Roadway Manual

Lexington-Fayette Urban County Government
Lexington, Kentucky

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CHAPTER 3
GEOMETRIC DESIGN STANDARDS

TABLE OF CONTENTS

FIGURES

TABLES

3.1 General

There are three primary elements that determine the geometric characteristics of a roadway. These are:

- Typical cross section
- Horizontal alignment
- Vertical alignment

Although the three primary design elements essentially establish the geometric characteristics of a roadway, there are numerous secondary design elements that must be considered in the total geometric design. Many of these secondary design elements are discussed here.

For any roadway project, the minimum values to use for these primary elements are established based on the design controls and design criteria for the particular roadway. Design controls and design criteria normally considered in the design of a roadway are:

- Functional classification
- Area (urban or rural)
- Volume of traffic (DHV and ADT)
- Percentage of trucks
- Design speed
- Topography (flat or rolling terrain)
- Level of service (*Highway Capacity Manual* for detail)
- Special considerations such as the length of project, the condition of roads in the vicinity of the project, and the likelihood of adjoining segments being improved in the foreseeable future.

In the early stages of a project, geometric design criteria shall be coordinated with the LFUCG. In a few cases, the typical cross-section design may depend also on whether or not the project is to be financed with federal-aid funds.

The Geometric Design Criteria in the Subdivision Regulations for each classification of roadway are used to determine the values for each of the components that make up the typical cross-section (i.e., pavement width and slope, shoulder width and slope, ditch width and slope, and typical earth slopes in cuts and fills for typical street sections.) Also, refer to LFUCG's "*Standard Drawings*."

3.2 Lexington-Fayette Urban County Standard Drawings

The Lexington-Fayette Urban County's "*Standard Drawings*," current edition shall be used in conjunction with this manual. The engineer is referred to these standard drawings for additional information and background material concerning the design criteria presented in this manual.

3.3 Kentucky Department of Highways Standards and Guidelines (KYDOH)

The Kentucky Transportation, Department of Highways “*Standard Drawings*” and “*Standard Specification for Road and Bridge Construction*,” current edition has also been approved for use in conjunction with this manual. The engineer is referred to this manual for additional information and background material concerning the design criteria presented in this manual. The engineer is advised that these documents have been prepared using metric units, therefore conversion to English or inch-pound units will be required. Table 3-4 is a metric conversion tables, included at the end of this chapter.

3.4 AASHTO Guidelines

The American Association of State Highway and Transportation Officials (AASHTO) is an organization that investigates and comments on the design policies of all states. The latest edition of AASHTO's "*A Policy on Geometric Design of Highways and Streets*" has been approved for use in conjunction with this manual. The engineer is referred to the AASHTO manual for additional information and background material concerning the design criteria presented in this manual.

3.5 Manual on Uniform Traffic Control Devices

The U.S. Department of Transportation Federal Highway Administration's "*Manual on Uniform Traffic Control Devices (MUTCD)*" current edition has been approved for use in conjunction with this manual. The engineer is referred to this manual for additional information and background material concerning the design criteria presented in the manual.

3.6 Highway Capacity Manual

The Transportation Research Board National Research Council's *Highway Capacity Manual Special Report 209* has been approved for use in conjunction with this manual. The engineer is referred to this manual for additional information and background material concerning the design criteria presented in this manual.

3.7 Typical Cross Section

There are four basic design controls that are used to determine the typical cross-section for a given roadway:

- Functional Classification
- Area (Rural or Urban)
- Volume of traffic
- Design speed

3.8 Horizontal Alignment

There are several components that comprise the total horizontal alignment design of a roadway. These components and their relationships are discussed below:

3.8.1 Circular Horizontal Curves

The minimum radius of a curve that can be used for a given design speed is shown in the Subdivision Regulations. This minimum has been established based on the laws of mechanics. Even though this minimum is allowable, the engineer should always strive to keep horizontal curves as flat as possible.

If compound curves are used, the radius of the flatter curve shall not be more than 50 percent greater than the radius of the adjacent sharper curve.

