APPENDIX A

SECTION A-1-GEOMETRIC DESIGN STANDARDS

INTRODUCTION

Highway improvement plans are based on established 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 A, Section A-4 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 A-4 to A-13 should be used for project development.

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.

ROADWAY WIDTH

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

DESIGN SPEED

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.

The geometric tables indicate a design speed range for each functional classification. 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.

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 economic 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 it.

Table A-1-1 indicates the various speed ranges applicable to each functional classification.

EXCEPTIONS

Where it is impractical or not economical to obtain the minimum design as shown in the Geometric Design Tables, an exception shall be secured from the State Location and Design Engineer on **all** projects. On all new or reconstruction Interstate projects deviations from AASHTO standards (desirable standards where specified) must obtain the written approval of the Federal Highway Administration regardless of funding source. For Interstate projects, other than new or major reconstruction, all deviations from minimum AASHTO standards (in place at the time of original construction of that portion of the Interstate) must be given written approval of the Federal Highway Administration regardless of funding source. For projects on the National Highway System with Federal Oversight, deviation from AASHTO Design standards must be given written approval by the Federal Highway Administration.

On State funded rural projects where design constraints require that the overall design speed selected for a project is less than the design speed which would be normally selected based on terrain, a design exception is not required if the speed falls within the range of design speeds shown in Table A-1-1 for that particular class of roadway. The designer must fully document the necessity for the use of a reduced design speed (or any design exception) and have it approved in accordance with Design Exception Requirements Form LD-440. For additional instructions on Design Exceptions, see Instructional and Informational Memorandum IIM-LD-227. The designer should exercise care to avoid selecting a speed which may be lower than the speed the average driver would expect because of impacts on traffic operations and safety which may result.

DESIGN SPEEDS FOR VARIOUS FUNCTIONAL CLASSIFICATIONS							
L=Min. for Level Terrain R=Min. for Rolling Terrain M=Min. for Mountainous Terrain (As defined by Section 23 of the Highway Capacity Manual) CBD=Min. for Central Business District S=Min. for Suburban Area D=Min. for Developing Area		SPEED (MPH)					
ROADWAY CLASSIFICATION		20	30	40	50	60	70
RURAL ARTERIAL	Freeways MIN. 50 MPH – M MIN. 60 MPH – R 70 MPH - Desirable			X M	X R	X L	X
RURAL COLLECTOR ROAD	ADT OVER 2000			X M	X R	X L	
	CURRENT ADT 400 TO 2000		X M	X R	X L		
	CURRENT ADT UNDER 400	X M	X R	X L			
RURAL LOCAL ROAD	CURRENT ADT OVER 400		X M	X R	X L		
	CURRENT ADT 400 OR UNDER	X M	X R	X L			
URBAN ARTERIAL	FREEWAYS MIN. 50 MPH		X CBD	X S	X	X D	X
URBAN COLLECTOR STREET			X	X	X		
URBAN LOCAL STREET		X	X				

DESIRABLE VALUES, unless noted otherwise, are greater than or equal to MINIMUM + 10 MPH.

For Urban Local Streets: Desirable value is greater than or equal to minimum + 10 MPH, but less than 50 MPH.

TABLE A-1-1

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

	TERRAIN	DESIGN SPEED (MPH)	MINIMUM RADIUS	(6) STOPPING SIGHT DISTANCE	MIN. WIDTH OF LANE	(1) MINIMUM WIDTH OF GRADED SHOULDERS		(2) PAVED SHOULDER WIDTH		(3) WIDTH OF DITCH (FRONT SLOPE)	(4) SLOPE	(5) NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
				Min.		FILL	CUT	RT.	LT.			
FREEWAYS	LEVEL	70	1821'	730'	12'	15'	12'	10'	4'	12'	CS-4B	2 THRU LANES SAME DIRECTION = 6' + PAVE. WIDTH + 12' 3 OR MORE THRU LANES SAME DIRECTION = 12' + PAVE. WIDTH + 12'
	ROLLING	60	1204'	570'								
	MOUNTAINOUS	50	760'	425'							CS-4E	
OTHER PRINCIPAL ARTERIALS	LEVEL	70	1821'	730'	12'	13'	10'	8'	4'	10'	CS-4 OR 4B	UNDIVIDED & DIVIDED 3 OR MORE THRU LANES SAME DIRECTION = 10' + PAVE. WIDTH + 10'
		60	1204'	570'								
	ROLLING	60	1204'	570'						6'	CS-4 OR 4E	
		50	760'	425'								
	MOUNTAINOUS	50	760'	425'							CS-3 OR 3B	DIVIDED 2 THRU LANES SAME DIRECTION 6' + PAVE. WIDTH + 10'
		40	465'	305'								

GENERAL NOTES

Freeways - A design speed of 70 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. All new and major reconstructed Interstate facilities will have a 70 mph design speed unless a lower design speed is approved by the Location and Design Engineer and FHWA.

