APPENDIX A1 GEOMETRIC DESIGN STANDARDS

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SECTION 1 - GEOMETRIC DESIGN STANDARDS

INTRODUCTION

VDOT has formally adopted the 2018 AASHTO *A Policy on Geometric Design of Highways and Streets*, commonly referred to as the AASHTO "Green Book", as our minimum design standards. Therefore, **all** design criteria must meet AASHTO minimum standards.

Highway improvement plans are based on established AASHTO geometric design standards for various elements of the roadway under design. The tables on the following pages provide the **minimum** geometric standards, which are to be used for development of VDOT projects except those projects which can be developed using the Guidelines for RRR Projects located in *Appendix A4* of this manual. Note that there are no specific RRR standards for Interstate projects. If the designer has determined that Guidelines for RRR Projects do not apply to the project in question, the Geometric Design Standard tables on pages 12 to 22 should be used for project development. See *Appendix B(1)* for the development of new residential and mixed-use streets functional classified as "local" streets and Appendix B(2) for multimodal design standards for mixed-use urban centers. *

The Geometric Standard Tables were developed using *A Policy on Geometric Design of Highways and Streets* published by the American Association of State Highway and Transportation Officials (AASHTO). These tables present basic practical guidelines compatible with traffic, topography and safety; however, due to the restrictive format, all variables could not be included. The designer is urged to refer to the above named publication and other related chapters in the *Road Design Manual* for further discussion of design considerations before selecting the proper design speed criteria for a given project.

THE APPLICATION OF THE CRITERIA PROVIDED IN THE GEOMETRIC DESIGN STANDARD TABLES MUST BE MADE IN RELATION TO THEIR EFFECT ON THE ROADWAY SYSTEM AND IN CONJUNCTION WITH SOUND ENGINEERING JUDGMENT TO ENSURE AN APPROPRIATE DESIGN. The economic, environmental and social factors involved in highway design shall also be considered. The designer should always attempt to provide for the highest degree of safety and best level of service that is economically feasible. The "minimum" design criteria shown in the tables should only be used when overriding economic or environmental considerations so dictate.

FLEXIBILITY AND PERFORMANCE BASED APPROACH

The 2018 edition of the Green Book introduces the consideration of five specific context classifications (rural, rural town, suburban, urban and urban core) as elements of the geometric design process and emphasizes the consideration of multimodal needs in design. Together, context classification and functional classification constitute a new framework of geometric design. The policy also encourages flexible design, which emphasizes the role of the planner and designer in determining the appropriate design dimensions based on project-specific conditions and existing and future roadway performance more than on meeting

* Rev. 1/19

specific nominal design criteria. Chapters 2 through 10 explains how the flexible, performance-based approach should be applied and can be used in implementing the functional and context classifications together in the design of new construction projects, reconstruction projects and projects on existing roads for all transportation modes. The context are defined based on development density (existence of structures and structure types), land use (primarily residential, commercial, industrial and/or agricultural), and building setbacks (distance of structures to adjacent roadway), which are easy to identify by observing the landscape adjacent to an existing or planned facility. For definitions of each of the 5 context zones, see Chapter 1, Sections 1.5 through 1.9.

Roads in rural areas should be designed for either the rural or rural town context. Each of these contexts is discussed below.

RURAL CONTEXT

The rural context applies to roads in rural areas that are not within a developed community. These include areas with the lowest development density; few houses or structures; widely dispersed or no residential, commercial, and industrial land uses; and usually large building setbacks. The rural context may include undeveloped land, farms, outdoor recreation areas, or low densities of other types of development. Most roads in rural areas fit the rural context and should be designed in a manner similar to past design criteria for rural facilities.

RURAL TOWN CONTEXT

The rural town context applies to roads in rural areas located within developed communities. Rural towns generally have low development densities with diverse land uses, on-street parking, and sidewalks in some locations, and small building setbacks. Rural towns may include residential neighborhoods, schools, industrial facilities, and commercial main street business districts, each of which present differing design challenges and differing levels of pedestrian and bicycle activity. The rural town context recognizes that rural highways change character where they enter a small town, or other rural community, and that design should meet the needs of not only through travelers, but also the residents of the community. Speed expectations of through travelers change when they enter a rural town. Guidance on the selection of design speeds and other design elements for the rural town context is presented in Chapters 5, 6, and 7 for local roads and streets, collectors, and arterials, respectively. Additional information on design for the rural town environment can be found in When Main Street is a State Highway (17) developed by the Maryland Department of Transportation and Main Street… When a Highway Runs Through It (19), developed by the Oregon Department of Transportation. Guidance on design and speed management for transition zones where a rural highway enters a rural town may be found in and NCHRP Report 737, Design Guidance for High-Speed to Low-Speed Transition Zones for Rural Highways (23).

CONTEXT CLASSES FOR ROADS AND STREETS IN URBAN AREAS*

Roads and streets in urban areas may be designed for the suburban, urban, and urban core contexts. These contexts differ in development density, land use, and building setbacks. Speed expectations of drivers vary markedly as drivers move between (and even within)

* Added 7/23

these contexts, as does the typical level of pedestrian, bicycle, and transit activity. Each of these contexts is discussed below.

SUBURBAN CONTEXT*

The suburban context applies to roads and streets, typically within the outlying portions of urban areas, with low to medium development density, mixed land uses (with single-family residences, some multi-family residential structures, and nonresidential development including mixed town centers, commercial corridors, big box commercial stores, light industrial development). Building setbacks are varied with mostly off-street parking. The suburban context generally has lower development densities and drivers have higher speed expectations than the urban and urban core contexts. Pedestrians and bicyclist flows are higher than in the rural context, but may not be as high as found in urban and urban core areas.

URBAN CONTEXT*

The urban context has high-density development, mixed land uses, and prominent destinations. On-street parking and sidewalks are generally more common than in the suburban context, and building setbacks are mixed. Urban locations often include multi-story and low- to medium-rise structures for residential, commercial, and educational uses. Many structures accommodate mixed uses: commercial, residential, and parking. The urban context includes light industrial, and sometimes heavy industrial, land use. The urban context also includes prominent destinations with specialized structures for entertainment, including athletic and social events, as well as conference centers. In small- and medium-sized communities, the central business district may be more an urban context than an urban core context. Driver speed expectations are generally lower and pedestrian and bicyclist flows higher than in suburban areas. The density of transit routes is generally greater in the urban context than the suburban context, including in-street rail transit in larger communities and transit terminals in small- and medium-sized communities.

URBAN CORE CONTEXT*

The urban core context includes areas of the highest density, with mixed land uses within and among predominantly high-rise structures, and with small building setbacks. The urban core context is found predominantly in the central business districts and adjoining portions of major metropolitan areas. On-street parking is often more limited and time restricted than in the urban context. Substantial parking is in multi-level structures attached to or integrated with other structures. The area is accessible to automobiles, commercial delivery vehicles, and public transit. Sidewalks are present nearly continuously, with pedestrian plazas and multi-level pedestrian bridges connecting commercial and parking structures in some locations. Transit corridors, including bus and rail transit, are typically common and major transit terminals may be present. Some government services are available, while other commercial uses predominate, including financial and legal services. Structures may have multiple uses and setbacks are not as generous as in the surrounding urban area. Residences are often

* Added 10/20

apartments or condominiums. Driver speed expectations are low and pedestrian and bicycle flows are high.

The policies and procedures addressed in *IIM-LD-235* (Context Sensitive Solutions) and *IIM-LD-255* (Practical Design Flexibility in the Project Development Process) are intended to clarify and emphasize VDOT's commitment to project and program development processes that provide flexibility, innovative design and Context Sensitive Solutions (CSS) to transportation challenges.

These processes have been structured and oriented to include stakeholders and citizens in the design of transportation systems that improve public mobility, while reflecting the community's values, preserving the scenic, aesthetic, historic and environmental resources, and without compromising safety and mobility

This policy emphasizes the importance of recognizing the flexibility within established standards, especially AASHTO's *Policy on Geometric Design of Highways and Streets* (Green Book), AASHTO's *A Guide for Achieving Flexibility in Highway Design and AASHTO's Guidelines for Geometric Design of Low-Volume Roads, Second Edition*. While practicable and innovative approaches to using the flexibility inherent in existing standards is encouraged by this policy, individual project development decisions on specific applications of flexibility ultimately rest with the responsible person working with the project manager and the project team. These decisions are made after carefully processing input from all project stakeholders as well as the project team, and evaluating this input with respect to project goals as well as safety and mobility concerns.

For applicable projects, the following note shall be placed on the title sheet under the Functional Classification and Traffic Data Block: NOTE: THESE PLANS WERE DESIGNED IN ACCORDANCE WITH THE AASHTO *GUIDELINES FOR GEOMETRIC DESIGN OF LOW-VOLUME ROADS, SECOND EDITION.*

SECONDARY PROJECT IMPROVEMENTS

The Special Session II of the 2008 General Assembly passed HB 6016, which amended and reenacted *§33.2-326*[*] of the Code of Virginia relating to improvements to the state secondary highway system components. The intent of this Bill is to ensure that the Department provides flexibility in the use of design criteria for improvements to any secondary highway system component(s) by not requiring the Department to comply with all design and engineering standards that would be applicable if the project involved new construction.

The Department currently utilizes the following flexible design Guidelines:

- **RRR Design Guidelines**, which involves the use of minimal improvements to extend the service life and safety for the existing roadway at a fraction of the cost. On Secondary projects that have a 15 year traffic projection of 750 vpd or less, the RRR guidelines are the design concept of choice.

[*] Rev. 10/20

- **Rural Rustic Road Design Guidelines**, which are used on the secondary highway system that have 1500 vpd or less to pave unpaved secondary roads with no or little geometric improvements.

In addition to the above mentioned practices that follow their own set of guidelines, the Department also encourages roadway designers to identify context sensitive solutions to project issues. It is the responsibility of the roadway design engineer working with the project manager to identify areas where flexibility can be introduced into the design process without compromising safety and mobility.

The Department has a process for documenting design solutions that do not meet current VDOT and AASHTO design geometric standards in the form of design waivers and design exceptions that shall be submitted in accordance with *IIM-LD-227*. Any design exception not granted may be appealed to the Chief Engineer.

ROADWAY WIDTH

Roadway width as referenced in this section is the portion of the highway, including shoulders (graded and paved), for vehicular use.

DESIGN SPEED (V)

Design speed is defined as a speed determined for design and correlation of the physical features of a highway that influence vehicle operation - the maximum safe speed maintainable over a specified section of highway when conditions permit design features to govern.

Except for local streets where speed controls are frequently included intentionally, every effort should be made to use as high a Design Speed as practical to attain a desired degree of safety, mobility, and efficiency within the constraints of environmental quality, economics, aesthetics, and social or political impacts (See 2018 AASHTO Green Book, Chapter 2).*

The geometric tables indicate a design speed range, or a portion of a range, for each functional classification. The design speed range for each roadway classification is available in the AASHTO Green Book. The selection of the proper design speed to be used on a particular project is of primary importance in project development. The design speed selected should:

- be logical with respect to topography, anticipated operating speed, adjacent land use, and functional classification of the highway.

- be as high as practicable to attain a desired degree of safety, mobility and efficiency while under the constraints of environmental quality, economics, aesthetics and social or political impacts.

- be consistent with the speed a driver is likely to expect. Drivers do not adjust their speeds to the importance of the highway, but to their perception of the physical limitations and traffic.

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* Rev. 7/14

Although the design speeds for rural highways are coupled with a terrain classification, terrain is only one of the several factors involved in determining the appropriate design speed of a highway.

Although the selected design speed establishes the maximum degree of curvature and minimum sight distance necessary for safe operation, there should be no restriction on the use of flatter horizontal curves or greater sight distances where such improvements can be provided as a part of performance based practical* design. However, if a succession of flatter

curves or tangent sections would encourage drivers to operate at higher speeds, that section of highway should be designed for a higher speed and all geometric features, particularly that of sight distance on crest vertical curves and intersection sight distance should be related to the higher design speed*.

The minimum Design Speed shall be based on the following criteria:

1) For roadways with a Posted Speed:

a) For high-speed roadways* (Posted 50 mph and higher) the Design Speed shall be a minimum of 5 mph higher than the Posted Speed.

- Example - Design Speed 60 mph – Posted Speed 55 mph

b) For low-speed roadways (Posted 45 mph and less) the Design Speed shall be equal to or higher than the Posted Speed.

