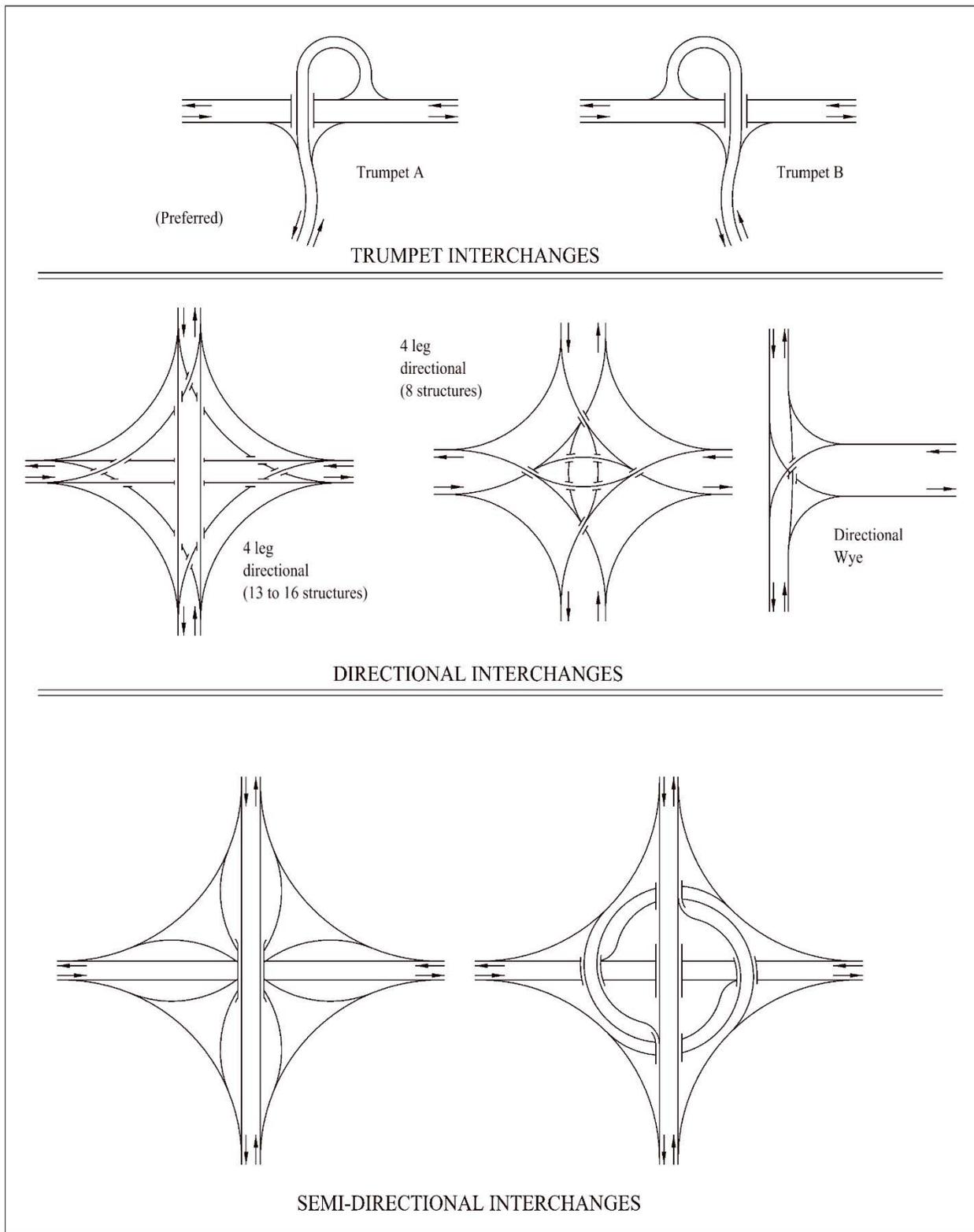


Exhibit 5.6 Common Interchange Configurations

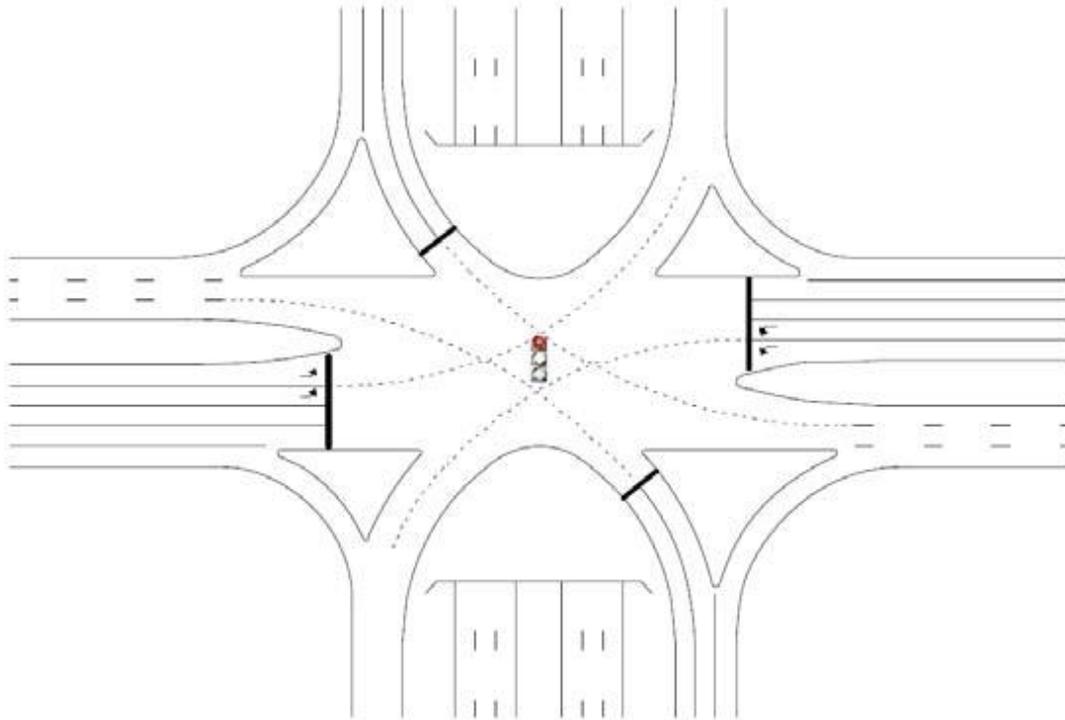


Exhibit 5.7 Single Point Urban Interchange (SPUI)
Source: Transportation Research Board

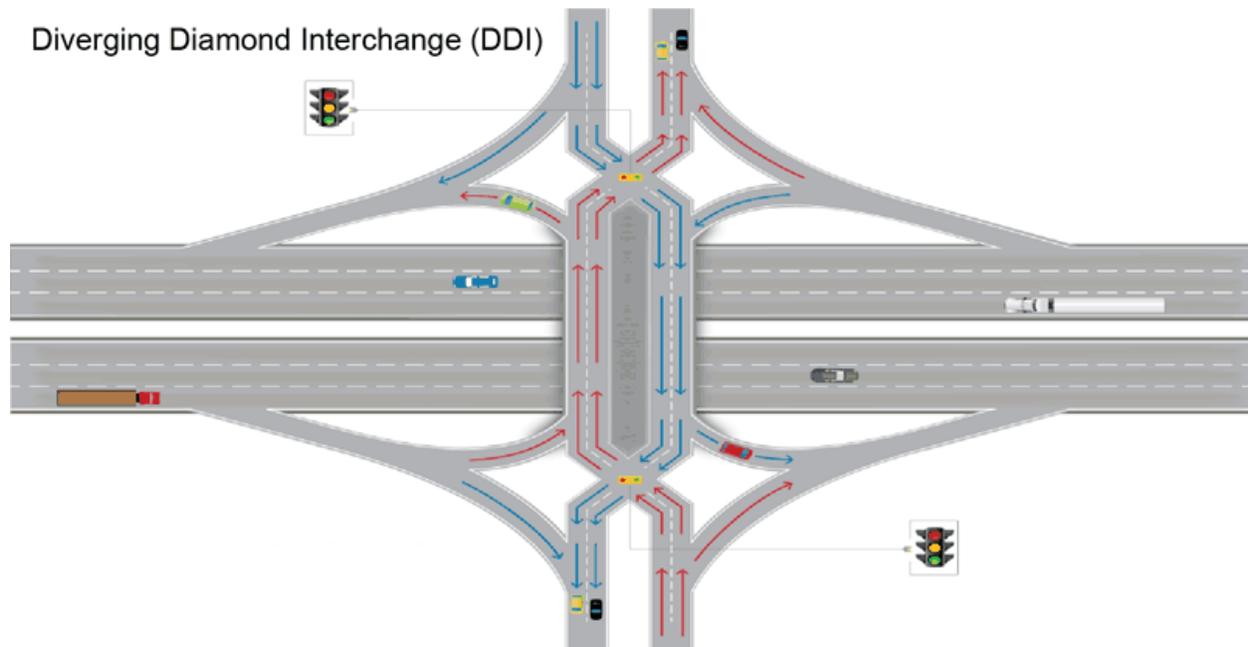


Exhibit 5.8 Diverging Diamond Interchange (DDI)
Source: Wisconsin DOT

2.G Pedestrian and Bicycle Accommodation at Interchanges

While the **State of Nebraska** does not allow pedestrians and bicycles on the Interstate or freeways (See Section 1.K of this chapter), the accommodation of pedestrians and bicyclists should be considered in the selection of an interchange. Pedestrian/ bicycle routes should be as direct as possible, and if practicable should be separate from the roadway. Crosswalk locations should be visible to the drivers and the crosswalks should be as short as possible with pedestrian refuge islands provided as necessary. For additional information, see Chapter 10, Section 10.9.7.2, of the *Green Book* (Ref. 5.2) and NDOT Operating Instruction 60-10, “ADA Accessibility Requirements in Transportation Projects” in Appendix B, “Selected NDOT Operating Instructions”, of this manual.