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 which is enforced during off peak hours.

Incorporated towns or other built-up areas, Urban Standard GS-5 may be used for design.

Standard TC-5.01R superelevation based on 8% maximum is to be used for all Rural Principal Arterials.

RELATIONSHIP OF MAXIMUM GRADES TO DESIGN SPEEDS

TYPE OF TERRAIN	FREEWAYS			ARTERIALS			
	DESIGN SPEED (MPH)						
	50	60	70	40	50	60	70
	GRADES (PERCENT) *						
LEVEL	4	3	3	5	4	3	3
ROLLING	5	4	4	6	5	4	4
MOUNTAINOUS	6	6	5	8	7	6	5

Clear Zone and Recoverable Area information can be found in Appendix A, Section A-2 of the Road Design Manual.

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

FOOTNOTES

(1) Shoulder widths shown are for right shoulders and independently graded median shoulders. An 8' graded median shoulder will be provided when the mainline is 4 lanes (both directions). For 6 or more lanes, the median shoulder provided will be the same as that shown for independent grading. On Freeways, if truck traffic exceeds 250 DDHV, the minimum width of graded shoulder should be 17' for fills and 14' for cuts.

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

(3) Ditch slopes to be 6:1 - 10' and 12' widths and 4:1 - 6' width.

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

(5) Vertical clearance at roadway underpasses for new and reconstructed bridges is to be 16'-6" (1' additional clearance required for non-vehicular overpasses).

(6) For intersection sight distance requirements see Appendix C, Table C-1-5.

FIGURE A - 1 – 1

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

TRAFFIC VOLUME	TERRAIN	DESIGN SPEED (MPH)	MIN. RADIUS	(8) STOPPING SIGHT DISTANCE Min.	MINIMUM PASSING SIGHT DISTANCE	(2) MIN. WIDTH OF LANE	(3) MIN. WIDTH OF GRADED SHOULDERS FILL W/GR	(3) MIN. WIDTH OF GRADED SHOULDERS CUT & FILL	(4) PAVED SHOULDER WIDTH RT	(4) PAVED SHOULDER WIDTH LT	(5) WIDTH OF DITCH (FRONT SLOPE)	(6) SLOPE	(7) NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
(1) ADT OVER 2000	LEVEL	70	1821'	730'	2500'	12'	13'	10'	8'	4'	10'	CS-4, CS-4A OR CS-4C	10' PLUS PAVEMENT WIDTH PLUS 10'
		60	1204'	570'	2150'								
	ROLLING	60	1204'	570'	2150'								
		50	760'	425'	1850'						6'	CS-3 OR CS-3B	
	MOUNTAINOUS	50	760'	425'	1850'								
		40	465'	305'	1500'								
(1) ADT 1500 TO 2000	LEVEL	70	1821'	730'	2500'	12'	11'	8'	6'	4'	6'	CS-4, CS-4A OR CS-4C	8' PLUS PAVEMENT WIDTH PLUS 8'
		60	1204'	570'	2150'								
	ROLLING	60	1204'	570'	2150'								
		50	760'	425'	1850'								
	MOUNTAINOUS	50	760'	425'	1850'							CS-3 OR CS-3B	
		40	465'	305'	1500'	11'							
ADT 400 TO 1500	LEVEL	70	1821'	730'	2500'	12'	11'	8'	6'	4'	6'	CS-4, CS-4A OR CS-4C	
		60	1204'	570'	2150'								
	ROLLING	60	1204'	570'	2150'								
		50	760'	425'	1850'	11'							
	MOUNTAINOUS	50	760'	425'	1850'							CS-3 0R CS-3B	
		40	465'	305'	1500'								
ADT UNDER 400	LEVEL	70	1821'	730'	2500'	12'	9'	6'	4'	4'	6'	CS-4, CS-4A OR CS-4C	6' PLUS PAVEMENT WIDTH PLUS 6'
		60	1204'	570'	2150'								
	ROLLING	60	1204'	570'	2150'								
		50	760'	425'	1850'	11'							
	MOUNTAINOUS	50	760'	425'	1850'							CS-3 OR CS-3B	
		40	465'	305'	1500'								

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.

Standard TC-5.01R superelevation based on 8% maximum is to be used for Rural Minor Collectors.
If medians are included, see Section 2E of the Road Design Manual.