- Example - Design Speed 40 mph – Posted Speed 40 mph

Posted Speed / Design Speed All speeds in miles per hour (mph)		
	Posted	Min. Design
Low-Speed Roadways	20	20
	25	25
	30	30
	35	35
	40	40
	45	45
High-Speed Roadways	50	55
	55	60
	60	65
	65	70
	70	75

Note:
The statutory speed limit
(See the *Code of Virginia § 46.2-870 Speed Limits*) is **55 mph for cars** and **45 mph for trucks** with the following exceptions:

- 25 mph in residential and business districts
- 35 mph in cities and towns
- 35 mph on Rural Rustic Roadways
- 35 mph on non-surface treated highways

2) For unposted roadways: Design Speed shall be equal to Statutory Speed or 85% percentile speed (based on speed analysis, rounded up to nearest 5 mph increment).

* Rev 10/20

3) Roadways with ADT < 2000, see the VDOT Road Design Manual, Appendix B(1), Tables 1 through 3 and AASHTO's *Guidelines for Geometric Design of Low-Volume Roads, Second Edition**

Whenever VDOT criteria (provided above in cases 1-3) are not met, a design waiver is required to document the design speed.

A Design Exception is required if AASHTO minimum design speeds for individual geometric elements are not met.

Additional information is available in NCHRP Report 504 "Design Speed, Operating Speed and Posted Speed Practices", at:
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_504.pdf .

For the determination of the roadway posted speed limits, the plans are to indicate the Design Speed (V) of each horizontal and vertical (crest and sag) curve along with the horizontal and vertical curve data.

The Design Speeds (V) are to be determined as follows:

- Crest Vertical Curves

  - See "Sight Distance on Crest Vertical Curves" (VDOT's *Road & Bridge Standards*, Section 600) to determine sight distance parameters.

  - See 2018 AASHTO Green Book Section 3.4.6.2 "Crest Vertical Curves" to determine the Design Controls.*

- Sag Vertical Curves

  - See 2018 AASHTO Green Book, Section 3.4.6.3 "Sag Vertical Curves" to determine the Design Controls.*

Horizontal Curves

- The appropriate Transition Curve Standard (TC-5.01R, TC-5.01U, or TC-5.04ULS, TC-5.11R, TC-5.11U, or TC-5.11ULS) from VDOT'S *Road and Bridge Standards*, Section 800, provides the Design Speed (V) for horizontal curves (based on the radius of curvature (R) and the superelevation rate (E) provided by GEOPAK.

SHOWING DESIGN SPEED (V) FOR HORIZONTAL CURVES

The Design Speed shown on the plans for each horizontal curve is not necessarily the Minimum Design Speed shown on the Title Sheet.

GEOPAK supplies the superelevation dependent upon the input (urban/rural, radius, etc.) for each curve but does not provide the design velocity.

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* Rev 10/20

Designers shall determine the Design Speed (V) for each curve. This data is to be shown on the plans in the horizontal curve data for each curve.

Example:

Title Sheet:
Urban Principal Arterial (TC-5.11U - 2018 AASHTO Green Book)
45 mph Minimum Design Speed

Horizontal Curve on plans:
Radius = 1533’
Superelevation = 3.3% (provided by GEOPAK)
V = ?

1. To verify the velocity of the horizontal curve compare project radius and superelevation with Design Factors Charts in Section 800 of the Road and Bridge Standards.

2. Start with Page 803.29 TC-5.11U for given Design Speed shown above (45 mph).*

   ⇨ Chart shows that a curve with 3.3% superelevation and radius of 1446’ will support a velocity of 45 mph. The radius on the plans is greater than 1446’ (1533’).

3. Go to Section 803.30 (50 mph Design Speed).

   ⇨ Chart shows that a curve with 3.3% superelevation and radius of 1857’ will support a velocity of 50 mph, but the radius on the plans is less than 1857’ (1533’).

4. Therefore, the project radius and superelevation will not support a 50 mph design velocity. The more conservative V = 45 mph shall be shown on the plans as the velocity of the curve.

A Design Exception is required whenever the horizontal curve radius and/or superelevation rate does not support the minimum design speed. See *IIM-LD-227* for information on Design Exceptions.

* Rev. 7/16

ADDITIONAL RESOURCES

Transportation Research Board, *NCHRP Report 504*, Design Speed, Operating Speed, and Posted Speed Practices, available at:
http://trb.org/publications/nchrp/nchrp_rpt_504.pdf

2018 AASHTO Green Book, "Speed", Chapter 2.3.6.

NS 23 CFR 625 available at:
http://www.fhwa.dot.gov/legsregs/directives/fapg/0625sup.htm

The Federal Aid Policy Guide (FAPG)

"*Compatibility of Design Speed, Operating Speed and Posted Speed*" (1995 - By FHWA and TXDOT)

ITE's "*Speed: Understanding Design, Operating and Posted Speed*" (1997 - By Ray Krammes (FHWA) and Kay Fitzpatrick (TTI)

Manual on Uniform Traffic Control Devices (MUTCD, 2009 Edition)

SHOWING DESIGN SPEED ON TITLE SHEET

See the current version of *Instructional and Informational Memorandum* *IIM-LD-204* for the method of showing design speed data on the plans.

An asterisk is to be shown adjacent to the Design Speed (Example - * 60 MPH) on the title sheet and the following note shown:

* See Plan and Profile Sheets for the horizontal and vertical curve design speeds.

OPERATING SPEED

Operating Speed is the speed at which drivers are observed operating their vehicles during free-flow conditions. The 85^{th} percentile of the distribution of observed speeds is the most frequently used measure of the operating speed associated with a particular location or geometric feature of a highway, or highway segment.

POSTED SPEED

The Posted Speed for existing, new or reconstructed roadways should be determined by factors outlined in the *MUTCD*, Section 2B.13. The MUTCD requires that an engineering study be conducted in accordance with established engineering practice. VDOT has a standard study template for developing speed limit recommendations which incorporates the MUTCD, Section 2B.13 as well as other considerations pertaining to VDOT's decision-making process for speed limit approvals, including enforcement consensus.

After a project is constructed, the responsible District Traffic Engineer will re-establish the speed limit based on established traffic engineering policies. An engineering study will be performed as needed in accordance with documented traffic engineering practices.

It is important to note that the Design Speed shown on the project title sheet may not be the same as the Design Speed of the individual geometric elements. Each curve on the project (horizontal and vertical) should show a distinct and separate Design Speed from that shown on the Title Sheet. In many cases the Design Speed for the project will equal the design speed for the curves.* Although these curves may present isolated instances where the physical roadway dictates the speed of vehicles, they shall not be the sole basis for determining the posted speed limit. It is more appropriate to address these locations by warning signs.

It is only where the physical roadway features dictate the speed of the vehicles on extended sections, for a major portion of the roadway that they should be considered as a limiting factor in setting the speed limit. Such limitations in speed due to physical features will become apparent in the speed analysis conducted as part of the traffic engineering study.

For design criteria and instructions on signing roadways with a design speed < 25 mph, see the VDOT Road Design Manual, Appendix B(1), Tables B(1)-1 through B(1)-3 and AASHTO's *Guidelines for Geometric Design of Low-Volume Roads Second Edition**.

DESIGN VEHICLE

The design vehicle is the type of vehicle that makes frequent turns without encroaching into the adjacent lane when making those turns. The tracking of the design vehicle is an important determinant of corner radii at intersections. When the design vehicle traverses an intersection, the design vehicle shall be able to turn from one street to another without deviating from the near travel lane and impeding other traffic flow. Therefore, the design vehicle determines the elements of design such as turning radius and lane width. The design vehicle is to be determined based on the *LD-104* Request for Traffic Data and discussed at the Project Scoping Meeting and recorded on the Scoping Worksheet - Roadway Design.

The WB-67 shall be the design vehicle used for intersections of freeway ramp terminals with other arterial crossroads and for other intersections of state highways and industrialized streets that carry high volumes of traffic, or roadways that provide local access for large trucks.

DESIGN WAIVERS

Design Waivers are required when deviations from VDOT's design criteria occur. When design criteria meet or exceed AASHTO minimal design but fall short of VDOT's minimal design, a Design Waiver shall be required. Design Waivers will be applicable to all projects regardless of functional classification and funding and shall be documented and approved in accordance with the Design Waiver Request Form *LD-448*. Please refer to *IIM-LD-227* for specific guideline on obtaining design waiver. **This Design Waiver Policy is applicable to VDOT owned and maintained roadways only.**

* Rev 10/20

DESIGN EXCEPTIONS

If there are geometric values that are below AASHTO minimum guidelines, the Project Manager/ Design Engineer shall seek to obtain approval of these design exceptions from the State Location and Design Engineer (all projects) and FHWA (if applicable) no later than Public Hearing Stage. Please refer to *IIM-LD-227* for specific guideline on obtaining design exceptions.

FUNCTIONAL CLASSIFICATION

VDOT uses functional classification for the purposes of, funding, design, determining the urban network to identify the thoroughfare system, determining statewide network for the State Highway Needs Assessment Study, and to help establish construction priorities.

According to VDOT's Functional Classification Comprehensive Guide, the highway system in Virginia has been functionally classified as Interstate, Other Freeways and Expressways Other Principal Arterial, Minor Arterial, Major Collector, Minor Collector and Local. The American Association of State Highway and Transportation Officials (AASHTO) utilizes, as presented in the publication: *A Policy on Geometric Design of Highways and Streets*, referred to as the AASHTO "Green Book", a similar functional classification system. The designations used are: Freeway, Arterial, Collector, and Local Roads and Streets.

These functional classes are defined in AASHTO "Green Book Section 1.4. Relationships between these two classification systems have been generally developed. Please refer to VDOT's Functional Classification website for additional guidance.

Interstates are the highest classification and designed with mobility and long-distance travel in mind. This classification is for highways designated as part of the Eisenhower Interstate System. Roadways classified as interstates are limited access, divided highways with the highest level of mobility. There is also no ambiguity in the functional classification, as only the Secretary of Transportation can designate a roadway as an interstate*.

Other Freeways and Expressways classification is for highways that are generally divided with partial or full control-of-access. They primarily serve through traffic and major circulation movements within or around urban areas. These routes provide connecting links between interstates, principal arterials and minor arterials.*

Other Principal Arterials serve corridor movements of substantial statewide or interstate travel and provides an integrated network without stub connections (dead ends). In urban areas they serve the major activity centers of a metropolitan area and the highest traffic volume corridors, carry a significant amount of intra-area travel, and serve demand between the central business district and outlying residential areas of a metropolitan area. See AASHTO Green Book Chapter 7 for more information on Arterials.*

Minor Arterials link cities and large towns, along with other major traffic generators, and form an integrated network providing interstate and inter-county service. In urban areas, Minor Arterials interconnect with principal arterials, augment the urban principal arterial system, and

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provide service to trips of moderate length at a lower level of travel mobility than principal arterials.*

Major Collectors provide service to any county seat not on an arterial system, to larger towns not directly served by higher systems. Major Collectors also link these places to nearby larger towns and cities or with arterial routes and serve the most important intra-county travel corridor. In Urban Areas, major collectors provide land access and traffic circulation within residential neighborhoods, commercial, and industrial areas. These collectors distribute trips from the arterials through the aforementioned areas to their ultimate destination, collect traffic from local streets, and channel it to the arterial system. See AASHTO Green Book Chapter 6 for more information on Collectors*.

Minor Collectors collect traffic from local roads and bring all developed areas within a reasonable distance of a collector road. Minor Collector facilities provide service to the remaining smaller communities and link local traffic generators with their rural surrounding areas. In urban areas, Minor Collectors serve both land access and traffic circulation in lower density residential and commercial/industrial areas. Typical operating characteristics include lower speeds and fewer signalized intersections. Minor Collectors penetrate residential neighborhoods, but only for a short distance.*

Local Roads and Streets serve primarily to provide direct access to adjacent land. Local Roads provide service to travel over relatively short distance as compared to collectors or other higher systems. Through traffic movement is deliberately discouraged for Local Roads in urban areas*

- All roadways are classified as to how the facility functions in accordance with Federal guidelines. See link to VDOT's *Functional Classification maps*.

- The Geometric Design Standards in Appendix A1 of VDOT's *Road Design Manual* are divided by Functional Classification (FC).*

- The terms "Urban" and "Rural" used in the FC do not necessarily coincide with the terms as applied to highway systems in Virginia.

  Urban - Urbanized areas within set boundaries having a population of 5,000 or more. This may include areas outside of incorporated cities and towns.

  Rural - Areas not designated as Urban. Includes incorporated cities and towns with populations less than 5,000.