2.H Interchange Spacing

Interchange spacing is influenced by such variables as roadway type, roadway location, interchange design, ramp design, etc. A Policy on Design Standards – Interstate System, May 2016 (Ref. 5.1) states that the minimum interchange spacing for the Interstate should be 1 mi. in urban areas and 3 mi. in rural areas. Spacing of less than 1 mi. may be developed in urban areas by grade-separated ramps or by collector-distributor roads (a design exception from **FHWA** is required). For **NDOT** spacing guidelines on other access controlled highways, see Chapter Fifteen: Right-of-Way, EXHIBIT 15.3, of this manual. For additional information on interchange spacing, see Chapter 10, Section 10.9.5.3, of the *Green Book* (Ref. 5.2).

2.I Interchange Lighting

Warrants for interchange lighting on Interstates will be as outlined in the **AASHTO** publication Roadway Lighting Design Guide (Ref. 5.7). The operational and maintenance costs of interchange lighting that falls within the corporate limits of a **City/ Village** will be the sole responsibility of the **City** or **Village**. See Chapter Ten: Miscellaneous Design Issues, Section 12, “Roadway Lighting” and NDOT Operating Instruction 60-11, “Municipal Cost Sharing” in Appendix B, “Selected NDOT Operating Instructions”, of this manual for additional information.

3. RAMPS

See Chapter 10, Section 10.9.6 of the *Green Book* (Ref. 5.2) for a detailed discussion of ramp design.

Additional guidance for ramp design, beyond that found in the *Green Book* (Ref. 5.2), is available in the following **National Cooperative Highway Research Program (NCHRP)** publications:

- NCHRP Report 687 “Guidelines for Ramp and Interchange Spacing” (April 2011) (<http://www.trb.org/main/blurbs/165126.aspx>).
- NCHRP Report 730 “Design Guidance for Freeway Mainline Ramp Terminals” (October 2012) (<http://www.trb.org/main/blurbs/167516.aspx>).
- NCHRP Web-Only Document 227 “Design of Interchange Loop Ramps and Pavement/Shoulder Cross-Slope Breaks” (February 2017) (<http://www.trb.org/main/blurbs/175608.aspx>).

3.A Ramp Types

Ramps are turning roadways connecting the legs at an interchange and are also used at rest areas and weigh stations. Figure 10-60 of Chapter 10 of the *Green Book* (Ref. 5.2) illustrates the general types of ramps.