Clear zone and Recoverable Area information can be found in Appendix A, Section A-2 of the Road Design Manual.

RELATIONSHIP OF MAXIMUM GRADES TO DESIGN SPEEDS

TYPE OF TERRAIN	DESIGN SPEED (MPH)			
	40	50	60	70
	GRADES (PERCENT)			
LEVEL	5	4	3	3
ROLLING	6	5	4	4
MOUNTAINOUS	8	7	6	5

FOOTNOTES

(1) Use current ADT for restoration type projects and use design year ADT for all other projects..

(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) If graded median is used, the width of median shoulder is to be 8'.

(4) The Paved widths shown are the widths to be used if the Materials Division recommends the shoulders be paved. When the mainline is 4 lanes (both directions) a minimum 8' wide paved shoulder will be provided on the right of traffic and a minimum 4' wide paved shoulder on the median side. Where the mainline is 6 or more lanes, both right and median paved shoulders will be 8' in width. If paved shoulders are not recommended by the Materials Division the mainline pavement structure will be extended 1' at the same slope into the shoulder to eliminate raveling of the pavement edge.

(5) Ditch slopes to be 6:1 - 10' width, 4:1 - 6' width.

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

(7) Vertical clearance at roadway underpasses for new and reconstructed bridges is to be 16'-6" (1' additional clearance required for non-vehicular overpasses).

(7) For intersection sight distance requirements see Appendix C, Table C-1-5.

FIGUREA-1–2

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

TRAFFIC VOLUME	TERRAIN	DESIGN SPEED (MPH)	MINIMUM RADIUS	(9) STOPPING SIGHT DISTANCE Min.	MINIMUM PASSING SIGHT DISTANCE	(2) MIN. WIDTH OF LANE	(3)(4) MIN. WIDTH OF GRADED SHOULDERS FILL W/GR	(3)(4) MIN. WIDTH OF GRADED SHOULDERS CUT & FILL	(5) WIDTH OF DITCH (FRONT SLOPE)	(6) RECOMMENDED SLOPE	(7)(8) NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
(1) ADT OVER 2000	LEVEL	60	1204'	570'	2150'	12'	11'	8'	10'	CS-4, CS-4A OR CS-4C	APPROACH ROADWAY WIDTH
	ROLLING	50	760'	425'	1850'						
	MOUNTAINOUS	40	465'	305'	1500'				6'	CS-3 OR CS-3B	
(1) ADT 1500 TO 2000	LEVEL	50	760'	425'	1850'	11'	9'	6'	6'	CS-4, CS-4A OR CS-4C	4' PLUS PAVEMENT WIDTH PLUS 4'
	ROLLING	40	465'	305'	1500'						
	MOUNTAINOUS	30	251'	200'	1100'				4'	CS-3 0R CS-3B	
CURRENT ADT 400 TO 1500	LEVEL	50	760'	425'	1850'	11'	7'	5'	6'	CS-4, CS-4A OR CS-4C	3' PLUS PAVEMENT WIDTH PLUS 3'
	ROLLING	40	465'	305'	1500'						
	MOUNTAINOUS	30	251'	200'	1100'	10'			4'	CS-3 OR CS-3B	
CURRENT ADT UNDER 400	LEVEL	40	465'	305'	1500'	10'	7'	2'	6'	CS-1	2' PLUS PAVEMENT WIDTH PLUS 2'
	ROLLING	30	251'	200'	1100'				4'		
	MOUNTAINOUS	20	108'	125'	800'						

GENERAL NOTES

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

Low design speeds (40 MPH and below) are generally applicable to highways with curvilinear alignment in rolling or mountainous terrain and where environmental conditions dictate.

High design speeds (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.

Standard TC-5.01R superelevation based on 8% maximum is to be used for Rural Collectors.

RELATIONSHIP OF MAXIMUM GRADES TO DESIGN SPEEDS

TYPE OF TERRAIN	DESIGN SPEED (MPH) 20	30	40	50	60
	GRADES (PERCENT)				
LEVEL	7	7	7	6	5
ROLLING	10	9	8	7	6
MOUNTAINOUS	12	10	10	9	8

Maximum grades of short length (less than 500'), on one-way downgrades and on low-volume Rural Collectors may be 2 percent steeper.

Clear zone and Recoverable Area information can be found in Appendix A, Section A-2 of the Road Design Manual.

FOOTNOTES

(1) Use current ADT for restoration type projects and use design year ADT for new construction.

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

(3) Provide 4' wide paved shoulders when design year ADT exceeds 2000 VPD, with 5% or more truck and bus usage. 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.