* Added. 10/20

VIRGINIA HIGHWAY SYSTEMS

Urban - Roadways within the boundaries of incorporated towns and cities with a population of 3,500 or more plus eight other designated urbanized areas (Bridgewater, Chase City, Elkton, Grottoes, Narrows, Pearisburg, Saltville and Woodstock). The urban program is administered by the Local Assistance Division.

Primary - Two-to-six-lane roads that connect cities and towns with each other and with interstates.

Secondary - Normally are local connector or county roads. These generally are numbered 600 and above. Arlington and Henrico counties maintain their own county roads. Projects are administered by the Local Assistance Division. Please see *Code of Virginia § 33.2-324* Secondary state highway system; composition for more information*

- A project classified as Urban in FC may be part of the Interstate, Arterial, Primary, or Secondary System and will be administered as such. This applies also to projects classified as Rural.

- The Functional Classification block on the title sheet is to show the Geometric Design Standard used.

  If more than one standard is used in the design, it will be necessary to set up two Functional Classification blocks since in most cases there would be a change in traffic volumes and scope of work.

EXAMPLE OF DETERMINING FUNCTIONAL CLASSIFICATION STANDARDS

When the Functional Classification for a project would normally warrant either Geometric Design Standard GS-1, GS-2, GS-3, or GS-4 and Geometric Design Standard GS-5, GS-6, GS-7 or GS-8, respectively, is used then it will be necessary to show the standard used in the design on the title sheet under the Functional Classification.

- If the normal Geometric standard would be GS-3 and Geometric Standard GS-7 is used, the title sheet is to show:

RURAL COLLECTOR-ROLLING-DIVIDED (Urban St'd. GS-7 was used)

* Rev 10/20

LANE/SHOULDER/PAVEMENT TRANSITIONS, MERGING TAPERS & SPEED CHANGE LENGTHS

Lane /pavement/shoulder transitions typically occur where new or reconstructed roadways tie-in to existing roadways. This also applies to where roadways tie-in to bridges. Permanent* lane/pavement/shoulder transitions*, merging tapers and speed change lengths shall meet the minimum length provided by the following equations:

For 40 mph or less	For 45 mph or greater
$L = S^2W \div 60$	$L = W \times S$

L = length of transition
S = Design Speed
W = Width of offset on each side

Source: *2009 MUTCD*, Section 6, Table 6C-4

For Temporary Merging, Temporary Shifting and Temporary Shoulder Tapers see 2009 *MUTCD*, Section 6, Table 6C-3 and 6C-4.

For Passing/ Left Turn lanes on Two-Lane Highway See *Appendix F, Figure 3-4*.

NOTE:

A pavement transition length of 1/2L (calculate L by using the applicable formula above) is to be used when establishing project termini for the majority of small bridge replacement and/or major bridge rehabilitation projects when “NO” horizontal or vertical geometric changes are required to tie into the existing approach alignment. For additional information see Volume 5, Part 2, of the *Structure and Bridge Manual*.

Pavement transition is separate from the length of need for guardrail. Length of need and shoulder prep for guardrail shall be in accordance with the VDOT RDM Appendix J and the *Road & Bridge Standards*.

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GEOMETRIC DESIGN STANDARDS FOR INTERSTATE SYSTEM (GS-INT)

<table>
<tr><th rowspan="2"></th><th rowspan="2">TERRAIN</th><th rowspan="2">MINIMUM DESIGN SPEED (MPH)</th><th rowspan="2">MINIMUM RADIUS</th><th rowspan="2">(7) MINIMUM STOPPING SIGHT DISTANCE</th><th rowspan="2">MINIMUM WIDTH OF LANE</th><th colspan="2">(1) MINIMUM WIDTH OF TOTAL SHOULDERS (GRADED + PAVED) (CUT & FILL)</th><th colspan="2">(2,3,4) MINIMUM PAVED SHOULDER WIDTH</th><th rowspan="2">(5) MINIMUM WIDTH OF DITCH FRONT SLOPE</th><th rowspan="2">(6) SLOPE</th><th rowspan="2">NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES</th></tr>
<tr><th>With GR</th><th>Without GR</th><th>LT.</th><th>RT.</th></tr>
<tr><td rowspan="4">INTERSTATE</td><td rowspan="2">Rural Non-Mountainous (Level or Rolling)</td><td>75</td><td>2215’</td><td>820’</td><td rowspan="4">12’</td><td rowspan="3">16’</td><td rowspan="3">12’</td><td rowspan="3">4’ ** Min.</td><td rowspan="3">10’ Min.</td><td rowspan="4">12’ @ 6:1</td><td rowspan="4">CS-4B</td><td rowspan="4">See Footnote (8)</td></tr>
<tr><td>70</td><td>1821’</td><td>730’</td></tr>
<tr><td>Urban</td><td rowspan="2">50</td><td rowspan="2">760’</td><td rowspan="2">425’</td></tr>
<tr><td>Rural Mountainous</td><td>14’</td><td>10’</td><td>4’ ** Min.</td><td>8’ ** Min.</td></tr>
</table>

GENERAL NOTES

Interstates - All new and major reconstructed Interstate facilities shall have a design speed 5 mph greater than the posted speed * unless concurrence from the State Location and Design Engineer is obtained.

Standard TC-5.11R superelevation based on 8% maximum is to be used for all Interstates.

Medians in urban or mountainous areas shall be wide enough to accommodate the left total shoulder width plus the space needed for a barrier. See Interstate Guide.

When barriers are provided right of traffic or in the median the total shoulder shall be paved.

Where curbs are provided, they shall not be closer to the traveled way than the outer edge of the paved shoulder, shall have a sloping face and be limited to the height of 4 inches (St’d CG-3). See Interstate Guide.

Maximum Grades

Type of Terrain	Design Speed (mph)						
	50	55	60	65	70	75	80
	*Grades (%)						
Level	4	4	3	3	3	3	3
Rolling	5	5	4	4	4	4	4
Mountainous	6	6	6	5	5	-	-

* Grades 1% Steeper than the value shown may be used in urban areas

FOOTNOTES

(1) Total shoulder widths include the paved portion and are applicable to the left and right shoulder.

Where truck traffic exceeds 250 DDHV, a wider total shoulder should be considered (14’ without guardrail; 18’ with guardrail).

(2) When the mainline is 6 or more lanes in rural non-mountainous or urban terrain, the left paved shoulder width shall be the same as the right paved shoulder.
** AASHTO Minimum, See Interstate Guide.

(3) When the mainline is 8 or more lanes in rural mountainous terrain, the median paved shoulder width shall be the same as the right paved shoulder.
** AASHTO Minimum, See Interstate Guide.

Where truck traffic exceeds 250 DDHV, additional shoulder width may be beneficial. Refer to AASHTO’s Green Book Chapter 8 for more information.

(4) Additional guidance on shoulder widths for tunnels and long bridges [overall length over 200 ft.] is provided in the AASHTO Interstate Guide.

(5) A hydraulic analysis is necessary to determine actual depth requirement.

(6) Additional or modified slope criteria to apply where shown on typical sections.

(7) For additional information on sight distance requirements on grades of 3 percent or greater, see Section 3.2.2, Table 3-2 of the AASHTO Green Book.

(8) See *Manual of the Structure and Bridge Division* – Volume V – Part 2 Design Aids – Chapter 6 Geometrics.

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GEOMETRIC DESIGN STANDARDS FOR RURAL PRINCIPAL ARTERIAL SYSTEM (GS-1)

	TERRAIN	DESIGN SPEED (MPH)	MINIMUM RADIUS	(6) MINIMUM STOPPING SIGHT DISTANCE	MINIMUM WIDTH OF LANE	(1) MINIMUM WIDTH OF TOTAL SHOULDERS (GRADED + PAVED) CUT & FILL		(2) MINIMUM PAVED SHOULDER WIDTH		(3) MINIMUM WIDTH OF DITCH FRONT SLOPE	(4) SLOPE	NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES See Footnote (5)
						With GR	Without GR	LT.	RT.			
FREEWAYS	LEVEL	75	2215'	820'	12'	16'	12'	4'	10'	12' @ 6:1	CS-4B	
		70	1821'	730'								
	ROLLING	60	1204'	570'								
	MOUNTAINOUS	50	760'	425'							CS-4E	
OTHER PRINCIPAL ARTERIALS	LEVEL	70	1821'	730'	12'	14'	10'	4'	8'	10' @ 6:1	CS-4/ CS-4B	
		60	1204'	570'								
	ROLLING	60	1204'	570'							CS-4/ CS-4E	
		50	760'	425'						6' @ 4:1		
	MOUNTAINOUS	50	760'	425'							CS-3/ CS-3B	
		45	589'	360'								
		40	446'	305'								

GENERAL NOTES

Freeways - A design speed of 75 mph should be used for Rural Freeways. Where terrain is mountainous, a design speed of 60 mph or 50 mph which is consistent with driver expectancy, may be used.

Other Principal Arterials - A design speed of 40 to 70 mph should be used depending on terrain, driver expectancy and whether the design is constructed on new location or reconstruction of an existing facility. An important safety consideration in the selection of one of the lower design speeds in each range is to have a properly posted speed limit.

Incorporated towns or other built-up areas, Urban Standard GS-5 may be used for design. "Built-up" is where there is sufficient development along the roadway that justifies a need to channelize traffic into and out of properties utilizing curb and gutter.

Standard TC-5.11R superelevation based on 8% maximum is to be used for all Rural Principal Arterials.

Clear Zone and Recoverable Area information can be found in Appendix A2 of the *Road Design Manual*.

If medians are included, see *Section 2E.3 of Chapter 2E* of the *Road Design Manual*.

For additional information on roadway widths and maximum grades relative to terrain and design speed, see AASHTO Green Book, Chapter 7, Section 7.2.2, Table 7-2 and Section 7.2.3, Table 7-3; for Freeways, see Chapter 8, Section 8.2.7, Table 8-1.

FOOTNOTES

(1) Total shoulder widths include the paved portion and are applicable to the left and right shoulder.

On Freeways, if truck traffic exceeds 250 DDHV, a wider total shoulder should be considered (14' without guardrail and 18' with guardrail).

(2) When the mainline is 6 or more lanes, the left paved shoulder width shall be the same as the right paved shoulder.

On Freeways, if truck traffic exceeds 250 DDHV, a wider right paved shoulder should be considered (12').*

(3) A hydraulic analysis is necessary to determine actual depth requirement.

(4) Additional or modified slope criteria to apply where shown on typical sections.

(5) See *Manual of the Structure and Bridge Division* – Volume V – Part 2 Design Aids – Chapter 6 Geometrics.

(6) For additional information on sight distance requirements on grades of 3 percent or greater, see Section 3.2.2, Table 3-2 of the AASHTO Green Book.

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GEOMETRIC DESIGN STANDARDS FOR RURAL MINOR ARTERIAL SYSTEM (GS-2)

TRAFFIC VOLUME	TERRAIN	DESIGN SPEED (MPH)	MINIMUM RADIUS	(7) MINIMUM STOPPING SIGHT DISTANCE	(2) MINIMUM WIDTH OF LANE	MINIMUM WIDTH OF TOTAL SHOULDERS (GRADED + PAVED) CUT & FILL (8)		(3) (9) MINIMUM PAVED SHOULDER WIDTH		(4) MINIMUM WIDTH OF DITCH FRONT SLOPE	(5) SLOPE	NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
						With GR	Without GR	LT.	RT.			
(1) ADT OVER 2000	LEVEL	70	1821’	730’	12’	12’*	8’	4’	6’*	10’ @ 6:1	CS-4, CS-4A OR CS-4C	See Footnote (6)
		60	1204’	570’								
	ROLLING	60	1204’	570’								
		50	760’	425’						6’ @ 4:1		
	MOUNTAINOUS	50	760’	425’							CS-3/ CS-3B	
		45	589’	360’								
		40	446’	305’								
(1) ADT 400 TO 2000	LEVEL	70	1821’	730’	12’	10’	6’	4’	4’*	6’ @ 4:1	CS-4, CS-4A OR CS-4C	
		60	1204’	570’								
	ROLLING	60	1204’	570’								
		50	760’	425’	11’							
	MOUNTAINOUS	50	760’	425’							CS-3/ CS-3B	
		45	589’	360’								
		40	446’	305’								
CURRENT ADT UNDER 400	LEVEL	70	1821’	730’	11’	8’	4’	2’*	2’*	6’ @ 4:1	CS-4, CS-4A OR CS-4C	
		60	1204’	570’								
	ROLLING	60	1204’	570’								
		50	760’	425’								
	MOUNTAINOUS	50	760’	425’							CS-3/ CS-3B	
		45	589’	360’	10’							
		40	446’	305’								

GENERAL NOTES

Rural Minor Arterials are designed with design speeds of 50 to 70 MPH, dependent on terrain features and traffic volumes, and occasionally may be as low as 40 MPH in mountainous terrain.