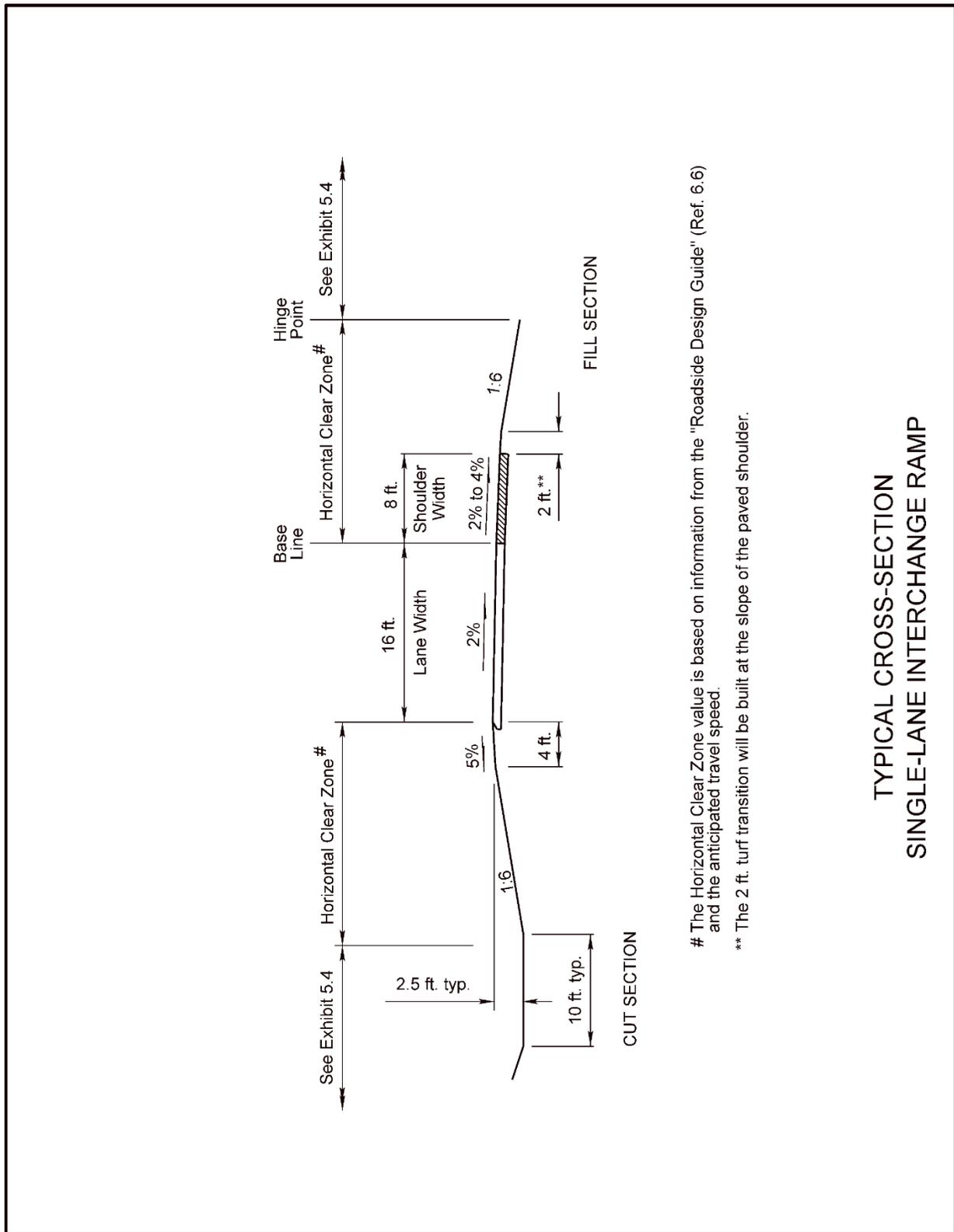
3.B General Ramp Design Considerations

As expanded upon in Section 10.9.6.2 of the *Green Book* (Ref. 5.2), the general considerations in ramp design include the following:

1. Design Speed. Table 10-1 of the *Green Book* (Ref. 5.2) presents guide values for ramp design speed related to highway design speed.
2. Portion of ramp to which design speed is applicable. Design speeds for ramps may be divided into three segments: speeds at each terminal and speed through the connecting roadway between the terminals.
3. Ramps for right turns.
4. Loop ramps. The **NDOT** desirable loop radius is 250 feet; the minimum loop radius is 100 feet
5. Two-Lane Ramps. See [EXHIBIT 5.10](#).
6. Semi-Direct Connections (a ramp where a left-turning vehicle first exits to the right).
7. Direct Connections (a ramp that does not deviate from the intended direction of travel).
8. Different Design Speeds on Intersecting Highways.
9. At-Grade Terminals.
10. Ramp Curvature. **NDOT** uses spiral transitions on ramp curves, See Section 3.C of this chapter.
11. Sight Distance.
12. Grade and Profile Design. Also discussed in Chapter Three: [Roadway Alignment](#), Section 3.A, “Grades”, of this manual.
13. Vertical Curves. Also discussed in Chapter Three: [Roadway Alignment](#), Section 3.B, “Vertical Curves”, of this manual.
14. Superelevation and Cross-Slope. Superelevation is discussed in Chapter Three: [Roadway Alignment](#), Section 2.B, “Superelevation”, of this manual. [EXHIBITS 5.9 & 5.10](#) shows the typical cross-sections for one-lane and two-lane interchange ramps. Superelevation and cross-slope are also discussed in Chapter 3, Section 3.3, of the *Green Book* (Ref. 5.2). The **NDOT** maximum allowable rollover rate (difference in cross-slope) is 7% between the ramp travel lane and the shoulder and 5% between lanes.
15. Gores. Gore generally refers to the area between a through roadway and an exit ramp (See the *Green Book* (Ref. 5.2), Figures 10-63 and 10-64). The maximum rollover rate in the gore area is 5%.
16. Ramp Traveled-Way Widths. See [EXHIBITS 5.9 & 5.10](#).
17. Ramp Shoulder Widths and Lateral Offset. See [EXHIBITS 5.9 & 5.10](#).
18. Shoulders and Curbs.
19. Ramp Terminals.
20. Drainage.

The following items are operational in nature and will be designed taking recommendations from **Traffic Engineering** into consideration.

