CHAPTER THREE

BASIC DESIGN CONTROLS

Volume I

- Highway Design Guide –

National Standards

December 2004

Chapter Three

TABLE OF CONTENTS

Page

3-1 *HIGHWAY DESIGN GUIDE* APPLICATION 3-1

3-1.01 General 3-1
3-1.02 Definitions 3-1
3-1.03 Acronyms 3-2

3-2 HIGHWAY SYSTEMS 3-3

3-2.01 Functional Classification System 3-3
3-2.02 Federal-Aid System 3-3

3-3 TRAFFIC VOLUME CONTROLS 3-7

3-3.01 Definitions 3-7
3-3.02 Selection of Design Year and DHV 3-8
3-3.03 Capacity Analysis 3-8

3-4 SPEED (Definitions) 3-10

3-5 ACCESS CONTROL (Definitions) 3-11

3-6 PROJECT SCOPE OF WORK 3-12

3-7 CONTROLLING DESIGN CRITERIA/DESIGN EXCEPTIONS 3-15

3-7.01 Federal-Aid Projects 3-15
3-7.02 Internal Department Application 3-16
3-7.03 Documentation 3-17

Chapter Three
BASIC DESIGN CONTROLS

3-1 *HIGHWAY DESIGN GUIDE* APPLICATION

3-1.01 General

1. ***Project Types***. The *Guide* applies to all projects on State highways or the Federal-aid system regardless of the source of funding. The *Guide* also applies to all projects off the State highway or Federal-aid system when Federal-aid participation or State funding is involved.

2. ***Preparation of Plans***. The *Guide* will be used by the Maine Department of Transportation, consultants retained by the Department, local governments and private developers for the preparation of plans for all projects to which the *Guide* applies.

3-1.02 Definitions

Many qualifying words are used in highway design and in this *Guide*. For consistency and uniformity in the application of various design criteria, the following definitions apply:

1. ***Shall, require, will, must***. A mandatory condition. Designers are obligated to adhere to the criteria and applications presented in this context. Generally, these statements are not included in this *Guide* for the application of geometric design and roadside safety criteria.

2. ***Should, recommend***. An advisory condition. Designers are encouraged to follow the criteria and guidance presented in this context, unless there is justification not to do so.

3. ***May, could, can, suggest, consider***. A permissive condition. Designers are allowed to apply individual judgment and discretion to the criteria when presented in this context. The decision will be based on a case-by-case assessment.

4. ***Desirable, preferred***. An indication that the designer should make an effort to meet the criteria

5. ***Minimum, maximum, upper, lower***. Representative of the limits of acceptability, although not implying that they are inviolable. Where the criteria presented in this context will not be met, the designer will in many cases need to request approval.

6. ***Practical, feasible, cost-effective, reasonable***. The designer will apply the design criteria based on a subjective analysis of the relative benefits and costs associated with the impacts of the decision. No formal analysis is intended, unless otherwise indicated.

7. ***Significant, major***. Indicating that the consequences from a given action are obvious to most observers and, in most cases, can be readily measured.

8. ***Warranted***. Indicating that some accepted threshold or set of conditions has been met. As used in this *Guide*, "warranted" may apply to either objective or subjective evaluations. When the "warranting" criteria have been met, this indicates that the designer should consider implementing the recommended treatment; meeting the "warranting" criteria does not indicate that the treatment is required.

3-1.03 Acronyms

The following acronyms are used throughout this *Guide*:

1. ***AASHTO***. American Association of State Highway and Transportation Officials.

2. ***FHWA***. Federal Highway Administration.

3. ***TRB***. Transportation Research Board.

4. ***MUTCD***. *Manual of Uniform Traffic Control Devices*.

5. ***NCHRP***. National Cooperative Highway Research Program.

6. ***HCM***. *Highway Capacity Manual*.