(4) When the mainline is four lanes, a minimum paved shoulder width of 6' right of traffic and 3' left of traffic will be provided.

(5) Ditch slopes to be 6:1 - 10' width, 4:1 - 6' width, 3:1 - 4' width.

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

(7) Where the approach roadway width (traveled way plus shoulder) is surfaced, that surfaced width shall be carried across all structures if that width exceeds the width shown in this table.

(8) Vertical clearance at roadway underpasses for new and reconstructed bridges is to be 16'-6" desirable and 14'-6" minimum (1' additional clearance required for non-vehicular overpasses).

(9) For intersection sight distance requirements see Appendix C, Table C-1-5.

FIGURE A - 1 – 3

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

TRAFFIC VOLUME	TERRAIN	DESIGN SPEED (MPH)	MINIMUM RADIUS	(9) STOPPING SIGHT DISTANCE Min.	MINIMUM PASSING SIGHT DISTANCE	(2) MINIMUM WIDTH OF SURFACING OR PAVEMENT	(3)(4)(5) MIN. WIDTH OF GRADED SHOULDERS FILL W/GR	(3)(4)(5) MIN. WIDTH OF GRADED SHOULDERS CUT & FILL	(6) WIDTH OF DITCH (FRONT SLOPE)	(7) RECOMMENDED SLOPE	(8) NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
(1) ADT OVER 2000	LEVEL	50	760'	425'	1850'	24'	11'	8'	6"	CS-4, 4A OR 4C	APPROACH ROADWAY WIDTH
	ROLLING	40	465'	305'	1500'					CS-3, 3A OR 3B	
	MOUNTAINOUS	30	251'	200'	1100'				4'		
(1) ADT 1500 TO 2000	LEVEL	50	760'	425'	1850'	22'	9'	6'	6'	CS-4, 4A OR 4C	3' PLUS PAVEMENT WIDTH PLUS 3'
	ROLLING	40	465'	305'	1500'					CS-3, 3A OR 3B	
	MOUNTAINOUS	30	251'	200'	1100'				4'		
ADT 400 TO 1500	LEVEL	50	760'	425'	1500'	20'	7'	5'	6'	CS-1	
	ROLLING	40	465'	305'	1100'						
	MOUNTAINOUS	30	251'	200'	800'				4'		
CURRENT ADT UNDER 400	LEVEL	40	465'	305'	1100'	18'	7'	2'	4'	CS-1	2' PLUS PAVEMENT WIDTH PLUS 2'
	ROLLING	30	251'	200'	800'						
	MOUNTAINOUS	20	108'	125'							

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.

Standard TC-5.01R superelevation based on 8% maximum is to be used.

In incorporated towns or other built-up areas, Urban Standard GS-8 may be used.

RELATIONSHIP OF MAXIMUM GRADES TO DESIGN SPEEDS

TYPE OF TERRAIN	DESIGN SPEED (MPH)				
	20	30	40	50	60
	GRADES (PERCENT)				
LEVEL	8	7	7	6	5
ROLLING	11	10	10	8	6
MOUNTAINOUS	16	14	13	10	--

FOOTNOTES

(1) Use current ADT for restoration type projects. Use design year ADT for new construction.

(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 2', but in no case shall the shoulder width be less than 2'.

(4) Minimum shoulder slope shall be 1":1' on low side and same slope as pavement on high side.

(5) Provide 4' wide paved shoulders when design year ADT exceeds 2000 VPD, with 5% or more truck and bus usage. 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.

(6) Ditch slopes to be 4:1 - 6' width, 3:1 - 4' width.

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

(8) Vertical clearance at roadway underpasses for new and reconstructed bridges is 16'-6" desirable and 14'-6" minimum (1' additional clearance required for non-vehicular overpasses).

(9) For intersection sight distance requirements see Appendix C, Table C-1-5.