1. Left-Side Entrances and Exits. Left-hand entrances and exits should only be used at weigh stations on expressways.
2. Ramp Terminal Location and Sight Distance.
3. Ramp Terminal Design.
4. Traffic Control. Traffic control will be designed by **Traffic Engineering**, see Chapter Fourteen: Traffic, of this manual.
5. Distance Between a Free-Flow Ramp Terminal and a Structure.
6. Distance Between Successive Ramp Terminals. Figure 10-71 of the *Green Book* (Ref. 5.2) presents the minimum recommended ramp terminal spacing.
7. Speed-Change Lanes. Auxiliary lanes are discussed in Chapter 10, Section 10.9.5.10 of the *Green Book* (Ref. 5.2).
8. Single-Lane Free-Flow Ramp Terminals.
 - Taper-Type Entrances. See Figure 10-72 of the *Green Book* (Ref. 5.2).
 - Parallel-Type Entrances. See Figure 10-72 of the *Green Book* (Ref. 5.2).
 - Taper-Type Exits. See Figure 10-73 of the *Green Book* (Ref. 5.2).
 - Parallel-Type Exits. See Figure 10-73 of the *Green Book* (Ref. 5.2).
 - Free-Flow Ramp Terminals on Curves. See Figures 10-74 and 10-75 of the *Green Book* (Ref. 5.2).
9. Multi-Lane Free-Flow Ramp Terminals.
 - Two-Lane Entrances. See Figure 10-76 of the *Green Book* (Ref. 5.2).
 - Two-Lane Exits. See Figure 10-77 of the *Green Book* (Ref. 5.2).
 - Two-Lane Terminals on Curved Alignments.
 - Major Forks and Branch Connections. See Figures 10-78 and 10-79 of the *Green Book* (Ref. 5.2).



The Horizontal Clear Zone value is based on information from the "Roadside Design Guide" (Ref. 6.6) and the anticipated travel speed.