7. ***FEMA***. Federal Emergency Management Administration

3-2 HIGHWAY SYSTEMS

3-2.01 Functional Classification System

Functional classification is the grouping of highways by the character of service they provide. The two primary factors in functionally classifying highways and streets are access to property and travel mobility. The geometric design criteria and procedures presented in this *Guide* are based on the functional classification system, which includes the following:

1. ***Freeways***. The freeway is the highest level of arterial. These facilities are characterized by full control of access, high design speeds and a high level of driver comfort and safety.

2. ***Arterials***. Arterial highways are characterized by high-volume roadways which provide linkage between major cities and towns and developed areas, capable of attracting travel over long distances. Basically, they provide service to interstate and intercounty travel demand. The arterial system typically provides for high travel speeds and the longest trip movements. The degree of access control on an arterial may range from full control (freeways) to entrance control on, for example, an urban arterial through a densely developed commercial area.

3. ***Collectors***. Collector routes are characterized by a roughly even distribution of their access and mobility functions. These routes gather traffic from lesser facilities and deliver it to the arterial system. Traffic volumes and speeds will typically be lower than those of arterials.

4. ***Local Roads and Streets***. All public roads and streets not classified as arterials or collectors will have a local classification. Local roads and streets are characterized by many points of direct access to adjacent properties and have a relatively minor role in accommodating mobility. Speeds and traffic volumes are usually low.

3-2.02 Federal-Aid System

The Federal-aid system consists of those routes within Maine which are eligible for the categorical Federal highway funds. The Department, working with the local governments and in cooperation with FHWA, has designated the eligible routes. United States Code, Title 23, describes the applicable Federal criteria for establishing the Federal-aid system.

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 implemented a major realignment of the Federal-aid system. The following sections briefly describe the Federal-aid system created by ISTEA. Figure 3-1 summarizes the system and ISTEA funding eligibility.

National Highway System

The National Highway System (NHS) is a system of those highways determined to have the greatest national importance to transportation, commerce and defense in the United States. It consists of the Interstate highway system, logical additions to the Interstate system, selected other principal arterials, and other facilities which meet the requirements of one of the subsystems within the NHS. Specifically, the NHS includes the following subsystems (note that a specific highway route may be on more than one subsystem):