FIGURE A - 1 – 4

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

	DESIGN SPEED (MPH)	MINIMUM RADIUS U	MINIMUM RADIUS ULS	(13) STOPPING SIGHT DISTANCE Min.	MIN. WIDTH OF LANE	(1) MINIMUM WIDTH GRADED SHOULDERS FILL W/GR	(1) MINIMUM WIDTH GRADED SHOULDERS CUT & FILL	(2) PAVED SHOULDER WIDTH RT.	(2) PAVED SHOULDER WIDTH LT.	(3) WIDTH OF DITCH (FRONT SLOPE)	(4) SLOPE	(7) NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
FREEWAYS	70	1821'	-	730'	12'	15'	12'	10'	4'	12'	CS-4 OR CS-4B	2 THRU LANES SAME DIRECTION = 6' + PAVE. WIDTH + 12' 3 OR MORE THRU LANES SAME DIRECTION = 12' + PAVE. WIDTH + 12'
	60	1204'	-	570'								
	50	760'	-	425'							CS-4 OR 4E	
OTHER PRINCIPAL ARTERIAL WITH SHOULDER DESIGN	60	1204'	-	570'	(12) 12'	13'	10'	8'	4'	10'	CS-4 OR CS-4E	UNDIVIDED & DIVIDED 3 OR MORE THRU LANES SAME DIRECTION = 10' + PAVE. WIDTH + 10'
	50	929'	-	425'								
	40	563'	593'	305'	(5)(6) (12) 11'					6'	CS-3 OR CS-3B	2 THRU LANES (DIVIDED) SAME DIRECTION 6' + PAVE. WIDTH + 10'
	30	300'	273'	200'								

	DESIGN SPEED (MPH)	MINIMUM RADIUS U	MINIMUM RADIUS ULS	STOPPING SIGHT DISTANCE MIN.	MIN. WIDTH OF LANE	(8) STANDARD CURB & GUTTER	BUFFER STRIP WIDTH	(9) MINIMUM SIDEWALK WIDTH	(10) SLOPE	(7) NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
OTHER PRINCIPAL ARTERIAL WITH CURB & GUTTER	60	1204'	-	570'	(12) 12'	CG-7	(11)	5'	2:1	SAME AS CURB TO CURB OF APPROACHES
	50	929'	-	425'						
	45	732'	795'	360'						
	40	563'	593'	305'	(5)(6) (12) 11'	CG-6				
	30	300'	273'	200'						

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 should never 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 high speed design. Under these conditions, a design speed of 70 mph is most desirable because the higher design speeds are closely related to the overall quality and safety of the facility.

Other Principal Arterials - Design speeds for Urban Arterials generally range from 40 to 60 mph, and occasionally may be as low as 30 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-5.01R superelevation based on 8% maximum is to be used for all Freeways and other Principal Arterials with a design speed greater than or equal to 60 mph.

Standard TC-5.01U (Urban) superelevation based on 4% maximum is to be used on Other Principal Arterials with a design speed less than 60 mph.

RELATIONSHIP OF MAXIMUM GRADES TO DESIGN SPEEDS

TYPE OF TERRAIN	FREEWAYS *			ARTERIALS				
	DESIGN SPEED (MPH)							
	50	60	70	30	40	45	50	60
	GRADES (PERCENT)							
LEVEL	4	3	3	8	7	6	6	5
ROLLING	5	4	4	9	8	7	7	6
MOUNTAINOUS	6	6	5	11	10	9	9	8

* Grades 1 percent steeper than the value shown may be used on Urban Freeways for extreme cases in urban areas where development precludes the use of flatter grades and for one-way downgrades, except in mountainous terrain.

Standard TC-5.01ULS (Urban Low Speed) superelevation based on 2% maximum is to be used on Other Principal Arterials with a design speed less than or equal to 45 mph (45 mph = 7° maximum).

Clear Zone and Recoverable Area information can be found in Appendix A, Section A-2 of the Road Design Manual.

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

A minimum 30' width of surfacing or a minimum 30' face to face of curb is to be used within incorporated cities or towns to qualify for maintenance payments.

For guidelines on Interchange Ramp, see Standard GS-R.

FOOTNOTES

(1) Shoulder widths shown are for right shoulders and independently graded median shoulders. An 8' graded median shoulder will be provided when the mainline is 4 lanes (both directions). For 6 or more lanes, the median shoulder provided will be the same as that shown for independent grading. On Freeways, if truck traffic exceeds 250 DDHV, the minimum width of graded shoulder should be 17' for fills and 14' for cuts.
(2) When the mainline is 6 or more lanes, the left paved shoulder width should be the same as the right paved shoulder. On Freeways, if truck traffic exceeds 250 DDHV, the right paved shoulder width should be 12', and on 6 or more lane Freeways, the left paved shoulder width should also be 12' if truck traffic exceeds 250 DDHV.
(3) Ditch slopes to be 6:1 - 10' and 12' widths and 4:1 - 6' width.
(4) Additional or modified slope criteria to apply where shown on typical sections.
(5) Minimum lane width to be 12' at all interchange locations.
(6) If heavy truck traffic is anticipated, an additional 1 foot width is desirable.
(7) Vertical clearance at roadway underpasses for new and reconstructed bridges is to be 16'-6" (1' additional clearance required for non-vehicular overpasses).
(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 may 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.
(11) If a buffer strip is used between the back of curb and sidewalk, it should be 2' minimum.
(12) Situations having restrictions on trucks may allow the use of lanes 1 foot less in width.
(13) For intersection sight distance requirements see Appendix C, Table C-1-5.