** The 2 ft. turf transition will be built at the slope of the paved shoulder.

TYPICAL CROSS-SECTION
 SINGLE-LANE INTERCHANGE RAMP

Exhibit 5.9 Typical Section of an Interchange Ramp
 One-Lane

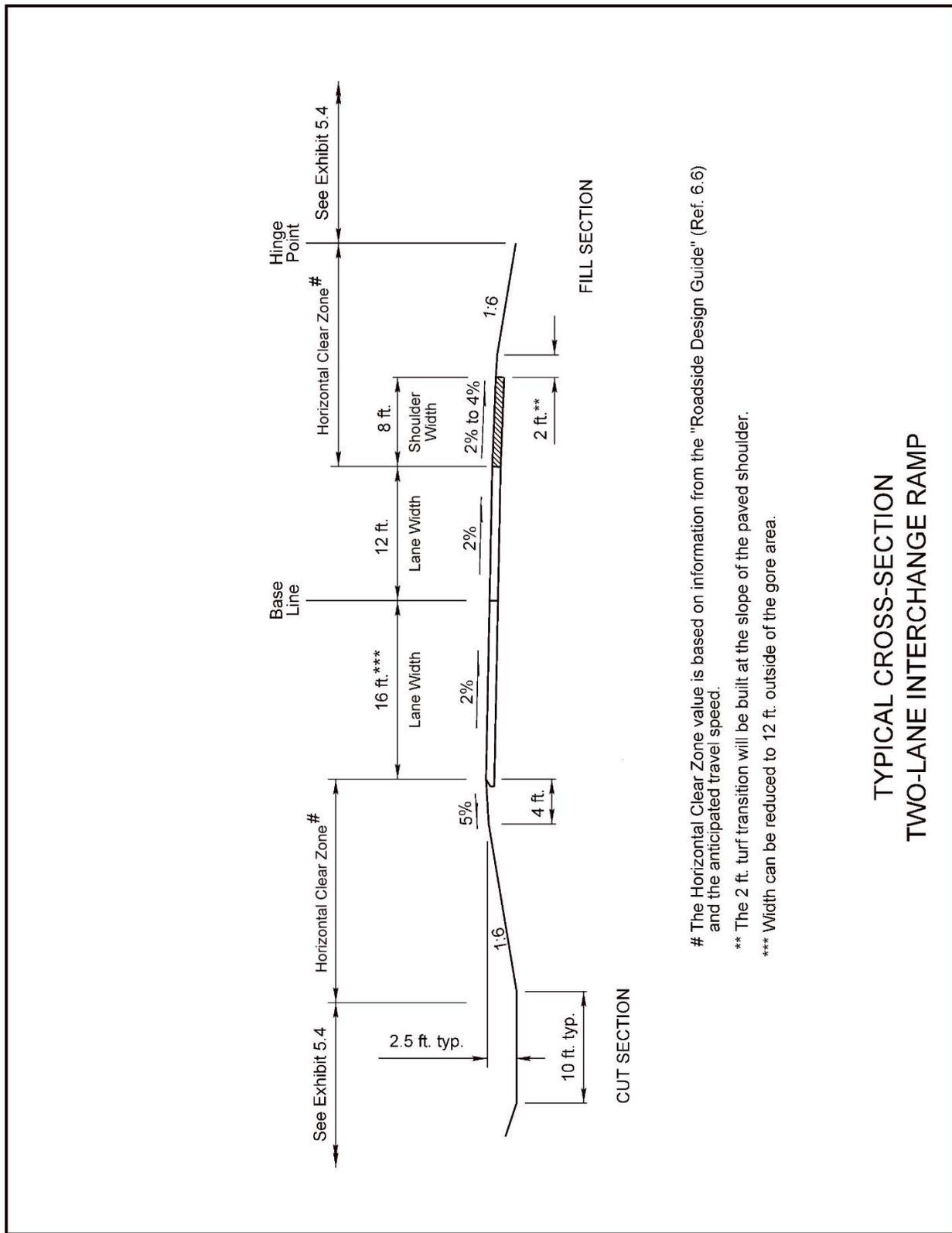


Exhibit 5.10 Typical Section of an Interchange Ramp
 Two-Lane

TYPICAL CROSS-SECTION
 TWO-LANE INTERCHANGE RAMP

3.C Spiral Transition Curves

Spiral transitions are provided on ramps to ease the change from a straight section of roadway to a curved section, gradually changing from an infinite radius at the tangent end to the curve radius at the circular curve end. Spiral transitions gradually increase and decrease centrifugal force as vehicles enter and exit circular curves, providing the driver with a natural path to follow and a more comfortable ride.

While **NDOT** sees only marginal benefits in the design of spiraled transition curves for new roadway alignments, spiral transition curves are preferred on Interstate ramps due to the higher percentage of truck traffic.

EXHIBITS 5.11 & 5.12 shows spiral curve information for the spiral in, spiral out of equal length condition. For additional information, see "Spiral Curve Transitions" in Chapter 3, Section 3.3.8.3, of the *Green Book* (Ref.5.2).