An alignment where horizontal curves, either in the same direction or opposite direction, are separated by only a short length of tangent should be avoided. This situation creates an alignment that is not pleasing in appearance and also creates problems in superelevation transition. It is preferable to use flatter curves connected by smooth spiral transition curves.

3.8.2 Spiral Transition Curves

When going from a tangent section into a horizontal curve, or vice versa, a motor vehicle does not follow a path that is parallel to the centerline of the road. The minimum length of spiral curves for given conditions is also shown on these tables. These minimum lengths should be rounded up to even lengths that permit simpler calculations. The accepted reference for calculating spiral curves is *Transition Curves for Highways* by Joseph Barnett and AASHTO's "*A Policy on Geometric Design of Highways and Streets.*"

3.8.3 Superelevation

When a motor vehicle traverses a horizontal curve, centrifugal force tends to move the vehicle radially outward. To help offset this force, the roadway is superelevated on horizontal curves.

Superelevation tables indicate the amount of superelevation to use for a given design speed and radius of curve. In general, a maximum rate of 4.0 percent should be used in urban areas. Refer to AASHTO tables for all other applications. In urban and suburban areas where frequent interruptions in traffic flow are anticipated, and the elevation of existing streets and development must be considered, a lesser rate of maximum superelevation may be used.

The superelevation runoff distance (L) should be the length of spiral, if spirals are used.

The tangent runout, the transition distance from a normal crown section to a flat section, shall be calculated by the formula:

$$R = \frac{L \times c}{e}$$

where:

L = Length of spiral or length of runoff
c = Normal rate of pavement crown (1/4 " per foot)
e = Superelevation rate

3.8.4 Pavement Widening on Curves

When traversing a horizontal curve, the rear wheels of a motor vehicle track inside the front wheels. In addition, it is difficult for a driver to hold his vehicle in the center of the lane when rounding a curve. These problems become more pronounced when lane widths are narrow and curves are sharp.

To partially offset these conditions, pavements shall be widened on horizontal curves when the degree of curve is 5 degrees or greater and the normal lane width is less than 12 feet.

Reference should be made to AASHTO'S "*A Policy on Geometric Design of Highways and Streets*," to determine the amount of widening to be used for a particular radius of a curve. When spiral transition curves are used, the widening should be equally divided between the inside and outside edges of pavement. The widening should transition from zero at the tangent to spiral (T.S.) to full widening at the spiral to curve (S.C.).

When spiral transition curves are not used, all the widening should be done on the inside edge of pavement. The widening should transition from zero at the beginning of the tangent runoff (L) to full widening at the point of full superelevation.

3.8.5 Horizontal Sight Distance

Sight distance is the length of roadway that is visible ahead to the driver as he traverses the roadway. In some cases, the sight distance across the inside of horizontal curves is obstructed by objects such as cut slopes, vegetation, buildings, etc. When designing the horizontal alignment, the engineer should check to determine that adequate sight distance is obtained on horizontal curves. In some instances, additional right-of-way may be required. The most recent edition of AASHTO's "*A Policy on Geometric Design of Highways and Streets*" will aid in that determination.

Both stopping sight distance and passing sight distance must be considered. Horizontal sight distance shall be coordinated with the vertical sight distance discussed in the following section of this manual.

Intersection sight distance is an additional subject that is to be considered in roadway design for roads with at-grade intersections. Refer to Chapter 5 of this manual for additional information.

3.9 Vertical Alignment

Vertical Alignment - As with horizontal alignment, there are several components that comprise the total vertical alignment design of a roadway. These components and their relationships are discussed below:

3.9.1 Grades

The grade line is a series of straight lines connected by parabolic vertical curves to which the straight lines are tangent. Under all conditions, these lines should be smooth flowing. Short, choppy grades are unsightly and disrupt roadway and vehicle operating conditions.

Maximum Grade: Maximum grades are determined primarily by the operation characteristics of vehicles on the grades. Nearly all passenger cars can readily negotiate upgrades as steep as seven (7) to eight (8) percent.