FIGURE A - 1 - 5

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

	DESIGN SPEED (MPH)	MINIMUM RADIUS		(12) STOPPING SIGHT DISTANCE	(11) MIN. WIDTH OF LANE	(3) STANDARD CURB & GUTTER	BUFFER STRIP WIDTH	(4) MINIMUM SIDEWALK WIDTH	(5) SLOPE	(6) NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
		U	ULS	Min.						
STREETS WITH CURB & GUTTER	60	1204'	-	570'	12'	CG-7	(10)	5'	2:1	SAME AS CURB TO CURB OF APPROACHES
	50	929'	-	425'						
	45	732'	795'	360'						
	40	563'	593'	305'	(1)(2) 11'	CG-6				
	30	300'	273'	200'						

	DESIGN SPEED (MPH)	MINIMUM RADIUS		STOPPING SIGHT DISTANCE	MIN. WIDTH OF LANE	(7) MIN. WIDTH OF GRADED SHOULDERS		(8) PAVED SHOULDER WIDTH		(9) WIDTH OF DITCH (FRONT) SLOPE	(5) SLOPE	(6) NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
		U	ULS	. MIN.		FILL W/GR	CUT & FILL	RT	LT			
STREETS WITH SHOULDER DESIGN	60	1204'	-	570'	12'	13'	10'	8'	4'	10'	2:1	10' + PAVEMENT WIDTH + 10'
	50	929'	-	425'						6'		
	40	563'	593'	305'	(1)(2) 11'	11'	8'	6'	4'			8' + PAVEMENT WIDTH + 8'
	30	300'	273'	200'								

GENERAL NOTES

Design Speeds for Urban Arterials generally range from 40 to 60 mph and occasionally may be as low as 30 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-5.01R superelevation based on 8% maximum is to be used for 60 mph design speed.

Standard TC-5.01U (Urban) superelevation based on 4% maximum is to be used for design speeds less than 60 mph.

Standard TC-5.01ULS (Urban Low Speed) superelevation based on 2% maximum may be used for design speeds less than or equal to 45 mph (45 mph = 7° maximum).

Clear Zone and Recoverable Area information can be found in Appendix A, Section A-2 of the Road Design Manual.

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

A minimum 30' width of surfacing or a minimum 30' face to face of curb is to be used within incorporated cities or towns to qualify for maintenance payments.

RELATIONSHIP OF MAXIMUM GRADES TO DESIGN SPEEDS

TYPE OF TERRAIN	DESIGN SPEED (MPH)				
	30	40	45	50	60
	GRADES (PERCENT)				
LEVEL	8	7	6	6	5
ROLLING	9	8	7	7	6
MOUNTAINOUS	11	10	9	9	8

FOOTNOTES

(7) Lane width to be 12' at all interchanges or if design year ADT exceeds 2000.

(7) If heavy truck traffic is anticipated, an additional 1' width is desirable.

(7) Or equivalent City or Town design.

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

(7) Slopes 3:1 and flatter may 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) Vertical clearance at roadway underpasses for new and reconstructed bridges is to be 16'-6" (1' additional clearance required for non-vehicular overpasses).

(7) If graded median is used, the width of median shoulder is to be 8'.

(8) The Paved widths shown are the widths to be used if the Materials Division recommends the shoulders be paved. When the mainline is 4 lanes (both directions) a minimum 8' wide paved shoulder will be provided on the right of traffic and a minimum 4' wide paved shoulder on the median side. Where the mainline is 6 or more lanes, both right and median paved shoulders will be 8' in width. If paved shoulders are not recommended by the Materials Division the mainline pavement structure will be extended 1' at the same slope into the shoulder to eliminate raveling of the pavement edge.

(9) Ditch slope to be 6:1 - 10' width and 4:1 - 6' width.

(10) If a buffer strip is used between the back of curb and sidewalk, it should be 2' minimum.

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

(12) For intersection sight distance requirements see Appendix C, Table C-1-5.