In incorporated towns or other built-up areas, Urban Standard GS-6 may be used for design. “Built-up” is where there is sufficient development along the roadway that justifies a need to channelize traffic into and out of properties utilizing curb and gutter.

Standard TC-5.11R superelevation based on 8% maximum is to be used for Rural Minor Arterials.

If medians are included, see *Section 2E.3 of Chapter 2E* of the *Road Design Manual*.

Clear Zone and Recoverable Area information can be found in Appendix A2 of the *Road Design Manual*.

For Passing Sight Distance Criteria, see AASHTO Green Book, Section 3.2.4,

For maximum grades relative to terrain and design speed, see AASHTO Green Book, Chapter 7, Section 7.2.2, Table 7-2.

FOOTNOTES

(1) Use Design Year ADT for new construction and reconstruction projects (not applicable to R.R.R. projects or roads with ADT < 400) in accordance with *Road Design Manual*, *Chapter 2A,* “REQUEST FOR TRAFFIC DATA” and Form *LD-104.*

(2) Lane width to be 12' at all interchange locations. For projects not on the National Highway System, width of traveled way may remain at 22' on reconstructed highways where alignment and safety records are satisfactory.

(3) Where the mainline is 6 or more lanes, both right and median paved shoulders shall be 8' in width. For additional guidance on shoulder widths/reductions, see AASHTO Green Book, Ch. 7, Section 7.2.11, & Section 7.2.3, Table 7-3.

(4) A hydraulic analysis is necessary to determine actual depth requirement.

(5) Additional or modified slope criteria to be applied where shown on typical sections.

(6) See *Manual of the Structure and Bridge Division* – Volume V – Part 2 Design Aids – Chapter 6 Geometrics.

(7) For additional information on sight distance requirements on grades of 3 percent or greater, see AASHTO Green Book, Chapter 3, Section 3.2.2, Table 3-2.

(8) Total shoulder widths include the paved portion and are applicable to the left and right shoulder.

(9) Additional paved width may be required for the installation of rumble strips.

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GEOMETRIC DESIGN STANDARDS FOR RURAL COLLECTOR ROAD SYSTEM (GS-3)

TRAFFIC VOLUME	TERRAIN	DESIGN SPEED (MPH)	MINIMUM RADIUS	(8) MINIMUM STOPPING SIGHT DISTANCE	(2) MINIMUM WIDTH OF LANE	(3) (4) MINIMUM WIDTH OF GRADED SHOULDERS CUT & FILL		(5) MINIMUM WIDTH OF DITCH FRONT SLOPE	(6) SLOPE	NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
						With GR	Without GR			
(1) ADT OVER 2000	LEVEL	60	1204’	570’	(9) 11’	10’	6	10’ @ 6:1	CS-4, CS-4A OR CS-4C	See Footnote (7)
	ROLLING	50	760’	425’				6’ @ 4:1		
	MOUNTAINOUS	45	589’	360’					CS-3 / CS-3B	
		40	446’	305’						
(1) ADT 400 TO 2000	LEVEL	50	760’	425’	11’	8’	4’	6’ @ 4:1	CS-4, CS-4A OR CS-4C	
	ROLLING	45	589’	360’						
		40	446’	305’						
	MOUNTAINOUS	35	316’	250’				4’ @ 3:1	CS-3/ CS-3B	
		30	215’	200’	10’					
CURRENT ADT UNDER 400	LEVEL	45	589’	360’	10’	6’	2’	6’ @ 4:1	CS-1	
		40	446’	305’						
	ROLLING	35	316’	250’				4’ @ 3:1		
		30	215’	200’						
	MOUNTAINOUS	25	135’	155’						
		20	77’	125’						

GENERAL NOTES

Geometric design features should be consistent with a design speed appropriate for the conditions.

Low design speeds (45 MPH and below) are generally applicable to highways with curvilinear alignment in rolling or mountainous terrain and where environmental conditions dictate.

High speed design (50 MPH and above) are generally applicable to highways in level terrain or where other environmental conditions are favorable.

Intermediate design speeds would be appropriate where terrain and other environmental conditions are a combination of those described for low and high design speed.

The designer should strive for higher values than the minimum where conditions of safety dictate and costs can be supported.

In incorporated towns or other built-up areas, Urban Standard GS-7 may be used. “Built-up” is where there is sufficient development along the roadway that justifies a need to channelize traffic into and out of properties utilizing curb and gutter.

Standard TC-5.11R superelevation based on 8% maximum is to be used for Rural Collectors.

Clear zone and Recoverable Area information can be found in *Appendix A2* of the *Road Design Manual*.

For Passing Sight Distance Criteria see AASHTO Green Book, Chapter 3, Section 3.2.4.

For maximum grades relative to terrain and design speed, see AASHTO Green Book, Chapter 6, Section 6.2.1, Table 6-2.

FOOTNOTES

(1) Use Design Year ADT for new construction and reconstruction projects (not applicable to R.R.R. projects or roads with ADT < 2000) in accordance with *Road Design Manual*, *Chapter 2A*, “REQUEST FOR TRAFFIC DATA” and Form *LD-104*.

(2) Lane width to be 12' at all interchange locations.

(3) When the mainline is 2 lanes provide 4' wide paved shoulders (right and left) when design year ADT exceeds 2000 VPD, with 5% or more truck and bus usage. Provide 5' wide right paved shoulder when design year ADT exceeds 2000 VPD, with 5% or more truck and bus usage and the route is an AASHTO approved U.S. Bicycle Route (1, 76 or 176) or designated as a bicycle route on a locally adopted transportation plan. All shoulders not being paved will have the mainline pavement structure extended 1' on the same slope into the shoulder to eliminate raveling at the pavement edge. For additional guidance on shoulder widths, see AASHTO Green Book, Chapter 6, Section 6.2.2.

(4) When the mainline is 4 lanes with ADT >2000, a minimum paved shoulder width of 6' right of traffic and 3' left of traffic shall be provided.

(5) A hydraulic analysis is necessary to determine actual depth requirement.

(6) Additional or modified slope criteria to be applied where shown on typical sections.

(7) See *Manual of the Structure and Bridge Division* – Volume V – Part 2 Design Aids – Chapter 6 Geometrics.

(8) For additional information on sight distance requirements on grades of 3 percent or greater, see AASHTO Green Book, Chapter 3, Section 3.2.2, Table 3-2.

(9) Consider using a lane width of 12 ft. where substantial truck volumes are present or agricultural equipment frequently uses the road. See AASHTO Green Book, Chapter 6, Section 6.2.2[*], Table 6-5 footnote b.

[*] Rev 7/22

GEOMETRIC DESIGN STANDARDS FOR RURAL LOCAL ROAD SYSTEM (GS-4)

<table>
<tr><th rowspan="2">TRAFFIC VOLUME</th><th rowspan="2">TERRAIN</th><th rowspan="2">DESIGN SPEED (MPH)</th><th rowspan="2">MINIMUM RADIUS</th><th rowspan="2">(9) MINIMUM STOPPING SIGHT DISTANCE</th><th rowspan="2">(2) MINIMUM WIDTH OF SURFACING OR PAVEMENT</th><th colspan="2">(3) (4) (5) MINIMUM WIDTH OF GRADED SHOULDERS CUT & FILL</th><th rowspan="2">(6) MINIMUM WIDTH OF DITCH FRONT SLOPE</th><th rowspan="2">(7) SLOPE</th><th rowspan="2">NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES</th></tr>
<tr><th>With GR</th><th>Without GR</th></tr>
<tr><td rowspan="5">(1) ADT OVER 2000</td><td>LEVEL</td><td>50</td><td>760’</td><td>425’</td><td rowspan="5">(10) 22’</td><td rowspan="5">10’</td><td rowspan="5">6’</td><td rowspan="3">6’ @ 4:1</td><td>CS-4, 4A / 4C</td><td rowspan="16">See Footnote (8)</td></tr>
<tr><td rowspan="2">ROLLING</td><td>45</td><td>589’</td><td>360’</td><td rowspan="4">CS-3, 3A / 3B</td></tr>
<tr><td>40</td><td>446’</td><td>305’</td></tr>
<tr><td rowspan="2">MOUNTAINOUS</td><td>35</td><td>316’</td><td>250’</td><td rowspan="2">4’ @ 3:1</td></tr>
<tr><td>30</td><td>215’</td><td>200’</td></tr>
<tr><td rowspan="5">(1) ADT 400 TO 2000</td><td>LEVEL</td><td>50</td><td>760’</td><td>425’</td><td rowspan="2">22’</td><td rowspan="5">7’</td><td rowspan="5">3’</td><td rowspan="2">6’ @ 4:1</td><td rowspan="5">CS-1</td></tr>
<tr><td rowspan="2">ROLLING</td><td>45</td><td>589’</td><td>360’</td></tr>
<tr><td>40</td><td>446’</td><td>305’</td><td rowspan="3">20’</td><td rowspan="3">4’ @ 3:1</td></tr>
<tr><td rowspan="2">MOUNTAINOUS</td><td>35</td><td>316’</td><td>250’</td></tr>
<tr><td>30</td><td>215’</td><td>200’</td></tr>
<tr><td rowspan="6">CURRENT ADT UNDER 400</td><td rowspan="2">LEVEL</td><td>45</td><td>589’</td><td>360’</td><td rowspan="6">18’</td><td rowspan="6">6’</td><td rowspan="6">2’</td><td rowspan="6">4’ @ 3:1</td><td rowspan="6">CS-1</td></tr>
<tr><td>40</td><td>446’</td><td>305’</td></tr>
<tr><td rowspan="2">ROLLING</td><td>35</td><td>316’</td><td>250’</td></tr>
<tr><td>30</td><td>215’</td><td>200’</td></tr>
<tr><td rowspan="2">MOUNTAINOUS</td><td>25</td><td>135’</td><td>155’</td></tr>
<tr><td>20</td><td>77’</td><td>125’</td></tr>
</table>

GENERAL NOTES

Low design speeds are generally applicable to roads with winding alignment in rolling or mountainous terrain where environmental conditions dictate.

High design speeds are generally applicable to roads in level terrain or where other environmental conditions are favorable.

Intermediate design speeds would be appropriate where terrain and other environmental conditions are a combination of those described for low and high speed.

For minimum design speeds for 250 ADT and under, see AASHTO Green Book, Chapter 5, Section 5.2.1, Table 5-1.

Standard TC-5.11R superelevation based on 8% maximum is to be used.

In incorporated towns or other built-up areas, Urban Standard GS-8 may be used. . “Built-up” is where there is sufficient development along the roadway that justifies a need to channelize traffic into and out of properties utilizing curb and gutter.

For Passing Sight Distance Criteria See AASHTO Green Book, Chapter 3, Section 3.2.4 .

For maximum grades relative to terrain and design speed, see AASHTO Green Book, Chapter 5, Section 5.2.1, Table 5-2.

For Recreational Access Road design standards, see AASHTO Green Book, Chapter 5, Section 5.4.2.

FOOTNOTES

(1) Use Design Year ADT for new construction and reconstruction projects in accordance with *Road Design Manual*, Chapter 2A, “REQUEST FOR TRAFFIC DATA” and Form *LD-104*. For RRR projects or roads with ADT < 2000, See Road Design Manual, Appendix A4*, “GUIDELINES FOR RRR PROJECTS.”

(2) Lane width to be 12' at all interchange locations.

(3) In mountainous terrain or sections with heavy earthwork, the graded width of shoulder in cuts may be decreased by 2', but in no case shall the cut shoulder width be less than 2'.

(4) Minimum shoulder slope shall be 8% on low side and same slope as pavement on high side (See St'd. GS-12).

(5) When the mainline is 2 lanes provide 4' wide paved shoulders (right and left) when design year ADT exceeds 2000 VPD, with 5% or more truck and bus usage. Provide 5' wide paved shoulder when design year ADT exceeds 2000 VPD, with 5% or more truck and bus usage and the route is an AASHTO approved U.S. Bicycle Route (1, 76 or 176) or designated as a bicycle route on a locally adopted transportation plan All shoulders not being paved will have the mainline pavement structure extended 1' on the same slope into the shoulder to eliminate raveling at the pavement edge. For additional guidance on shoulder widths, see AASHTO Green Book, Chapter 5, Section 5.2.2.

(6) A hydraulic analysis is necessary to determine actual depth requirement.

(7) Additional or modified slope criteria to be applied where shown on typical sections.

(8) See *Manual of the Structure and Bridge Division* – Volume V – Part 2 Design Aids – Chapter 6 Geometrics.