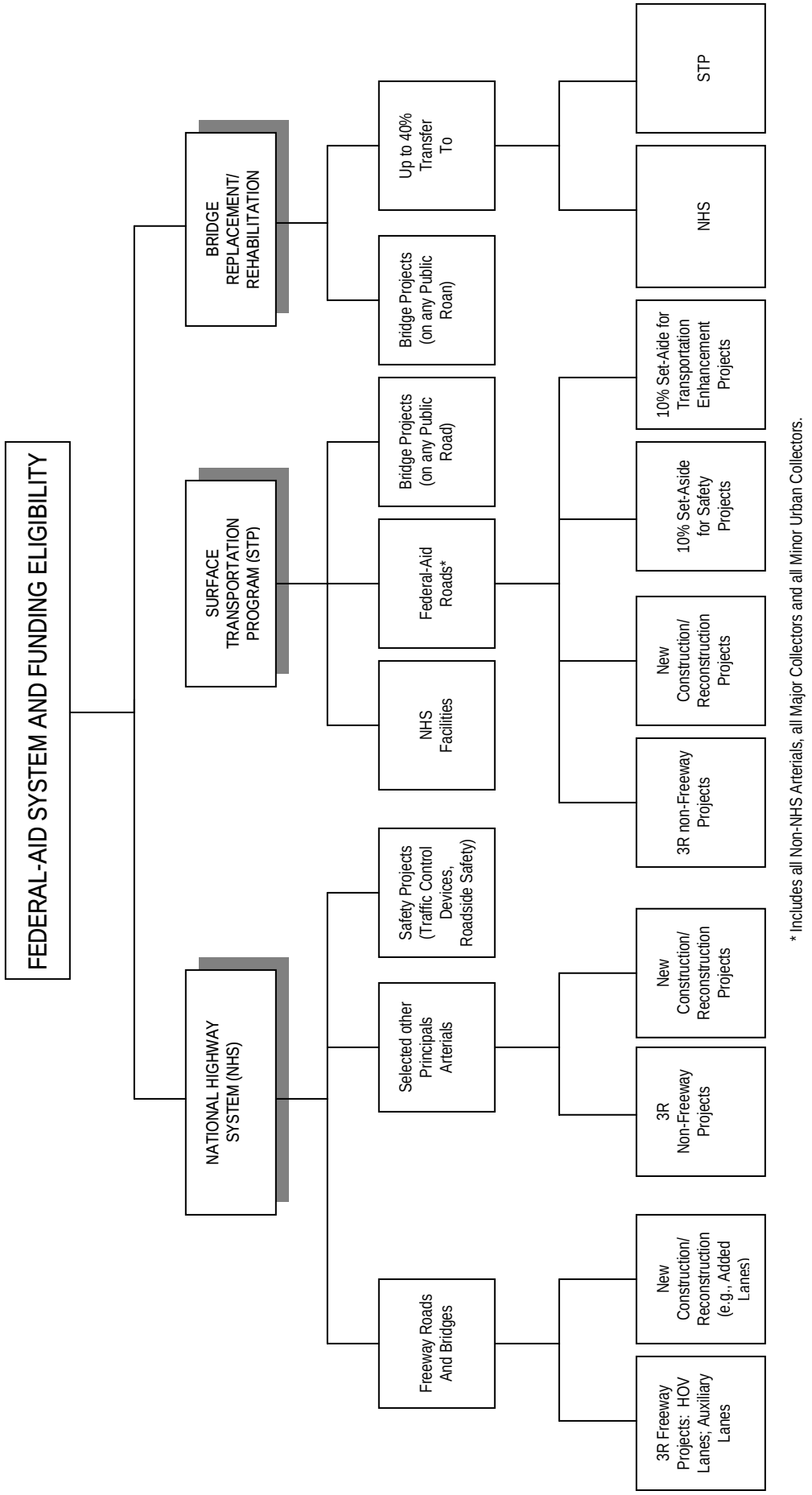
1. ***Interstate.*** The current Interstate system of highways retains its separate identity within the NHS. There are also provisions to add kilometers to the existing Interstate subsystem.

2. ***Other Principal Arterials***. These are highways in rural and urban areas that provide access between an arterial and a major port, airport, public transportation facility or other intermodal transportation facility.

3. ***Strategic Highway Network.*** This is a network of highways that are important to the United States' strategic defense policy and which provide defense access, continuity and emergency capabilities for defense purposes.

4. ***Major Strategic Highway Network Connectors***. These are highways that provide access between major military installations and highways which are part of the Strategic Highway Network.

To properly manage the NHS, the FHWA has mandated that each State highway agency develop and implement several management systems for those facilities on the NHS. These include management systems for pavements, bridges, traffic monitoring, congestion and safety.



* Includes all Non-NHS Arterials, all Major Collectors and all Minor Urban Collectors.

Note: This is the Federal-Aide system as established by the Intermodal Surface Transportation Efficiency Act of 1991

FEDERAL-AID SYSTEM

Figure 3-1

Surface Transportation Program

The Surface Transportation Program (STP) is a category of Federal-aid funds for any public road not functionally classified as a minor rural collector or a local road or street. The STP replaced a portion of the former Federal-aid primary system and replaced all of the former Federal-aid secondary and urban systems, and it includes some collector routes which were not previously on any Federal-aid system. Collectively, these are called Federal-aid Roads. In addition, bridge projects using STP funds are not restricted to Federal-aid roads but may be used on any public road. Transit capital projects are also eligible under the STP program.

The basic objective of the STP is to provide Federal funds for improvements to facilities not considered to have significant national importance with a minimum of Federal requirements for funding eligibility.