FIGURE A - 1 – 6

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

	DESIGN SPEED (MPH)	MINIMUM RADIUS U	MINIMUM RADIUS ULS	(11) STOPPING SIGHT DISTANCE Min.	(1) (2) MIN. WIDTH OF LANE	(3) STANDARD CURB & GUTTER	BUFFER STRIP WIDTH	(4) MINIMUM SIDEWALK WIDTH	(5) SLOPE	(8)(9) NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
STREETS WITH CURB & GUTTER	50	929'	-	425'	12'	CG-7	(10)	5'	2:1	SAME AS CURB TO CURB OF APPROACHES
	45	730'	795'	360'		CG-6				
	40	563'	593'	305'	(1)(2) 11'					
	30	300'	273'	200'						
	DESIGN SPEED (MPH)	MINIMUM RADIUS U	MINIMUM RADIUS ULS	STOPPING SIGHT DISTANCE MIN.	(1)(2) MIN. WIDTH OF LANE	(7) MINIMUM WIDTH GRADED SHOULDERS FILL W/GR.	(7) MINIMUM WIDTH GRADED SHOULDERS CUT & FILL	(10) WIDTH OF DITCH (FRONT) SLOPE	(5) SLOPE	(8)(9) NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
STREETS WITH SHOULDER DESIGN	50	929'	-	425'	12'	11'	8'	6'	2:1	8' + PAVEMENT WIDTH + 8'
	40	563'	593'	305'	(1)(2) 11'					
	30	300'	273'	200'		7'	4'	4'		4' + PAVEMENT WIDTH + 4

GENERAL NOTES

A minimum design speed of 30 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-5.01U (Urban) superelevation based on 4% maximum.

Standard TC-5.01ULS (Urban-Low Speed) superelevation based on 2% maximum may be used with a design speed of 45 mph or less (45 MPH = 7° maximum).

A minimum 30' width of surfacing or a minimum 30' curb to curb is to be used within incorporated cities or towns to qualify for maintenance payments.

Clear zone and Recoverable Area information can be found in Appendix A, Section A-2 of the Road Design Manual.

RELATIONSHIP OF MAXIMUM GRADES TO DESIGN SPEEDS

TYPE OF TERRAIN	DESIGN SPEED (MPH) 30	40	45	50
	GRADES (PERCENT)			
LEVEL	9	9	8	7
ROLLING	11	10	9	8
MOUNTAINOUS	12	12	11	10

Maximum grades of short lengths (less than 500 ft.) and one-way down grades may be 2% steeper.

FOOTNOTES

(1) 12' when ADT exceeds 2000'. Where feasible, lanes should be 12' wide in industrial areas; however, where available or attainable right of way imposes severe limitations, 10' lanes can be used in residential areas and 11' lanes can be used in industrial areas.

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

(3) Or equivalent City or Town Design.

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

(5) 3:1 and flatter slopes may 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) Ditch slopes to be 4:1 - 6' width and 3:1 - 4' width.

(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 or provide 3' wide paved shoulders when the graded shoulder is 4' wide. 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.

(8) Where the approach roadway width (traveled way plus shoulder) is surfaced, that surfaced width shall be carried across all structures if that width exceeds the width shown in this table.

(9) Vertical clearance at roadway underpasses for new and reconstructed bridges is to be 16'-6" desirable and 14'-6" minimum (1' additional clearance required for non-vehicular overpasses).

(10) If a buffer strip is used between the back of curb and sidewalk, it should be 2' minimum.

(11) For intersection sight distance requirements see Appendix C, Table C-1-5.

FIGURE A - 1 – 7

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

	DESIGN SPEED (MPH)	MINIMUM RADIUS		(1) MAXIMUM PERCENT OF GRADE	(11) STOPPING SIGHT DISTANCE	(2) MIN. WIDTH OF LANE	(3) STANDARD CURB & GUTTER	(4) BUFFER STRIP WIDTH	(5) MINIMUM SIDEWALK WIDTH	(6) SLOPES	(9) (10) NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
		U	ULS								
STREETS WITH CURB & GUTTER	30	300'	273'	15	200'	10'	CG-6	(10)	5'	2:1	SAME AS CURB TO CURB OF APPROACHES
	20	127'	92'		125'						

	DESIGN SPEED (MPH)	MINIMUM RADIUS		(1) MAXIMUM PERCENT OF GRADE	STOPPING SIGHT DISTANCE	(2) MIN. WIDTH OF LANE	(7) MINIMUM WIDTH GRADED SHOULDERS		(8) WIDTH OF DITCH (FRONT) SLOPE	(6) SLOPES	(9) NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
		U	ULS				FILL W/GR.	CUT & FILL			
STREETS WITH SHOULDER DESIGN	30	300'	273'	15	200'	10'	7'	4'	4'	3:1	4' + PAVEMENT WIDTH + 4'
	20	127'	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-5.01U (Urban) superelevation based on 4% maximum.

Standard TC-5.01 ULS (Urban Low Speed) superelevation based on 2% maximum may be used with a design speed of 45 mph or less (45 mph = 7° maximum).