(9) For additional information on sight distance requirements on grades of 3 percent or greater, see AASHTO Green Book, Chapter 3, Section 3.2.2, Table 3-2.

(10) Consider using a lane width of 12 ft. where substantial truck volumes are present or agricultural equipment frequently uses the road. See AASHTO Green Book, Chapter 5, Section 5.2.2, Table 5-5 footnote b.

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GEOMETRIC DESIGN STANDARDS FOR URBAN PRINCIPAL ARTERIAL SYSTEM (GS-5)

	DESIGN SPEED (MPH)	MINIMUM RADIUS		(13) MINIMUM STOPPING SIGHT DISTANCE	MINIMUM WIDTH OF LANE	(1) MIN. WIDTH OF TOTAL SHOULDERS (GRADED + PAVED) CUT & FILL		(2) MINIMUM PAVED SHOULDER WIDTH		(3) MINIMUM WIDTH OF DITCH FRONT SLOPE	(4) SLOPE	NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
		U	ULS			With GR	Without GR	LT.	RT.			
FREEWAYS	70	* See GS-1	-	730'	12'	16'	12'	4'	10'	12' @ 6:1	CS-4 OR 4B	See Footnote (7)
	60		-	570'								
	50		-	425'							CS-4 OR 4E	
OTHER PRINCIPAL ARTERIAL WITH SHOULDER DESIGN	60		-	570'	(12) 12'	14'	10'	4'	8'	10' @ 6:1	CS-4 OR 4E	
	50	929'	-	425'						6' @ 4:1		
	45	713'	795'	360'	(5) (6) (12) 11'						CS-3 OR 3B	
	40	536'	593'	305'								
	35	373'	408'	250'								
	30	251'	273'	200'								

	DESIGN SPEED (MPH)	MINIMUM RADIUS		(13) MINIMUM STOPPING SIGHT DISTANCE	MINIMUM WIDTH OF LANE	(8) STANDARD CURB & CURB & GUTTER	BUFFER STRIP WIDTH	(9) MINIMUM SIDEWALK WIDTH	(10) SLOPE	
		U	ULS							
OTHER PRINCIPAL ARTERIAL WITH CURB & GUTTER	60	GS-1	-	570'	(12) 12'	CG-3 / CG-7	(11)	5'	2:1	See Footnote (7)
	50	929'	-	425'						
	45	713'	795'	360'	(5) (6) (12) 11'	(14) CG-2 / CG-6				
	40	536'	593'	305'						
	35	373'	408'	250'						
	30	251'	273'	200'						
	25	155'	167'	155'						

GENERAL NOTES

Freeways - Urban Freeways should accommodate desired safe operating speeds during non-peak hours, but should not be so high as to exceed the limits of prudent construction, right of way and socioeconomic costs due to the large proportion of vehicles which are accommodated during periods of peak flow when lower speeds are necessary. The design speeds for Freeways shall not be less than 50 mph.

On many Urban Freeways, particularly in suburban areas, a design speed of 60 mph or higher can be provided with little additional cost above that required for 50 mph design speed. The corridor of the mainline may be relatively straight and the character and location of interchanges may permit a higher design speed. Under these conditions, a design speed of 70 mph should be considered.

Other Principal Arterials - Design speeds for Urban Arterials generally range from 40 to 60 mph, and occasionally may be as low as 25 mph. The lower (40 mph and below) speeds apply in the central business district and intermediate areas. The higher speeds are more applicable to the outlying business and developing areas.

Standard TC-5.11R (Rural) superelevation based on 8% maximum is to be used for **ALL** Freeways (50 – 70 mph) and for Other Principal Arterials with a design speed of 60 mph. For minimum radius, see GS-1.

Standard TC-5.11U (Urban) superelevation based on 4% maximum is to be used on Other Principal Arterials with a design speed of 50 mph and less.

Standard TC-5.11ULS (Urban Low Speed) superelevation based on +2% maximum may be used for design speeds less than or equal to 45 mph.

For Standard TC-5.11 ULS superelevation based on -2%, please refer to Road and Bridge Standards 803.23.

Clear Zone and Recoverable Area information can be found in Appendix A2 of the *Road Design Manual*.

If medians are included, see *Section 2E.3 of Chapter 2E* of the *Road Design Manual*. For minimum widths for roadway & right of way used within incorporated cities or towns to qualify for maintenance funds see Code of Va. Section *33.2-319*.

For maximum grades relative to terrain and design speed, see AASHTO Green Book, Chapter 7, Section 7.3.2, Table 7-4a, for Freeways, see Chapter 8, Section 8.2.7, Table 8-1.

FOOTNOTES

(1) Total shoulder widths include the paved portion and are applicable to the left and right shoulder. On Freeways, if truck traffic exceeds 250 DDHV, a wider total shoulder should be considered (14' without guardrail and 18' with guardrail).

(2) When the mainline is 6 or more lanes, the left paved shoulder width shall be the same as the right paved shoulder. On Freeways, if truck traffic exceeds 250 DDHV, a wider right paved shoulder should be considered (12').

(3) A hydraulic analysis is necessary to determine actual depth requirement.

(4) Additional or modified slope criteria apply where shown on typical sections.

(5) Minimum lane widths to be 12' at all interchange locations.

(6) Where heavy truck volume (equal to or greater than 10%) or bus traffic is anticipated, an additional 1 foot width should be considered.

(7) See *Manual of the Structure and Bridge Division* – Volume V – Part 2 Design Aids – Chapter 6 Geometrics.

(8) Or equivalent City or Town design.

(9) Width of 8' or more may be needed in commercial areas.

(10) 3:1 and flatter slopes shall be used where the right of way is behind the sidewalk (or sidewalk space) in residential or other areas where slopes will be maintained by the property owner.

(11) For buffer strip widths see *Appendix A(1), Section A(1)-1 Bicycle & Pedestrian Facility Guidelines.*

(12) Situations having restrictions on trucks may allow the use of lanes 1 foot less in width.

(13) For additional information on sight distance requirements on grades of 3 percent or greater, see AASHTO Green Book, Section 3.2.2, Table 3-2. For Intersection sight distance requirements see Appendix F, Table 2-5.

(14) Where bicycle accommodation is next to curb or curb and gutter, mountable curb (CG-3) or mountable curb and gutter (CG-7) shall be used for design speeds of 45 mph and below.

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GEOMETRIC DESIGN STANDARDS FOR URBAN MINOR ARTERIAL STREET SYSTEM (GS-6)

	DESIGN SPEED (MPH)	MINIMUM RADIUS U	MINIMUM RADIUS ULS	(11) MINIMUM STOPPING SIGHT DISTANCE	(10) MINIMUM WIDTH OF LANE	(3) STANDARD CURB / CURB & GUTTER	BUFFER STRIP WIDTH	(4) MINIMUM SIDEWALK WIDTH	(5) SLOPE	NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
STREETS WITH CURB & GUTTER	60	1204'	-	570'	12'	CG-3 / CG-7	(9)	5'	2:1	See Footnote (6)
	50	929'	-	425'						
	45	713'	795'	360'	(1) (2) 11'	(13) (14) CG-2 / CG-6				
	40	536'	593'	305'						
	35	373'	408'	250'						
	30	251'	273'	200'						
	25	155'	167'	155'						

	DESIGN SPEED (MPH)	MINIMUM RADIUS U	MINIMUM RADIUS ULS	(11) MINIMUM STOPPING SIGHT DISTANCE	(10) MINIMUM WIDTH OF LANE	(15) MINIMUM WIDTH OF TOTAL SHOULDERS (GRADED + PAVED) CUT & FILL With GR	(15) Without GR	(12) (7) MINIMUM PAVED SHOULDER WIDTH LT.	(12) (7) RT.	(8) MINIMUM WIDTH OF DITCH FRONT SLOPE	(5) SLOPE	NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
(12) STREETS WITH SHOULDER DESIGN	60	1204'	-	570'	12'	REFER TO MINIMUM WIDTH OF GRADED SHOULDERS CUT AND FILL FOR GS-2		See * GS-2	See GS-2	10'@ 6:1	2:1	See Footnote (6)
	50	929'	-	425'						6' @ 4:1		
	45	713'	795'	360'	(1) (2) 11'							
	40	536'	593'	305'								
	35	373'	408'	250'								
	30	251'	273'	200'								

GENERAL NOTES

Design Speeds for Urban Arterials generally range from 40 to 60 mph and occasionally may be as low as 25 mph. The lower (40 mph and below) speeds apply in the central business district and intermediate areas. The higher speeds are more applicable to the outlying business and developing areas.

Standard TC-5.11R (Rural) superelevation based on 8% maximum is to be used for 60 mph design speed.

Standard TC-5.11U (Urban) superelevation based on 4% maximum is to be used for design speeds less than 60 mph.

Standard TC-5.11ULS (Urban Low Speed) superelevation based on +2% maximum may be used for design speeds less than or equal to 45 mph.

For Standard TC-5.11 ULS superelevation based on -2%, please refer to Road and Bridge Standards 803.23.

Clear Zone and Recoverable Area information can be found in Appendix A2 of the *Road Design Manual.*

If medians are included, see *Section 2E.3 of Chapter 2E* of the *Road Design Manual*.

For minimum widths for roadway and right of way used within incorporated cities or towns to qualify for maintenance funds see Code of Virginia Section *33.2-319*.

For maximum grades relative to terrain and design speed, see AASHTO Green Book, Chapter 7, Section 7.3.2, Table 7-4a.

FOOTNOTES

(1) Lane width to be 12' at all interchanges.

(2) Where heavy truck volume (equal to or greater than 10%) or bus traffic is anticipated, an additional 1 foot width should be considered.

(3) Or equivalent City or Town design.

(4) A width of 8' or more may be needed in commercial areas.

(5) Slopes 3:1 and flatter shall be used when the right of way is behind the sidewalk (or sidewalk space) in residential or other areas where slopes will be maintained by the property owner.

(6) See *Manual of the Structure and Bridge Division* – Volume V – Part 2 Design Aids – Chapter 6 Geometrics.

(7) Where the mainline is 6 or more lanes, both right and median paved shoulders shall be 8' in width. For additional guidance on shoulder widths/reductions, see AASHTO Green Book, Chapter 7, Section 7.2.11.

(8) A hydraulic analysis is necessary to determine actual depth requirement.

(9) For buffer strip widths see *Appendix A(1), Section A(1)-1 Bicycle & Pedestrian Facility Guidelines.*

(10) Situations having restrictions on trucks may allow the use of lanes 1 foot less in width.

(11) For additional information on sight distance requirements on grades of 3 percent or greater, see AASHTO Green Book, Chapter 3, Section 3.2.2, Table 3-2.

(12) For information on reduced shoulder widths, see AASHTO Green Book, Chapter 7, Section 7.2.3, Table 7-3.

(13) Where bicycle accommodation is next to curb or curb and gutter, mountable curb (CG-3) or mountable curb and gutter (CG-7) shall be used for design speeds of 45 mph and below.

(14) See Appendix J for guardrail installation adjacent to curb or curb and gutter.

(15) Total shoulder widths include the paved portion and are applicable to the left and right shoulder.

* Rev 7/22

GEOMETRIC DESIGN STANDARDS FOR URBAN COLLECTOR STREET SYSTEM (GS-7)

	DESIGN SPEED (MPH)	MINIMUM RADIUS		(10) MINIMUM STOPPING SIGHT DISTANCE	(13) MINIMUM WIDTH OF LANE	(3) STANDARD CURB & CURB & GUTTER	BUFFER STRIP WIDTH	(4) MINIMUM SIDEWALK WIDTH	(5) SLOPE	NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
		U	ULS							
STREET WITH CURB & GUTTER	50	929’	-	425’	12’	CG-3 / CG-7	(9)	5’	2:1	See Footnote (8)
	45	713’	795’	360’	(1) (2) (12) 11’	(14) CG-2 / CG-6				
	40	536’	593’	305’						
	35	373’	408’	250’						
	30	251’	273’	200’						
	25	115’	167’	155’						

	DESIGN SPEED (MPH)	MINIMUM RADIUS		(10) MINIMUM STOPPING SIGHT DISTANCE	(13) MINIMUM WIDTH OF LANE	(7) (11) MINIMUM WIDTH OF GRADED SHOULDERS CUT & FILL		(6) MINIMUM WIDTH OF DITCH FRONT SLOPE	(5) SLOPE	NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
		U	ULS*			With GR	Without GR			
(11) STREET WITH SHOULDER DESIGN	50	929’	-	425’	12’	REFER TO MINIMUM WIDTH OF GRADED SHOULDERS CUT AND FILL FOR GS-3*		6’ @ 4:1	2:1	See Footnote (8)
	45	713’	795’	360’	(1) (2) (12) 11’					
	40	536’	593’	305’						
	35	373’	408’	250’				4’ @ 3:1		
	30	251’	273’	200’						

GENERAL NOTES

A minimum design speed of 25 mph or higher should be used for collector streets, depending on available right of way, terrain, adjacent development and other area controls.

