New Jersey Department of Transportation
1035 Parkway Avenue, PO Box 600, Trenton, New Jersey 08625-0600

Baseline Document Change Announcement

ANNOUNCEMENT: **BDC16MR-02**

DATE: **September 27, 2016**

SUBJECT: **AASHTO Green Book, 2011 changes**
-Revisions to "Roadway Design Manual, 2015" conforming to AASHTO Green Book, 2011.

The NJDOT has updated the "Roadway Design Manual, 2015" conforming to the AASHTO Green Book, 2011.

The Summary of Revisions are attached.

The Sections that have been revised are as follows:

Section 1 – Introduction
Section 2 – General Design Criteria
Section 3 – Definition and Terminology
Section 4 – Basic Geometric Design Elements
Section 5 – Major Cross section Elements
Section 6 – At Grade Intersections
Section 8 – Guide Rail Design and Median Barriers
Section 13 – Ground Mounted Sign Supports

The following pages of the 2015 Roadway Design Manual have been revised and replaced:

Page 1-1
page 1-2
Page 2-1
Page 2-2
Page 2-3 – No change
Page 2-4
Page 2-5
Page 2-6
Page 2-7 – No change
Page 2-8 – No change
Page 3-5 – No change
Page 3-6

Page 4-1 – No change
Page 4-2
Page 4-7
Page 4-8
Page 4-9
Page 4-10 – No change
Page 4-25 – No change
Page 4-26
Page 4-27
Page 4-28
Page 4-29
Page 4-30 – No change
Page 5-1 – No change
Page 5-2
Page 5-3
Page 5-4 – No change
Page 5-5
Page 5-6 – No change
Page 5-15 – No change
Page 5-16
Page 5-17
Page 5-18 – No change
Page 5-19 – No change
Page 5-20 – No change
Page 5-21 – No change
Page 5-22 – No change
Page 6-3 – No change
Page 6-4
Page 6-11
Page 6-12 – No change
Page 6-17 – No change
Page 6-18
Page 6-19
Page 6-20 – No change
Page 8-31
Page 8-32 – No change
Page 13-1
Page 13-2 – No change

Implementation Code R (ROUTINE)

Changes must be implemented in all applicable Department projects scheduled for Final Design Submission at least one month after the date of the BDC announcement. This will allow designers to make necessary plan, specifications, and estimate/proposal changes without requiring the need for an addenda or postponement of advertisement or receipt of bids.

Recommended By:	**Approved By:**
Paul F. Schneider	Eli D. Lambert III, P.E.
Acting Director	Assistant Commissioner
Capital Program Support	Capital Program Management

Attachment: Summary of the Revisions.
2015 Roadway Design Manual 1-1, &1-2.
2-1, 2-2, 2-3, 2-4, 2-5, 2-6. 2-7, & 2-8.
3-5, & 3-6.
4-1, 4-2, 4-7, 4-8, 4-9, 4-10, 4-25, 4-26, 4-27, 4-28, 4-29, & 4-30.
5-1, 5-2, 5-3, 5-4, 5-5, 5-6, 5-15, 5-16, 5-17, 5-18, 5-19, 5-20, 5-21, & 5-22.
6-3, 6-4, 6-11, 6-12, 6-17, 6-18, 6-19, & 6-20.
8-31, & 8-32.
13-1 & 13-2.

YK

SUMMARY OF THE REVISIONS

Changes Made to the Roadway Design Manual Based on AASHTO 2011 “A Policy on Geometric Design of Highways and Streets”

1.1 – INTRODUCTION

Remove “Structural Capacity” and replace it with “Design Loading” under Controlling Design Elements (Structural).

1.3 – REFERENCE PUBLICATIONS

A.

Updated the “AASHTO – A Policy on Geometric Design of Highways and Streets” reference from 2004 to 2011.

2.2.2 – PRINCIPAL ARTERIAL HIGHWAYS

THE FOLLOWING IS ADDED AFTER THE 2nd SENTENCE OF THE 3rd PARAGRAPH:

> For facilities within the subclass of other principal arterials in urban areas, mobility is often balanced against the need to provide direct access as well as the need to accommodate pedestrians, bicyclists, and transit users.

2.2.3 – MINOR ARTERIAL HIGHWAYS

THE FOLLOWING IS ADDED AT THE END OF THE 5th SENTENCE:

> …consistent with the context of the project area and considering the range or variety of users.

2.3.3 – SECONDARY CONTROLS

A. Design Speed

THE FOLLOWING IS ADDED AT THE END OF THE 4th SENTENCE OF THE 2nd PARAGRAPH:

> On lower speed facilities, use of above-minimum design criteria may encourage travel at speeds higher than the design speed.

B. Design Vehicle

TABLE 2-2 HAS BEEN UPDATED. THE FOLLOWING ARE THE CHANGES:

- Single-Unit Truck symbol changed from SU to SU-30
- Added SU-40 Single-Unit Truck (three-axle)
- BUS-40 wheel base, overhang, and overall values
- WB-40 wheel base and overhang values
- WB-62 wheel base, overall, and overhang values
- WB-67D wheel base, overall, and overhang values

3.3 – ROADWAY DESIGN TERMS

THE FOLLOWING TERM IS ADDED:

> **3R Project -** 3R stands for resurfacing, restoration, and rehabilitation.

4.2.2 – PASSING SIGHT DISTANCE

Passing minimum sight distance values in Table 4-1 have been upgraded.

FIGURE 4-B: VALUES OF SUPERELEVATION FOR RURAL HIGHWAYS AND RURAL OR URBAN FREEWAY
Removed "2004 AASHTO" reference.

FIGURE 4-C: VALUES OF SUPERELEVATION FOR URBAN HIGHWAYS
Revised the figure's title and removed "2004 AASHTO" reference.

FIGURE 4-C1: VALUES OF SUPERELEVATION FOR LOW-SPEED URBAN STREETS IN BUILT-UP AREAS
Removed "2004 AASHTO" reference.

FIGURE 4-I: DESIGN CONTROLS FOR CREST VERTICAL CURVES
Graph is updated to look exactly the same as the graph in 2011 AASHTO.

FIGURE 4-J: DESIGN CONTROLS FOR SAG VERTICAL CURVES
Graph is updated to look exactly the same as the graph in 2011 AASHTO.

4.5 – CLIMBING LANE

Changed the references from Exhibit 3-59 to Figure 3-28 and Exhibit 3-60 to Figure 3-29.

5.3 – LANE WIDTHS

THE FOLLOWING IS ADDED AFTER THE "--- adjacent to the outside lane" IN THE 1st SENTENCE OF THE 3rd PARAGRAPH:

> …(design exception required)

THE FOLLOWING IS ADDED AT THE END OF THE 3rd SENTENCE OF THE 5th PARAGRAPH:

> …(no design exception required)

5.4.2 – WIDTH OF SHOULDERS

THE FOLLOWING SENTENCE HAS BEEN REMOVED FROM THE 5th PARAGRAPH:

> In order to provide wider lanes on 3R projects, the left shoulder width on an existing divided multilane land service highway may be reduced to 1 foot (Programmatic Design Exception).

5.7.4 – PUBLIC SIDEWALK CURB RAMP

Flares

THE ENTIRE TEXT IS CHANGED TO:

> Where a pedestrian circulation path crosses the curb ramp, the ramp is required to have side flares; sharp returns present tripping hazards. This typically occurs where the sidewalk is next to the curb (no grass buffer). Curb ramp flares are graded transitions from a curb ramp to the surrounding sidewalk. Flares are not intended to be mobility device routes, and are typically steeper than the curb ramp (10:1 max) with significant cross-slopes. If curb ramp is situated in such a way that a pedestrian cannot walk perpendicular across the ramp (ie: blocked by utility pole), flare may be replaced with a 1.5 foot transition or returned curb adjacent to the ramp.
>
> Flares are only needed in locations where the ramp edge abuts pavement. A 1.5 foot transition or returned curb is used where the ramp edge abuts grass or other landscaping. Straight returned curbs are a useful orientation cue to provide direction for visually impaired pedestrians. (See the Construction Details)

6.3.4 – YIELD CONTROL

Changed the references from Exhibit 9-51 to Table 9-3 and Exhibit 9-64 to Table 9-12.

6.5.1 – GENERAL

THE FOLLOWING IS ADDED AT THE END OF THE LAST SENTENCE OF THE 2nd PARAGRAPH:

> …and Table 9-18, respectively.

FIGURE 6-H: LAND SERVICE HIGHWAY AUXILIARY LANE LENGTHS

Changed the reference in Note 2 from Exhibit 10-71 to Table 10-4. The end of Note 3 has been changed to "…but parallel section must be 300 from where the nose width equals 2 feet". The "Length of Acceleration Lanes" figure has been updated to show the nose width location.

6.5.4 – MEDIAN OPENINGS

Table for control radius values has been upgraded.

FIGURE 8-H: GUIDE RAIL TREATMENT FOR CRITICAL EMBANKMENT SLOPES

THE HEADING IS CHANGED TO "FIGURE 8-H".

13.1 – INTRODUCTION

In the 2nd paragraph, remove "2006" in "2006 AASHTO A Policy on Geometric Design of Highways and Streets.

THE FOLLOWING IS ADDED AFTER THE 2nd PARAGRAPH:

> Designers are to ensure that all new signs or those signs to remain in a project conform to the requirements of the 2012 Supplemental Guide Signing Manual. http://www.state.nj.us/transportation/eng/documents/BDC/pdf/SGSM2012.pdf

Section 1 - Introduction

1.1 Introduction

This manual presents the current Department guidelines pertaining to roadway design on the State Highway system (www.state.nj.us/transportation/refdata/sldiag/). It provides a means of developing uniformity and safety in the design of a highway system consistent with the needs of the motoring and non-motoring users.

It is recognized that situations occur where good engineering judgment will dictate deviation from the current Department design guidelines. Any such deviations from design guidelines relative to the following controlling design elements (CDE's), as contained in Sections 4 through 7, will require an approved design exception (Except where Exempted by the *NJDOT Design Exception Manual*):

Controlling Design Elements (Roadway)

- Stopping Sight Distance (vertical curves, horizontal curves, and non-signalized intersections)
- Superelevation (for mainline and ramps)
- Minimum Radius of Curve (for mainline and ramps)
- Minimum and Maximum Grades
- Cross Slope
- Lane Width (through and auxiliary)
- Shoulder Width
- Through Lane Drop Transition Length
- Acceleration and Deceleration Lane Length (for ramps)
- Horizontal Clearance (N/A in New Jersey – minimum allowable offset 0'-0")
- Design Speed (a design exception for a reduction in the design speed will not be approved)

Controlling Design Elements (Structural)

- Bridge Width
- Vertical Clearance
- Design Loading

The above Controlling Design Element (CDE) list is in accordance with the *Design Exception Manual*.

The guidelines contained in this manual, other than the CDE's shown above, are primarily informational or guidance in character and serve to assist the engineer in attaining good design. Deviations from this information or guidance do not require a design exception.

It is not the intent of this manual to reproduce all the information that is adequately covered by textbooks and other publications which are readily available to designers and technicians.

This manual, when used in conjunction with engineering knowledge of highway design and good judgment, should enable the designer to perform their job more efficiently.

The geometric design of streets and highways not on the State Highway system should conform to the standards as indicated in the current AASHTO – *A Policy on*

Geometric Design of Highways and Streets. The design of traffic barriers and drainage systems shall conform to the *NJDOT Roadway Design Manual*.

1.2 Policy on Use of AASHTO Standards

The American Association of State Highway and Transportation Officials (AASHTO) has published policies on highway design practice. These are approved references to be used in conjunction with this manual. AASHTO policies represent nationwide standards that do not always satisfy New Jersey conditions. When standards differ, the instructions in this manual shall govern except on Interstate highways. The geometric design of the Interstate System, as a minimum, shall comply with the standards presented in the AASHTO publications; but the design of traffic barriers shall conform to the *NJDOT Roadway Design Manual.*

1.3 Reference Publications

- **Note**: **If there is a date given for the publication and a revised edition exists, use the current FHWA approved edition.**

A. American Association of State Highway and Transportation Officials (AASHTO), American Association of State Highway Officials (AASHO)

- AASHTO – *A Policy on Geometric Design of Highways and Streets*, 2011
- AASHTO – *A Policy on Design Standards - Interstate System*, 2005
- AASHTO – *Roadside Design Guide*, 2006
- AASHTO – *A Guide for the Development of Rest Areas on Major Arterials and Freeways,* 2001
- AASHTO – *Guide for the Development of Bicycle Facilities*,2012
- AASHTO – *An Informational Guide for Roadway Lighting*, (1984)
- AASHTO – *Guide for the Planning, Design and Operation of Pedestrian Facilities,* 2004
- AASHO – *Highway Definitions*, 1968
- AASHO – *A Policy on U-Turn Median Openings on Freeways*, 1960

B. Transportation Research Board (TRB)

- TRB – Highway *Capacity Manual*, (2010)

C. Federal Highway Administration (FHWA)

- FHWA – National Transportation Communications for ITS Protocol http://www.ntcip.org/info/
- FHWA – Federal-Aid Policy Guide (FAPG), (1991 with Updates)
- FHWA – Roundabouts: An Informational Guide, (2000), Publication No. FHWA-RD-00-067
- FHWA – Roadway Lighting Handbook, (1978 and Addendums)
- FHWA – Pedestrian Facilities Users Guide: Providing Safety and Mobility Publication No. FHWA-RD-01-102 (1999)
- System Engineering Guidebook for ITS, (2007), http://www.fhwa.dot.gov/cadiv/segb/
- FHWA – Manual on Uniform Traffic Control Devices, (2009)

D. Institute of Transportation Engineers (ITE)

- ITE – *Alternative Treatments for At-Grade Pedestrian Crossings*, (2001)

Section 2 - General Design Criteria

2.1 General

Geometric design is the design of the visible dimensions of a highway with the objective of forming or shaping the facility to the characteristics and behavior of drivers, vehicles, and traffic. Therefore, geometric design deals with features of location, alignment, profile, cross section, intersection, and highway types.

2.2 Highway Classification

2.2.1 General

Highway classification refers to a process by which roadways are classified into a set of sub-systems, described below, based on the way each roadway is used. Central to this process is an understanding that travel rarely involves movement along a single roadway. Rather each trip or sub-trip initiates at a land use, proceeds through a sequence of streets, roads and highways, and terminates at a second land use.

The highway classification process is required by federal law. Each state must assign roadways into different classes in accordance with standards and procedures established by the Federal Highway Administration. Separate standards and procedures have been established for rural and urban areas. For a further description of the classification process, see USDOT, FHWA, *Highway Functional Classification: Concepts, Criteria and Procedures*.

2.2.2 Principal Arterial Highways

Principal arterial highways form an inter-connected network of continuous routes serving corridor movements having the highest traffic volumes and the longest trip lengths. In rural areas, travel patterns should be indicative of substantial statewide or interstate travel. In urban areas, principal arterials should carry a high proportion of total urban area travel on a minimum of mileage.

The principal arterial highway system is stratified into the following two sub-systems:

- **Interstate system** - all presently designated routes of the Interstate System.
- **Other principal arterials** - all non-Interstate principal arterials.

"Other principal arterial" highways may be freeways, expressways or land service highways. However, because of the function of principal arterial highways, the concept of service to abutting land should be subordinate to the provision of travel service to major traffic movements. For facilities within the subclass of other principal arterials in urban areas, mobility is often balanced against the need to provide direct access as well as the need to accommodate pedestrians, bicyclists, and transit users. Where permitted, direct access to abutting property should be carefully regulated by license. No absolute right exists for access to a principal highway, and the rights of the traveling public to a safe and efficient roadway must be guaranteed. However, abutting property owners do have a right of reasonable access to the system of highways, unless such right has been acquired by the State.

