# CHAPTER 1
# HIGHWAY FUNCTIONS

## SYSTEMS AND CLASSIFICATIONS

The classification of highways into different operational systems, functional classes, or geometric types is necessary for communication among engineers, administrators, and the general public. Different classification schemes have been applied for different purposes in different rural and urban regions. Classification of highways by design types based on the major geometric features (e.g., freeways and conventional streets and highways) is the most helpful one for highway location and design procedures. Classification by route numbering (e.g., U.S., State, County) is the most helpful for traffic operations. Administrative classification (e.g., National Highway System or Non-National Highway System) is used to denote the levels of government responsible for, and the method of financing, highway facilities. Functional classification, the grouping of highways by the character of service they provide, was developed for transportation planning purposes. Comprehensive transportation planning, an integral part of total economic and social development, uses functional classification as an important planning tool. The emergence of functional classification as the predominant method of grouping highways is consistent with the policies contained in this publication.

## THE CONCEPT OF FUNCTIONAL CLASSIFICATION

This section introduces the basic concepts needed for understanding the functional classification of highway facilities and systems.

### Hierarchies of Movements and Components

A complete functional design system provides a series of distinct travel movements. The six recognizable stages in most trips include main movement, transition, distribution, collection, access, and termination. For example, Exhibit 1-1 shows a hypothetical highway trip using a freeway, where the main movement of vehicles is uninterrupted, high-speed flow. When approaching destinations from the freeway, vehicles reduce speed on freeway ramps, which act as transition roadways. The vehicles then enter moderate-speed arterials (distributor facilities) that bring them nearer to the vicinity of their destination neighborhoods. They next enter collector roads that penetrate neighborhoods. The vehicles finally enter local access roads that provide direct approaches to individual residences or other terminations. At their destinations the vehicles are parked at an appropriate terminal facility.

Each of the six stages of a typical trip is handled by a separate facility designed specifically for its function. Because the movement hierarchy is based on the total amount of traffic volume, freeway travel is generally highest in the movement hierarchy, followed by distributor arterial travel, which is in turn higher in the movement hierarchy than travel on collectors and local access routes.

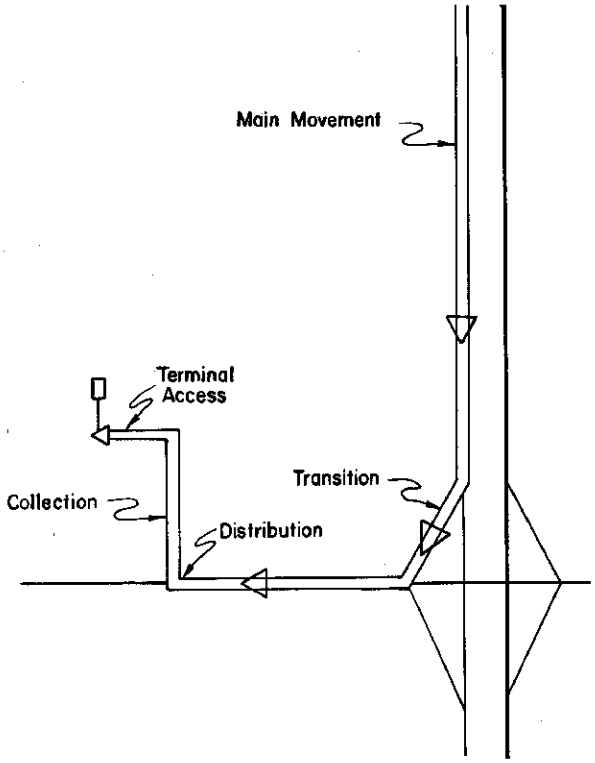


**Exhibit 1-1. Hierarchy of Movement**

Although many trips can be subdivided into all of the six recognizable stages, intermediate facilities are not always needed. The complete hierarchy of circulation facilities relates especially to conditions of low-density suburban development, where traffic flows are cumulative on successive elements of the system. However, it sometimes is desirable to reduce the number of components in the chain. For instance, a large single traffic generator may fill one or more lanes of a freeway during certain periods. In this situation, it is expedient to lead traffic directly onto a freeway ramp without introducing arterial facilities that unnecessarily mix already-concentrated traffic flows with additional vehicles. This deletion of intermediate facilities does not eliminate the functional need for the remaining parts of the flow hierarchy or the functional design components, although it may change their physical characters. The order of movement is still identifiable.