In the typical street grid, the closely spaced intersections usually limit vehicular speeds and thus make the effect of design speed of less significance. Nevertheless, the longer sight distances and curve radii commensurate with design speeds higher than the value indicated result in safer highways and should be used to the extent practicable.

Standard TC-5.11U (Urban) superelevation based on 4% maximum.

*Standard TC-5.11ULS (Urban-Low Speed) superelevation based on +2% maximum may be used with a design speed of 45 mph or less.

*For Standard TC-5.11 ULS superelevation based on -2%, please refer to Road and Bridge Standards 803.23.

For minimum widths for roadway and right of way used within incorporated cities or towns to qualify for maintenance funds see *Code of Virginia Section 33.2-319*.

Clear zone and Recoverable Area information can be found in *Appendix A2** of the *Road Design Manual*.

For maximum grades relative to terrain and design speed, see AASHTO Green Book, Chapter 6, Section 6.3.1, Table 6-7.

FOOTNOTES

(1) Lane width should be 12’ in industrial areas. Where Right of Way is restricted 11’ lanes may be used in industrial areas. (See AASHTO Green Book Chapter6, Section 6.2.2 and 6.3.2, Table 6-5).

(2) Lane width to be 12' at all interchange locations.

(3) Or equivalent City or Town Design.

(4) 8' or more may be needed in commercial areas.

(5) 3:1 and flatter slopes shall be used when right of way is behind the sidewalk (or sidewalk space) in residential or other areas where the slopes will be maintained by the property owner.

(6) A hydraulic analysis is necessary to determine actual depth requirement.

(7) When Design year ADT exceeds 2000 VPD, with greater than 10% total truck and bus usage: Provide 4’ wide paved shoulders (right and left) when the graded shoulder is 5’ wide or greater. Provide 5’ wide paved shoulder when design year ADT exceeds 2000 VPD, with 5% or more truck and bus usage and the route is an AASHTO approved U.S. Bicycle Route (1, 76 or 176) or designated as a bicycle route on a locally adopted transportation plan. All shoulders not being paved will have the mainline pavement structure extended 1’, on the same slope, into the shoulder to eliminate raveling at the pavement edge. (See Standard GS-11 for shoulder design).

(8) See *Manual of the Structure and Bridge Division* – Volume V – Part 2 Design Aids – Chapter 6 Geometrics.

(9) For buffer strip widths see Appendix A(1), Section A(1)-1 Bicycle & Pedestrian Facility Guidelines.

(10) For additional information on sight distance requirements on grades of 3 percent or greater, see AASHTO, Green Book, Chapter 3, Section 3.2.2, Table 3-2.

(11) Where shoulders are provided, roadway widths in accordance with Table 6-5 should be considered. (See AASHTO Green Book, Chapter 6, Section 6.2.2)

(12) Where heavy truck volume (equal to or greater than 10%) or bus traffic is anticipated, an additional 1 foot width should be considered.

(13) Situations having restrictions on trucks may allow the use of lanes 1 foot less in width.

(14) Where bicycle accommodation is next to curb or curb and gutter, mountable curb (CG-3) or mountable curb and gutter (CG-7) shall be used for design speeds of 45 mph and below.

* Rev 10/20

GEOMETRIC DESIGN STANDARDS FOR URBAN LOCAL STREET SYSTEM (GS-8)

	DESIGN SPEED (MPH)	MINIMUM RADIUS		(1) MAXIMUM PERCENT OF GRADE	(10) MINIMUM STOPPING SIGHT DISTANCE	(2) MINIMUM WIDTH OF LANE	(3) STANDARD CURB / CURB & GUTTER	BUFFER STRIP WIDTH	(5) MINIMUM SIDEWALK WIDTH	(6) SLOPE	NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
		U	ULS								
STREET WITH CURB & GUTTER	30	251'	273'	15	200'	10'	(12) CG-2 / CG-6	(4)	5'	2:1	See Footnote (9)
	25	155'	167'		155'						
	20	87'	92'		125'						
	DESIGN SPEED (MPH)	MINIMUM RADIUS		(1) MAXIMUM PERCENT OF GRADE	(10) MINIMUM STOPPING SIGHT DISTANCE	(2) MINIMUM WIDTH OF LANE	(7) (11) MINIMUM WIDTH OF GRADED SHOULDERS CUT & FILL		(8) MINIMUM WIDTH OF DITCH FRONT SLOPE	SLOPE	
		U	ULS				With GR	Without GR			
(11) STREET WITH SHOULDER DESIGN	30	251'	273'	15	200'	10'	REFER TO MINIMUM WIDTH OF GRADED SHOULDERS CUT AND FILL FOR GS-4*		4' @ 3:1	3:1	
	25	155'	167'		155'						
	20	87'	92'		125'						

GENERAL NOTES

Design Speed is not a major factor for local streets. For consistency in design elements, design speeds ranging from 20 to 30 mph may be used, depending on available right of way, terrain, adjacent development and other area controls.

In the typical street grid, the closely spaced intersections usually limit vehicular speeds, making the effect of a design speed of less significance.

Design speeds exceeding 30 mph in residential areas may require longer sight distances and increased curve radii, which would be contrary to the basic function of a local street.

Standard TC-5.11U (Urban) superelevation based on 4% maximum.

Standard TC-5.11ULS (Urban Low Speed) superelevation based on +2% maximum may be used with a design speed of 45 mph or less.

*For Standard TC-5.11 ULS superelevation based on -2%, please refer to Road and Bridge Standards 803.23.

For minimum widths for roadway and right of way used within incorporated cities or towns to qualify for maintenance funds see *Code of Virginia Section 33.2-319.*

FOOTNOTES

(1) Grades in commercial and industrial areas should be less than 8 percent; desirably, less than 5 percent. For maximum grades relative to terrain and design speed, see AASHTO Green Book, Chapter 5, Section 5.2.1, Table 5-2.

(2) Where feasible, lanes should be 11' wide and in industrial areas should be 12' wide; however, where available or attainable right of way imposes severe limitations, 9' lanes can be used in residential areas and 11' lanes can be used in industrial areas.

(3) Or equivalent City or Town design.

(4) For buffer strip widths see *Appendix A(1), Section A(1)-1 Bicycle & Pedestrian Facility Guidelines*.

(5) A width of 8' or more may be needed in commercial areas.

(6) 3:1 and flatter slopes shall be used when the right of way is behind the sidewalk (or sidewalk space) in residential or other areas where slopes will be maintained by the property owner.

(7) When Design year ADT exceeds 2000 VPD, with greater than 5% total truck and bus usage: Provide 4' wide paved shoulders when the graded shoulder is 5' wide or greater. Provide 5' wide paved shoulder when design year ADT exceeds 2000 VPD, with 5% or more truck and bus usage and the route is an AASHTO approved U.S. Bicycle Route (1, 76 or 176) or designated as a bicycle route on a locally adopted transportation plan. All shoulders not being paved will have the mainline pavement structure extended 1', on the same slope, into the shoulder to eliminate raveling at the pavement edge (See Standard GS-12 for shoulder design).

(8) A hydraulic analysis is necessary to determine actual depth requirement.

(9) See *Manual of the Structure and Bridge Division* – Volume V – Part 2 Design Aids – Chapter 6 Geometrics.

(10) For additional information on sight distance requirements on grades of 3 percent or greater, see AASHTO Green Book, Chapter 3, Section 3.2.2, Table 3-2.

(11) For information on reduced shoulder widths, see AASHTO Green Book, Chapter 5, Section 5.2.2, Table 5-5.

(12) Where bicycle accommodation is next to curb or curb and gutter, mountable curb (CG-3) or mountable curb and gutter (CG-7) shall be used for design speeds of 45 mph and below.

* Rev 10/20

GEOMETRIC DESIGN STANDARDS FOR SERVICE ROADS (GS-9)

(1) DEAD END SERVICE ROADS UNDER 25 VPD								
PROPERTIES SERVED	DESIGN SPEED (MPH)	MINIMUM RADIUS	STOPPING SIGHT DISTANCE	(2) MINIMUM TRAVEL WAY WIDTH	MINIMUM WIDTH OF SHOULDER CUT & FILL		(3) MINIMUM WIDTH OF DITCH FRONT SLOPE	SLOPE
					With GR	Without GR		
1	10	30'	50'	12'	6'	2'	3' @ 3:1	(4)
	15	38'	80'					
OVER 1	20	77'	125'	16'				
	25	135'	155'					
	30	215'	200'	18'				
	35	316'	250'					
	40	446'	305'					

GENERAL NOTES

The minimum design speed for service roads should be 20 mph except for one lane service roads serving one property which may have a minimum design speed of 10 mph.

Standard TC-5.11R superelevation is based on 8% maximum.

Standard TC-5.11U (Urban) superelevation based on 4% maximum.*

Standard TC-5.11ULS (Urban Low Speed) superelevation based on +2% maximum may be used with a design speed of 45 mph or less.*

For Standard TC-5.11 ULS superelevation based on -2%, please refer to Road and Bridge Standards 803.23.*

For Passing Sight Distance Criteria See AASHTO Green Book, Chapter 3, Section 3.2.4.

RELATIONSHIP OF MAXIMUM GRADES TO DESIGN SPEED				
TYPE OF TERRAIN	DESIGN SPEED (MPH)			
	10	20	30	40
	GRADES (PERCENT)			
LEVEL	8	8	7	7
ROLLING	12	11	10	9
MOUNTAINOUS	18	16	14	12

FOOTNOTES

(1) For through service roads and dead end service roads with over 25 VPD, use Standards shown for Local Roads and Streets (Also See Standard GS-12).

(2) Under adverse conditions, intermittent shoulder sections or turnouts for passing may be required (see AASHTO Green Book, Chapter 5, Section 5.4*)

(3) A hydraulic analysis is necessary to determine actual depth requirement.

(4) Slopes to be same as mainline when service road is parallel to or otherwise visible from the mainline. For other cases, slopes should be in accordance with standards for Local Roads and Streets.

* Added 1/21

GEOMETRIC DESIGN STANDARDS FOR INTERCHANGE RAMPS (GS-R)

<table>
<tr><th rowspan="4"></th><th rowspan="4">RAMP DESIGN SPEED (MPH)</th><th rowspan="4">MINIMUM RADIUS</th><th rowspan="4">(6) MINIMUM STOPPING SIGHT DISTANCE</th><th rowspan="4">(1) MINIMUM RAMP PAVEMENT WIDTHS</th><th colspan="5">MINIMUM WIDTH OF SHOULDER</th><th rowspan="4">(5) MINIMUM WIDTH OF DITCH FRONT SLOPE</th><th rowspan="4">NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES</th></tr>
<tr><th colspan="3">LEFT OF TRAFFIC</th><th colspan="2">RIGHT OF TRAFFIC</th></tr>
<tr><th colspan="2">GRADED WIDTH CUT & FILL</th><th rowspan="2">(2) (3) PAVED WIDTH</th><th rowspan="2">(7) GRADED WIDTH</th><th rowspan="2">(2) (3) PAVED WIDTH</th></tr>
<tr><th>With GR</th><th>Without GR</th></tr>
<tr><td rowspan="8">INTERCHANGE RAMPS</td><td>60</td><td>1204’</td><td>570’</td><td rowspan="6">16’</td><td rowspan="8">10’</td><td rowspan="8">6’</td><td rowspan="8">4’</td><td rowspan="8">10’</td><td rowspan="8">8’</td><td rowspan="8">10’ @ 6:1</td><td rowspan="8">See Footnote (4)</td></tr>
<tr><td>50</td><td>760’</td><td>425’</td></tr>
<tr><td>45</td><td>589’</td><td>360’</td></tr>
<tr><td>40</td><td>446’</td><td>305’</td></tr>
<tr><td>35</td><td>316’</td><td>250’</td></tr>
<tr><td>30</td><td>215’</td><td>200’</td></tr>
<tr><td>25</td><td>135’</td><td>155’</td><td rowspan="2">18’</td></tr>
<tr><td>20</td><td>77’</td><td>125’</td></tr>
<tr><td>AUXILIARY LANES (ACCEL/ DECEL)</td><td colspan="10">(8)
GEOMETRIC DESIGN ELEMENTS ARE TO BE THE SAME AS MAINLINE THROUGH LANES. SEE APPLICABLE FUNCTIONAL CLASSIFICATION GS STANDARDS.</td><td>AUXILARY LANE SHOULDER WIDTHS ARE TO BE THE SAME AS MAINLINE THROUGH LANES</td></tr>
</table>

GENERAL NOTES

The determination of the proper design speed for any particular ramp should be made using guidelines shown in the AASHTO Green Book, Chapter 10, Section 10.9.6, Table 10-1.