Except for toll roads, most "other principal arterials" are included in the Federal consolidated primary (FAP) highway system.

2.2.3 Minor Arterial Highways

Minor arterial highways interconnect with and augment the principal highway system. In urban areas, minor arterial highways are usually included in the Federal-aid urban system (FAUS), and serve trips of moderate length at a somewhat lower level of travel mobility. Access to abutting property should be minimized to facilitate traffic flow and safety. In rural areas, minor arterial highways will usually be included in the Federal consolidated primary (FAP) system, and serve trip lengths and travel densities greater than those served by collector roads. Rural minor arterials should provide relatively high overall travel speeds, with minimum interference to through movements consistent with the context of the project area and considering the range or variety of users. Because of the high speeds, access to abutting property should be either controlled or carefully regulated.

2.2.4 Collector Roads

Collector roads primarily serve trips of intracounty rather than statewide importance. Travel speeds and volumes are less than on arterial roadways, but are still high relative to local roads. These roads provide for both land access and traffic circulation. In urban areas, these roads connect neighborhoods or other districts with the arterial system, and will usually be part of the Federal-aid urban system (FAUS). In rural areas, these roads may be subclassified into two groups:

- **Major collectors** - Serve important intracounty traffic corridors and provide service to major county traffic generators. These roads will usually be included in the Federal-aid secondary (FAS) system.
- **Minor collectors** - Serve smaller places and towns and connect locally important traffic generators. These roads usually will not be on a Federal-aid system.

2.2.5 Local Roads

The local street and road system constitutes all roads not included in the higher classifications. These streets and roads provide direct access to abutting land and permit access to the roads of higher classification. They offer the lowest level of mobility. Service to through traffic movement usually is deliberately discouraged, especially in urban areas. The local road system contains the large majority of all roadway mileage in a state, but only a small percentage of total traffic. For example, in New Jersey local roads include 72 percent of total road mileage, but only 16 percent of total vehicular miles traveled.

2.3 Design Controls

2.3.1 General

The location and geometric design of highways are affected by numerous factors and controlling features. These may be considered in two broad categories as follows:

A. Primary Controls

- Highway Classification
- Topography and Physical Features
- Traffic

B. Secondary Controls

- Design Speed
- Design Vehicle
- Capacity

2.3.2 Primary Controls

A. Highway Classification

Separate design standards are appropriate for different classes of roads, since the classes serve different types of trips and operate under different conditions of both speed and traffic volume. The design of streets and highways on the State highway system should conform to the guidelines as indicated in this manual. In special cases of restrictive or unusual conditions, it may not be practical to meet these guide values. For detailed descriptions of the various guide values, please refer to the appropriate Sections of this Manual.

B. Topography and Physical Features

The location and the geometric features of a highway are influenced to a large degree by the topography, physical features, and land use of the area traversed. The character of the terrain has a pronounced effect upon the longitudinal features of the highway, and frequently upon the cross sectional features as well. Geological conditions may also affect the location and the geometrics of the highway. Climatic, soil and drainage conditions may affect the profile of a road relative to existing ground.

Man-made features and land use may also have considerable effect upon the location and the design of the highway. Industrial, commercial, and residential areas will each dictate different geometric requirements.

C. Traffic

The traffic characteristics, volume, composition and speed, indicate the service for which the highway improvement is being made and directly affects the geometric features of design.

The traffic volume affects the capacity, and thus the number of lanes required. For planning and design purposes, the demand of traffic is generally expressed in terms of the design-hourly volume (DHV), predicated on the design year. The design year for new construction and reconstruction is to be 20 years beyond the anticipated date of Plans, Specifications and Estimate (PS&E), and 10 years beyond the anticipated date of PS&E for resurfacing, restoration and rehabilitation projects.

The composition of traffic, i.e., proportion of trucks and buses, is another characteristic which affects the location and geometrics of highways. Types, sizes and load-power characteristics are some of the aspects taken into account.

The following definitions apply to traffic data elements pertinent to design.

ADT Average Daily Traffic - The total volume during a given time period greater than one day but less than one year divided by the number of days actually counted.

AADT Average Annual Daily Traffic - The total yearly volume in both directions of travel divided by 365 days.

DHV Design-Hourly Volume - Normally estimated as the 30th highest hour two-way traffic volume for the design year selected.

K Ratio of DHV to ADT, expressed as a percent.

D The directional distribution of traffic during the design hour. It is the one-way volume in the predominant direction of travel expressed as a percentage of DHV.

T The proportion of trucks, exclusive of light delivery trucks, expressed as a percentage of DHV.

V Design Speed – Expressed in mph.

2.3.3 Secondary Controls

A. Design Speed

"Design Speed" is a selected speed used to determine the various design features of the roadway.

The assumed design speed should be a logical one with respect to topography, anticipated operating speed, the adjacent land use, the presence of bicycle and pedestrian accommodations, and the functional classification of the highway. Except for local streets where speed controls are frequently included intentionally, every effort should be made to use as high a design speed as practicable to attain a desired degree of safety, mobility and efficiency within the constraints of environmental quality, economics, aesthetics and social or political impacts. Once the design speed is selected, all of the pertinent features of the highway should be related to it to obtain a balanced design. Above minimum design values should be used, where practical. On lower speed facilities, use of above-minimum design criteria may encourage travel at speeds higher than the design speed. Some design features, such as curvature, superelevation, and sight distance are directly related to and vary appreciably with design speed. Other features, such as widths of lanes and shoulders, and clearances to walls and rails, are not directly related to design speed, but they affect vehicle speeds. Therefore, wider lanes, shoulders, and clearances should be considered for higher design speeds. Thus, when a change is made in design speed, many elements of the highway design will change accordingly.

Since design speed is predicated on the favorable conditions of climate and little or no traffic on the highway, it is influenced principally by:

- Character of the terrain;
- Extent of man-made features;
- Economic considerations (as related to construction and right-of-way costs).

These three factors apply only to the selection of a specific design speed within a logical range pertinent to a particular system or classification of which the facility is a part.

The design speed (mph) as it relates to the posted speed (mph) is shown below:

Table 2-1
Design Speed vs. Posted Speed

Posted Speed	Design Speed *	
	Existing Highways	New Highways or Alignment
20 mph	25 mph	30 mph
25 mph	30 mph	35 mph
30 mph	35 mph	40 mph
35 mph	40 mph	45 mph
40 mph	45 mph	50 mph
45 mph	50 mph	55 mph
50 mph	55 mph	60 mph
55 mph	60 mph	65 mph

* Generally, for freeways and the Interstate system, the design speed shall be 70 mph for either column shown in Table 2-1. But in certain urban areas, the Interstate highway or freeway was designed at 60 mph. Therefore the design speed shall be 60 mph in either column for these areas. Refer to the Traffic Calming Section of this manual for speeds used in traffic calming areas.

B. Design Vehicle

The physical characteristics of vehicles and the proportions of the various size vehicles using the highways are positive controls in geometric design. A design vehicle is a selected motor vehicle, the weight, dimensions and operating characteristics of which are used to establish highway design controls to accommodate vehicles of a designated type. The symbols and dimensions of design vehicles are shown in Table 2-2.

Table 2-2
Design Vehicles (Dimensions in feet*)

Design Vehicle		Wheel Base	Overhang		Overall	
Type	Symbol		Front	Rear	Length	Width
Passenger Car	P	11.0	3.0	5.0	19.0	7.0
Single Unit Truck	SU-30	20.0	4.0	6.0	30.0	8.0
Single Unit Truck (three-axle)	SU-40	25.0	4.0	10.5	39.5	8.0
Single Unit Bus	BUS-40	25.3	6.3	9.0	40.5	8.5
Articulated Bus	A-BUS	22+ 19.4 = 41.4	8.6	10.0	60.0	8.5
Semitrailer Intermediate	WB-40	12.5+25.5 = 38	3.0	4.5	45.5	8.0
Semitrailer Large	WB-50	14.6+35.4 = 50	3.0	2.0	55	8.5
Semitrailer Interstate	WB-62	19.5+41.0 = 60.5	4.0	4.5	69.0	8.5

"Double Bottom" Semitrailer	WB-67D	11+23+10+22.5 = 66.5	2.3	3.0	72.3	8.5
Delivery Truck	DL	16	3	5	24	7.5

Source: *A Policy on Geometric Design of Highways and Streets*, AASHTO

***** Design vehicle dimensions are intended for use in the design of roadways and do not define the legal vehicle dimensions in the State.

***** The delivery truck is based on a typical USPS, UPS or FedEx truck.

C. Capacity

1. General

The term "capacity" is used to express the maximum number of vehicles which have a reasonable expectation of passing over a section of a lane or a roadway during a given time period under prevailing roadway and traffic conditions. However, in a broad sense, capacity encompasses the relationship between highway characteristics and conditions, traffic composition and flow patterns, and the relative degree of congestion at various traffic volumes throughout the range from light volumes to those equaling the capacity of the facility as defined above.

Highway capacity information serves three general purposes:

a. For transportation planning studies to assess the adequacy or sufficiency of existing highway networks to current traffic demand, and to estimate when, in time, projected traffic demand, may exceed the capacity of the existing highway network or may cause undesirable congestion on the highway system.

b. For identifying and analyzing bottleneck locations (both existing and potential), and for the evaluation of traffic operational improvement projects on the highway network.

c. For highway design purposes.

2. Level of Service (LOS)

The level of service concept places various traffic flow conditions into 6 levels of service. These levels of service, designated A through F, from best to worst, cover the entire range of traffic operations that may occur.

The factors that may be considered in evaluating level of service include the following.

- Speed and travel time
- Traffic interruptions or restrictions
- Freedom to maneuver
- Safety
- Driving comfort and convenience
- Economy

However, in a practical approach to identifying the level of service, travel time and the ratio of demand volume to capacity are commonly used.

In general, the various levels of service would have the following characteristics:

Level of Service A is free flow, with low volumes and high speeds. Traffic density is low, with speeds controlled by driver desires, speed limits, and physical roadway conditions. There is little or no restriction in maneuverability due to presence of other vehicles. Drivers can maintain their desired speed with little or no delay.

Level of Service B is in the zone of stable flow, with operating speeds beginning to be restricted somewhat by traffic conditions. Drivers still have reasonable freedom to select their speed and lane of operation. Reductions in speed are not unreasonable, with a low probability of traffic flow being restricted. The lower limit (lowest speed, highest volume) of this level of service has been associated with service volumes used in the design of rural highways.

Level of Service C is still in the zone of stable flow, but speeds and maneuverability are more closely controlled by the higher volumes. Most of the drivers are restricted in their freedom to select their own speed, change lanes, or pass. A relatively satisfactory operating speed is still obtained, with service volumes perhaps suitable for urban design practice.

Level of Service D approaches unstable flow, with tolerable operating speeds being maintained though considerably affected by changes in operating conditions. Fluctuations in volume and temporary restrictions to flow may cause substantial drops in operating speeds. Drivers have little freedom to maneuver, and comfort and convenience are low, but conditions can be tolerated for short periods of time.

Level of Service E cannot be described by speed alone, but represents operations at even lower operating speeds than in Level D, with volumes at or near the capacity of the highway. At capacity, speeds are typically, but not always, in the neighborhood of 25 mph; flow is unstable, and there may be stoppages of momentary duration.

Level of Service F describes forced flow operation at low speeds, where volumes are below capacity. These conditions usually result from queues of vehicles backing up from a restriction downstream. The section under study will be serving as a storage area during parts or all of the peak hour. Speeds are reduced substantially and stoppages may occur for short or long periods of time because of the downstream congestion. In the extreme, both speed and volume can drop to zero.

Reference is made to the Transportation Research Board, "*Highway Capacity Manual*," for a thorough discussion on the level of service concept.

3. Service Volume

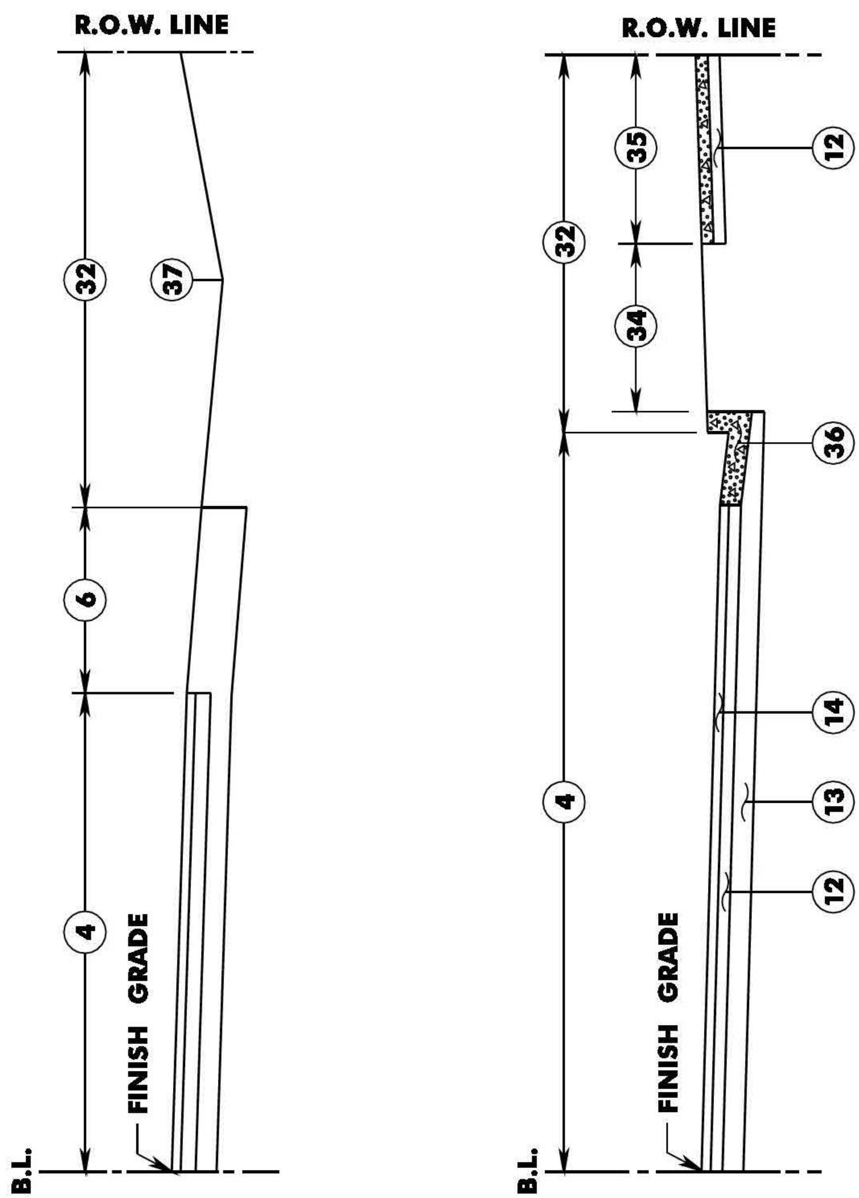
For highway design purposes, the service volume is related to the "Level of Service" selected for the proposed facility. (No service volumes are defined for Level of Service F). Service volume is defined as the maximum rate of flow which may be accommodated under prevailing traffic and roadway conditions while still maintaining a quality of service appropriate to the indicated Level of Service.