The maximum allowable gradient for all roadway classes is based on the design speed and type of terrain. These maximum gradients are shown in the Subdivision Regulations.

Minimum Grade: If it is necessary to maintain a minimum grade in order to provide adequate drainage; a minimum longitudinal grade of at least 0.80% should be maintained in all cut areas.

3.9.2 Vertical Curves

The transition from one rate of grade to another is effected by the introduction of vertical curves. The curve that is used for this purpose is a simple parabola. All standard route surveying textbooks cover the method of calculating vertical curves and that subject is not covered in this manual.

Minimum and desirable lengths of vertical curve for a given design speed are based on sight distance, as shown on Figures 3-1 and 3-2 for design controls for crest and sag vertical curves.

In addition to sight distance, the engineer should consider riding comfort and appearance when selecting a length of vertical curve. Long curves give a more pleasing appearance and provide a smoother ride than short vertical curves.

3.9.3 Sight Distance

Sight distance is the length of roadway visible ahead to the driver. In roadway design, consideration must be given to stopping sight distance and passing sight distance.

3.9.4 Stopping Sight Distance

Stopping sight distance is that distance that is required for a driver to bring their vehicle to a safe stop after the object becomes visible when traveling at the designated design speed.

For crest vertical curves, stopping sight distance is based on a height of eye of 3.50 feet and a height of object of six inches as indicated in Figure 3-1. For sag curves, stopping sight distance is based on a two-foot headlight height and a 1° angle of light spread upward from the headlight beam as indicated in Figure 3-1. The desirable value shall be used unless special circumstances require use of the shorter minimum value.