The failure to recognize and accommodate by suitable design each of the different trip stages of the movement hierarchy is a prominent cause of highway obsolescence. Conflicts and congestion occur at interfaces between public highways and private traffic-generating facilities when the functional transitions are inadequate. Examples are commercial driveways that lead directly from a relatively high-speed arterial into a parking aisle without intermediate provisions for transition deceleration and arterial distribution or, more seriously, freeway ramps that lead directly into or from large traffic generators such as major shopping centers.

Inadequate acceptance capacity of the distributor arterial or internal circulation deficiencies within the traffic absorber may lead to traffic backing up onto the freeway. Successful internal design that provides facilities to accommodate all the intermediate functions between the high-speed freeway and the terminal parking facility will alleviate such a situation.

In the case of the freeway leading to a large traffic generator, deceleration from rapid movement on the freeway occurs on the exit ramp. Distribution to various parking areas is then accomplished by primary distribution-type roads or lanes within the parking facility. These roads or lanes supplant the distributor arterial function. Collector-type roads or lanes within the parking facility may then deliver segments of the entering flow to the parking bays. The parking aisle, in leading to individual parking space terminals, then becomes the equivalent of an access street. Thus, the principal functions within the hierarchical movement system are recognizable. In addition, each functional category also is related to a range of vehicle speeds.

The same principles of design are also relevant to terminal facilities that adjoin distributor arterials or collectors. The functional design of the facility includes each movement stage, with internal circulation in the terminal design to accommodate the order of movement. The need to design for all stages of the movement hierarchy varies with the size of the traffic generator. For relatively small generators, two or more stages may be accommodated on the same internal facility. For larger traffic generators, each movement stage should have a separate functional facility.

To determine the number of design components needed, the customary volumes of traffic handled by public streets of different functional categories can be compared. The volume range on private internal facilities can be related to the comparable range on public streets. These volumes may not be directly comparable, inasmuch as the physical space available within a private facility is smaller and the operational criteria are necessarily quite different. However, the same principles of flow specialization and movement hierarchy can be applied.

Some further examples may demonstrate how the principles of movement hierarchy are related to a logical system of classification of traffic generation intensity. At the highest practical level of traffic generation, a single generator fills an entire freeway, and for this condition, intermediate public streets could not be inserted between the generator and the freeway, so the various movement stages should be accommodated internally with appropriate design features. At the next level of traffic generation a single traffic generator could fill a single freeway lane. It is then appropriate to construct a freeway ramp for the exclusive use of the generator without intervening public streets. At still smaller volumes it becomes desirable to combine the traffic from several generators with additional traffic before the flow arrives at a freeway entrance ramp. The road performing this function then becomes a collector facility, accumulating these small flows until a traffic volume that will fill the freeway ramp is reached.

Similar principles can be applied at the distributor arterial level of service. If a given traffic generator is of sufficient size, an exclusive intersection driveway for that generator is justified. In other cases an intermediate collector street should combine smaller traffic flows until they reach a volume that warrants an intersection along the distributor. The same theory can be applied with regard to the criteria for direct access to the collector street. A moderately sized traffic generator

usually warrants a direct connection to the collector without an intermediate access street; however, in a district of single-family residences a local access street should assemble the traffic from a group of residences and lead it into a collector street at a single point of access. In practice, direct access to arterials and collectors should be provided from commercial and residential properties, particularly in established neighborhoods.

In short, each element of the functional hierarchy can serve as a collecting facility for the next higher element, but an element should be present only where the intermediate collection is needed to satisfy the spacing needs and traffic volume demands of the next higher facility. By defining the spacing needs and traffic volume demands for a system element, it is possible to determine which cases should use the full system and in which cases intermediate elements may be bypassed.