The service volume varies with a number of factors, including:

- Level of service selected;
- Width of lanes;
- Number of lanes;
- Presence or absence of shoulders;
- Grades;
- Horizontal alignment;
- Operating speed;
- Lateral clearance;
- Side friction generated by parking, driveways, intersections, and interchanges;
- Volumes of trucks, buses, and recreational vehicles;
- Spacing and timing of traffic signals.

The objective in highway design is to create a highway of appropriate type with dimensional values and alignment characteristics such that the resulting service volume will be at least as great as the design volume, but not much greater as to represent extravagance or waste. More detailed data on service volume are available in the Transportation Research Board, "*Highway Capacity Manual*," and AASHTO, "*A Policy on Geometric Design of Highways and Streets*".

FIGURE 3–B:
ROAD CROSS SECTION TERMINOLOGY



REV. DATE: JUNE 30, 2015

3.3 Roadway Design Terms

Following are terms utilized by Roadway Designers.

3R Project – 3R stands for resurfacing, restoration, and rehabilitation.

Arterial Highway – This is a general term, denoting a highway used primarily for through traffic, usually a continuous route.

Auxiliary Lane - The portion of the roadway adjoining the traveled way intended for speed change, storage, weaving, climbing lane, and for other purposes supplementary to through traffic movement.

- **Acceleration Lane** - An auxiliary lane including tapered areas, primarily for the acceleration of vehicles entering the through traffic lanes.
- **Collector-Distributor Lane** - An auxiliary lane approximately 1/4 to 1/5 mile in length, designated to accommodate right turn access to and from the State highway at more than one location, and normally terminating at an intersection or an interchange ramp. It is not intended for through traffic, and is not physically separated from the through lanes. (Reference: N.J.A.C 16:47-1.1)
- **Deceleration Lane** - An auxiliary lane including tapered areas, primarily for the deceleration of vehicles leaving the through traffic lanes.

Buffer space - The space that separates traffic flow from the work activity and provides recovery space for an errant vehicle. Neither work activity nor storage of equipment, vehicles, or material should occur in this space. Buffer spaces may be positioned longitudinally and laterally, with respect to the direction of traffic flow.

Capacity - The maximum number of vehicles which has a reasonable expectation of passing over a given section of a lane or a roadway in one direction or in both directions for a two-lane or a three-lane highway during a given time period under prevailing roadway and traffic conditions.

Climbing Lane - An auxiliary lane introduced at the beginning of a sustained positive grade in the direction of traffic flow, to be used by slow moving vehicles such as trucks and buses.

Collector-Distributor Road, (C-D) - An auxiliary roadway separated laterally from, but generally parallel to, an expressway which serves to collect and distribute traffic from several access connections between selected points of ingress to and egress from the through traffic lanes. Control of access is exercised outside a C-D Road.

Control of Access - The condition where the rights of owners, occupants or other persons of land abutting a highway to access, light, air or view in connection with the highway are fully or partially controlled by a public agency.

- **Full Control** - The condition under which the authority to control access is exercised to give preference to through traffic to a degree, but in addition to interchange connections with selected public roads there may be some intersections at grade.
- **Partial Control** - The condition under which the authority to control access is exercised to give preference to through traffic to a degree that, in addition to access connections with selected public roads, there may be some crossings at grade and some private driveway connections.

Section 4 - Basic Geometric Design Elements

4.1 General

Geometric highway design pertains to the visible features of the highway. It may be considered as the tailoring of the highway to the terrain, to the controls of the land usage, and to the type of traffic anticipated.

Design parameters covering highway types, design vehicles, and traffic data are included in Section 2, "General Design Criteria."

This section covers design criteria and guidelines on the geometric design elements that must be considered in the location and the design of the various types of highways. Included are criteria and guidelines on sight distances, horizontal and vertical alignment, and other features common to the several types of roadways and highways.

In applying these criteria and guidelines, it is important to follow the basic principle that consistency in design standards is of major importance on any section of road. The highway should offer no surprises to the driver, bicyclist or pedestrian in terms of geometrics. Problem locations are generally at the point where minimum design standards are introduced on a section of highway where otherwise higher standards should have been applied. The ideal highway design is one with uniformly high standards applied consistently along a section of highway, particularly on major highways designed to serve large volumes of traffic at high operating speeds.

4.2 Sight Distances

4.2.1 General

Sight distance is the continuous length of highway ahead visible to the driver. In design, two sight distances are considered: passing sight distance and stopping sight distance. Stopping sight distance is the minimum sight distance to be provided at all points on multi-lane highways and on two-lane roads when passing sight distance is not economically obtainable.

Stopping sight distance also is to be provided for all elements of interchanges and intersections at grade, including driveways**.**

Table 4-1 shows the standards for passing and stopping sight distance related to design speed.

4.2.2 Passing Sight Distance

Passing sight distance is the minimum sight distance that must be available to enable the driver of one vehicle to pass another vehicle, safely and comfortably, without interfering with the speed of an oncoming vehicle traveling at the design speed, should it come into view after the overtaking maneuver is started. The sight 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 3.5 feet high on the road.

Passing sight distance is considered only on two-lane roads. At critical locations, a stretch of four-lane construction with stopping sight distance is sometimes more economical than two lanes with passing sight distance.

Table 4-1
Sight Distances for Design

Design Speed Mph	Sight Distance in feet	
	Stopping Minimum	Passing* Minimum
25	155	450
30	200	500
35	250	550
40	305	600
45	360	700
50	425	800
55	495	900
60	570	1000
65	645	1100
70	730	1200

*****Not applicable to multi-lane highways.

4.2.3 Stopping Sight Distance

The minimum stopping sight distance is the distance required by the driver of a vehicle, traveling at a given speed, to bring his vehicle to a stop after an object on the road becomes visible. Stopping sight distance is measured from the driver's eyes, which is 3.5 feet above the pavement surface, to an object 2 feet high on the road.

The stopping sight distances shown in Table 4-1 should be increased when sustained downgrades are steeper than 3 percent. Increases in the stopping sight distances on downgrades are indicated in AASHTO, "*A Policy on Geometric Design of Highways and Streets*."

4.2.4 Stopping Sight Distance on Vertical Curves

See Section 4.4.4 "Standards for Grade**"** for discussion on vertical curves.

4.2.5 Stopping Sight Distance on Horizontal Curves

Where an object off the pavement such as a longitudinal barrier, bridge pier, bridge rail, building, cut slope, or natural growth restricts sight distance, the minimum radius of curvature is determined by the stopping sight distance.

Stopping sight distance for passenger vehicles on horizontal curves is obtained from Figure 4-A. For sight distance calculations, the driver's eyes are 3.5 feet above the center of the inside lane (inside with respect to curve) and the object is 2 feet high. The line of sight is assumed to intercept the view obstruction at the midpoint of the sight line and 2.75 feet above the center of the inside lane. Of course, the midpoint elevation will be higher or lower than 2.75 feet, if it is located on a sag or crest vertical curve respectively. The horizontal sightline offset (HSO) is measured from the center of the inside lane to the obstruction.

The general problem is to determine the clear distance from the centerline of inside lane to a median barrier, retaining wall, bridge pier, abutment, cut slope, or other obstruction for a given design speed. Using radius of curvature and sight distance for the design speed, Figure 4-A illustrates the HSO, which is the clear distance from

FIGURE 4–B: VALUES OF SUPERELEVATION FOR RURAL HIGHWAYS AND RURAL OR URBAN FREEWAY

Note: Use of e_{max} = 4% should be limted to urban conditions

e	V_d	V_d	V_d	V_d	V_d	V_d	V_d	V_d	V_d	V_d	V_d
(%)	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph	60 mph	65 mph	70 mph	75 mph
	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)
N.C.	2290	3130	4100	5230	6480	7870	9410	11100	12600	14100	15700
R.C.	1630	2240	2950	3770	4680	5700	6820	8060	9130	10300	11500
2.2	1450	2000	2630	3370	4190	5100	6110	7230	8200	9240	10400
2.4	1300	1790	2360	3030	3770	4600	5520	6540	7430	8380	9420
2.6	1170	1610	2130	2740	3420	4170	5020	5950	6770	7660	8620
2.8	1050	1460	1930	2490	3110	3800	4580	5440	6200	7030	7630
3.0	944	1320	1760	2270	2840	3480	4200	4990	5710	6490	7330
3.2	850	1200	1600	2080	2600	3200	3860	4600	5280	6010	6810
3.4	761	1080	1460	1900	2390	2940	3560	4250	4890	5580	6340
3.6	673	972	1320	1740	2190	2710	3290	3940	4540	5210	5930
3.8	583	864	1190	1590	2010	2490	3040	3650	4230	4860	5560
4.0	511	766	1070	1440	1840	2300	2810	3390	3950	4550	5220
4.2	452	684	960	1310	1680	2110	2590	3140	3630	4270	4910
4.4	402	615	868	1190	1540	1940	2400	2920	3440	4010	4630
4.6	360	555	788	1090	1410	1780	2210	2710	3220	3770	4380
4.8	324	502	718	995	1300	1640	2050	2510	3000	3550	4140
5.0	292	4566	654	911	1190	1510	1890	2330	2800	3330	3910
5.2	264	413	595	833	1090	1390	1750	2160	2610	3120	3690
5.4	237	373	540	759	995	1280	1610	1990	2420	2910	3460
5.6	212	335	487	687	903	1160	1470	1830	2230	2700	3230
5.8	186	296	431	611	806	1040	1320	1650	2020	2460	2970
6.0	144	231	340	485	643	833	1060	1330	1660	2040	2500

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FIGURE 4–C:
VALUES OF SUPERELEVATION FOR URBAN HIGHWAYS

Note: Use of e_{max} = 4% should be limited to urban conditions

e (%)	V_d = 25mph R (ft)	V_d = 30mph R (ft)	V_d = 35mph R (ft)	V_d = 40mph R (ft)	V_d = 45mph R (ft)	V_d = 50mph R (ft)	V_d = 55mph R (ft)	V_d = 60mph R (ft)
N.C.	2050	2830	3730	4770	5930	7220	8650	10300
R.C.	1340	1880	2490	3220	4040	4940	5950	7080
2.2	1110	1580	2120	2760	3480	4280	5180	6190
2.4	838	1270	1760	2340	2980	3690	4500	5410
2.6	650	1000	1420	1930	2490	3130	3870	4700
2.8	524	817	1170	1620	2100	2660	3310	4060
3.0	433	681	983	1370	1800	2290	2860	3530
3.2	363	576	835	1180	1550	1980	2490	3090
3.4	307	490	714	1010	1340	1720	2170	2700
3.6	259	416	610	865	1150	1480	1880	2350
3.8	215	348	512	730	970	1260	1600	2010
4.0	154	250	371	533	711	926	1190	1500

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FIGURE 4–C1: VALUES OF SUPERELEVATION FOR LOW–SPEED URBAN STREETS IN BUILT–UP AREAS

e (%)	V_d = 25mph R (ft)	V_d = 30mph R (ft)	V_d = 35mph R (ft)	V_d = 40mph R (ft)	V_d = 45mph R (ft)
–2.6	204	345	530	796	1089
–2.4	202	341	524	784	1071
–2.2	200	337	517	773	1055
–2.0	198	333	510	762	1039
–1.5	194	324	495	736	1000
0	181	300	454	667	900
N.C.	170	279	419	610	818
R.C.	167	273	408	593	794
2.2	165	270	404	586	785
2.4	164	268	400	580	776
2.6	163	265	396	573	767
2.8	161	263	393	567	758
3.0	160	261	389	561	750
3.2	159	259	385	556	742
3.4	158	256	382	550	734
3.6	157	254	378	544	726
3.8	155	252	375	539	718
4.0	154	250	371	533	711
4.2	153	248	368	528	703
4.4	152	246	365	523	696
4.6	151	244	361	518	689
4.8	150	242	358	513	682
5.0	149	240	355	508	675
5.2	148	238	352	503	668
5.4	147	236	349	498	662
5.6	146	234	346	494	655
5.8	145	233	343	489	649
6.0	144	231	340	485	643

NOTES:

1. COMPUTED USING SUPERELEVATION DISTRIBUTION METHOD 2.
2. SUPERELEVATION MAY BE OPTIONAL ON LOW–SPEED URBAN STREETS.
3. NEGATIVE SUPERELEVATION VALUES BEYOND – 2.0 % SHOULD BE USED FOR LOW TYPE SURFACES SUCH AS GRAVEL, CRUSHED STONE, AND EARTH. HOWEVER, AREAS WITH INTENSE RAINRALL MAY USE NORMAL CROSS SLOPES ON HIGH TYPE SURFACES OF –2.5%.

REV. DATE: MARCH 23, 2016

A. Axis of Rotation

1. Undivided Highways

   For undivided highways, the axis of rotation for superelevation is usually the centerline of the traveled way. However, in special cases where curves are preceded by long, relatively level tangents, the plane of superelevation may be rotated about the inside edge of the pavement to improve perception of the curve. In flat terrain, drainage pockets caused by superelevation may be avoided by changing the axis of rotation from the centerline to the inside edge of the pavement.

2. Ramps and Freeway to Freeway Connections

   The axis of rotation may be about either edge of pavement or centerline if multi-lane. Appearance and drainage considerations should always be taken into account in selection of the axis rotation.

3. Divided Highways

   a. Freeways

      Where the initial median width is 30 feet or less, the axis of rotation should be at the median centerline.

      Where the initial median width is greater than 30 feet and the ultimate median width is 30 feet or less, the axis of rotation should be at the median centerline, except where the resulting initial median slope would be steeper than 10H:1V. In the latter case, the axis of rotation should be at the ultimate median edges of pavement.

      Where the ultimate median width is greater than 30 feet, the axis of rotation should be at the proposed median edges of pavement.

      To avoid a sawtooth on bridges with decked medians, the axis of rotation, if not already on the median centerline, should be shifted to the median centerline.

   b. Other Divided Highways

      The axis of rotation should be considered on an individual project basis and the most appropriate case for the conditions should be selected.

      The selection of the axis of rotation should always be considered in conjunction with the design of the profile and superelevation transition.

B. Superelevation Transition

The superelevation transition consists of the superelevation runoff (length of roadway needed to accomplish the change in outside-lane cross slope from zero to full superelevation or vice versa) and tangent runout (length of roadway needed to accomplish the change in outside-lane cross slope from the normal cross slope to zero or vice versa). The definition of and method of deriving superelevation runoff and runout in this manual is the same as described in AASHTO, "*A Policy on Geometric Design of Highways and Streets*."

