SECTION 2

GENERAL DESIGN CRITERIA

2-01 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.

2-02 HIGHWAY CLASSIFICATION

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 futher description of the classification process, see *Highway Functional Classification: Concepts, Criteria and Procedures*, USDOT, FHWA, revised March 1989.

2-02.1 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:

1. <u>Interstate system</u> - all presently designated routes of the Interstate System.

2. <u>Other principal arterials</u> - all non-Interstate principal arterials.

"Other principal arterial" highways may be freeways, expressways or land service highways (see types of 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. 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 travelling 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.

2-02.2 Minor Arterial Highways

Minor arterial highways interconnect with and augment the principal highway system. In urban areas, minor arterial highways are ususally 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. Because of the high speeds, access to abutting property should be either controlled or carefully regulated.

2-02.3 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:

1. 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.

2. Minor collectors - Serve smaller places and towns and connect locally important traffic generators. These roads usually will not be on a federal aid system.

2-02.4 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 67% of total road mileage, but only 20% of total vehicular miles travelled.

2-03 DESIGN CONTROLS

2-03.1 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:

1. Primary Controls

   - Highway Classification
   - Topography and Physical Features
   - Traffic

2. Secondary controls

   - Design Speed
   - Design Vehicle
   - Capacity

2-03.2 Primary Controls

1. 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.

2. 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.

3. 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 loadpower 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 The 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 The design speed in miles per hour.

2-03.3 Secondary Controls

1. Design Speed

"Design Speed" is a speed determined for design and correlation of the physical features of a highway that influence vehicle operation. It 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 character of terrain and the type highway. For through roads, every effort should be made to use as high a design speed as practicable to attain a desired degree of safety, mobility and efficiency. Once selected, all the pertinent features of the highway should be related to it to obtain a balanced design. Some features, such as curvature, superelevation, and sight distance are directly related to and vary appreciably with, design speed. Other features, such as widths of pavements and shoulders, and clearances to walls and rails, are not directly related to design speed, but they affect vehicle speed, and higher standards should be accorded these features for the higher design speeds. Thus, nearly all design elements of the highway are subject to increase or decrease with a change in design speed.

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.

On new highways or highways on new alignment, the design speed must be 10 mph greater than the posted speed or anticipated posted speed on the highway under design. On existing highways, the design speed must be a minimum of 5 mph greater than the posted speed and desirably should be 10 mph greater than the posted speed.

2. 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 established highway design controls to accommodate vehicles of a designated type. The symbols and dimensions of design vehicles are shown in Table 2-1.

Table 2-1

Design Vehicles
(Dimensions in Feet*)

Design Vehicle		Wheel Base	Overhang		Overall	
Type	Symbol		Front	Rear	Length	Width
Passenger Car	P	11	3	5	19	7
Single Unit Truck	SU	20	4	6	30	8.5
Single Unit Bus	BUS	25	7	8	40	8.5
Articulated Bus	A-BUS	18	8.5	9.5	60	8.5
Semitrailer Intermediate	WB-40	13+27=40	4	6	50	8.5
Semitrailer Large	WB-50	20+30=50	3	2	55	8.5
Semitrailer Interstate	WB-**62**	20+**(40 to 42)=60 to 62**	**3**	3	**69**	8.5
Semitrailer Full Trailer Combination	WB-60	9.7+20+9.4+ 20.9=60	2	3	65	8.5

Source: *A Policy on Geometric Design of Highways and Streets*, **1990**

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

3. Capacity

a. 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:

(1) 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 undersirable congestion on the highway system.

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

(3) For highway design purposes.

b. Level of Service

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.

(1) Speed and travel time
(2) Traffic interruptions or restrictions
(3) Freedom to maneuver
(4) Safety
(5) Driving comfort and convenience
(6) 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:

(1) 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, and drivers can maintain their desired speeds with little or no delay.

(2) 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.

(3) 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.

(4) 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.

(5) 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 30 mph. flow is unstable, and there may be stoppages of momentary duration.