## Functional Relationships

Functional classification thus groups streets and highways according to the character of service they are intended to provide. This classification recognizes that individual roads and streets do not serve travel independently. Rather, most travel involves movement through networks of roads and can be categorized relative to such networks in a logical and efficient manner. Thus, functional classification of roads and streets is also consistent with categorization of travel.

A schematic illustration of this basic idea is shown in Exhibit 1-2. In Exhibit 1-2A, lines of travel desire are straight lines connecting trip origins and destinations (circles). The relative widths of the lines indicate the relative amounts of travel desire. The relative sizes of the circles indicate the relative trip generating and attracting power of the places shown. Because it is impractical to provide direct-line connections for every desire line, trips should be channelized on

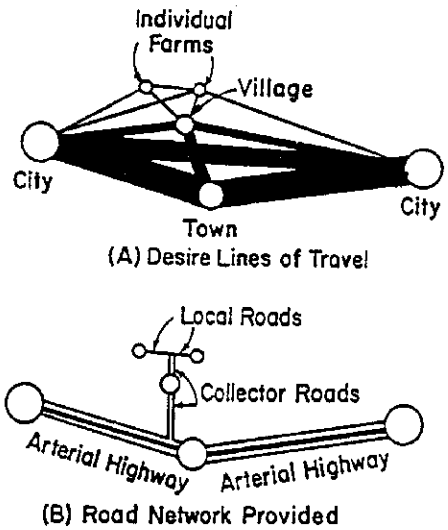


**Exhibit 1-2. Channelization of Trips**

a limited road network in the manner shown in Exhibit 1-2B. Heavy travel movements are directly served or nearly so the smaller movements are channeled into somewhat indirect paths. The facilities in Exhibit 1-2 are labeled local access, collector, and arterial, which are terms that describe their functional relationships. In this scheme the functional hierarchy is also seen to be related to the hierarchy of trip distances served by the network.

A more complete illustration of a functionally classified rural network is shown in Exhibit 1-3. The arterial highways generally provide direct service between cities and larger towns, which generate and attract a large proportion of the relatively longer trips. Roads of the intermediate functional category (collectors) serve small towns directly, connecting them to the arterial network. Roads of this category collect traffic from the local roads, which serve individual farms and other rural land uses or distribute traffic to these local roads from the arterials.

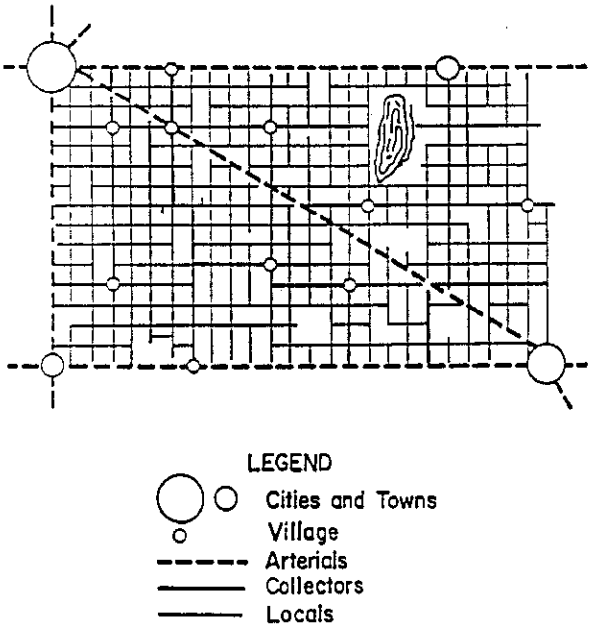


**Exhibit 1-3. Schematic Illustration of a Functionally Classified Rural Highway Network**

Although this example has a rural setting, the same basic concepts also apply in urban and suburban areas. A similar hierarchy of systems can be defined; however, because of the high intensity of land use and travel, specific travel generation centers are more difficult to identify. In urban and suburban areas additional considerations, such as the spacing of intersections, become more important in defining a logical and efficient network. A schematic illustration of a functionally classified suburban street network is shown in Exhibit 1-4.