The superelevation transition should be designed to satisfy the requirements of safety and comfort and be pleasing in appearance. The minimum length of superelevation runoff and runout should be based on the following formula:

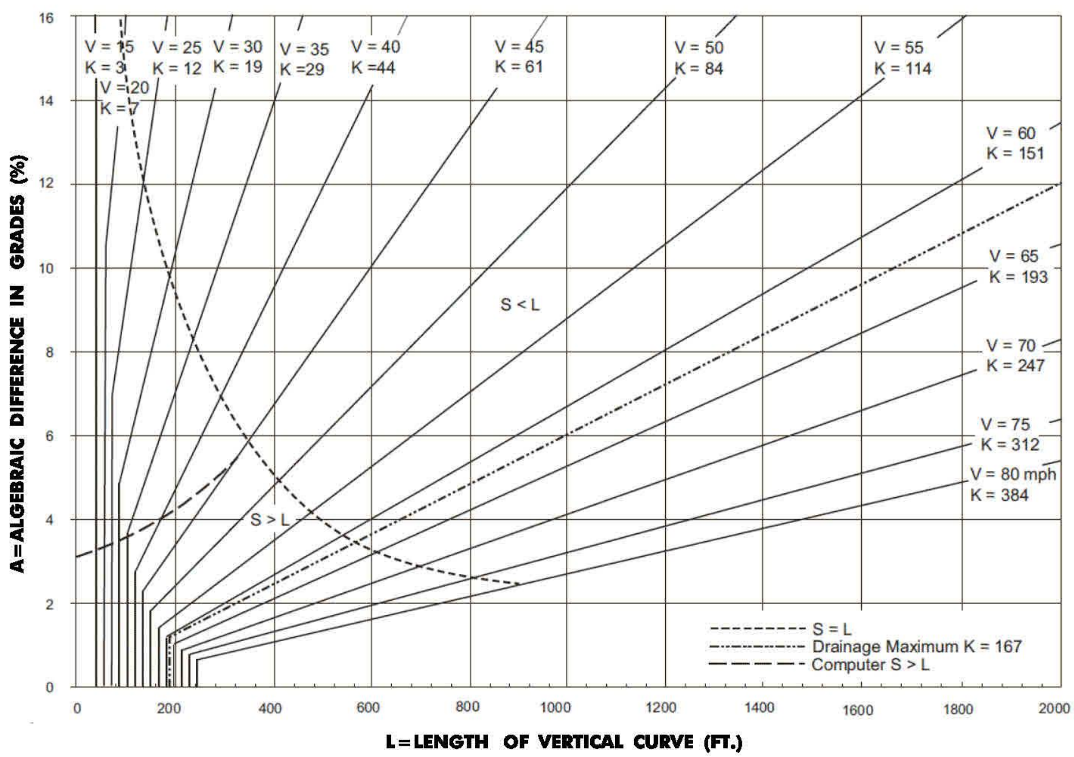
4.4.7 Coordination with Horizontal Alignment

A proper balance between curvature and grades should be sought. When possible, vertical curves should be superimposed on horizontal curves. This reduces the number of sight distance restrictions on the project, makes changes in profile less apparent, particularly in rolling terrain, and results in a pleasing appearance. For safety reasons, the horizontal curve should lead the vertical curve. On the other hand, where the change in horizontal alignment at a grade summit is slight, it safely may be concealed by making the vertical curve overlay the horizontal curve.

When vertical and horizontal curves are thus superimposed, the superelevation may cause distortion in the outer pavement edges. Profiles of the pavement edge should be plotted and smooth curves introduced to remove any irregularities.

A sharp horizontal curve should not be introduced at or near a pronounced summit or grade sag. This presents a distorted appearance and is particularly hazardous at night.

FIGURE 4–I:
DESIGN CONTROLS FOR CREST VERTICAL CURVES



NOTE: Drainage of the Roadway on CREST Vertical Curves must be more carefully designed when the Design Speed exceeds 60 MPH.

When S is greater than L, $L = 2S - \frac{2158}{A}$

When S is less than L, $L = \frac{AS^2}{2158}$

V=Design Speed
S=Stopping Sight Distance, Feet
A=Algebraic Difference In Tangent Grades, Percent
K=Horizontal Distance Required To Effect A Percent Change In Gradient, Feet
L=KA

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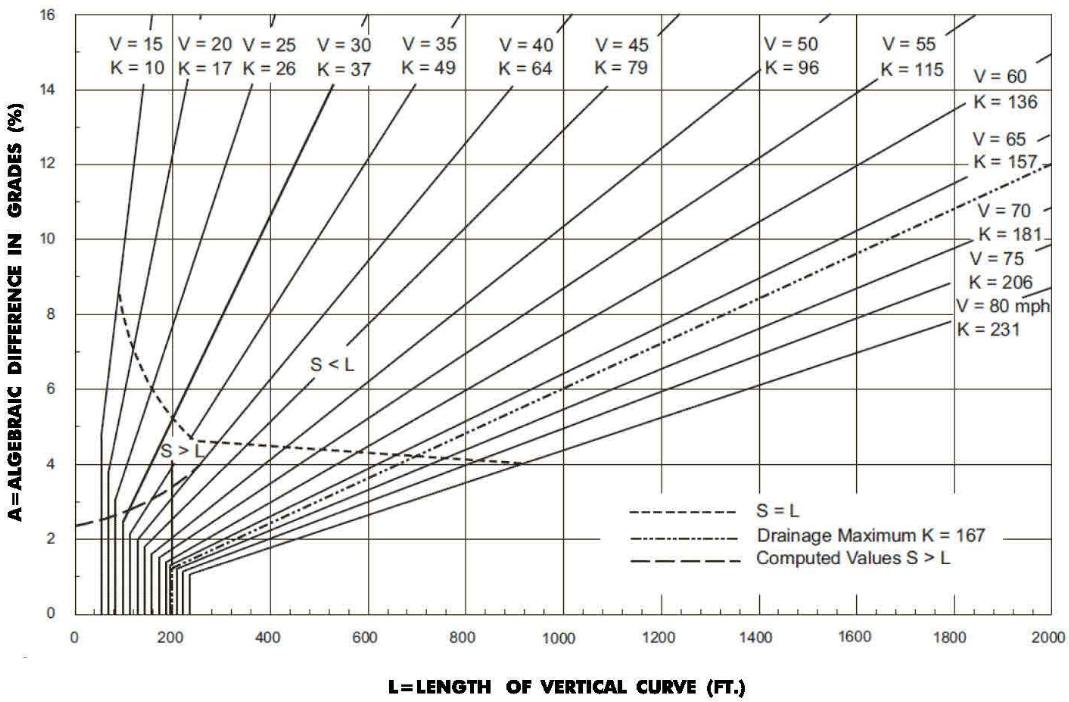
FIGURE 4–J: DESIGN CONTROLS FOR SAG VERTICAL CURVES



NOTE: Drainage of the Roadway on SAG Vertical Curves must be more carefully designed when the Design Speed exceeds 65 MPH.

When S is greater than L, $L = 2S - \frac{400 + 3.5S}{A}$

When S is less than L, $L = \frac{AS^2}{400 + 3.5S}$

V = Design Speed

S = Light Beam Distance, Feet

A = Algebraic Difference In Tangent Grades, Percent

K = Horizontal Distance Required To Effect A Percent Change In Gradient, Feet

L = KA

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4.5 Climbing Lane

A climbing lane, as shown in Figure 4-K, is an auxiliary lane introduced at the beginning of a sustained positive grade for the diversion of slow traffic.

Generally, climbing lanes will be provided when the following conditions are satisfied. These conditions could be waived if slower moving truck traffic was the major contributing factor causing a high accident rate and could be corrected by addition of a climbing lane.

A. Two-Lane Highways

The following three conditions should be satisfied to justify a climbing lane:

1. Upgrade traffic flow rate in excess of 200 vehicles per hour.
2. Upgrade truck flow rate in excess of 20 vehicles per hour.
3. **One** of the following conditions exists:
   a. A 10 mph or greater speed reduction is expected for a typical heavy truck.
   b. Level of Service E or F exists on the grade.
   c. A reduction of two or more levels of service is experienced when moving from the approach segment of the grade.

   A complete explanation and a sample calculation on how to check for these conditions are shown in the section on "Climbing Lanes" contained in Chapter 3, "Elements of Design", of the AASHTO, "*A Policy on Geometric Design of Highways and Streets*."

B. Freeways and Multi-lane Highways

Both of the following conditions should be satisfied to justify a climbing lane:

1. A 10 mph or greater speed reduction is expected for a typical heavy truck.
2. The service volume on an individual grade should not exceed that attained by using the next poorer level of service from that used for the basic design. The one exception is that the service volume derived from employing Level of Service D should not be exceeded.

If the analysis indicates that a climbing lane is required, an additional check must be made to determine if the number of lanes required on the grade are sufficient even with a climbing lane.

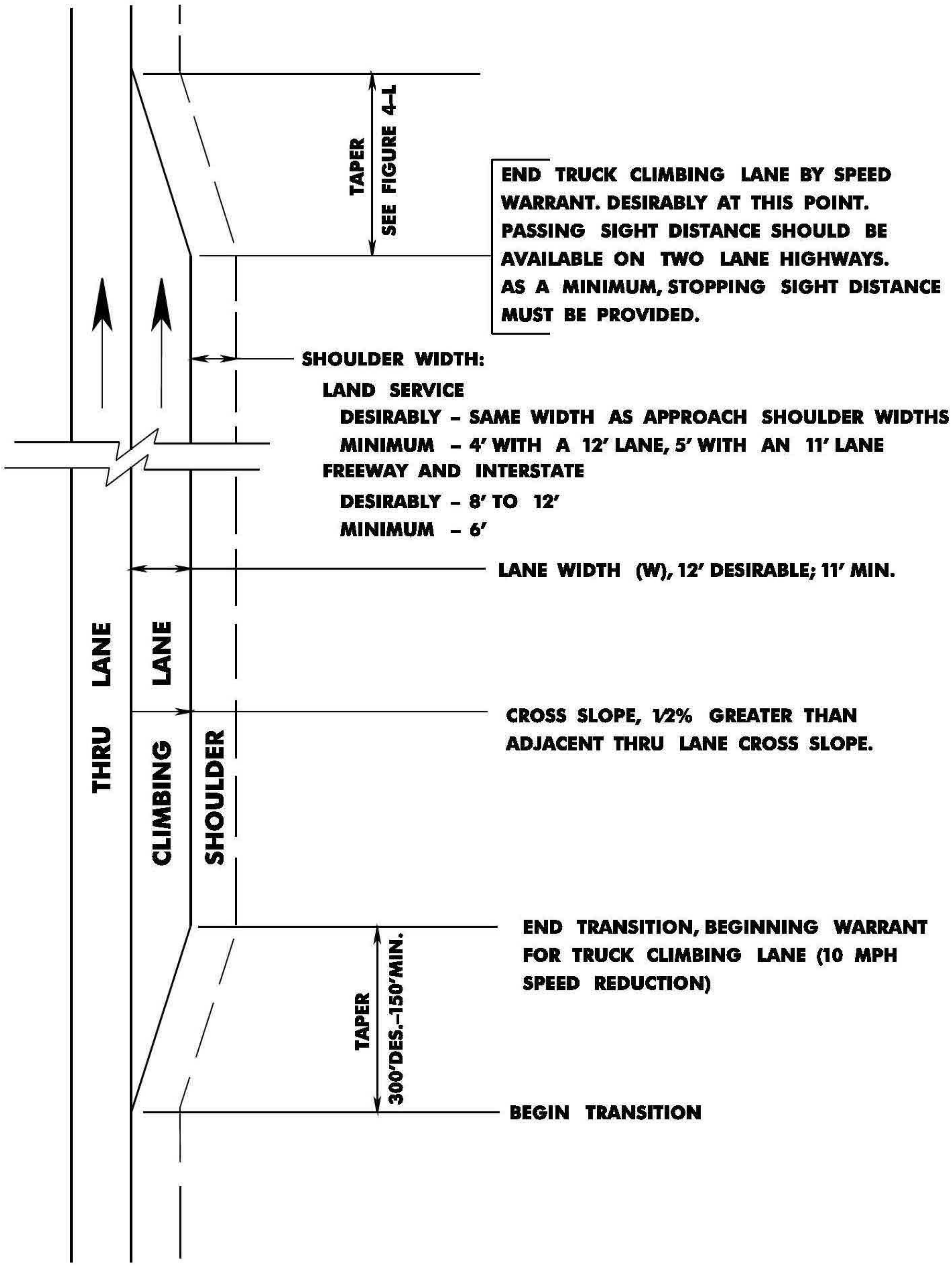
A complete explanation and a sample calculation on how to check for these conditions are shown in the section on "Climbing Lanes" contained in Chapter 3, "Elements of Design", of the AASHTO, "*A Policy on Geometric Design of Highways and Streets*."

The beginning warrant for a truck climbing lane shall be that point where truck operating speed is reduced by 10 mph. To locate this point, use Figure 3-28 or Figure 3-29 of the aforementioned AASHTO Policy, depending on the weight/horsepower ratio of the appropriate truck. The beginning of the climbing lane should be preceded by a tapered section, desirably 300 feet, however, a 150 feet minimum taper may be used.

Desirably, the point of ending of a climbing lane would be to a point beyond the crest, where a typical truck could attain a speed that is about 10 mph below the operating speed of the highway. This point can be determined from Figure 3-29 of the aforementioned AASHTO Policy. If it is not practical to end the climbing lane as per Figure 3-29, end the climbing lane at a point where the truck has proper sight distance to safely merge into the normal lane, or preferably, 200 feet beyond this point. For two lane highways, passing sight distance should be available. For freeways and multi-lane highways, passing sight distance need not be considered. For all highways, as a minimum, stopping sight distance shall be available. The ending taper beyond this point shall be according to Figure 4-L.

A distance-speed profile should be developed for the area of a climbing lane. The profile should start at the bottom of the first long downgrade prior to the upgrade being considered for a climbing lane, speeds through long vertical curves can be approximated by considering 25 percent of the vertical curve length (chord) as part of the grade under question.

FIGURE 4–K: CLIMBING LANE



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Section 5 - Major Cross Section Elements

5.1 General

The major cross section elements considered in the design of streets and highways include the pavement surface type, cross slope, lane widths, shoulders, roadside or border, curbs, sidewalks, driveways, and medians. Due consideration should be given to the motoring and non-motoring users in designing the cross section.

5.2 Pavement

5.2.1 Surface Type

Pavement surface type is determined by soil conditions, traffic volume, traffic composition, material availability, initial cost, and the extent and cost of maintenance. All of these affect the relationship of cost to traffic service.

Generally, all roadways in the State are surfaced with hot mix asphalt materials or Portland cement concrete. These pavements provide good riding qualities, help to maintain the cross section, and adequately support the expected volume and weights of vehicles without failure due to fatigue. In considering cyclists and pedestrian traffic, other roadway surfaces include textured and colored asphalt, textured and colored concrete, and brick and other unit pavers. As part of urban design, landscape or streetscape treatments, these are used in crosswalks, bike lanes, shoulders, and traffic calming devices.

Important characteristics in relation to geometric design are the ability of a surface to sustain its shape and dimensions, the ability to drain, and the effect on driver, bicyclist, and pedestrian behavior.

5.2.2 Cross Slope

The cross slope of the pavement is the slope of the pavement surface measured transverse to the centerline of the highway. The high point of a normal cross slope of a roadway is known as the crown. Undivided pavements on tangents or on flat curves have a high point (crown) in the middle of the traveled way and slope downward toward both edges.

The minimum cross slope for concrete pavement and hot mix asphalt pavement should be 1.5 percent. The cross slope shall be uniform across the pavement section, from the high point to the edge of lane. The cross slope in each successive lane should be increased by 0.5 percent. However, it may be increased on each successive pair of lanes by 0.5 to 1 percent in order to cause the least disturbance to the existing border area, to limit the amount of resurfacing weight on a structure, or to minimize the cross slope in the outer lane when more than three lanes are sloped in the same direction.

In addition, if the cross slope of the left-turn lane is in the same direction as the adjacent lane, the adjacent lane cross slope may be used.

On a divided highway, each one way pavement may be crowned separately, as on a two lane highway, or it may have a unidirectional slope across the entire width of pavement, which is almost always downward to the outer edge.