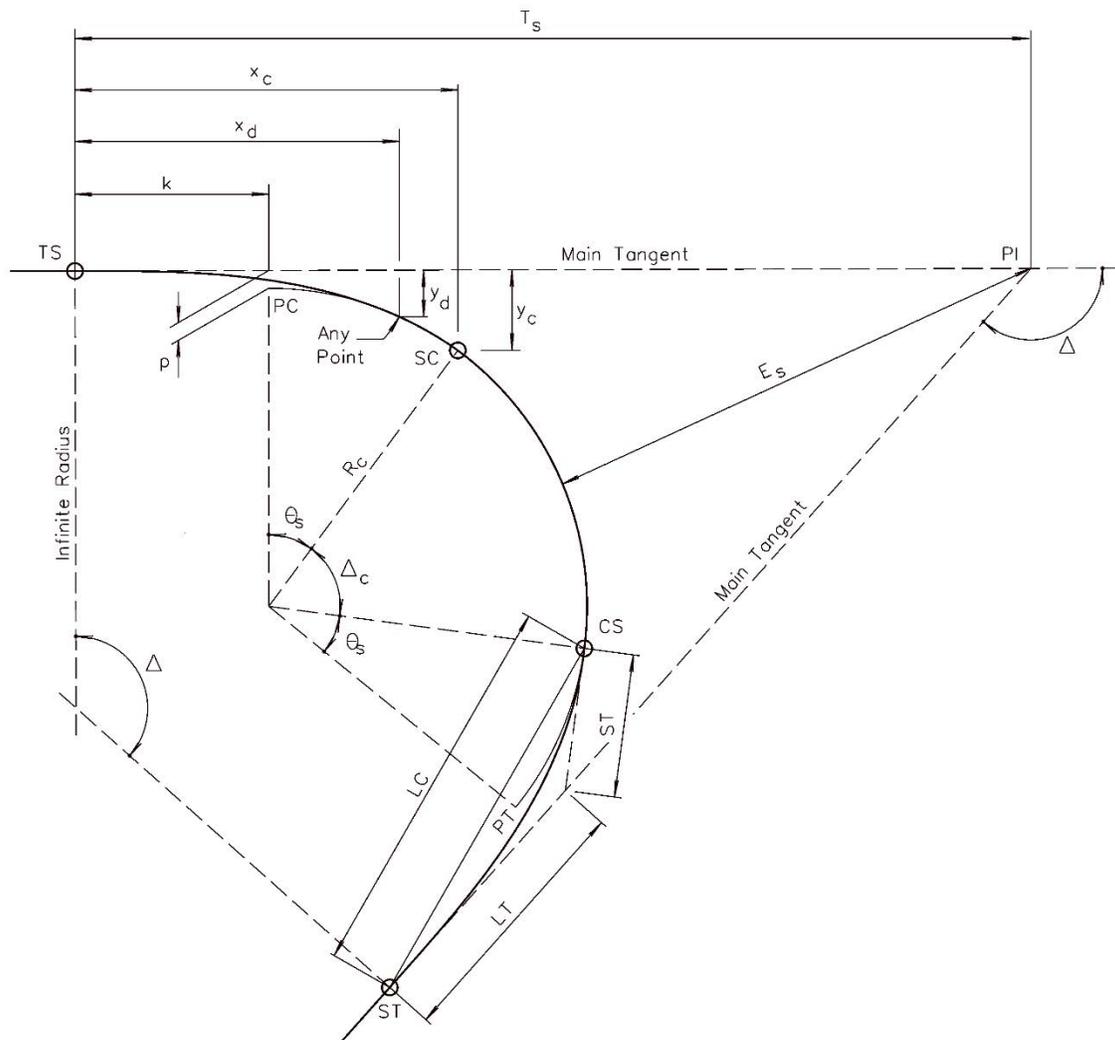


Exhibit 5.11 Components of a Spiral Curve, Spiral In, Spiral Out of Equal Length

Stations:

PI Sta. = point of intersection
 TS Sta. = tangent to spiral
 SC Sta. = spiral to circular curve
 CS Sta. = circular curve to spiral
 ST Sta. = spiral to tangent

Station Formulas:

TS Sta. = PI Sta. - T
 SC Sta. = TS Sta. + L_s
 CS Sta. = SC Sta. = L_c
 ST Sta. = CS Sta. + L_s

Terminology:

Δ = total deflection angle
 θ_s = spiral deflection angle
 Δ_c = circular curve deflection angle
 D_c = degree of circular curve
 L_s = length of spiral curve
 L_c = length of circular curve
 R_c = radius of circular curve
 T_s = total tangent length
 LT = long tangent of spiral curve
 ST = short tangent of spiral curve
 LC = straight chord line distance TS to SC / CS to ST
 x_c, y_c = coordinates of SC point referred to the main tangent as the X-axis and the TS as origin
 x_d, y_d = coordinates of any point on spiral referred to the main tangent as the X-axis and the TS as origin at a distance (d) from the TS
 p = offset distance from the main tangent to the PC of the circular curve
 k = distance from the TS to a point on the main tangent opposite the PC of the circular curve
 E_s = external distance from circular curve to point of intersection for total curve
 d = distance along spiral from TS

Formulas (θ_s in radians):

θ_s = $L_s/(2R_c)$
 y_c = $L_s(\theta_s/3 - \theta_s^3/42)$
 x_c = $L_s(1 - \theta_s^2/10)$
 p = $y_c - R_c(1 - \cos \theta_s)$
 k = $x_c - (R_c \sin \theta_s)$
 x_d = $d - (d\theta_d^2)/10$
 y_d = $(d\theta_d)/3$

Formulas ($\theta_s, \Delta, \Delta_c$ in degrees):

(See Appendix G: "Degree of Curvature")

T_s = $(R_c + P) (\tan \Delta/2) + k$
 E_s = $(R_c + P) (\sec \Delta/2 - 1) + p$
 θ_s = $(L_s D_c)/200$
 Δ_c = $\Delta - 2\theta_s$
 L_c = $100(\Delta_c/D_c)$
 R_c = $5729.578/D_c$
 LT = $x_c - (y_c \cot \theta_s)$
 ST = $y_c \csc \theta_s$

Exhibit 5.12 Spiral Curve Information, Spiral In, Spiral Out of Equal Length

3.D Additional NDOT Ramp Considerations

Baseline: The baseline on ramps and loops is usually located at the right edge of the 16 foot travel lane (See [EXHIBIT 5.9](#)).

Earthwork: When earthwork is calculated, ramps should have separate roadways and shear lines (See Chapter Seven: [Earthwork](#), Section 3.E, “Shear Lines”).

Identification: A ramp is identified on the plans with an R and a loop is identified with an L. They are numbered clockwise from the NE quadrant. Unique letter and roadway stationing shall be used for each element (See [EXHIBIT 5.13](#)).

Stationing: Stationing is along the direction of travel (See [EXHIBIT 5.13](#)).