Bridge Replacement and Rehabilitation Program

Because of the nationwide emphasis on bridges, the Bridge Replacement and Rehabilitation Program (BRRP) has retained its separate identity within the Federal-aid program. BRRP funds are eligible for work on any bridge on a public road regardless of its functional classification.

3-3 TRAFFIC VOLUME CONTROLS

3-3.01 Definitions

1. ***Average Annual Daily Traffic (AADT).*** The total yearly volume in both directions of travel divided by the number of days in the year.

2. ***Average Daily Traffic (ADT).*** The traffic volume in both directions of travel in a time period greater than one day and less than one year divided by the number of days in that time period. Although incorrect, ADT is sometimes used interchangeably with AADT.

3. ***Design Hourly Volume (DHV).*** The one-hour volume in both directions of travel in the design year selected for determining the highway design. The DHV is typically the 30th highest hourly volume within the design year.

4. ***Level of Service (LOS).*** A qualitative concept which has been developed to characterize acceptable degrees of congestion. In the *Highway Capacity Manual*, the qualitative descriptions of each level of service (A to F) have been converted into quantitative measures for the capacity analysis for each highway element. This includes:

   a. freeway mainline segments,
   b. weaving areas,
   c. freeway mainline/ramp junctions,
   d. freeway ramps,
   e. two-lane, two-way rural highways,
   f. multilane rural highways (other than freeways),
   g. signalized intersections,
   h. unsignalized intersections, and
   i. urban/suburban arterials.

5. ***Capacity.*** The maximum number of vehicles which can reasonably be expected to traverse a point or uniform section of a road during a given time period under prevailing roadway, traffic and control conditions. The time period most often used for analysis is 15 minutes. "Capacity" technically corresponds to LOS E.

6. ***Directional Distribution (D).*** The division, by percent, of the traffic volume in each direction of travel during the DHV, ADT or AADT.

7. ***Traffic Composition (T).*** A factor which reflects the percentage of heavy vehicles (trucks, buses and recreational vehicles) in the traffic stream during the DHV, ADT or AADT.
8. ***(Design) Service Flow Rate.*** The maximum hourly vehicular volume which can pass through a highway element at the selected level of service. The basic intent of a highway capacity analysis is to ensure that the DHV does not exceed the calculated design service volume of the highway element when considering the prevailing roadway, traffic and control conditions.

9. ***Density***. The number of vehicles occupying a given length of lane, averaged over time. It is usually expressed as vehicles per mile per lane (vpmpl).

10. ***Peak-Hour Traffic***. The highest number of vehicles found to be passing through a highway element during 60 consecutive minutes.

11. ***Peak-Hour Factor (PHF).*** A ratio of the volume occurring during the peak hour to the maximum rate of flow during a given time period within the peak hour. Typically, this is 15 minutes.

3-3.02 Selection of Design Year and DHV

A highway should be designed to accommodate the traffic volumes that might occur within the life of the facility under reasonable maintenance. This involves projecting the traffic conditions for a selected future year. Recommended design years based on the project scope of work are presented in Table 3-1. These are measured from the expected construction completion date.

3-3.03 Capacity Analysis

The highway mainline, intersection or other highway element should be designed to accommodate the design hourly volume (DHV) at the selected level of service. This involves adjusting the various highway factors which affect capacity until the proposed design has a design service flow rate which equals or exceeds the DHV.

Chapter Seven presents the criteria for level of service (LOS) for new construction and reconstruction projects based on functional class and urban/rural location. Chapter Eleven provides LOS criteria for 4R freeway projects, rehabilitation non-freeway projects and restoration/resurfacing non-freeway projects. The LOS and DHV should be used with the detailed methodologies and procedures in the *Highway Capacity Manual* to conduct the capacity analysis

Project Scope of Work	Design Year[1]
New Construction/Reconstruction (All Functional Classes)	20 Years
4R Freeway	20 Years
Rehabilitation (non-freeway)	20 Years
Restoration/Resurfacing (non-freeway)	10 Years

[1] Design year is measured from the expected construction completion date.