A cross section where each roadway has a separate high point (crown) has an advantage of rapidly draining the pavement as shown in the top two drawings of Figure 5-A. In addition, the difference between high and low points in the cross section is kept to a minimum. The disadvantage is, additional drainage inlets and subsurface drainage lines are required. In addition, treatments of at grade intersections are more difficult because of the creation of several high and low points on the cross section. Preferably, use of such sections should be limited to regions of high rainfall. A cross section having no curbing and a wide depressed median are particularly well suited for high rainfall conditions.

Roadways that slope only in one direction provide more comfort to drivers because vehicles tend to be pulled in the same direction when changing lanes (As shown in the bottom four drawings of Figure 5-A). Roadways with a unidirectional slope may drain away from or toward the median. Providing drainage away from the median may affect a savings in drainage structures and simplify treatment of intersecting streets. Advantages of drainage toward the median are:

1. An economical drainage system, in that all surface runoff is collected into a single conduit.
2. Outer lanes, used by most traffic, are freer of surface water.

A major disadvantage of drainage toward the median is all the pavement drainage must pass over the inner, higher speed lanes. Where curbed medians exist, the drainage is concentrated next to and on higher speed lanes. This concentration of drainage, when the median is narrow, results in annoying and undesirable splashing onto the windshields of opposing traffic.

The rate of cross slope on curves as well as on tangent alignment is an important element in cross section design. See Section 4, “Basic Geometric Design Elements,” for speed curvature relationships to determine pavement superelevation on curves.

5.3 Lane Widths

Lane widths have a great influence on driving safety and comfort. The predominant lane width on freeways and land service highways is 12 feet.

While lane widths of 12 feet are desirable on land service highways, circumstances may necessitate the use of lanes less than 12 feet. Lane widths of 11 feet in urban areas are acceptable. Existing lane widths of 10 feet have been provided in certain locations where right of way and existing development became stringent controls and where truck volumes were limited. However, new or reconstructed 10 foot wide lanes would not be proposed today, except in traffic calming areas.

On land service highways, where it is not practical to provide a shoulder adjacent to the outside lane (design exception required), the outside lane width shall be 15 feet to accommodate bicyclists. Where alternate bike access is provided, the outside lane width should be 1 foot wider than the adjacent through lane width. The designer should strive to accommodate the bicyclist and pedestrian on all projects.

When resurfacing existing highways that have lane widths of 10 feet or less, the existing lanes should be widened to either 11 foot minimum or 12 foot desirable.

Auxiliary lanes at intersections are often provided to facilitate traffic movements. Such lanes should be equal in width to the through lanes but not less than 10 foot wide when constructed adjacent to a shoulder. When there is no right shoulder adjacent to a new or reconstructed auxiliary lane, the width of the auxiliary lane shall be designed to accommodate the bicyclist (no design exception required). Where alternate bike access is provided, the auxiliary lane width should be 1 foot wider than the adjacent through lane width. The criteria in this paragraph shall also apply to auxiliary lanes at interchanges on land service highways.

On Interstates and freeways, the width of the auxiliary lane shall be 12 feet. Lane widths for specific types of highways are enumerated as part of the typical sections illustrated at the end of this section.

For the width of climbing lanes and left-turn lanes, see Section 4, "Basic Geometric Design Elements" and Section 6, "At-Grade Intersections," respectively.

5.4 Shoulders

5.4.1 General

A shoulder is the portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of subbase, base and surface courses.

Some of the more important advantages of providing shoulders are:

1. Space for the motorist to pull completely off the roadway for emergencies.
2. An escape zone to allow motorists to avoid potential accidents or reduce accident severity.
3. An aid to driver comforts by creating a sense of openness; improves highway capacity.
4. An improvement in sight distance in cut sections.
5. A provision to enhance lateral clearance for the placement of signs, guide rails, or other roadside appurtenances.
6. Space for pedestrians where there is no sidewalk and for bicycle usage.

New Jersey shoulder pavement design is based on the following engineering considerations.

A. The New Jersey state highway system constitutes the heart of our state's surface transportation network. As a corridor state, the New Jersey highway system is subjected to the highest traffic count and loading in the nation.

B. New Jersey highways continue to be faced with a serious backlog of deficient pavements in poor to fair condition. As such, many of the pavements are in the process of or will eventually be rehabilitated or reconstructed.

C. Due to frequent traffic encroachment over the longitudinal joints next to the shoulder and the need to stage traffic on shoulders during rehabilitation, progressive shoulder deterioration will result if adequate shoulder pavement strength is not provided in the original construction.

D. Shoulders of adequate pavement strength will carry traffic during the future construction of additional lanes, and the widening, resurfacing, rehabilitation and recycling of the existing lanes. The shoulders will also be used as an additional riding lane during peak hours relieving traffic congestion, such as in the case of "bus/shoulder" lanes.

The following shoulder pavement design policy is based on the above consideration. The term "Full Pavement Shoulder" is a shoulder pavement equal to that of the mainline pavement.

Full pavement shoulders shall be used as follows:

Full pavement shoulders shall be used for all new construction, reconstruction and widening on all portions of the NJ highway system.

For mainline pavement rehabilitation projects, shoulder pavement shall be designed to carry mainline traffic for a minimum period of 2 years or the following minimum section (whichever is greater):

2" Hot Mix Asphalt ___ Surface Course

3" Hot Mix Asphalt ___ Intermediate Course

8" Dense Graded Aggregate Base Course

5.4.2 Width of Shoulders

Desirably, a vehicle stopped on the right shoulder should clear the pavement edge by at least 1 foot, preferably by 2 feet. On land service highways, in difficult terrain, or in areas where right of way is restricted due to roadside development or environmental factors, a minimum 8 foot wide shoulder may be provided. On 3R projects, the existing shoulder width may be reduced to 8 feet to provide wider lanes. New or reconstructed shoulders on heavily traveled and high speed land service highways, especially those carrying large numbers of trucks (250 DHV), where turning volumes are high or dualization is anticipated, should have usable shoulders at least 10 feet and preferably 12 feet wide. Shoulders should be provided adjacent to all new acceleration and deceleration lanes at interchanges, where practical, in major new construction or reconstruction projects along major land service highways having an AADT of 10,500 per lane (DHV of 1,500 per lane) or greater, for the project design year. "Practical" is defined as given consideration to social, economic, and environmental impacts in concert with safe and overall efficient traffic operations.

Shoulder widths on freeways and Interstate highways shall be 10 feet minimum. However, where truck traffic exceeds 250 DDHV, a 12 foot shoulder should be provided. A 10 foot shoulder shall be provided adjacent to all new or reconstructed auxiliary lanes. Where no right shoulder exists, the existing auxiliary lane width may be maintained on Interstate and freeway resurfacing, restoration and rehabilitation (3R) projects. However, whenever practical, a 10 foot desirable or a 6 foot minimum shoulder should be provided on Interstate and freeway 3R projects.

Shoulder widths for specific types of highways are enumerated as part of the typical sections illustrated at the end of this section.

Although it is desirable that a shoulder be wide enough for a vehicle to be driven completely off the traveled way, narrower shoulders are better than none at all. Partial shoulders are sometimes used when full shoulders are unduly costly, as on long span bridges or in mountainous terrain. Regardless of the width, a shoulder should be continuous where feasible.

Left shoulders are preferred on all divided highways. The desirable median shoulder width on a 4 lane and 6 to 8 lane highway is 5 feet and 10 feet respectively. The minimum left shoulder width on land service highways is 3 feet and on a freeway is 4 feet.

Shoulders on structures should have the same width as the usable shoulders on the approach roadways, both right and left. This design is essential on freeways, and is desirable on all arterials where shoulders are provided. Long span, high cost structures usually warrant detailed special studies to determine feasible dimensions. Wherever practicable, full shoulders should be included, but as has been indicated, for some cases, it may be judged proper to use only partial width shoulders.

5.4.3 Cross Slope

Shoulders are important links in the lateral drainage systems. A shoulder should be flush with the roadway surface and abut the edge of the through lane/auxiliary lane. On a divided highway with a depressed median, all shoulders should be sloped to drain away from the traveled way. With a raised narrow median, the median shoulder may slope in the same direction as the traveled way. All shoulders should be pitched sufficiently to rapidly drain surface water.

Desirably, a shoulder cross slope should not be less than 4 percent to minimize ponding on the roadway. As a minimum, a shoulder cross slope should not be less than 2 percent. However, when a left shoulder is less than 5 feet in width and the median slopes away from the roadway or where the median and adjacent lane both slope toward the median gutter, the shoulder cross slope may be at the same rate and direction as the adjacent lane for ease of construction.

On 3R and reconstruction projects, shoulder cross slope may be increased to 6 percent to minimize impacts on existing curb, drainage, adjacent properties, access, etc. But, shoulder cross slope should not exceed 5 percent where a curb ramp is present since the angle of incidence between a mobility device descending a curb ramp and the counter slope of the gutter must be limited to avoid catching the mobility device, e.g. wheelchair footrest.

Shoulder on the high side of a superelevated section should be designed to drain away from the adjacent traffic lanes. A shoulder cross slope that drains away from the paved surface on the high side of a superelevated section should be designed to avoid too great a cross slope break. The cross slope of the shoulder shall be as follows:

1. The shoulder cross slope should be 4 percent where the superelevation rate is 3 percent or less.
2. For superelevation rates greater than 3 percent and less than 5 percent, a maximum rollover rate of 7 percent will be used to establish the shoulder cross slope.
3. When superelevation rates range from 5 percent to 6 percent, the shoulder cross slope will be 2 percent.

On an existing superelevated curve where there is a history of run off the road accidents, the location should be evaluated for proper clear zone, sight distance, superelevation, and signing. The shoulder cross slope on the outside of the curve may be constructed in the same direction as the adjacent lane. However, consideration should be given to snow storage in border area (snow melting in border area then draining and refreezing on roadway surface) by sloping the border away from roadway or by providing slotted drainage along shoulder.

The shoulder on the inside of a curve or on the low side of a superelevated section should be sloped at 4 percent, or equal to the superelevation of the adjacent lane, whichever is greater.

5.4.4 Intermittent Shoulders or Turnouts

It will not always be economically feasible to provide desirably wide shoulders continuously along the highway through high cut areas or along steep mountainsides. In such cases, consideration should be given to the use of intermittent sections of shoulders or turnouts that can be placed at favorable locations along the highway. Where intermittent shoulders or turnouts are provided, the length of the transition section should be approximately 50 feet to encourage usage and to permit safe entry and exit.

5.5 Roadside or Border

5.5.1 General

The area between the roadway and the highway right of way is referred to as the roadside or border. The term "roadside" generally applies to freeways and the term "border" applies to land service highways. The distance between the outside edge of roadway and the hinge point may be less than the width of the roadside or border area.

5.5.2 Width

The right-of-way width on rural and urban freeways is typically 300 feet and 150 feet respectively. Depending upon the median, traveled way and shoulder widths, the roadside width is in the range of 70 feet for rural freeways and 25 feet for urban freeways.

were rebuilt or replaced, at a minimum the new portion of sidewalk would be subject to ADA compliance including curb ramps, among other things. However, compliance with these guidelines would not extend to untouched sections of sidewalk outside the planned alterations.

Based on FHWA Office of Civil Rights and the US Department of Transportation General Counsel approval, there are a number of roadway preservation and preventative maintenance projects that do not require curb ramps to be constructed. These projects may involve, but are not limited to:

- Bridge deck patching
- Demolition
- Fencing
- Fender repair
- Fiber optics
- Guide rail
- Landscape
- Raised pavement markers
- Signing and striping in-kind
- Lighting
- Minor Signal Upgrades (i.e. retiming signal installation)
- Utility work that does not alter pedestrian facilities
- Seismic retrofit
- Pavement patching
- Shoulder repair
- Restoration of drainage systems
- Crack sealing
- Bridge painting
- Scour countermeasures
- Other roadway preservation and preventative maintenance projects. The following are some examples of such projects.

    1. Pavement repair
    2. Joint replacement or repair
    3. Bridge deck restoration and component patching
    4. Chip seals
    5. Diamond Grinding
    6. Fog Seals
    7. Joint Crack Seals
    8. Scrub Sealing
    9. Slurry Seals
    10. Spot High-Friction Treatments
    11. Surface Sealing

In most cases, the unique projects mentioned previously will not modify a pedestrian route. However, the designer should consider every project as an opportunity to further the accessibility of its pedestrian network and should not unnecessarily restrict the scope of work so as to avoid the requirements for new curb ramps.

The sight distance should be checked to ensure curb ramps are not placed in such a location that a motorist will find it difficult to perceive the low profile of a mobility device occupant crossing the roadway.

Curb ramps shall be designed to accommodate all users, thus, transitions from the sidewalk to the curb ramp or to the turning space shall be gradual. Relocation of the sidewalk at an intersection is permissible, and in some cases necessary in order to obtain the required sidewalk and curb ramp slope.

Gutters & Counter Slopes

Gutters require a counter slope at the point at which a curb ramp meets the street. This counter slope shall not exceed 5%. The change in angle must be flush, without a lip, raised joint or gap. Lips or gaps between the curb ramp slope and counter slope can arrest forward motion by catching caster wheels or crutch tips.

Turning and Clear Spaces

A curb ramp with a turning space is required wherever a public sidewalk crosses a curb or other change in level. Turning spaces are required anywhere a turning maneuver is required by a user of a mobility device. Turning spaces shall provide a nearly level area (2% cross slope or less) for mobility device users to wait, maneuver into or out of a curb ramp, or to bypass the ramp altogether. A turning space of 4 feet minimum by 4 feet minimum is required. This accommodates the length and wheelbase of mobility devices (standard wheelchairs and scooters). When one curb ramp at the center of the corner radius (corner type curb ramp) is used, the bottom of the curb ramp shall have a clear space 4’ minimum outside active traffic lanes of the roadway. The clear space should be wholly within the crosswalks. See Figure 5-Q for illustration.

Landings or a level cut through should also be provided at raised medians or crossing islands.

Running Slope

The curb ramp shall have a running slope of 12:1 maximum. It may be necessary to limit the running slope of a parallel or perpendicular curb ramp in order to avoid chasing grade indefinitely. The curb ramp length should not exceed 15 feet. Adjust the curb ramp slope as needed to provide access to the maximum extent feasible.

Flares

Where a pedestrian circulation path crosses the curb ramp, the ramp is required to have side flares; sharp returns present tripping hazards. This typically occurs where the sidewalk is next to the curb (no grass buffer). Curb ramp flares are graded transitions from a curb ramp to the surrounding sidewalk. Flares are not intended to be mobility device routes, and are typically steeper than the curb ramp (10:1 max) with significant cross-slopes. If curb ramp is situated in such a way that a pedestrian cannot walk perpendicular across the ramp (ie: blocked by utility pole), flares may be replaced with a 1.5 foot transition or returned curb adjacent to the ramp.

Flares are only needed in locations where the ramp edge abuts pavement. A 1.5 foot transition or returned curb is used where the ramp edge abuts grass or other landscaping. Straight returned curbs are a useful orientation cue to provide direction for visually impaired pedestrians. (See the Construction Details)

Curb Ramp - Types and Placement

The appropriate type of curb ramp to be used is a function of sidewalk and border width, curb height, curb radius and topography of the street corner. There are seven curb ramp types used in street corner designs as shown in the Construction Details. In all cases, the curb ramp should be located entirely within the marked crosswalks (where they exist). Drainage grates or inlets should not be located in the area at the base of the curb ramp. Grates are a problem for mobility devices, strollers and those who use walkers. Wheelchair safe grates should be used where relocation is impracticable.