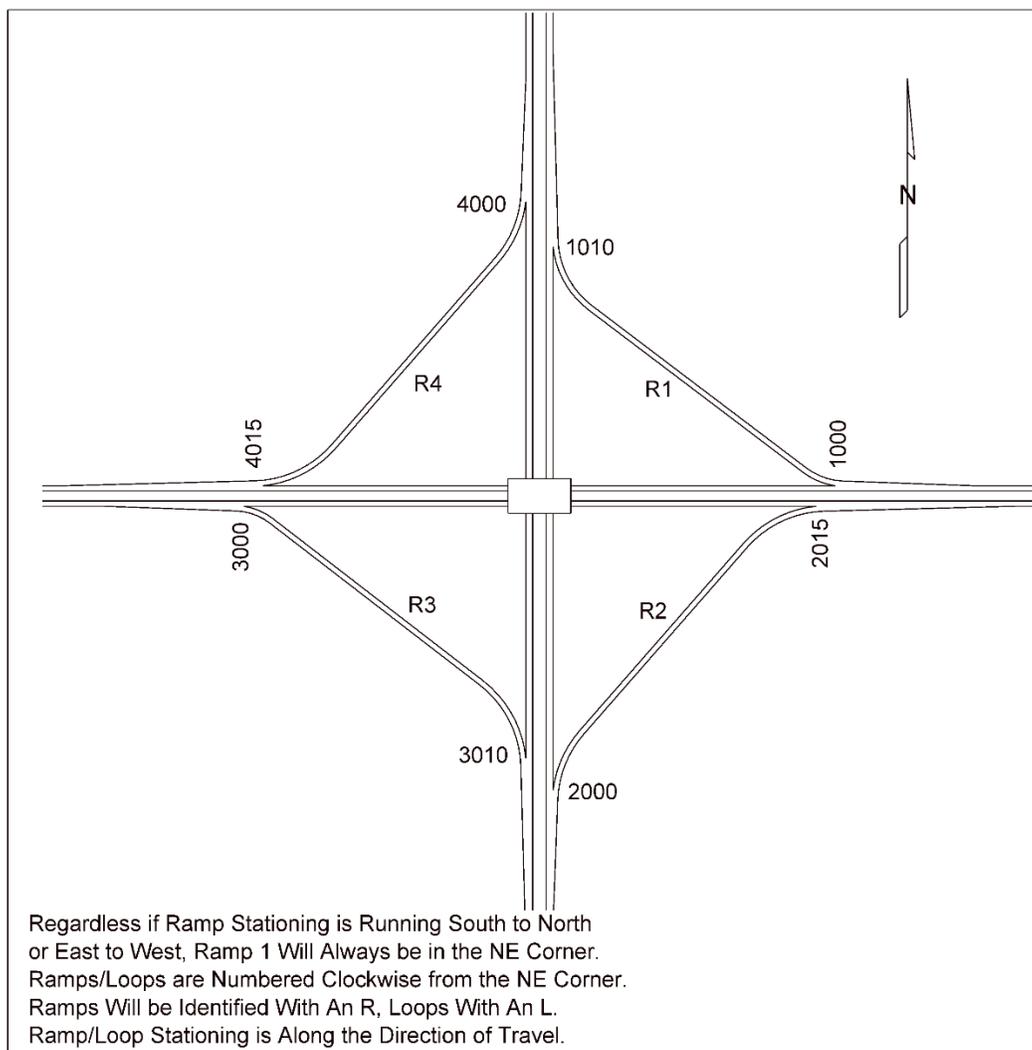


Exhibit 5.13 Stationing for Ramps and Loops

4. REFERENCES

- 5.1 American Association of State Highway and Transportation Officials, A Policy on Design Standards – Interstate System, Washington, DC, May 2016.
- 5.2 American Association of State Highway and Transportation Officials, A Policy on the Geometric Design of Highways and Streets (the *Green Book*), Washington, DC, 2018.
- 5.3 Transportation Research Board, National Research Council, Highway Capacity Manual, Sixth Edition, Washington, DC, 2017.
- 5.4 U.S. Department of Transportation, Federal Highway Administration, Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), Washington, DC, 2009. (<http://dot.nebraska.gov/business-center/contractor/mutcd/>)
- 5.5 Board of Public Roads Classifications and Standards, Nebraska Administrative Code, Title 428, Chapter Two (MDS), Current Edition. (<http://dot.nebraska.gov/media/5593/nac-428-rules-regs-nbcs.pdf>)
- 5.6 Nebraska Department of Transportation, Standard Specifications for Highway Construction (*Spec Book*), 2017. (<http://dot.nebraska.gov/media/10343/2017-specbook.pdf>)
- 5.7 American Association of State Highway and Transportation Officials, Roadway Lighting Design Guide, Washington, D.C., 2018.
- 5.8 Nebraska Department of Transportation, Drainage Design and Erosion Control Manual, Current Edition. (<http://dot.nebraska.gov/business-center/design-consultant/rd-manuals/>)