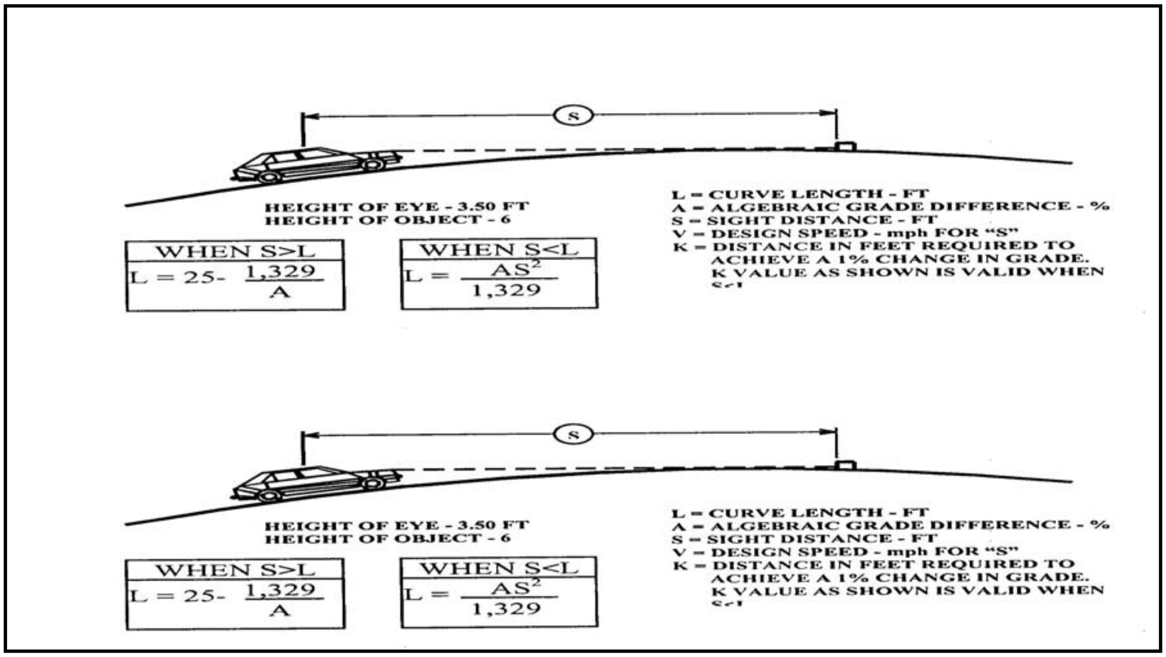
3.9.5 Passing Sight Distance

Passing sight distance is the minimum sight distance required for the driver of one vehicle to pass another vehicle safely and comfortably. Passing must be accomplished without reducing the speed of an oncoming vehicle traveling at the design sped should it come into view after the overtaking maneuver is started. The distance available for passing at any place is the