RECOMMENDED PROJECT DESIGN YEAR
(Capacity Analyses)

Table 3-1

3-4 SPEED (Definitions)

1. ***Design Speed***. Design speed is the maximum safe speed that can be maintained over a specified section of highway when conditions are so favorable that the design features of the highway govern. The assumed design speed should be a logical one with respect to the topography, the adjacent land use and the functional classification of highway. Chapter Seven presents the design speed criteria for new construction and reconstruction projects. Chapter Eleven provides the design speed criteria for 4R freeway projects, rehabilitation non-freeway projects and restoration/resurfacing non-freeway projects.

   In addition, for new construction/reconstruction projects, the selected design speed should equal or exceed the anticipated posted/ regulatory speed limit of the facility after construction. See Chapter Eleven for a discussion on the relationship between design speed and posted speed limit for 3R projects on non-freeways.

2. ***Running Speed***. Running speed is the average speed of a vehicle over a specified section of highway. It is equal to the distance traveled divided by the running time (the time the vehicle is in motion). The average running speed is the distance summation for all vehicles divided by the running time summation for all vehicles.

3. ***85th-Percentile Speed***. The 85th-percentile speed is the speed below which 85 percent of the vehicles travel on a given highway. The most common application of the value is its use as one of the factors for determining the posted, legal speed limit of a highway section. In most cases, the field measurements for the 85th-percentile speed will be conducted during off-peak hours.

4. ***Posted Speed Limit***. The posted speed limit is based on an engineering and traffic investigation conducted after each Department project is completed. The Traffic Engineering Division within the Bureau of Maintenance and Operations conducts the study on all public roads. The selection of a posted speed limit is based on several factors, although the 85th-percentile speed will usually serve as the maximum speed limit.

3-5 ACCESS CONTROL (Definitions)

Access control is the condition where the government exercises its authority to control the right of abutting owners to have access to and from the public highway. The following definitions apply:

1. ***Controlled Access***. A controlled access highway is one on which priority is given to through traffic by providing access only at grade separation interchanges with selected public roads. Abutting property owners have no right of direct access. The freeway is the most common type of controlled access highway.

2. ***Limited Access.*** A limited access highway is one on which priority is given to through traffic, but a few at-grade intersections and private driveway connections may be allowed.

3. ***Entrance Control.*** Entrance control, or control by regulation, is exercised by the Department or other public agency to determine where private interests may have access to and from the public road system. Abutting property owners are permitted access to the street or highway; however, the location, number and geometrics of the access points will be governed by driveway and entrance policies. Driveway design criteria are discussed in detail in Chapter Eight.

3-6 PROJECT SCOPE OF WORK

The project scope of work will reflect the basic intent of the highway project and will determine the overall level of highway improvement. This will be documented in the Transportation Investment and Planning Report. This decision will determine which criteria in the *Maine Highway Design Guide* apply to the project. The following descriptions are intended to provide general definitions for the project scope of work.

1. ***New Construction on New Location (All Functional Classes).*** New horizontal and vertical alignment on new location is considered new construction. The tables of geometric design criteria in Chapter Seven provide the basic criteria for new construction.

2. ***Reconstruction (Non-Freeways).*** One of the primary factors which will characterize this scope of work will be the extent of the improvements to the pavement structure. If a new pavement structure (from the subgrade up) will be constructed for more than half of the project length, this will typically be considered a reconstruction project. Reconstruction of an existing non-freeway may also include significant drainage improvements, the addition of travel lanes and/or significant changes to the existing horizontal and vertical alignment, but essentially within the existing highway corridor. These projects will often require right-of-way acquisitions.