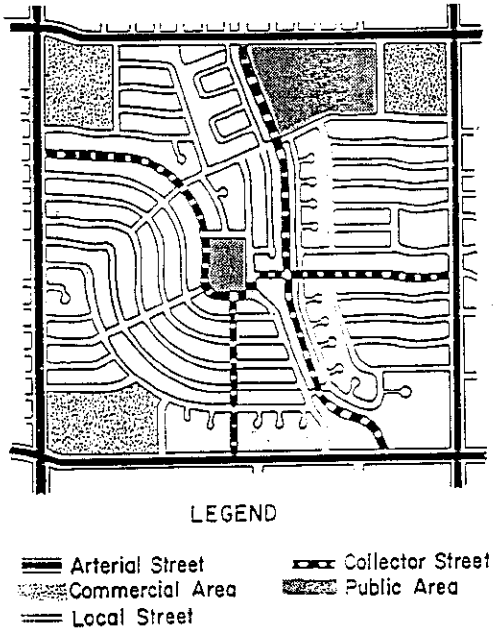


**Exhibit 1-4. Schematic Illustration of a Portion of a Suburban Street Network**

## Access Needs and Controls

The two major considerations in classifying highway and street networks functionally are access and mobility. The conflict between serving through movement and providing access to a dispersed pattern of trip origins and destinations necessitates the differences and gradations in the various functional types. Regulated limitation of access is needed on arterials to enhance their primary function of mobility.

Conversely, the primary function of local roads and streets is to provide access (implementation of which causes a limitation of mobility). The extent and degree of access control is thus a significant factor in defining the functional category of a street or highway.

Allied to the idea of traffic categorization is the dual role that the highway and street network plays in providing (1) access to property and (2) travel mobility. Access is a fixed need for every area served by the highway system. Mobility is provided at varying levels of service. Mobility can incorporate several qualitative elements, such as riding comfort and absence of speed changes, but the most basic factor is operating speed or trip travel time.

Exhibit 1-2 shows that the concept of traffic categorization leads logically not only to a functional hierarchy of road classes but also to a similar hierarchy of relative travel distances served by these road classes. The hierarchy of travel distances can be related logically to functional specialization in meeting the property access and travel mobility needs. Local rural facilities emphasize the land access function. Arterials for main movement or distribution

emphasize the high level of mobility for through movement. Collectors offer approximately balanced service for both functions. This scheme is illustrated conceptually in Exhibit 1-5.

Further discussion of the various degrees of access control appropriate to street and highway development is provided in the section on "Access Control and Access Management" in Chapter 2.

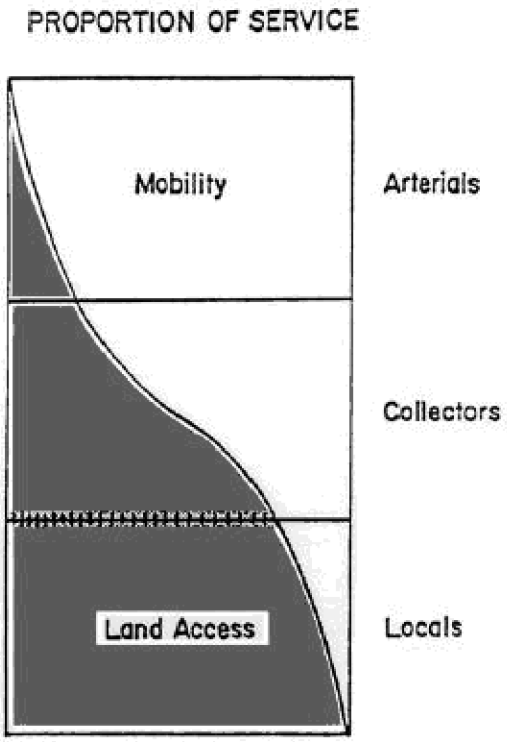


**Exhibit 1-5. Relationship of Functionally Classified Systems in Serving Traffic Mobility and Land Access**

## FUNCTIONAL SYSTEM CHARACTERISTICS

This section contains definitions and characteristics of highway facilities in urban and rural settings based on their functional classifications. It presents information, in revised form, from the Federal Highway Administration publication *Highway Functional Classification: Concepts, Criteria, and Procedures* (**1**).