longest distance at which a driver whose eyes are 3.5 feet above the pavement surface can see the top of an object 4.25 feet high on the road as indicated in Figure 3-2.

FIGURE 3. 1 - DESIGN CONTROLS FOR VERTICAL CURVES AND FOR STOPPING SIGHT DISTANCE

STOPPING SIGHT DISTANCE ON CREST VERTICAL CURVES

STOPPING SIGHT DISTANCE ON SAG VERTICAL CURVES



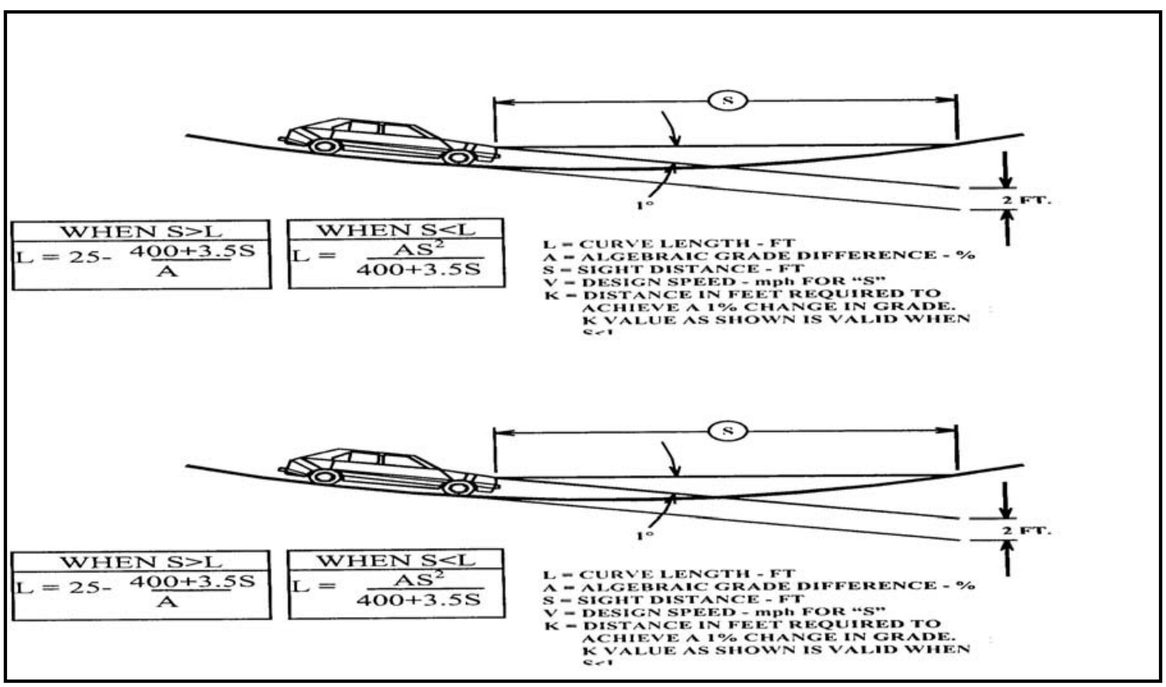
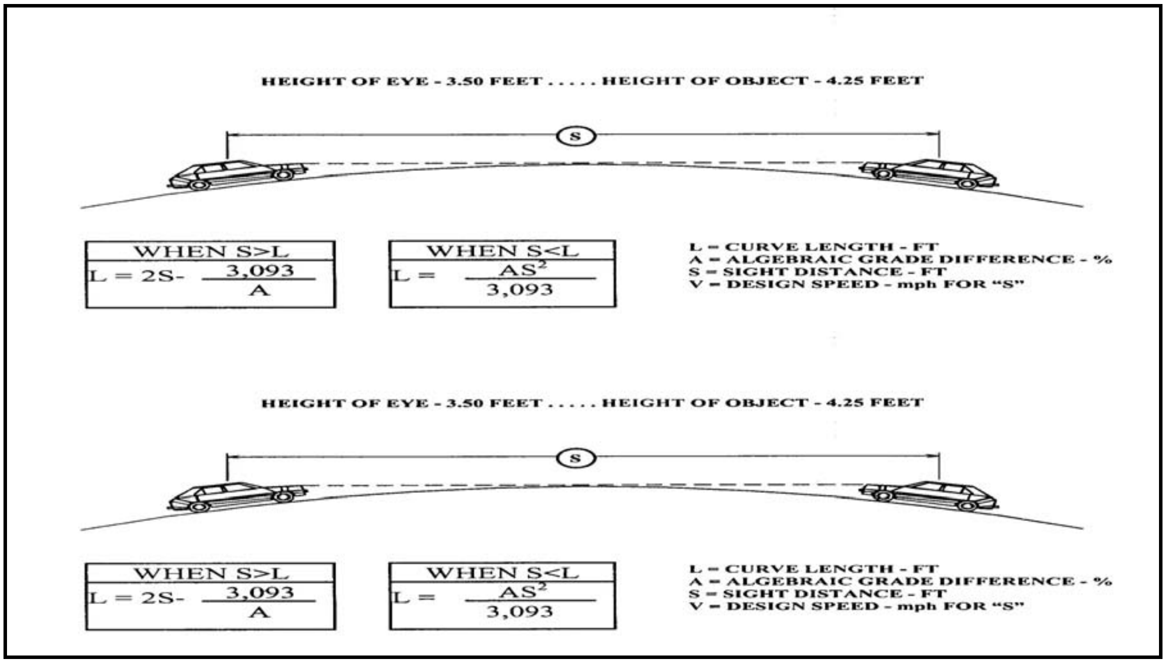