   The primary reason to perform reconstruction is that the existing facility (e.g., its pavement structure or traffic capacity) cannot accommodate its current or future traffic demands or because the existing alignment is deficient. Because of the level of work for reconstruction, the design of the project should be determined by the criteria for new construction. Therefore, the tables in Chapter Seven will apply.

3. ***3R Projects (Non-Freeways)***. 3R (rehabilitation, restoration and resurfacing) projects are primarily intended to extend the service life of the existing facility and to enhance highway safety. In addition, 3R projects should make improvements to the existing geometrics, where practical. 3R work on an existing non-freeway is work essentially within the existing alignment. Right-of-way acquisition will usually be limited takings, easements and grading rights. Typical improvements for 3R projects may include:

   a. pavement resurfacing, pavement rehabilitation or pavement reconstruction (up to half of project length);

   b. lane and shoulder widening;

   c. flattening an occasional horizontal or vertical curve;

d. widening the roadside clear zone;

e. flattening side slopes;

f. converting an existing median to a continuous two-way left-turn (CTWLT) lane;

g. adding a truck-climbing lane;

h. revising the location, spacing or design of existing entrances along the mainline;

i. adding or removing parking lanes;

j. adding curbs and islands for entrance control and sidewalks;

k. relocating utility poles;

l. upgrading guardrail to meet current safety criteria;

m. drainage improvements; and/or

n. intersection improvements (e.g., adding turn lanes, flattening turning radii, channelization, corner sight distance improvements, etc.).

For the application of geometric design criteria, 3R projects are subdivided as follows:

a. Rehabilitation. These projects may involve significant improvements to the pavement structure, including a new pavement structure (from the subgrade up) for up to half of the project length. In general, rehabilitation projects warrant the consideration of more significant improvements to the geometric design than restoration/resurfacing projects.

b. Restoration/Resurfacing. These projects are usually intended to resurface, restore or rehabilitate the existing pavement. Geometric design improvements are usually only included to correct obvious deficiencies on the existing highway.

Chapter Eleven presents the Department's geometric design criteria for 3R non-freeway projects.

4. ***4R Projects (Freeways)*.** 4R projects (resurfacing, restoration, rehabilitation and/or reconstruction) on existing freeways are primarily intended to extend the service life of

the existing facility, to enhance highway safety and to make improvements to the existing geometrics, where practical. Typical improvements for 4R projects may include:

a. pavement resurfacing, rehabilitation or reconstruction;
b. widening the roadside clear zone;
c. flattening side slopes;
d. improvements to interchange gore areas;
e. regrading median ditch plugs;
f. upgrading guardrail to meet current safety criteria;
g. drainage improvements;
h. addition of travel lanes or auxiliary lanes;
i. flattening a horizontal or vertical curve;
j. lengthening existing acceleration or deceleration lanes;
k. realigning or widening an existing ramp; and/or
l. upgrading signing to meet current MUTCD criteria.

Chapter Eleven presents the Department's criteria for 4R freeway projects.

5. ***Spot Improvements (Non-Freeways).*** Spot improvements are intended to correct an identified deficiency at an isolated location. The deficiency may be related to structural, geometric, safety, drainage or traffic control problems. These projects are not intended to provide a general upgrading of the highway, as are projects categorized as new construction, reconstruction, 3R or 4R. Two types of spot improvements are:

a. safety improvements at isolated locations, and

b. bridge improvement projects funded by the Highway Bridge Replacement and Rehabilitation Program.

Chapter Eleven discusses the Department's criteria for the geometric design of spot improvement projects.

3-7 CONTROLLING DESIGN CRITERIA/DESIGN EXCEPTIONS

3-7.01 Federal-Aid Projects

The FHWA has identified "controlling" design criteria for all Federal-aid projects on the National Highway System (NHS). These criteria are for those highway design elements which are judged to be the most critical indicators of a highway's safety and its overall serviceability. The following presents the controlling design criteria:

1. design speed,
2. lane widths,
3. shoulder width
4. cross slopes,
5. bridge widths,
6. structural capacity,
7. horizontal alignment,
8. superelevation
9. stopping sight distance,
10. vertical alignment,
11. maximum grades,
12. minimum vertical clearances;
13. horizontal clearance.