### Definitions of Urban and Rural Areas

Urban and rural areas have fundamentally different characteristics with regard to density and types of land use, density of street and highway networks, nature of travel patterns, and the way in which these elements are related. Consequently, urban and rural functional systems are classified separately.

*Urban areas* are those places within boundaries set by the responsible State and local officials having a population of 5,000 or more. Urban areas are further subdivided into *urbanized areas* (population of 50,000 and over) and *small urban areas* (population between 5,000 and 50,000). For design purposes, the population forecast for the design year should be used. (For legal definition of urban areas, see Section 101 of Title 23, U.S. Code.)

*Rural areas* are those areas outside the boundaries of urban areas.

## Functional Categories

The roads making up the functional systems differ for urban and rural areas. The hierarchy of the functional systems consists of principal arterials (for main movement), minor arterials (distributors), collectors, and local roads and streets; however, in urban areas there are relatively more arterials with further functional subdivisions of the arterial category whereas in rural areas there are relatively more collectors with further functional subdivisions of the collector category.

## Functional Systems for Rural Areas

Rural roads consist of facilities outside of urban areas. The names provided for the recognizable systems are principal arterials (roads), minor arterials (roads), major and minor collectors (roads), and local roads.

### Rural Principal Arterial System

The rural principal arterial system consists of a network of routes with the following service characteristics:

1. Corridor movement with trip length and density suitable for substantial statewide or interstate travel.
2. Movements between all, or virtually all, urban areas with populations over 50,000 and a large majority of those with populations over 25,000.
3. Integrated movement without stub connections except where unusual geographic or traffic flow conditions dictate otherwise (e.g., international boundary connections or connections to coastal cities).

In the more densely populated states, this class of highway includes most (but not all) heavily traveled routes that might warrant multilane improvements in the majority of states; the principal arterial system includes most (if not all) existing rural freeways.

The principal arterial system is stratified into the following two design types: (1) freeways and (2) other principal arterials.

## Rural Minor Arterial System

The rural minor arterial road system, in conjunction with the rural principal arterial system, forms a network with the following service characteristics:

1. Linkage of cities, larger towns, and other traffic generators (such as major resort areas) that are capable of attracting travel over similarly long distances.
2. Integrated interstate and intercounty service.
3. Internal spacing consistent with population density, so that all developed areas of the state are within reasonable distances of arterial highways.
4. Corridor movements consistent with items (1) through (3) with trip lengths and travel densities greater than those predominantly served by rural collector or local systems.

Minor arterials therefore constitute routes, the design of which should be expected to provide for relatively high travel speeds and minimum interference to through movement.

## Rural Collector System

The rural collector routes generally serve travel of primarily intracounty rather than statewide importance and constitute those routes on which (regardless of traffic volume) predominant travel distances are shorter than on arterial routes. Consequently, more moderate speeds may be typical. To define rural collectors more clearly, this system is subclassified according to the following criteria:

- Major Collector Roads. These routes (1) serve county seats not on arterial routes, larger towns not directly served by the higher systems, and other traffic generators of equivalent intracounty importance, such as consolidated schools, shipping points, county parks, and important mining and agricultural areas; (2) link these places with nearby larger towns or cities, or with routes of higher classifications; and (3) serve the more important intracounty travel corridors.
- Minor Collector Roads. These routes should (1) be spaced at intervals consistent with population density to accumulate traffic from local roads and bring all developed areas within reasonable distances of collector roads; (2) provide service to the remaining smaller communities; and (3) link the locally important traffic generators with their rural hinterland.

## Rural Local Road System

The rural local road system, in comparison to collectors and arterial systems, primarily provides access to land adjacent to the collector network and serves travel over relatively short distances. The local road system constitutes all rural roads not classified as principal arterials, minor arterials, or collector roads.