(6) 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 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 *1985 Highway Capacity Manual* for a thorough discussion on the level of service concept.

c. 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:

(1) Level of service selected;
(2) Width of lanes;
(3) Number of lanes;
(4) Presence or absence of shoulders;
(5) Grades;
(6) Horizontal alignment;
(7) Operating speed;
(8) Lateral clearance;
(9) Side friction generated by parking, driveways, intersections, and interchanges;
(10) Volumes of trucks, buses, and recreational vehicles;
(11) 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 *Highway Capacity Manual* published by the Transportation Research Board in 1985 and AASHTO *A Policy on Geometric Design of Highways and Streets*, **1990.**

V O I D

Table 2-2

General Design Controls for Urban Streets and Highways

Highway Type	Arterial	Collector	Local
Design Speed, MPH	30-60	30-60	20-30
Level of Service	C	C	-----
Design Vehicle	SU; WB-50	SU; WB-50	SU
Design Traffic Projections	20 yrs. New Alignment; 10 yrs. Resurfacing	20 yrs. New Alignment; 10 yrs. Resurfacing	20 yrs. New Alignment; 10 yrs. Resurfacing
Number of Lanes	2 to 8	2 to 4	2
Lane Width, Feet	12 Desirable 11 Minimum	12 Desirable 10 Minimum	12 Desirable 10 Minimum
Median Width (Where Applicable)	8' Minimum w\ barrier; 32' Minimum w\o barrier	16' minimum	----
Right Shoulder Width	8' to 12'	----	----
Left Shoulder Width	3'to 5' (4 Lanes); 10' (6 to 8 Lanes)	3' to 5'	----
Superelevation, Maximum Percent	6	6	4
Curve Radius	Fig. 4-B	Fig. 4-B	Fig. 4-C
Stopping Sight Distance	Table 4-1	Table 4-1	Table 4-1
Passing Sight Distance	Table 4-1	Table 4-1	Table 4-1
Profile Grade, Maximum Percent	5 Level 6 Rolling 8 Mountain	6 Level 7 Rolling 9 Mountain	7 Level 10 Rolling 14 Mountain

V O I D

Table 2-3

General Design Controls for Rural Roads and Highways

Highway Type	Arterial	Collector	Local
Design Speed, MPH	50-70	30-60	20-50
Level of Service	B	C	----
Design Vehicle	SU; WB-50	SU; WB-50	SU
Design Traffic Projections	20 yrs. New Alignment; 10 yrs. Resurfacing	20 yrs. New Alignment; 10 yrs. Resurfacing	20 yrs. New Alignment; 10 yrs. Resurfacing
Number of Lanes	2 to 6	2 to 4	2
Lane Width, Feet	12 Desirable 11 Minimum	12 Desirable 10 Minimum	12 Desirable 10 minimum
Median Width (Where Applicable)	46' Desirable	36' Desirable	----
Right Shoulder Width	8' to 12'	4' to 8'	2'to 8'
Left Shoulder Width	3'to 5' (4 Lanes); 10' (6 lanes)	5'	----
Superelevation, Maximum Percent	6	6	6
Curve Radius	Fig. 4-B	Fig. 4-B	Fig. 4-B
Stopping Sight Distance	Table 4-1	Table 4-1	Table 4-1
Passing Sight Distance	Table 4-1	Table 4-1	Table 4-1
Profile Grade, Maximum Percent	3 Level 4 Rolling 6 Mountain	5 Level 6 Rolling 8 Mountain	6 Level 8 Rolling 10 Mountain

V O I D

Table 2-4

General Design Controls for Interstate and Freeways

Location	Urban	Rural
Design Speed, MPH	50-70	70
Level of Service	C	B
Design Vehicle	SU;WB-60	SU; WB-60
Design Traffic Projections	20 yrs. New Alignment; 10 yrs. Resurfacing	20 yrs.New Alignment; 10 yrs. Resurfacing
Number of Lanes	4 to 8	4 to 6
Lane Width, Feet	12	12
Median Width (Where Applicable)	**46' Desirable for Future Expansion, 22' Desirable for No Expansion**	**84' Desirable for Future Expansion, 60' Desirable for No Expansion**
Right Shoulder Width	12'	12'
Left Shoulder Width	5' (4 lanes); 10' (6 to 8 lanes)	5 (4 lanes); 10' (6 to 8 lanes)
Superelevation, Maximum Percent	6	6
Curve Radius	Fig. 4-B	Fig. 4-B
Stopping Sight Distance	Table 4-1	Table 4-1
Profile Grade, Maximum Percent	3 level 4 Rolling 5 Mountain	3 level 4 Rolling 5 Mountain