Any controlling design element in an applicable project which does not meet the Department's criteria must be approved as a design exception by FHWA. This only applies to Federal-aid projects on the NHS; it does not, for example, apply to STP-funded projects not on the NHS. However, it will be necessary to obtain an internal Department exception on projects where FHWA approval is not required.

A special note is necessary for the application of the stopping sight distance (SSD) criteria to, for example, horizontal and vertical curves. Section 4-1.01 presents SSD criteria for freeways (Table 4-1) and for non-freeways (Table 4-2). These tables present SSD values corrected for grade. However, for the purpose of identifying the "controlling" criteria, the level SSD value will be used. Therefore, the design exception process will only apply when the proposed design does not provide at least the level SSD value at, for example, a crest vertical curve.

Chapters Seven and Eleven present the Department's tables of geometric design criteria for all project scopes of work, functional classes and urban/rural location. The designer will note that the FHWA controlling design criteria are designated by an asterisk in each table. This provides a convenient summarization of the numerical criteria which apply to a project under design.

3-7.02 Internal Department Application

The *Urban and Arterial Highway Design Guide* presents criteria on many aspects of highway design in addition to the FHWA controlling design criteria. In general, designers are responsible for meeting all design criteria in the *Guide* considering, of course, the practicality of their application to a project or specific site. In addition, where desirable and minimum values are presented, the designer should provide the desirable values if reasonable; the minimum values should only be used where the desirable values cannot be obtained without unreasonable impacts.

Section 3-7.01 presents the list of controlling design criteria. Where a proposed project will not meet the Department's criteria for one or more of these elements, the following procedure will apply:

1. The Project Manager will prepare a written justification explaining why the Department's criteria will not be met.

2. The Program Manager will review and, if in agreement, approve the proposed design.

This procedure applies to all projects whether or not FHWA approval is required.

Where the proposed project design will not meet the Department's criteria in the *Highway Design Guide* for design elements other than controlling design criteria, the designer should discuss this informally with his/her Project Team and gain the Team's verbal approval. On consultant-designed projects where the Department's criteria will not be met, the consultant's project designer will notify the Department informally and gain the Department's verbal approval. This will be addressed as part of the consultant's normal project coordination activities with the Department.

3-7.03 Documentation

See Table 3-2 for the Department's requirements for documenting the applicable design criteria for a proposed project (Form HD-06).

HIGHWAY DESIGN DOCUMENTATION REQUIREMENTS
(Form HD-06)

PROJECT LOCATION: _____ ROUTE: _____

P.I.N.:_____ DESIGNER:_____

GIVEN

SCOPE: ___ New Construction/Reconstruction ___ Rehabilitation
Restoration/Resurfacing ___ 4R ___ Spot

DESIGN CRITERIA: ___ National Highway ___ State

FUNCTIONAL CLASS: ___ Urban ___ Rural
Freeway ___ Arterial ___ Collector ___ Local

V_{posted} (m/h) = ___ AADT = _____ DHV = _____ 18 kip = _____

REQUIRED

	Design	Minimum	Maximum
V (m/h) =	_____	_____	_____
Slope $_{T.L.}$ =	_____	_____	_____
*W_{lane} (ft) =	_____	_____	_____
*$W_{shoulder}$ (ft) =	_____	_____	_____
R_{min} =	_____	_____	_____
e =	_____	_____	_____
SSD (ft) =	_____	_____	_____
G_{max}(%) =	_____	_____	_____
V.Cl. =	_____	_____	_____

COMMENTS

_____

_____

_____

_____

_____

_____

* Check for any corridor requirements and/or history that may govern widths.

Table 3-2