Two curb ramps are required at each corner, one on each highway within the crosswalk area. If the curb ramp cannot be constructed within the existing crosswalk, the crosswalk shall be modified to include the ramp. The preferred location for a curb ramp is usually parallel to the sidewalk and out of the normal pedestrian path. Where field conditions prohibit the placement of two curb ramps, one ramp at the center of the corner radius is acceptable. Where the travel lane is next to the curb, use a curb ramp at the center of the corner radius in order to provide for a clear space, or a Type 7 curb ramp may be used where needed to ensure that the clear space remains outside the travel way. Curb ramp designs which result in wide painted cross walks greater than 10 feet should be avoided.

The Standard Roadway Construction Detail illustrates the design criteria for public sidewalk curb ramps. The designer should take into consideration the existing conditions at a curb ramp location when evaluating project impacts. These impacts may include constructability issues, quantities and cost.

At a curb ramp location where the sidewalk is greater than 6 feet in width and there is no grass buffer strip, the approach sidewalk transition shall be as shown for Curb Ramp Type 1 and 3 in the Standard Roadway Construction Details. However, where a grass buffer strip exists between the curb and the sidewalk at a curb ramp location, the flared side slope and approach sidewalk transition should be altered as shown for Type 2 and 4 in the Standard Roadway Construction Details.

The designer may want to guide pedestrians away from crossing the mainline of a high volume and/or high speed section of highway except at signalized intersections or at a pedestrian overpass. Therefore, at unsignalized intersections along such highways a curb ramp would be required on the side street corner but not on the mainline corner. In these cases, prohibition for pedestrian crossing signage needs to be provided. Curb Ramp Type 5 and 6 in the Standard Roadway Construction Details are examples of curb ramp locations for crossing the side street. The preferred treatment for Curb Ramp Type 5 and 6 is out of the normal pedestrian path, but not necessary where right of way width cannot accommodate the offset.

Where there is limited right of way (ROW) at a curb ramp location, the approach sidewalk transition should be altered and the turning space made flush with the gutter line as shown for Curb Ramp Type 7 in the Standard Roadway Construction Details. These limited ROW locations are where the distance from the gutter line to the outside edge of sidewalk is 6 feet or less.

There are also several design solutions that a designer can utilize in order to solve "Limited ROW" constraints without actually acquiring ROW. They are contained in the Special report: Accessible Public Rights-of-Way Planning and Designing for Alterations, Public Rights-of-Way Access Advisory Committee (ACCESS Board), July, 2007, which include but are not limited to:

- Use Curb Ramp Type 3, 4 or 7 where there is not enough room for the landing behind the curb ramp:

  This is basically done by employing a Type 3 or 4 type curb ramp. If there still is not enough room, try using a Type 7 curb ramp. If the side street has a high curb, try lowering the curb around the intersection corner radius. For example, if the side street has existing 8 inch curb and it also continues along the corner radius, replace this high curb along the corner radius with 4 inch or less curb and then transition to the 8 inch curb on the side street. This will make your 12:1 ramps much shorter.

- Reduce street width and provide curb ramp type 3, 4 or 7:
  Check design vehicle types for turning radius requirements for the particular intersection corner. If a smaller design vehicle can be used at that corner, reduce the corner radius and provide the appropriate curb ramp. By reducing the corner radius, the new gutter line will be moved further into the street creating more room to provide the sidewalk and curb ramps.

- Lower sidewalk to street surface using blended transition:

  Lower the sidewalk grade at the intersection to make the sidewalk elevation flush with the gutter elevation. Then provide 12:1 ramps at the radius returns to bring sidewalk up to existing elevation. In other words, make a Curb Ramp type 7 turning space encompass the entire intersection radius.

- Corner Curb extension:

  It may be used where posted speeds are 35 MPH or below, see Section 15, “Traffic Calming.”

- Elevate intersection to sidewalk level:

  A vertical raised intersection may be used where posted speeds are 35 MPH or below, see Section 15, “Traffic Calming.”

  Intersections may have unique characteristics that can make the proper placement of curb ramps difficult, particularly in alteration projects. However, there are some fundamental guidelines that should be followed.

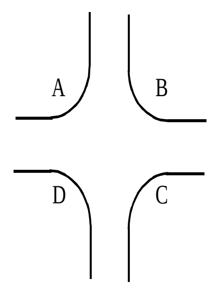
- Their full width at the gutter line (exclusive of flares) must be within the crosswalk. Aligning the ramp to the crosswalk, if possible, will enable the visually impaired pedestrian to more safely navigate across the intersection and exit the roadway on the adjoining curb ramp.
- Curb ramps should avoid storm drain inlets, which can catch mobility device casters or cane tips.
- Curb ramps should be adequately drained. A puddle of water at the base of a ramp can hide pavement discontinuities. Puddles can also freeze and cause the user to slip and fall.
- Curb ramps must be situated so that they are adequately separated from parking lanes.

Curb Ramps at Intersections

The clear width of a curb ramp should be a minimum of 4 feet, excluding flares.

The following criteria shall apply to providing curb ramps at intersections:

1. Where all the corners of an intersection have existing or proposed sidewalk, curb ramps shall be provided at each corner.
2. Where all the corners of an intersection do not have existing or proposed sidewalk, the following provisions shall apply:
   a. Where sidewalk exists or is proposed at only one corner, A only, B only, C only or D only; no curb ramp is required. If the curb at the corner with sidewalk is to be constructed or reconstructed, it is optional to provide depressed curb for future curb ramps for compatibility with other corners.



   b. Where there is existing or proposed sidewalk at two adjacent corners only, such as A and B, curb ramps shall be constructed at corners A and B only.
   c. Where there is existing or proposed sidewalk at two diagonally opposite corners only, such as A and C, curb ramps shall be constructed at corners A and C together with a curb ramp at one of the other corners (B or D).
   d. Where sidewalk exists or is proposed at three corners, curb ramps shall be constructed at each corner where existing sidewalk is to remain or where new sidewalk is proposed.

Where a corner at an intersection is without existing or proposed sidewalk, but with curb to be constructed or replaced or with existing curb to remain as is; it is optional to provide depressed curb for future curb ramps.

Where islands exist or are proposed at intersections with curb ramps, the following provisions shall apply:

1. Where a small channelizing island (50 to 75 square feet) is encountered at an intersection, it is not necessary to provide for a curb ramp or walkway opening for the island, but crosswalks shall be adjusted to safely accommodate a person with disabilities without encroaching into the adjacent traveled way.
2. Where a channelizing island is greater than 75 square feet, provide a 5 foot wide walkway opening level with the street in the part of the island intersected by the crosswalk. Where the walkway opening would be long or would create drainage problems, an alternate design is to place curb ramps at both sides of the island where it is intersected by the crosswalks and have a level area of at least 4 feet between the curb ramps.
3. At intersections where a left turn island or divisional island is encountered and the island cannot be moved back so that the nose is out of the crosswalk, provide a 5 foot wide walkway opening level with the street in the part of the island intersected by the crosswalk. See the Standard Roadway Construction Details.

At a location where a curb ramp is not presently required, the curb ramp area should be kept clear of obstructions such as light standards, traffic signals, meter boxes, controller boxes, junction boxes, utility poles, inlets, fire hydrants, guide rail, signs, planters, etc. which would interfere with future curb ramp construction.

The Department's or local public agency's transition plan should be reviewed to determine where future curb ramps are needed. It may be economical to include those improvements with current projects instead of through separate pedestrian improvement projects.

The surface of a public sidewalk curb ramp shall be stable, firm and slip-resistant. The surface of a concrete curb ramp (excluding turning space and flared sides) shall have a detectable warning surface. Detectable warnings shall consist of raised truncated domes and shall be the color red where the adjoining public sidewalk surface is also concrete. Where the adjoining public sidewalk surface is not concrete, the surface of a public sidewalk curb ramp shall contrast visually with adjoining public sidewalk surfaces, either light-on-dark or dark-on-light. Curb ramp surfaces shall be covered with a detectable warning surface per the Standard Construction Details and Specifications. Detectable warning surfaces are also required at pedestrian railroad crossings.

The curb ramp area (curb ramp, turning space, and approach sidewalk transition) shall be kept clear of existing and proposed obstructions such as light standards, traffic signals, meter boxes, controller boxes, utility poles, inlets, fire hydrants, guide rail, signs, planters, etc. Existing obstructions should be relocated as necessary, so as to provide maximum visibility of and for the curb ramp user. The preferred treatment for existing manholes, junction boxes, and valve boxes is to locate them outside of the limits of the curb ramp. However, as an alternate treatment, these items may remain in the curb ramp area and be reset to the slope of the curb ramp. If they are within the area of the detectable warning surface, provide more detectable warning surface to compensate for the loss of area. Wherever possible, curb ramps should be located to avoid drainage low points in the gutter grade. Gratings or similar access covers shall not be located in the area at the base of the public sidewalk curb ramp.

Accessible Pedestrian Signals, Push Buttons and Curb Ramps

If pedestrian pushbuttons are provided, they should be capable of easy activation and conveniently located near each end of the crosswalk. Curb ramps with a turning space shall allow mobility device users to access existing or proposed pedestrian pushbuttons. Where pedestrian pushbuttons have been provided at intersections with no sidewalk, curb ramps with landing areas shall be provided at both ends of the crosswalk associated with the pedestrian pushbuttons (i.e., Pedestrian pushbuttons may have only been provided to cross the wide state highway and not the narrow side street). See “Section 4E.08 Pedestrian Detectors” of the current Manual on Uniform Traffic Control Devices for guidance on locating pedestrian pushbuttons at curb ramps.

5.8 Driveways

Driveway terminals are, in effect, low volume intersections. The number of driveways and their location has a definite effect on highway capacity, primarily on arterial highways.

Design requirements for driveways and the process under which the Department of Transportation will handle an access permit request are contained in the Department's publication, New Jersey State Highway Access Management Code and the Access Design Guidelines, 2012.

To determine the adequacy of the sight distance at driveways, see Section 6 for sight distance at intersections.

Sidewalks across driveways shall have a 2% maximum cross slope where placing new sidewalk at driveways or reconstructing driveway aprons.

5.8.1 Pedestrian Accommodations at Driveways

In commercial areas, conventional driveways (i.e. where there is a change in grade between the street and abutting property and the driveway entrance is connected to the street via a sloped concrete apron) are preferred over access points that resemble at-grade street intersections where there is no grade change. In the design of conventional driveways, the pedestrian right of way is established more clearly and vehicles must turn more slowly into and out of the driveway. If an intersection-style driveway is used, vehicle turns can be slowed by using a small curb radius. In addition, driveway width should be made no wider than necessary. Wide driveways allow faster turns and more exposure for pedestrians. The sidewalk at driveways should remain at grade and may have the same surface material or crosswalk delineation across the driveway so motorists know they are crossing a pedestrian access route.

The intersection of driveways and sidewalks are the most common locations for severe cross slopes for sidewalk users. Sloped driveway entrances can cause mobility device users to lose directional control, veer downhill toward the street and potentially tip over. Therefore, the following solutions are recommended:

- At locations with a buffer between the sidewalk and the street, provide a level path of pedestrian travel (as an extension of the regular sidewalk) through the driveway cut, and resume the driveway slope within the buffer.
- On narrow sidewalks against the curb, achieve a similar level landing area by moving the sidewalk back away from the highway as it crosses the driveway, where possible.
- Lower the driveway crossing to the grade of the street similar to a curb ramp type 7 as per the Standard Roadway Construction Details. (Note, although this solution is preferable to a severe cross slope, it can create steep grades on both sides of the driveway and can cause drainage problems on the landing.)

Sidewalk crossings of residential driveways and most commercial driveways should not generally be provided with detectable warning surfaces, since the pedestrian right-of-way continues across most driveway aprons and the overuse of detectable warning surfaces diminishes message clarity. However, where commercial driveways are provided with traffic control devices or otherwise are permitted to operate like public streets, detectable warnings should be provided at the junction between the pedestrian route and the street.

5.9 Medians

5.9.1 General

A median is a highly desirable element on all arterials carrying four or more lanes. It separates the traveled ways for traffic in opposing directions. The median width is expressed as the dimension between the through lane edges and includes the left shoulders, if any. The principal functions of a median are to:

1. Provide the desired freedom from the interference of opposing traffic.
2. Provide a refuge area for pedestrians and bicyclists.
3. Provide a recovery area for out of control vehicles.
4. Provide a stopping area in case of emergencies.
5. Provide for speed changes and storage of left turning and U turning vehicles.
6. Minimize headlight glare.
7. Provide width for future lanes.
8. Add open green space in an urban area.
9. Serve as traffic calming devices on low speed roadways.

For maximum efficiency, a median should be highly visible both night and day and in definite contrast to the through traffic lanes. A median may vary in scope from pavement markings to an expansive grass area of varying width between two independently designed roadways. Medians may be depressed, raised, or flush with the pavement surface.

5.9.2 Islands, Medians, and Pedestrian Refuges

Along with their function of controlling and directing traffic movement (usually turns), and dividing traffic streams, islands serve to increase the safety and comfort of pedestrians crossing at intersections and midblock locations by providing a refuge. When channelizing islands are designed for this purpose, they are often termed “pedestrian crossing islands” or “median refuges.” See Sections 5.7 and 6.5 for design guidance.

space for 2 vehicles, approximately 50 feet, should be provided for minor streets where stop sign control is employed and the approach grade is up towards the intersection. Such slopes should desirably be less than one percent and no more than 3 percent.

The profile lines and cross sections on the intersection legs should be adjusted for a distance back from the intersection proper to provide a smooth junction and proper drainage. Normally, the profile line of the major highway should be carried through the intersection, and that of the cross road adjusted to it. Intersections with a minor road crossing a multi-lane divided highway with narrow median and superelevated curve should be avoided whenever possible because of the difficulty in adjusting grades to provide a suitable crossing. Profile lines of separate turning roadways should be designed to fit the cross slopes and longitudinal grades of the intersection legs.

As a rule, the horizontal and vertical alignments are subject to greater restrictions at or near intersecting roads than on the open road. Their combination at or near the intersection must produce traffic lanes that are clearly visible to the motorists, bicyclists, and pedestrians at all times and definitely understandable for any desired direction of travel, free from sudden appearance of potential hazards, and consistent with the portions of the highway just traveled.

6.2.4 Cross Section

The cross section of the pavement surface within an intersection should be reviewed on a case-by-case basis. The development of the centerline profiles and edge of pavement profiles should flow smoothly through the intersection.

6.3 Sight Distance

6.3.1 General

There must be unobstructed sight along both roads at an intersection and across their included corner for distances sufficient to allow the operators of vehicles approaching the intersection or stopped at the intersection to observe pedestrians and cyclists and carry out whatever maneuvers may be required to negotiate the intersection. It is of equal importance that pedestrians be able to view and react to potential conflicts with vehicles.

Any object within the sight triangle high enough above the elevation of the adjacent roadways to constitute a sight obstruction should be removed or lowered. Such objects include but are not limited to cut slopes, hedges, bushes, tall crops, signs, buildings, parked vehicles, etc. Also check the vertical curve on the highway to see if it obscures the line of sight from the driver's eye (3.5 feet above the road) to the approaching vehicle (3.5 feet above the road) as per the sight distance determined in the next three sections.

6.3.2 Sight Distance for Bicycle Facilities

In general the sight distance required to see a bicycle is no greater than that to see a vehicle, so bicycle sight distance need not be calculated at intersections also used by vehicles. At locations where a separated bicycle facility crosses the roadway, or elsewhere where cyclists may enter or cross the roadway independent of vehicles, appropriate sight distance should be provided.