A minimum 30' width of surfacing or a minimum 30' curb to curb is to be used within incorporated cities or towns to qualify for maintenance payments.

FOOTNOTES

(1) Grades in commercial and industrial areas should be less than 8 percent; desirably, less than 5 percent.

(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) The minimum buffer strip width with no sidewalk or sidewalk space is to be 5'.

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

(6) 3:1 and flatter slopes may 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 or provide 3' wide paved shoulders when the graded shoulder is 4' wide. 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.

(8) Ditch slopes to be 3:1 - 4' width.

(9) Vertical clearance at roadway underpasses for new and reconstructed bridges is to be 16'-6" desirable and 14'-6" minimum (1' additional clearance required for non-vehicular overpasses).

(10) If a buffer strip is used between the back of curb and sidewalk, it should be 2' minimum.

(11) For intersection sight distance requirements see Appendix C, Table C-1-5.

FIGURE A - 1 - 8

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	MINIMUM PASSING SIGHT DISTANCE	(2) MINIMUM TRAVELED WAY WIDTH	MINIMUM WIDTH OF SHOULDER		(3) WIDTH OF DITCH (FRONT SLOPE)	SLOPES
						FILL W/GR.	CUT & FILL		
1	10	30'	50'	-	12'	4'	2'	3'	(4)
OVER 1	20	127'	125'	800'	14'	5'			

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-5.01R superelevation based on 8% maximum to be used.

RELATIONSHIP OF MAXIMUM GRADES TO DESIGN SPEEDS				
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.

(2) Under adverse conditions, intermittent shoulder sections or turnouts for passing may be required (see page 415, 2001 AASHTO A Policy on Geometric Design of Highways and Streets).

(3) Ditch slope to be 3:1.

(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.

FIGURE A - 1 – 9

GEOMETRIC DESIGN STANDARDS FOR INTERCHANGE RAMPS (GS-RM)

	RAMP DESIGN SPEED (MPH	MINIMUM RADIUS	(6) STOPPING SIGHT DISTANCE Min.	(1) MINIMUM RAMP PAVEMENT WIDTHS	MINIMUM WIDTH OF SHOULDER					(5) WIDTH OF DITCH (FRONT SLOPE)	(4) NEW AND RECONSTRUCTED MINIMUM BRIDGE WIDTHS AND VERTICAL CLEARANCES
					RIGHT OF TRAFFIC		LEFT OF TRAFFIC				
					GRADED WIDTH	(2) (3) PAVED WIDTH	GRADED WIDTH FILL W/GR.	GRADED WIDTH CUT & FILL	(2) (3) PAVED WIDTH		
INTERCHANGE RAMPS	60	1204’	570’	16’	11’	8’	9’	6’	4’	10’	6’ PLUS PAVEMENT WIDTH PLUS 8’
	50	760’	425’								
	40	465’	305’								
	30	251’	200’								
	25	172’	155’	18’							
	20	108’	125’								
AUXILIARY LANES											AUXILIARY LANE SHOULDER WIDTHS ARE TO BE THE SAME AS MAINLINE THROUGH LANES

GENERAL NOTES

The determination of the proper design speed for any particular ramp should be made using guidelines shown in Exhibit 10-56 of the 2001 AASHTO A Policy On Geometric Design of Highways and Streets.

Standard TC-5.01R is to be used. Maximum ramp superelevation to be 8%.

Clear Zone and Recoverable Area information can be found in Appendix A, Section A-2 of the Road Design Manual.

RELATIONSHIP OF MAXIMUM GRADES TO DESIGN SPEED			
DESIGN SPEED (MPH)			
15 - 20	25 -30	35 - 40	45 - 50
GRADES (PERCENT)			
6 - 8	5 - 7	4 - 6	3 - 5

Where topographic conditions dictate, grades steeper than desirable 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.

FOOTNOTES

(1) Interchange ramp widths shown are for one lane traffic. For two lane or other conditions see Exhibit 10-67 in the 2001 AASHTO A Policy on Geometric Design of Highways and Streets.

(2) Shoulder widths on ramps with a design speed of 40 mph or less may be reduced to 6’ right, or 3’ left, when justifiable. However, the sum of the right and left shoulder shall not be less than 10’. See 2001 AASHTO Green Book, page 842.

(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) Vertical clearance at roadway underpasses for new and reconstructed bridges is to be 16'-6" desirable and 14'-6" minimum (1' additional clearance required for non-vehicular overpasses).

(5) Ditch slopes to be 6:1.

(6) For intersection sight distance requirements see Appendix C, Table C-1-5.

FIGURE A - 1 – 10