FIGURE 3. 2 - DESIGN CONTROLS FOR CREST VERTICAL CURVES AND FOR PASSING SIGHT DISTANCE



3.10 Cul-de-sacs

Cul-de-sacs shall not generally be longer than one thousand (1000) feet, including the turnaround which shall be provided at the closed end with a right-of-way radius of fifty (50) feet, curb radius of forty (40) feet, and a transition curve radius of seventy-five (75) feet. Longer cul-de-sacs may be permitted because of unusual topographic or other conditions and, in such cases the Planning Commission may require additional paving width if necessary to prevent overloading of street capacity. Temporary turnarounds may be required at the end of stub streets as long as it is retained within the street right-of-way.

FIGURE 3. 3 - CUL-DE-SAC WITH MEDIAN

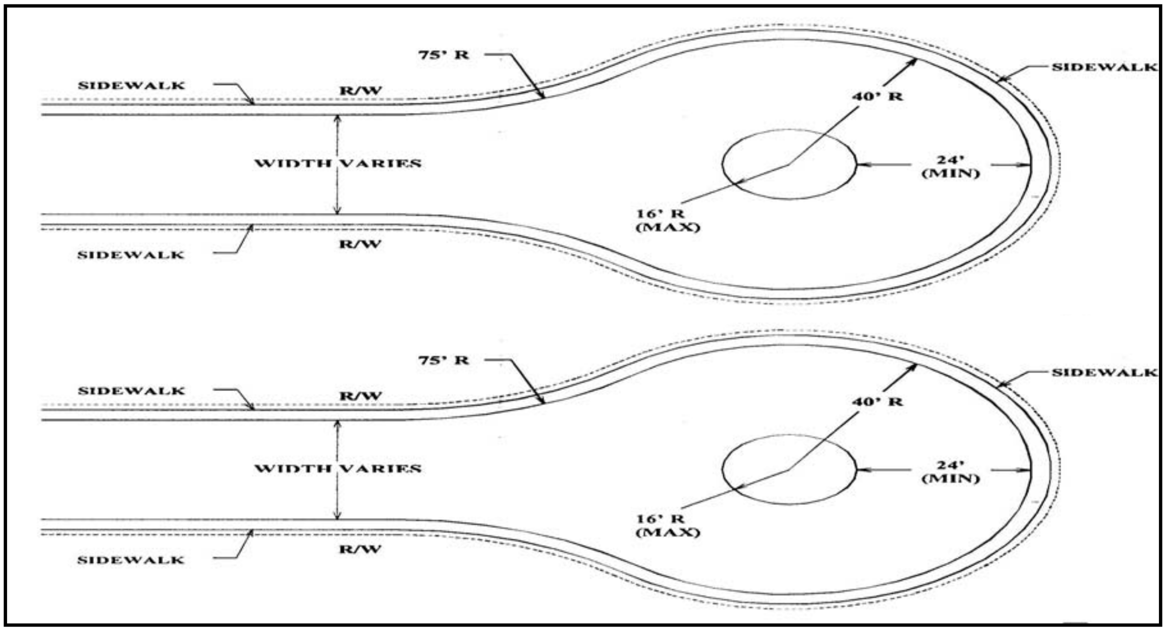
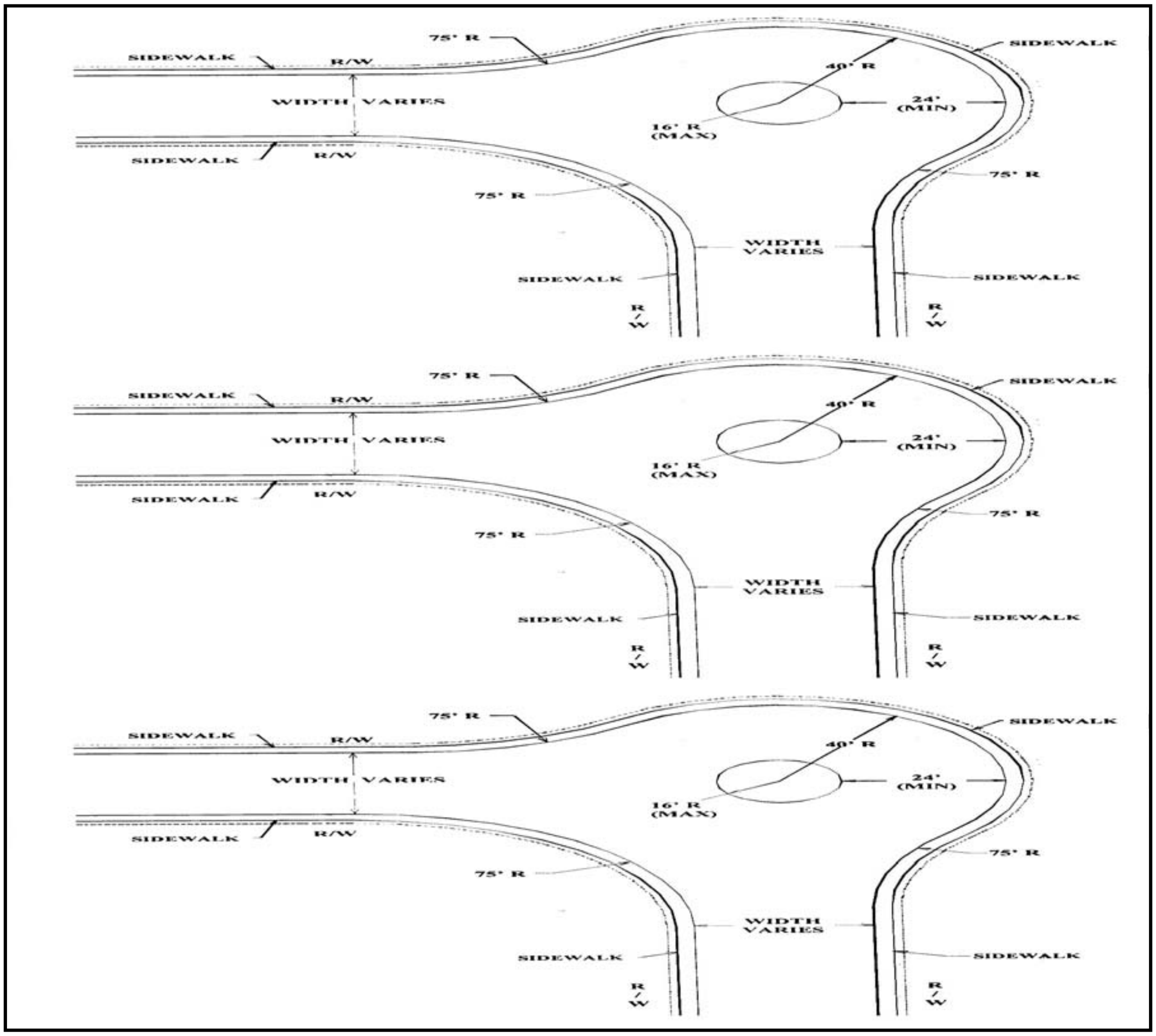