Vehicles parked near crosswalks create sight distance problems, and for this reason New Jersey State Statutes prohibit motor vehicle parking “within 25 feet of the nearest crosswalk or side line of a street or intersecting highway, except at alleys,” and within 50 feet of a stop sign (Title 39:4-138). These relationships also apply to other locations where pedestrians are likely to cross (mid-block crosswalks, T-intersections, gaps in median barriers).

The parking setback distance can be reduced in locations where curb extensions have been provided to reduce crossing distance and increase the visibility of pedestrians as long as the provisions of Title 39 are also met.

6.3.3 Stop Control on Cross Street

Intersection designs should provide sufficient sight distances to avoid potential conflicts between vehicles turning onto or crossing a highway from a stopped position and vehicles on the through highway operating at the design speed.

As a minimum stopping sight distance must be provided. However, to enhance traffic operations, the recommended sight distance along the major roadway from Figure 6-A for various design vehicles to turn left, right or cross should be provided. Where the median width on a divided highway is 25 feet or greater, the crossing can be accomplished in 2 steps. The vehicle crosses the first pavement, stops within the median opening, and proceeds when a safe gap in traffic occurs to cross the second pavement. However, when the median width is less than that of a vehicle, the crossing must be made in one step and the median must be included as part of the roadway width (w).

6.3.4 Yield Control

When an intersection is controlled by a yield sign, the sight triangle is governed by the design speed on the main highway and that of the approach highway or ramp.

Suggested approach speeds on the yield controlled approach are 15 mph for urban conditions and 20 mph to 25 mph for rural conditions. Where two major highways intersect and one leg is controlled by a yield sign, the design speed on both highways should be used in determining the minimum sight triangle.

Figure 6-B illustrates the method for establishing the recommended sight triangle for yield controlled intersections.

The table "WITH ACCELERATION LANE" is from Table 9-3 of AASHTO - *A Policy on Geometric Design of Highways and Streets*. The distances shown in this table are less than the stopping sight distance for the same design speed. Since motorists slow down to some extent on approaches to uncontrolled intersections, the provision of a clear sight triangle with legs equal to the full stopping sight distance is not essential.

The recommended distances in the bottom table "WITHOUT ACCELERATION LANE" are from Table 9-12, of AASHTO - *A Policy on Geometric Design of Highways and Streets*. Yield -controlled approaches without acceleration lanes generally need greater sight distance than stop controlled approaches. If sufficient sight distance for yield control is not available, use of a stop sign instead of a yield sign should be considered. Another solution to where the recommended sight distance cannot be provided, consider installing regulatory signs to reduce the speed of the approaching vehicles.

6.5 Channelization

6.5.1 General

Where the inner edges of pavement for right turns at intersections are designed to accommodate semi-trailer combinations, or where the design permits passenger vehicles to turn at speeds of 15 mph or more, the pavement area at the intersection may become excessively large for proper control of traffic. To avoid this condition, a corner island, curbed or painted, should be provided to form a separate turning roadway.

At-grade intersections having large paved areas, such as those with large corner radii and those at oblique angle crossings, permit and encourage undesirable vehicle movements, require long pedestrian crossings, and have unused pavement areas. Even at a simple intersection, appreciable areas may exist on which some vehicles can wander from natural and expected paths. Conflicts may be reduced in extent and intensity by a layout designed to include islands. For the design of 3-centered curves for right angle turns with corner islands and oblique angle turns with corner islands, see *A Policy on Geometric Design of Highways and Streets,* AASHTO, Figure 9-43 and Table 9-18, respectively.

6.5.2 Islands

An island is a defined area between traffic lanes for control of vehicle movements. Islands also provide an area for pedestrian refuge and traffic control devices. Within an intersection, a median or an outer separation is considered an island. This definition makes evident that an island is no single physical type; it may range from an area delineated by curbs to a pavement area marked by paint.

Islands generally are included in intersection design for one or more of the following purposes:

- Separation of conflicts;
- Control of angle of conflict;
- Reduction in excessive pavement areas;
- Regulation of traffic and indication of proper use of intersection;
- Arrangements to favor a predominant turning movement;
- Protection of pedestrians;
- Protection and storage of turning and crossing vehicles;
- Location of traffic control devices;
- Traffic calming and speed moderating purposes;

Islands generally are either elongated or triangular in shape, and are situated in areas normally unused as vehicle paths. The dimensions depend on the particular intersection design. Islands should be located and designed to offer little hazard to vehicles and bicycles, be relatively inexpensive to build and maintain, and occupy a minimum of roadway space but yet be commanding enough that motorists will not drive over them. Island details depend on particular conditions and should be designed to conform to the general principles that follow.

Curbed islands are sometimes difficult to see at night because of the glare from oncoming headlights or from distant luminaires or roadside businesses. Accordingly, where curbed islands are used, the intersection should have fixed-source lighting.

When various intersections are involved in a given project and the warrants are sufficiently similar, a common geometric design for each intersection should be used. This design approach will enhance driver expectancy. The designer should also refer to Part V of the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) for guidance.

Painted, flush medians and islands may be preferred to the curbed type under certain conditions including the following: in lightly developed areas; at intersections where approach speeds are relatively high; where there is little pedestrian traffic; where fixed-source lighting is not provided; and where signals, signs, or lighting standards are not needed on the median or island.

Islands may be grouped into 3 major functional classes: (1) channelizing islands designed to control and direct traffic movement, usually turning, (2) divisional islands designed to divide opposing or same-direction traffic streams, usually through movements, and (3) refuge islands to provide refuge for pedestrians. Most islands combine 2 or all of these functions:

1. Size

   Island sizes and shapes vary materially from one intersection to another. Islands should be large enough to command attention. The smallest curbed island that normally should be considered is one that has an area of approximately 50 square feet for urban streets, and 75 square feet for rural intersections. However 100 square feet is the minimum desirable size for islands used in both urban and rural areas.

2. Approach-End Treatment

   The approach end of a curbed island should be conspicuous to approaching drivers and should be physically and visually clear of vehicle paths, so that drivers will not veer from the island.

   The nose offset should be 3 feet from the normal edge of through lane. Figure 6-D shows the recommended design details of curbed triangular islands under conditions of no shoulder on the approach roadways.

   On highways with auxiliary lanes or shoulders, the corner islands should be offset the full auxiliary lane or shoulder width on both the main highway and the cross road as shown in Figure 6-E.

3. Divisional Islands

   The most common type of elongated divisional island is the median island, for which a design guide is illustrated on Figure 6-F.

4. Bicycle Accommodation

   Raised channelization islands should be located so as not to interfere with bicycle traffic.

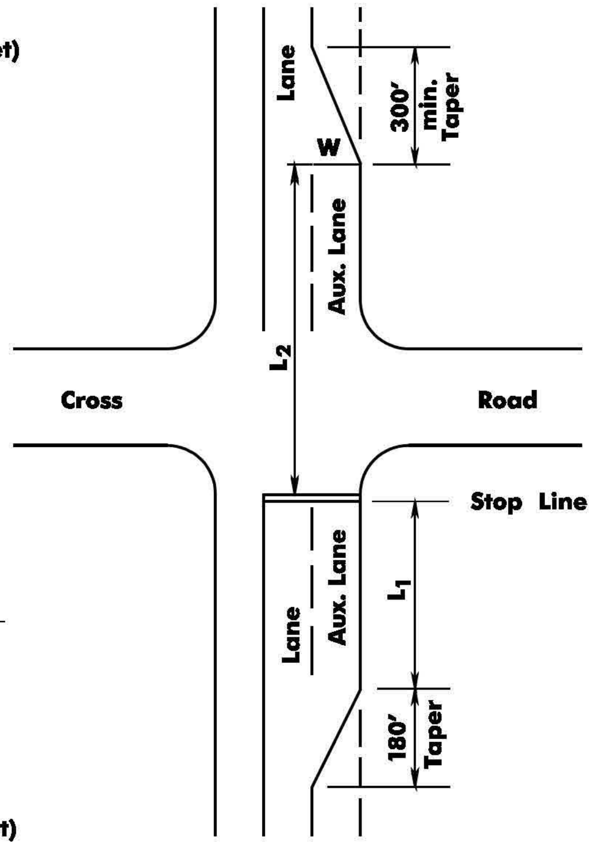
5. Pedestrian Accommodations

FIGURE 6–G: AUXILIARY LANE ADDITIONS AT SIGNALIZED INTERSECTIONS

LENGTH OF ADDITIONAL WIDENING IN ADVANCE OF INTERSECTION

L_1 = Length of auxiliary lane:

DESIGN SPEED (mph)	L_1 (Feet)
40 or less	315
45	375
50	435
55	485
60	570



LENGTH OF ADDITIONAL WIDENING BEYOND INTERSECTION

L_2 = Length of auxiliary lane equals the greater of:

DESIGN SPEED (mph)	L_2 (Feet)
40 or less	380
45	560
50	760
55	960
60	1170

OR

L_2 = 12 x Minimum green time G (sec.) for approach signal. If G = 40, then L_2 = 12 x 40 sec = 480′

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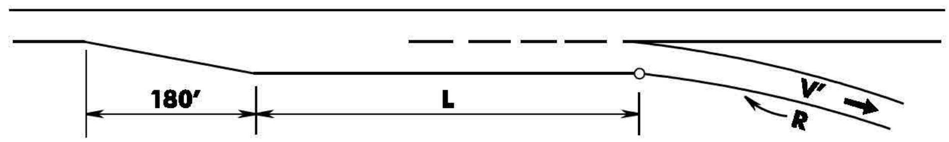
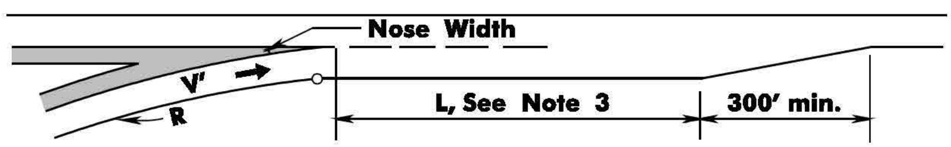
FIGURE 6–H: LAND SERVICE HIGHWAY AUXILIARY LANE LENGTHS

LENGTH OF DECELERATION LANES



HIGHWAY DESIGN SPEED MPH (V)	L = LENGTH OF DECELERATION LANE – FEET								
	FOR DESIGN SPEED OF EXIT CURVE – MPH (V′)								
	STOP CONDITION	15 50′ R	20 90′ R	25 150′ R	30 230′ R	35 340′ R	40 485′ R	45 660′ R	50 850′ R
	FOR AVERAGE RUNNING SPEED ON EXIT CURVE – MPH (V′a)								
	0	14	18	22	26	30	36	40	44
30	235	200	170	140	—	—	—	—	—
40	320	295	265	235	185	155	—	—	—
50	435	405	385	355	315	285	225	175	—
60	530	500	480	460	430	405	350	300	240
65	570	540	520	500	470	440	390	340	280
70	615	590	570	550	520	490	440	390	340

LENGTH OF ACCELERATION LANES



HIGHWAY DESIGN SPEED MPH (V)	L = LENGTH OF ACCELERATION LANE – FEET								
	FOR DESIGN SPEED OF ENTRANCE CURVE – MPH (V′)								
	STOP CONDITION	15 50′ R	20 90′ R	25 150′ R	30 230′ R	35 340′ R	40 485′ R	45 660′ R	50 850′ R
	AND INITIAL SPEED – MPH (V′a)								
	0	14	18	22	26	30	36	40	44
30	180	140	—	—	—	—	—	—	—
40	360	300	270	210	120	—	—	—	—
50	720	660	610	550	450	350	130	—	—
60	1,200	1,140	1,100	1,020	910	800	550	420	180
70	1,620	1,560	1,520	1,420	1,350	1,230	1,000	820	580

NOTES:

1. Minimum radii shown are for intersection curves. For design speeds of more than 40 mph, use values for open highway curves.
2. These tables apply to flat grades of 2% or less. For grades steeper than 2%, use the adjustments for grade in Table 10–4 of the source shown below.
3. "L" may start back on the curvature of the ramp where the entrance radius is equal to or greater than 1,000 feet and the motorist on the ramp has an unobstructed view of traffic on the through lanes to his left, but parallel section must be 300 from where the nose width equals 2 feet.

Source: A Policy on Geometric Design of Highways and Streets.

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6.5.4 Median Openings

Median openings on divided roadways are provided to permit intended movements only. Figures 6-I and 6-J show the application of grass median and concrete barrier curb median openings, respectively, to control the various types of movements along a divided roadway.

The length of the median opening desirably should equal the full roadway width of the cross road, shoulder to shoulder plus 10 feet on both sides to accommodate a crosswalk, except where the median extends into the sidewalk/crosswalk area as described below. The control radius (R1) should also be considered in determining the minimum length of median opening. The control radius (R1) is determined by the design vehicle as follows:

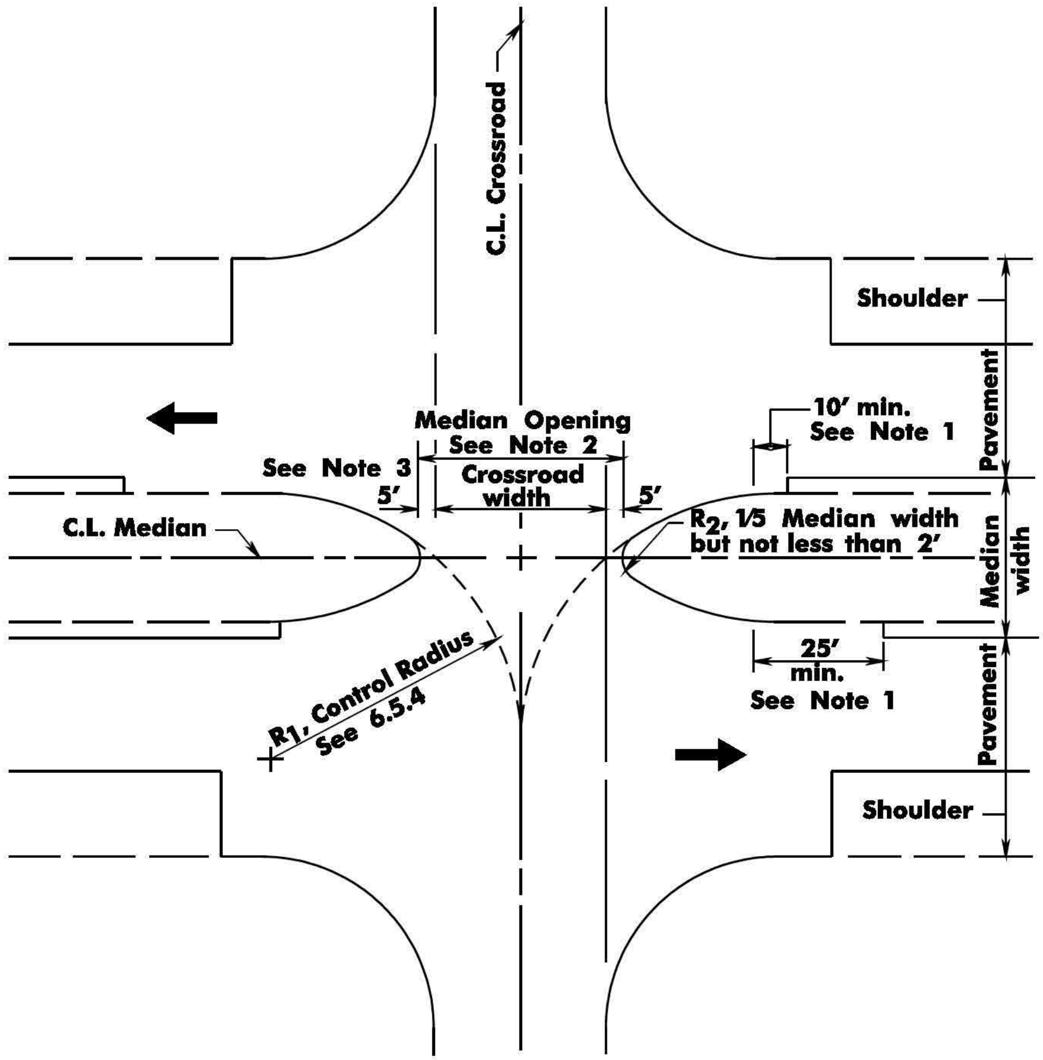
Design Vehicle	Control Radius	Description
P and SU-30	40 feet	A control radius of 40 feet accommodates P design vehicles suitably and occasional SU-30 design vehicles with some swinging wide
SU-30, SU-40, BUS, WB-40	50 feet	A control radius of 50 feet accommodates SU-30 design vehicles and occasional SU-40, BUS, and WB-40 design vehicles with some swinging wide
SU-40, WB-40, WB-50, WB-62	75 feet	A control radius of 75 feet accommodates SU-40, WB-40, WB-50, and WB-62 design vehicles with minor swinging wide at the end of the turn
WB-62, WB-67	130 feet	A control radius of 130 feet accommodates WB-62 design vehicles and occasional WB-67 vehicles with minor swinging wide at the end of the turn

Where possible, medians that are at least 6 feet wide may be designed to provide a safe refuge location for pedestrians. At signalized intersections, where medians are used as a pedestrian refuge, pedestrian push buttons should be used in the median where signal timing does not allow sufficient time for pedestrians to cross the entire roadway in one cycle. Barrier curb medians should not be used as a refuge for pedestrians.