Standard TC-5.11R is to be used. Maximum ramp superelevation is to be 8%.

Clear Zone and Recoverable Area information can be found in *Appendix A2* of the *Road Design Manual*.

<table>
<tr><th colspan="4">RELATIONSHIP OF MAXIMUM GRADES TO DESIGN SPEED</th></tr>
<tr><td colspan="4">DESIGN SPEED (MPH)</td></tr>
<tr><td>15 -20</td><td>25 - 30</td><td>35 - 40</td><td>45 - 60</td></tr>
<tr><td colspan="4">GRADES (PERCENT)</td></tr>
<tr><td>6 - 8</td><td>5 - 7</td><td>4 - 6</td><td>3 - 5</td></tr>
</table>

Where topographic conditions dictate, grades steeper than those above may be used. One-way descending gradients on ramps should be held to the same general maximums, but in special cases they may be 2 percent greater. However, downgrades with sharp horizontal curvature and significant heavy truck or bus traffic should be limited to 4 percent. See Section 10.9.6.2.12 of the AASHTO Green Book.

See the *IIM-LD- 227* and AASHTO Green Book Chapter 10, Section 10.9.6, for further guidance on ramp design.

FOOTNOTES

(1) Interchange ramp widths shown are for one lane traffic. For two lane or other conditions see Table 3-27 in the AASHTO Green Book.

(2) Paved shoulder widths on ramps with a design speed of 40 mph or less may be reduced to 6’ right, or 2’ left, when justifiable. However, the sum of the right and left shoulder shall not be less than 10’. See AASHTO Green Book, Chapter 10, Section 10.9.6.

(3) On ramps with a radius of less than 500', consider (depending on degree of curvature, percent of trucks) the extension of the full pavement structure (on the same slope as the pavement) through the inside paved shoulder area to eliminate raveling of the pavement edge.

(4) See *Manual of the Structure and Bridge Division* – Volume V – Part 2 Design Aids – Chapter 6 Geometrics.

(5) A hydraulic analysis is necessary to determine actual depth requirement.

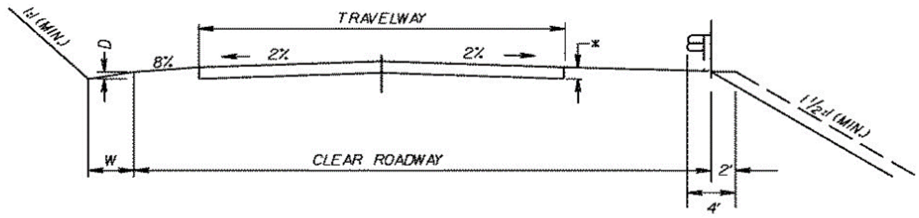
(6) For additional information on sight distance requirements on grades of 3 percent or greater, see the AASHTO Green Book, Chapter 3, Section 3.2.2, Table 3-2.

(7) Graded shoulder width to be increased additional 4’ when guardrail is required.

(8) See AASHTO Green Book*, Chapter 10, Section 10.9.5, for further guidance on Auxiliary Lanes.

* Rev 7/22

FIGURE A1-1 GEOMETRIC DESIGN STANDARDS FOR TEMPORARY DIVERSION (GS-10)



TYPICAL SECTION

BRIDGE WIDTH = APPROACH ROADWAY WIDTH (CLEAR ROADWAY).

* SEE PLANS FOR BASE DEPTH AND TYPE AND PAVED SURFACE TREATMENT WHERE REQUIRED.

NOTE: WHEN GUARDRAIL IS REQUIRED IT SHALL BE INSTALLED IN ACCORDANCE WITH THE ROAD & BRIDGE STANDARDS

WIDTHS FOR TWO-WAY TRAFFIC (LESSER WIDTH MAY BE USED FOR ONE WAY TRAFFIC)								
Type	Current ADT	(1) Travelway width (ft.)	Surface		Minimum Roadway shoulder to shoulder (ft.)	Ditch Width (ft.)	Ditch Depth (in.)	Pay Item
			Unpaved	Paved				
A	0-250	18	✓		22	4	16	L.F.
B	251-750	20	✓		24-30	4	16	L.F.
C	751-2000	22		✓	30-34	4	16	(2)
D	2001-5500	24		✓	40	4	16	(2)
E	5501-15000	24		✓	40	4	16	(2)
F	15001-above	24		✓	40	6	18	(2)

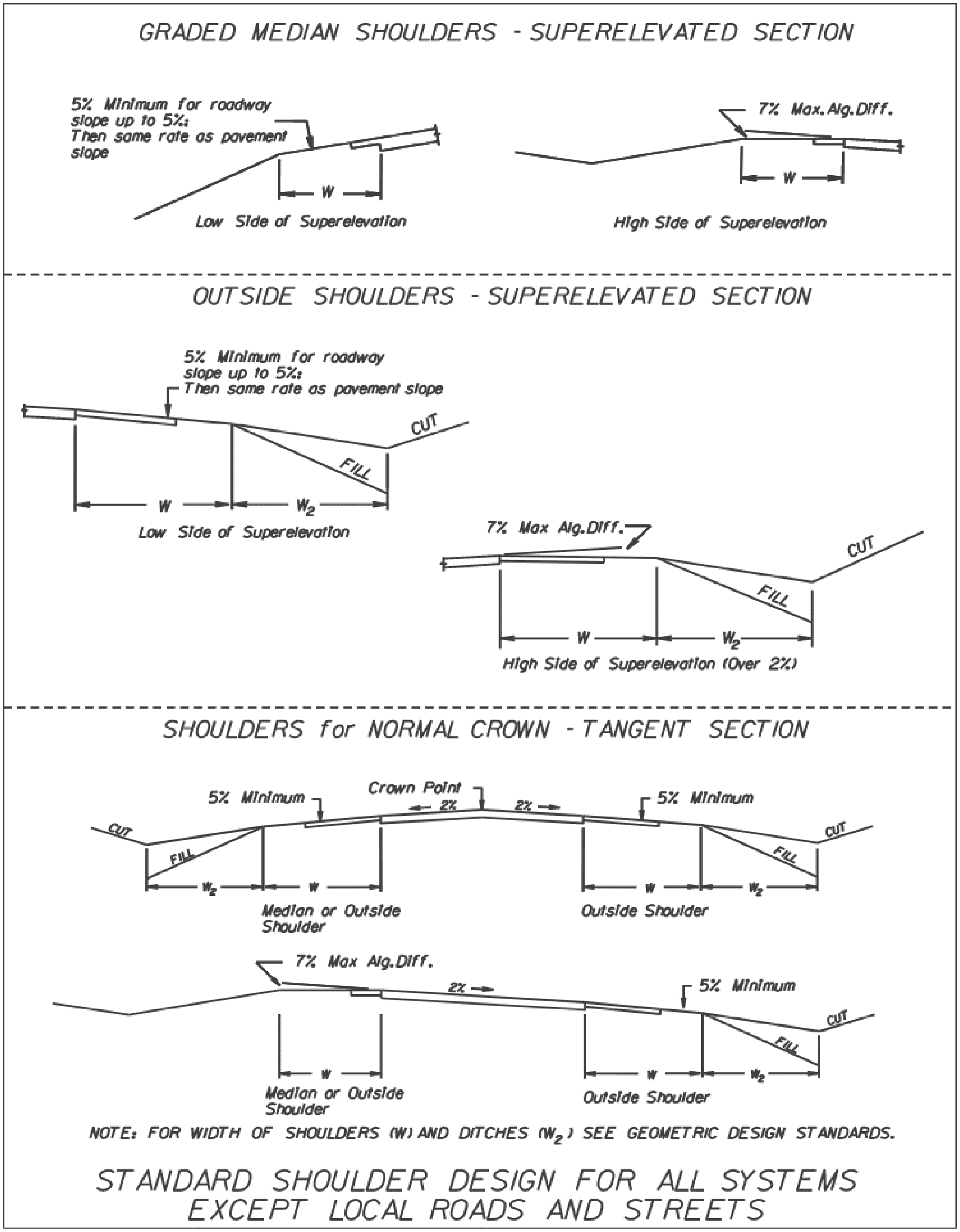
Note: Width for two way traffic shall not be less than the proposed typical section
(1) Curves to be widened in accordance with TC-5.11R; does not include shoulder width
(2) Paid for by Individual Quantities

GEOMETRICS*							
Design Speed (mph)		20	25	30	35	40	45
Min Radius		76	134	214	314	444	587
Max % Grade		For maximum allowable grades, please see appropriate GS Standard*					
Stopping Sight Distance	Minimum	115	155	200	250	305	360
Maximum Superelevation		8%	8%	8%	8%	8%	8%

*** All detours for roadways with design speeds over 45 shall be designed using the same minimum geometrics as the roadway under design.**

* Rev 10/20

FIGURE A1-2 GEOMETRIC DESIGN STANDARDS FOR SHOULDER DESIGN (GS-11)*



* Rev 1/21

FIGURE A1-3 GEOMETRIC DESIGN STANDARDS FOR SHOULDER DESIGN LOCAL ROAD & STREETS (GS-12)

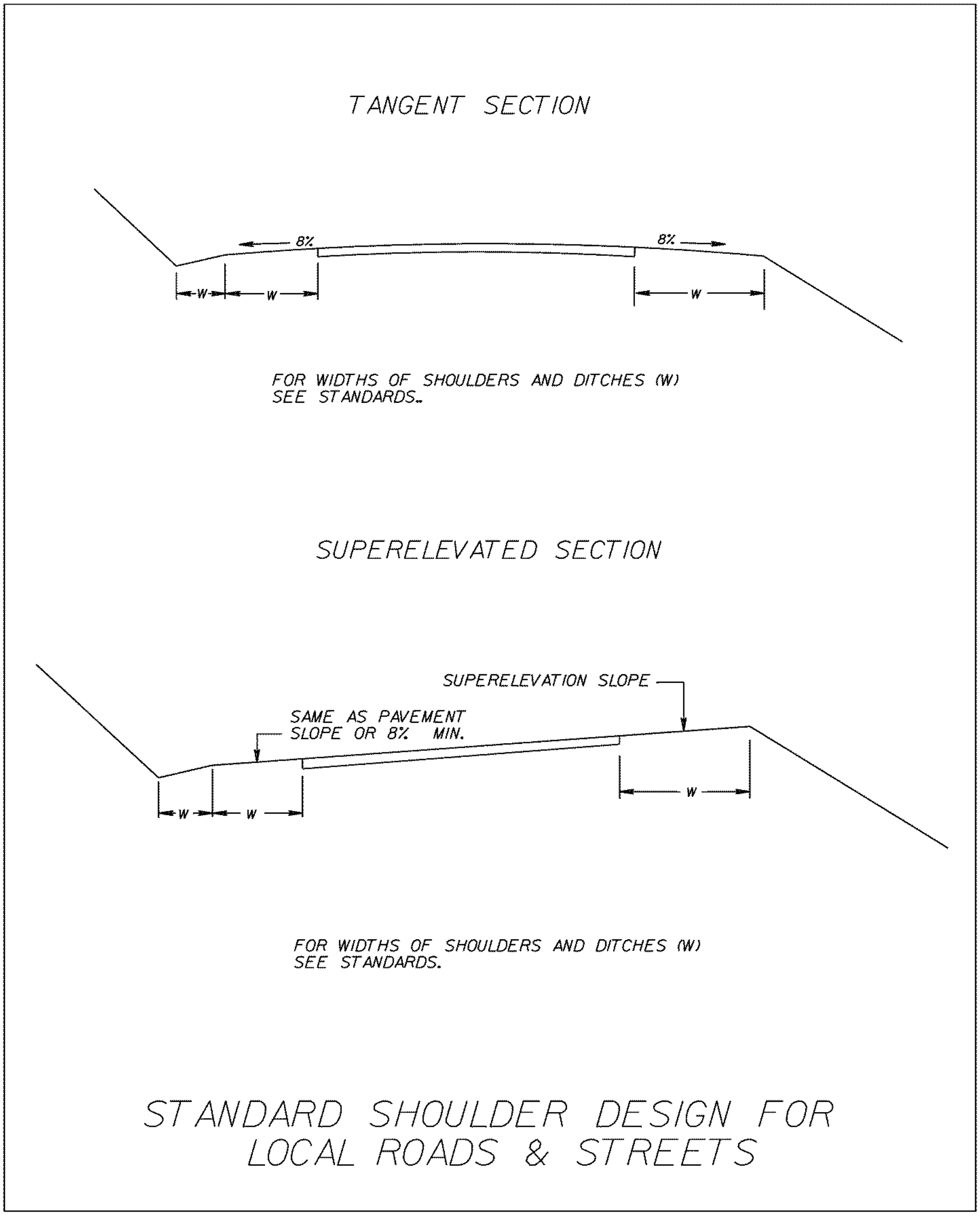
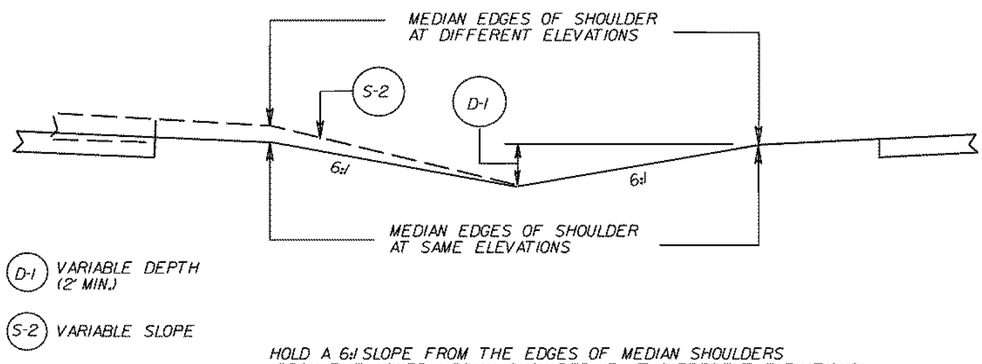