FIGURE 3. 4 - 90° CORNER WITH ADDED CUL-DE-SAC



3.11 Medians

Medians are the portion of a divided roadway that separates the traffic moving in opposite directions. They provide benefits to traffic operation by: providing space for traffic control devices and turn lanes, increasing overall traffic safety, and (if sufficiently wide) provide future roadway expansion space.

Medians may be depressed, raised, or flush with respect to the adjacent roadway. Depressed medians may be edged with raised curbs or they may slope from the edge of the roadway directly. Often sections wider than 16 feet are depressed to collect drainage. Often slopes of 10:1 (with a maximum of 6:1) are preferred to allow for vehicle recovery. Flush medians are typically narrow and paved. They do not prevent access to adjacent property and serve the purpose of separating opposing flows at less cost. Raised medians may be preferred for access control and landscaping purposes where drainage is not a problem. Raised medians also provide a positive visual barrier, which prevents erratic cross-traffic movements.

TABLE 3. 1 - RECOMMENDED MEDIAN WIDTHS FOR SPECIFIC FUNCTIONS

Function:	**Minimum Width (Feet)**	**Desirable Width (Feet)**
Separation of Opposing Traffic (without providing space for turn lanes)	4	6
Pedestrian Refuge and Space for Traffic Control	6	16
Left-Turn, Speed-Change, and Vehicle Turn Storage	14	16
Crossing/Entering Vehicle Protection	20	23
“U”-Turns, Speed Change, and Vehicle Turn Storage	20	23
Channelized “T”, Speed Change, and Storage	20	23-30

TABLE 3. 2 - A. & B. - CONVERSION FACTORS FROM ENGLISH UNITS TO SI (MODERN METRIC) UNITS / CONVERSION FACTORS FROM SI (MODERN METRIC) UNITS TO ENGLISH UNITS

A. APPROXIMATE CONVERSION TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in2	square inches	645.2	millimeters squared	mm2
ft2	square feet	0.093	meters squared	m2
yd2	square yards	0.836	meters squared	m2
ac	acres	0.405	hectares	ha
mi2	square miles	2.59	kilometers squared	km2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft3	cubic feet	0.028	meters cubed	m3
yd3	cubic yards	0.765	meters cubed	m3
Note: Volumes greater than 1000 L shall be shown in m3				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE		
°F	Fahrenheit temperature	5(F-32) ÷ 9	Celsius temperature	°C

B. APPROXIMATE CONVERSION FROM SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm2	millimeters squared	0.0016	square inches	in2
m2	meters squared	10.764	square feet	ft2
ha	hectares	2.47	acres	ac
km2	kilometers squared	0.386	square miles	mi2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m3	meters cubed	35.315	cubic feet	ft3
m3	meters cubed	1.308	cubic yards	yd3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE		
°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F