The use of a 40 feet minimum length of opening without regard to the width of median, the cross road width, pedestrian traffic or the control radius should not be considered The 40 feet minimum length of opening does not apply to openings for U-turns except at very minor crossroads. Consult A Policy on Geometric Design of Highways and Streets, AASHTO, current edition, for the design of U-turn median openings.

On urban divided roadways, median openings for U-turns should not be provided. U-turn movements may be permitted at signalized intersections where there is sufficient pavement width to accommodate the movement. Provisions for U-turns should be made on rural divided roadways where intersections are spaced in excess of one half mile apart. Median widths in such cases should be at least 20 feet and desirably 30 feet to provide adequate protection for the vehicle executing the U-turn movement from the median. It is highly desirable to construct a median left-turn lane in advance of the U-turn opening to eliminate stopping on the through lanes.

FIGURE 6–I: GRASS MEDIAN OPENING



NOTES:
1. Where lane and shoulder pavement are different, use the minimum offsets shown above.
2. In no case shall the length of the median opening be less than 40 feet.
3. Provide 10 feet where there is a marked or unmarked pedestrian crosswalk. As an alternate, provide median cut through for pedestrian traffic.

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FIGURE 8–H:
GUIDE RAIL TREATMENT FOR CRITICAL EMBANKMENT SLOPES

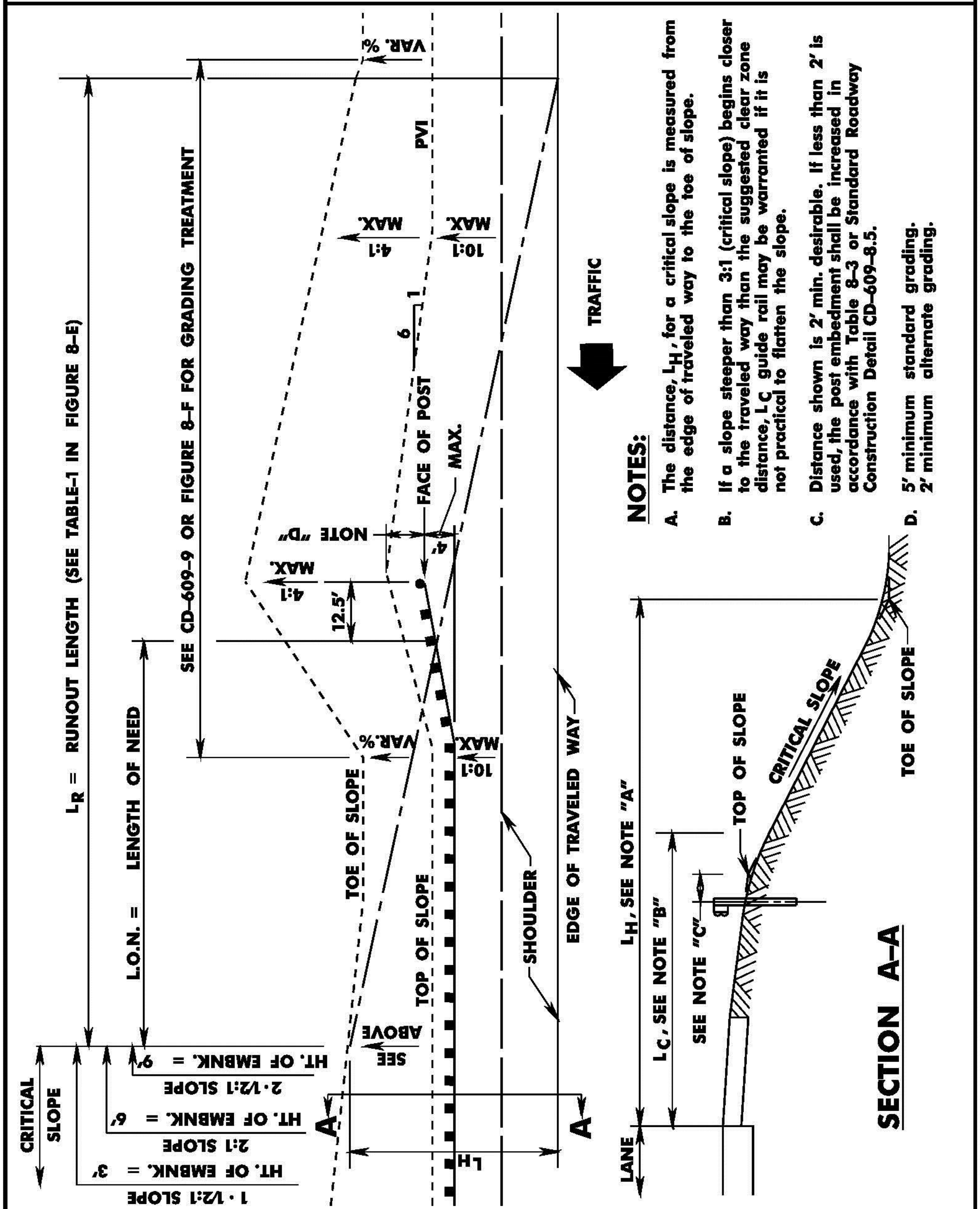

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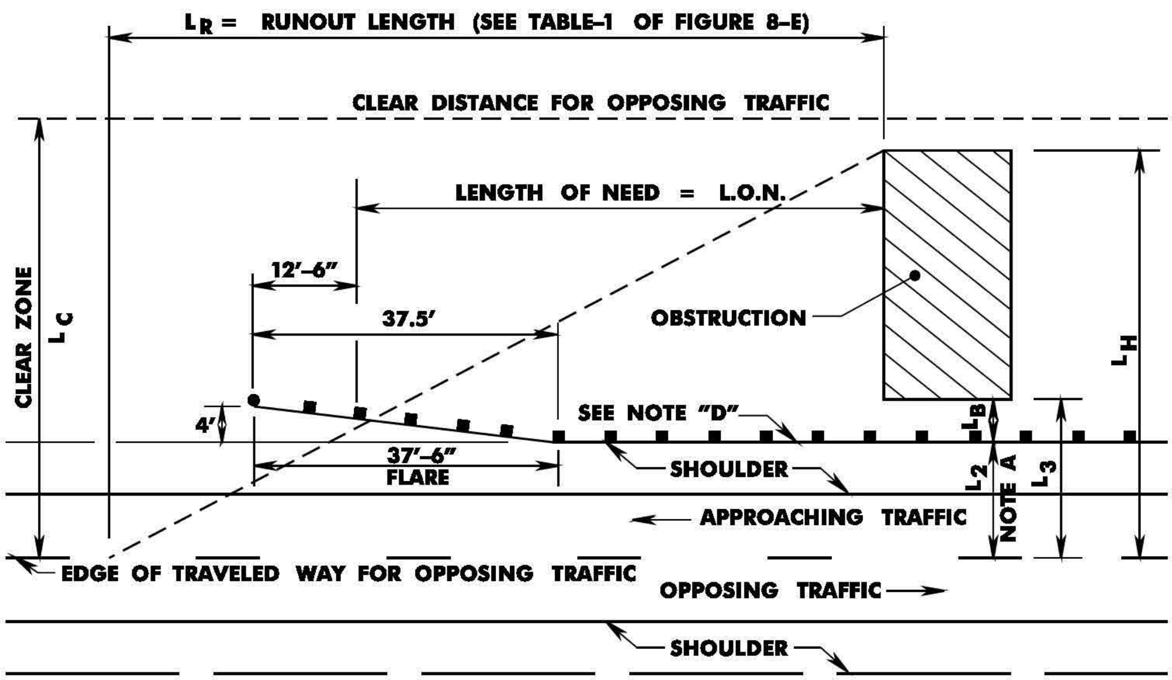
FIGURE 8–I: APPROACH LENGTH OF NEED OPPOSING TRAFFIC ON EMBANKMENT (FILL) SLOPES

STEP 1. $L_2 > L_C$:
If guide rail is outside the clear zone (L_C). No additional guide rail and no crashworthy end treatment is required: Therefore, use beam guide rail end anchorage as shown in the Standard Roadway Construction Detail CD–609–4.

STEP 2. $L_2 < L_C$ and $L_3 > L_C$:
If guide rail is within the clear zone, but the obstruction is beyond it, use a flared or tangent terminal with the minimum functional lengths shown in Table–2 in Figure 8–E.

STEP 3. $L_3 < L_C$:
If the obstruction is within the clear zone (L_C), see below. Use variables as shown below and Steps 1 through 4 as shown in Figure 8–E to determine the required L.O.N.



NOTES:

A. L_2 shall be measured from the outside edge of the approaching traffic lane where passing is permitted.

B. If there is a traversable median separating traffic, the median width should be included when determining L_2, L_3, and L_H for opposing traffic.

C. For a divided highway with a nontraversable median, use beam guide rail end anchorage, shown in the Standard Roadway Construction Detail CD–609–4.

D. See Standard Roadway Construction Detail CD–609–8 for required post spacing and double rail element requirements.

REV. DATE: JUNE 30, 2016

Section 13 - Ground Mounted Sign Supports

13.1 Introduction

Highway signs fall into two main categories, which are subdivided as follows:

1. Overhead Signs
   a. Sign Bridge Structures (GO)
   b. Sign Cantilever Structures (GO)
   c. Bridge Mounted (GOX)
2. Ground Mounted Signs
   a. Small Highway Signs (GA)
   b. Large Highway Signs (GA)

This section covers the design guidelines for Ground Mounted Sign Supports. These guidelines have been developed utilizing the 2011 AASHTO *A Policy on Geometric Design of Highways and Streets*, the 2009 AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, the 2011 AASHTO *Roadside Design Guide*, and the 2009 *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD).

Designers are to ensure that all new signs or those signs to remain in a project conform to the requirements of the 2012 Supplemental Guide Signing Manual. http://www.state.nj.us/transportation/eng/documents/BDC/pdf/SGSM2012.pdf

Design guidelines and standard drawings for overhead and cantilever signs are covered in the NJDOT *General Design Criteria and Standard Drawings for Overhead and Cantilever Sign Support Structures*, 2007.

The designer has four options from which to choose when locating signs within the highway right-of-way. These options are:

1. Locate the sign beyond the clear zone.
2. Mount the sign overhead.
3. Utilize a breakaway support to reduce impact severity
4. Shield the sign with a longitudinal barrier and/or crash cushion

Ground mounted signs should desirably be located beyond the clear zone. In addition, all ground mounted highway signs are to be installed on breakaway supports, unless otherwise indicated herein. When a small sign is located behind a traffic barrier (which is required for another reason), non-breakaway supports may be used. In cases where noise walls are required at a particular sign location, additional berm widths may be necessary.

In considering the above, it is critical that sign locations and the design of the sign support be considered early in the Initial Design Development Stage. Depending upon the size of the sign, additional right-of-way, or slope easements may be required (see Standard Roadway Construction Details CD-612-4 and CD-612-7 for grading details). Also, where sign supports must be shielded, sufficient area must be provided to accommodate guide rail, crash cushions, or other traffic barriers.

13.2 Small Highway Signs

Small highway signs are defined as those with total panel areas less than 50 square feet. When this category of sign is used, the design guidelines for its support shall be steel "U" post sign supports. Aluminum posts are not permitted for small highway signs. Small highway signs shall not be placed in front of guide rail, and the posts shall not straddle guide rail. All small highway sign supports shall be of the breakaway type with the exception of those installed behind guide rail or behind other traffic barriers.

For those signs included in the NJDOT Standard Roadway Construction Details (CD-612-1, 2 and 3), the contractor shall be responsible for determining the horizontal offset, the quantity of posts, the post size and their associated lengths by utilizing the information provided in Standard Roadway Construction Details CD-612-4.

For signs not included in the NJDOT Standard Roadway Construction Details, the designer shall be responsible for establishing all offsets, quantity of posts, post sizes and lengths by following the step-by-step design guidelines below:

Step 1 Once provided with the necessary panel size, determine the horizontal offset (X1) from edge of pavement to inside edge of sign, as shown in Figure 13-A, by applying Section 2A.19 of the MUTCD as follows:

a. Urban installations – In areas where lateral offsets are limited, a minimum lateral offset of 2 ft. is desirable. A minimum offset of 1 ft. from the face of the curb may be used in areas where the sidewalk width is limited or where existing poles are close to the curb.

b. Rural installations – 6 ft. minimum desirable from edge of shoulder, but 12 ft. minimum desirable from edge of traffic or auxiliary lane.

c. Interstate and Freeway installations – 6 ft. minimum from edge of shoulder, but not less than 12 ft. from the edge of traffic or auxiliary lane.

d. Ramp installations – 6 ft. minimum from edge of road.

e. Behind guide rail: 4 ft. minimum from back of beam guide rail element to sign post.

Step 2 When determining the height of ground mounted signs, the following checks should be made:

a. When signs are installed on slopes 10H:1V or flatter the minimum vertical clearance above the edge of pavement to bottom of the sign panel as shown in Figure 13-A is as follows:

(1) Sign Panels:

For single post installations, the minimum distance above the edge of pavement to the bottom of any panel must be 7 ft. and the minimum distance from edge of pavement to the top of any sign panel must be 9 ft.
For multi-post installations, the minimum distance above the edge of pavement to the bottom of a main sign panel must be 7 ft.

(2) Secondary Sign Panels:
For land service highways, the minimum distance above the edge of pavement to the bottom of a secondary sign panel is 6 ft.