FIGURE A1-4 GEOMETRIC DESIGN STANDARDS FOR GRADED MEDIAN DESIGN (GS-13)

MEDIAN EDGES OF SHOULDER AT SAME OR APPROXIMATELY SAME ELEVATION

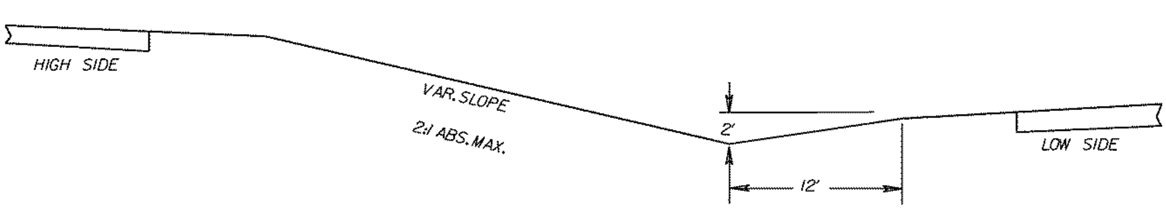
(GRADING TO CENTER OF MEDIAN)



HOLD A 6:1 SLOPE FROM THE EDGES OF MEDIAN SHOULDERS (FROM THE LOWER MEDIAN SHOULDER IF AT DIFFERENT ELEVATIONS) TO THE CENTER OF MEDIAN..

MEDIAN EDGES OF SHOULDER AT DIFFERENT ELEVATIONS

(GRADING FROM HIGH SHOULDER TO DITCH ADJACENT TO LOWER ROADWAY)



HOLD A 2' DITCH DEPTH, 12' WIDE, ADJACENT TO LOWER SHOULDER.

STANDARD GRADED MEDIAN DESIGNS

SECTION 2 - SIGHT DISTANCE

STOPPING SIGHT DISTANCE

Stopping sight distances exceeding those shown in the table below should be used as basis for design wherever practical. *

In computing and measuring stopping sight distances, the height of the driver's eye is estimated to be 3.5 feet and the height of the object to be seen by the driver is 2 feet, equivalent to the taillight height of a passenger car. The "K Values" shown are a coefficient by which the algebraic difference in grade may be multiplied to determine the length in feet of the vertical curve that will provide minimum sight distance. Crest vertical curves shall meet or exceed AASHTO design criteria for Stopping Sight Distance, not the "k" Values. The "K" valves for sag vertical curves take into account the headlight sight distance.

Height of Eye 3.5'										**Height of Object 2'**
Design Speed (mph) **	25	30	35	40	45	50	55	60	65	70	75
Min. Sight Distance (ft.)	155	200	250	305	360	425	495	570	645	730	820

Source: 2018 AASHTO Green Book, Chapter 3, Section 3.2.2

Minimum K Value For:											
Crest Vertical Curves	12	19	29	44	61	84	114	151	193	247	312
Sag Vertical Curves	26	37	49	64	79	96	115	136	157	181	206

Source: 2018 AASHTO Green Book, Chapter 3, Section 3.4.6

TABLE A1-1 STOPPING SIGHT DISTANCE

**For all tables, use design speed if available, if not use legal speed.

* Rev. 1/16

When a highway is on a grade, the sight distances in the table below shall be used. *

Design Speed (mph) **	Stopping Sight Distance on Grades					
	Downgrades			Upgrades		
	3%	6%	9%	3%	6%	9%
15	80	82	85	75	74	73
20	116	120	126	109	107	104
25	158	165	173	147	143	140
30	205	215	227	200	184	179
35	257	271	287	237	229	222
40	315	333	354	289	278	269
45	378	400	427	344	331	320
50	446	474	507	405	388	375
55	520	553	593	469	450	433
60	598	638	686	538	515	495
65	682	728	785	612	584	561
70	771	825	891	690	658	631
75	866	927	1003	772	736	704

TABLE A1-2 STOPPING SIGHT DISTANCE ON GRADES

(See 2018 AASHTO Green Book, Chapter 3, Section 3.2.2
**For all tables, use design speed if available, if not use legal speed.

Connection grades are to provide for a smooth tie-in with the mainline edge of pavement in accordance with *Appendix F, Section 2-INTERSECTING CROSS ROAD GRADES* and are to provide for adequate sight distance.

Current practice is to eliminate scuppers on most bridge designs. For this reason a minimum gradient of 0.5 percent is desirable to facilitate surface run-off. There will be instances where flatter gradients are required, through vertical curves, long water crossings, etc.; therefore, the water should be removed by means of inlets in lieu of open scuppers. Gradients are to be computed to as few decimal places as possible and should be in numbers evenly divisible by four, where feasible.

All grades are to be checked, as accurately as possible at this stage. See GS standards or proper minimum vertical clearances at underpasses and overpasses.

Minimum vertical clearances for structures or limits of work at grade crossing of railroads are to be obtained from the Department of Rail and Public Transportation.

Drainage of the existing terrain and adequate cover for drainage structures are also important factors to be considered in designing grades.

Proposed grades for roadside ditches and/or special design ditches are to be shown on corresponding profile sheet. See Chapter 7 of VDOT *Drainage Manual.*

* Rev. 1/16

Conflicts with utilities are to be avoided wherever practicable. See VDOT *Survey Manual,* Chapter 8 for additional analysis information.

The Department's permit policy allows vehicles with excess heights to operate on our highways under an over-height permit. If temporary reduction in the vertical clearance is unavoidable and is apparent in the design stage, the Permit Office is to be advised when the project is turned in to the Construction Division. For bridge vertical clearances, see the Structure and Bridge Manual of Instructions, Chapter 6 Geometrics – Road Classifications *https://www.virginiadot.org/business/resources/bridge/Manuals/Part2/Chapter6.pdf*.*

The following information is to be furnished so that permit holders can be notified:

- Route, County, and Mile Post
- Name of railroad or Route overpass
- Minimum overhead clearance prior to change
- Minimum overhead clearance after change

Date of change
Temporary or permanent

Deleted Language

* Rev. 7/23

INTERSECTION SIGHT DISTANCE

The following table shows intersection sight distance requirements for various speeds along major roads: *

Height of Eye 3.5'											Height of Object 3.5'
Design Speed (mph)**		**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
SDL=SDR: 2 Lane Major Road		225	280	335	390	445	500	555	610	665	720	775
SDR: 4 Lane Major Road (Undivided) or 3 Lane		250	315	375	440	500	565	625	690	750	815	875
SDL: 4 Lane Major Road (Undivided) or 3 Lane		240	295	355	415	475	530	590	650	710	765	825
SDR: 4 Lane Major Road (Divided – 18' Median)		275	340	410	480	545	615	680	750	820	885	955
SDL: 4 Lane Major Road (Divided – 18' Median)		240	295	355	415	475	530	590	650	710	765	825
SDR: 5 Lane Major Road (continuous two-way turn-lane)	In Feet	265	335	400	465	530	600	665	730	800	860	930
SDL: 5 Lane Major Road (continuous two-way turn-lane)		250	315	375	440	500	565	625	690	750	815	875
SDR: 6 Lane Major Road (Divided – 18' Median)		290	360	430	505	575	645	720	790	860	935	1005
SDL: 6 Lane Major Road (Divided – 18' Median)		250	315	375	440	500	565	625	690	750	815	875
SDL: (Where left turns are physically restricted)		210	260	310	365	415	465	515	566	620	670	725

TABLE A1-3 INTERSECTION SIGHT DISTANCE

Source: 2018 AASHTO Green Book, Chapter 9, Section 9.5.3, page 9-37 thru 9-52, Table 9-6 thru 9-17

**For all tables, use design speed if available, if not use legal speed.

* Added 7/17

SDR = Sight Distance Right (For a vehicle making a left turn)
SDL = Sight Distance Left (For a vehicle making a right or left turn)

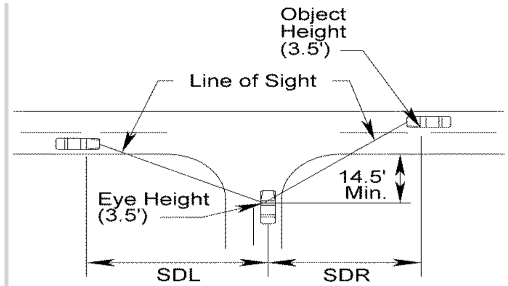


FIGURE A1-5 LINE OF SIGHT

Note: Both SDR and SDL must be met at the entrance or intersection, unless left turns are physically restricted by a median or channelization island; then only SDL is needed. Intersection sight distance determinations apply both horizontally and vertically, measured in each direction, and are to be based on a height of driver's eye of 3.5' and a height of object 3.5'.*

The term "Major Road" refers to the road with the higher functional classification, or if both have the same classification, the road with the higher volume.

Intersection sight distance does not control the access spacing for entrances and intersections shown in *Appendix F, Table 2-2*.

For major roadways of more than four lanes, large truck volumes on a minor road or median crossover, or median widths over 60', see AASHTO's *A Policy on Geometric Design of Highways and Streets*.

The Engineer must check each entrance and intersection to insure that adequate sight distance is provided. On a typical two-lane road horizontal curve there are numerous objects that restrict sight distance such as cut slopes, buildings, vegetation, vehicles, etc.

These obstructions should be considered when reviewing commercial entrances. A divided highway can have similar problems. It is very important to obtain adequate intersection sight distance for all "New" and "Reconstructed" commercial entrances from the entrance as well as the left turn position into the entrance. If the minimum intersection sight distance values in the table mentioned above cannot be met, including applying the adjustment factors for sight distances based on approach grades, a Design Waiver shall be requested in accordance with *IIM-LD-227*, see 2018 AASHTO Green Book, Chapter 9, Section 9.5.3, for further guidance. Design Waiver and Design Exception requirements are based on the following;

1) Design Waiver – Meets Stopping Sight Distance but not Intersection Stopping Sight Distance.
2) Design Exception – Does not meet the minimum Stopping Sight Distance.

* Added 7/17

The Intersection Sight Distance values in Table A1-3 permit a vehicle stopped on a minor road or median crossover to cross the major road safely or merge safely in the case of turns. The Intersection Sight Distance table above is based on the following criteria:

The AASHTO Green Book shows that it requires 7.5 seconds for a passenger car to turn left onto a two-lane road. For a passenger vehicle to turn right into the first lane, the Green Book shows that only 6.5 seconds is required because drivers making right turns generally accept gaps that slightly shorter than those accepted in making left turns.

The reference to 18’ median in Table A1-3 applies to medians up to 18’ in width (18’ or less). For medians up to this width there is not sufficient room to stop so more sight distance is needed. For wider medians, there would be room to stop in the middle of the highway so sight distance can be less.*

* Added 7/17