### Extent of Rural Systems

The functional criteria for road systems have been expressed herein primarily in qualitative rather than quantitative terms. Because of varying geographic conditions (e.g., population densities, spacing between and sizes of cities, and densities and patterns of road networks), criteria on sizes of population centers, trip lengths, traffic volumes, and route spacings do not apply to all systems in all States. However, the results of classification studies conducted in many States show considerable consistency (when expressed in percentages of the total length of rural roads) in the relative extents of the functional systems.

Highway systems developed by using these criteria are generally expected, in all States except Alaska and Hawaii, to fall within the percentage ranges shown in Exhibit 1-6. The higher values of the ranges given in Exhibit 1-6 apply to States having less extensive total road networks relative to the population density. In States having more extensive total road networks relative to the population density, the lower values are applicable. The range of percentages of rural collectors represents the total length of both major and minor collector roads and applies to the statewide rural roadway totals the percentages in particular counties may vary considerably from the statewide average. Areas having an extensive regular grid pattern of roads usually have a smaller percentage of collectors than areas within which geographic conditions have imposed a restricted or less regular pattern of road development.

| Systems | Percentage of Total Rural Road Length |
|---|---|
| Principal arterial system | 2–4% |
| Principal arterial plus minor arterial system | 6–12%, with most States falling in 7–10% range |
| Collector road | 20–25% |
| Local road system | 65–75% |

**Exhibit 1-6. Typical Distribution of Rural Functional Systems**

## Functional Highway Systems in Urbanized Areas

The four functional highway systems for urbanized areas are urban principal arterials (streets), minor arterials (streets), collectors (streets), and local streets. The differences in the nature and intensity of development in rural and urban areas warrant corresponding differences in urban system characteristics relative to the correspondingly named rural systems.

### Urban Principal Arterial System

In every urban environment, one system of streets and highways can be identified as unusually significant in terms of the nature and composition of travel it serves. In small urban areas (population under 50,000), these facilities may be very limited in number and extent, and their importance may be derived primarily from the service provided to through travel. In urbanized areas, their importance also derives from service to rurally oriented traffic, but equally

or even more importantly, from service for major circulation movements within these urbanized areas.

The urban principal arterial system serves the major centers of activity of urbanized areas, the highest traffic volume corridors, and the longest trip desires and carries a high proportion of the total urban area travel even though it constitutes a relatively small percentage of the total roadway network. The system should be integrated both internally and between major rural connections.

The principal arterial system carries most of the trips entering and leaving the urban area, as well as most of the through movements bypassing the central city. In addition, significant intra-area travel, such as between central business districts and outlying residential areas, between major inner-city communities, and between major suburban centers, is served by this class of facility. Frequently, the principal arterial system carries important intra-urban as well as intercity bus routes. Finally, in urbanized areas, this system provides continuity for all rural arterials that intercept the urban boundary.

Because of the nature of the travel served by the principal arterial system, almost all fully and partially controlled access facilities are usually part of this functional class. However, this system is not restricted to controlled-access routes. To preserve the identification of controlled-access facilities, the principal arterial system should be stratified as follows: (1) interstate, (2) other freeways, and (3) other principal arterials (with partial or no control of access).

The spacing of urban principal arterials is closely related to the trip-end density characteristics of particular portions of the urban areas. Although no firm spacing rule applies in all or even in most circumstances, the spacing between principal arterials (in larger urban areas) may vary from less than 1.6 km [1 mi] in the highly developed central business areas to 8 km [5 mi] or more in the sparsely developed urban fringes.

For principal arterials, service to abutting land is subordinate to travel service to major traffic movements. Only facilities within the subclass of other principal arterials are capable of providing any direct access to land, and such service should be purely incidental to the primary functional responsibility of this class of roads.

## Urban Minor Arterial Street System

The minor arterial street system interconnects with and augments the urban principal arterial system. It accommodates trips of moderate length at a somewhat lower level of travel mobility than principal arterials do. This system distributes travel to geographic areas smaller than those identified with the higher system.

The minor arterial street system includes all arterials not classified as principal. This system places more emphasis on land access than the higher system does and offers lower traffic mobility. Such a facility may carry local bus routes and provide intracommunity continuity but ideally does not penetrate identifiable neighborhoods. This system includes urban connections to

rural collector roads where such connections have not been classified as urban principal arterials for internal reasons.

The spacing of minor arterial streets may vary from 0.2 to 1.0 km [0.1 to 0.5 mi] in the central business district to 3 to 5 km [2 to 3 mi] in the suburban fringes but is normally not more than 2 km [1 mi] in fully developed areas.

## Urban Collector Street System

The collector street system provides both land access service and traffic circulation within residential neighborhoods and commercial and industrial areas. It differs from the arterial system in that facilities on the collector system may penetrate residential neighborhoods, distributing trips from the arterials through the area to their ultimate destinations. Conversely, the collector street also collects traffic from local streets in residential neighborhoods and channels it into the arterial system. In the central business district, and in other areas of similar development and traffic density, the collector system may include the entire street grid. The collector street system may also carry local bus routes.

## Urban Local Street System

The local street system comprises all facilities not in one of the higher systems. It primarily permits direct access to abutting lands and connections to the higher order systems. It offers the lowest level of mobility and usually contains no bus routes. Service to through-traffic movement usually is deliberately discouraged.

## Length of Roadway and Travel on Urban Systems

Exhibit 1-7 contains the typical distribution of travel volume and length of roadway of the functional systems for urbanized areas. Systems developed for urbanized areas using the criteria herein usually fall within the percentage ranges shown.

| Systems | Range | |
|---|---|---|
| | Travel volume (%) | Length (%) |
| Principal arterial system | 40–65 | 5–10 |
| Principal arterial plus minor arterial street system | 65–80 | 15–25 |
| Collector road | 5–10 | 5–10 |
| Local road system | 10–30 | 65–80 |

**Exhibit 1-7. Typical Distribution of Urban Functional Systems**

## Functional Classification as a Design Type

This text has utilized the functional classification system as a design type of highway. Two major difficulties arise from this usage. The first major problem involves freeways. A freeway is not a functional class in itself but is normally classified as a principal arterial. It does, however, have unique geometric criteria that demand a separate design designation apart from other arterials. Therefore, a separate chapter on freeways has been included along with chapters on arterials, collectors, and local roads and streets. The addition of the universally familiar term "freeway" to the basic functional classes seems preferable to the adoption of a complete separate system of design types.

The second major difficulty is that, in the past, geometric design criteria and capacity levels have traditionally been based on a classification of traffic volume ranges. Under such a system, highways with comparable traffic volumes are constructed to the same criteria and provide identical levels of service, although there may be considerable difference in the functions they serve.

Under a functional classification system, design criteria and level of service vary according to the function of the highway facility. Volumes serve to further refine the design criteria for each class.

Arterials are expected to provide a high degree of mobility for the longer trip length. Therefore, they should provide a high operating speed and level of service. Since access to abutting property is not their major function, some degree of access control is desirable to enhance mobility. The collectors serve a dual function in accommodating the shorter trip and feeding the arterials. They should provide some degree of mobility and also serve abutting property. Thus, an intermediate design speed and level of service is appropriate. Local roads and streets have relatively short trip lengths, and, because property access is their main function, there is little need for mobility or high operating speeds. This function is reflected by use of a lower design speed and level of service.

The functional concept is important to the designer. Even though many of the geometric design values could be determined without reference to the functional classification, the designer should keep in mind the overall purpose that the street or highway is intended to serve. This concept is consistent with a systematic approach to highway planning and design.

The first step in the design process is to define the function that the facility is to serve. The level of service needed to fulfill this function for the anticipated volume and composition of traffic provides a rational and cost-effective basis for the selection of design speed and geometric criteria within the ranges of values available to the designer. The use of functional classification as a design type should appropriately integrate the highway planning and design process.

# REFERENCES

1. U.S. Department of Transportation, Federal Highway Administration. *Highway Functional Classification: Concepts, Criteria, and Procedures,* Washington, D.C.: 1989.
2. U.S. Department of Transportation, Federal Highway Administration, Office of Information Management. *Our Nation's Highways—Selected Facts and Figures*, Report No. FHWA-PL-98-015, Washington, D.C.: 1998.