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Chapter Nineteen

FREEWAYS

# General

Freeways are functionally classified as Principal Arterials and are constructed with full control of access. Freeways are intended to provide high levels of safety and efficiency in moving high volumes of traffic at high speeds. The operational efficiency, capacity, safety and cost of the highway facility are largely dependent upon its design. Rural freeways are connecting roadway links between major cities, towns and urban areas. Similarly, urban freeways provide service for large volumes of traffic within and through urbanized areas. This Chapter provides guidance in the design of rural and urban freeways including specific design criteria, frontage roads, lane drops, justification for grade separations, access control along the freeway and safety. Additional information that is applicable to freeways is also included in the following chapters:

Chapter 9 provides guidelines for access control along interchange crossroads. It also discusses the procedures for depicting control of access in the Plans.

Chapters 9, 10, 11, 12 and 13 provide guidance on the geometric design elements.

Chapter 14 provides guidelines on roadside safety issues.

Chapter 16 discusses the type, location and design of interchanges.

## Urban Versus Rural Freeways

Urban and rural freeways are similar in that they are intended to provide safe, rapid and high-quality transportation facilities for motorists. The primary difference between rural and urban freeways is in the concept of operational freedom. Motorists on rural freeways expect more operational freedom and greater travel speeds than urban motorists.

Urban freeways are designed to carry large traffic volumes and have multilanes in each direction. Typically, urban freeways have two lanes in each direction, and can be designed for six or more lanes. Urban freeways take many forms (e.g., depressed, ground level, elevated embankment, elevated viaduct or a combination). In most instances, right of way restrictions cause designers to evaluate alternatives so that socio-economic factors, right of way and construction costs are considered.

Rural freeways are similar in design to urban ground level freeways. Designers must consider the differences between rural and urban freeways when applying freeway design criteria to a project.

## Design Studies

Freeway design considerations evolve around traffic volumes, design speed and level of service. These are the primary factors that either individually or collectively are instrumental in governing the selection of appropriate roadway geometric criteria and/or cross section elements in the design of freeways. When developing a freeway alignment, first determine the location and type of interchanges. Then develop the freeway alignment between the interchanges. Other factors that may influence the freeway alignment include:

* the location of grade separations, including major river crossings;
* access control along the freeway and along interchange crossroads;
* topography;
* environmental restrictions; and
* property lines and right of way restrictions.

# Design Elements

## Traffic

### Traffic Volume

Traffic volumes are a major consideration in justifying highway facilities and assisting designers in the establishment of preliminary geometric and cross section design characteristics. Future 20-year projected traffic volumes are used in determining design elements of urban and rural freeways.

### Level of Service (LOS)

The LOS consideration in the design of freeways is based on traffic volumes. Because LOS is a measure of the freedom of movement and operational delays for traffic, it is appropriate that freeways are designed to operate at a high LOS.

Rural freeways should be designed to operate at a LOS B. LOS B is in the stable traffic flow range in which the motorist’s freedom to select the desired operating speed is relatively unaffected and motorist freedom of maneuvering is only slightly restricted. In rural mountainous terrain, it may be necessary to reduce the design to LOS C in which the ability to maneuver within the traffic stream becomes increasingly affected by the presence of other vehicles. Further discussion on the LOS design concept is included in Section 9.6.4.1.

For urban freeways, a LOS C is desirable, but in some cases it may not be economically feasible.

## Design Speed

Freeways are intended to accommodate high-speed traffic. Urban and rural freeways should have design speeds between 65 and 75 miles per hour. In mountainous terrain, rural freeway design speeds may be reduced to 55 miles per hour. For urban freeways, limited right of way, high construction costs and social or environmental concerns may suggest a lower design speed. Urban freeway design speeds should be no lower than 55 miles per hour to maintain an overall high quality, smooth-flowing and safe facility.

## Alignment

Designed for high-volume and high-speed operations, freeways should have smooth horizontal and vertical alignments. Proper combinations of curvature, tangents, grades, variable median widths and separate roadway elevations all combine to enhance safety and aesthetics of freeways. When designing freeway alignments, consider the following guidelines:

1. Horizontal Alignment. The following guidelines should be applied when laying out the horizontal alignment:

* Use large radius curves.
* Only use minimum radii where it is necessary due to restricted conditions.
* Avoid alignments that require superelevation transitions on bridges or bridge approach slabs.

1. Vertical Alignment. Even though the profile may satisfy all design controls, the use of minimum criteria may appear forced and angular. Therefore, use higher values to produce a smoother, more aesthetically pleasing alignment keeping in mind that curves which are too flat will produce flat areas that may cause drainage problems.
2. Horizontal and Vertical Combinations. Consider the relationship between horizontal and vertical alignments simultaneously to obtain a desirable condition. Section 12.2.2 discusses this relationship in detail and its effect on aesthetics and safety.
3. Freeway River Crossings. During the development of freeways, the alignment may need to cross major rivers, streams or bays. In selecting the location for a bridge site, consider the following guidelines:
   1. Crossing Angle. Cross the river at a nearly right angle to minimize the length of the main span.
   2. Bluffs. If a bluff exists adjacent to the river, attempt to locate one of the abutments on a bluff closest to the river. This will minimize the overall length of the bridge and, therefore, reduce the cost of the structure.
   3. River Bends. Avoid locating the bridge on a bend in the river. Locating a bridge on a bend may result in unnecessarily long spans and may increase the chance of ships and boats colliding with the main bridge piers.
   4. Freeway Alignment. Examine how the freeway alignment will tie into the ends of the bridge. Approach horizontal and vertical alignments can significantly improve the aesthetics of the bridge location. Make every effort to avoid placing horizontal curves and superelevation transitions on the bridge.
   5. Foundation Conditions. Investigate the soil conditions at each bridge abutment and the depth of bedrock at each pier location. Poor foundation conditions may limit possible bridge sites.
   6. Existing Structures. Existing structures may limit the location of a new bridge. Provide sufficient separation between structures.
   7. Environmental Considerations. Avoid or minimize the impact on environmentally or historically sensitive areas wherever practical in conjunction with the above guidelines.
4. Interchanges. When developing the alignment and profile of freeways near proposed interchanges, see Chapter 16 for detailed guidelines.
5. Climbing Lanes. Section 12.4 discusses the warrants and design criteria for climbing lanes. For most freeways, climbing lanes are not warranted unless a drop in the level of service is significant.

## Sight Distance

Sight distances for freeways should desirably be provided based upon the decision sight distance in areas where driver confusion may occur (e.g., within interchanges, changes in cross sections, lane drops).

See Chapter 10 for additional information on sight distance.

## Cross Sections

### Lane and Shoulder Widths

The minimum lane widths on freeways should be 12 feet. The inside shoulder should be 10 feet and the outside shoulder should be 12 feet. Where reduced shoulder widths are provided, consider incorporating the following:

* adding advisory and regulatory signing,
* additional raised pavement markings,
* constructing frequent emergency pull-outs,
* using changeable overhead message signs,
* providing continuous lighting,
* incorporating truck-lane restrictions, and/or
* setting up dedicated service patrols and other incident management measures.

For more information on cross section design elements, see Section 13.2.

### Typical Sections

Figures 19.2A through 19.2C illustrate typical cross-sections for various freeway designs. Figure 19.2A provides a typical section for a rural/urban four-lane divided freeway with a depressed median. Figures 19.2B and 19.2C provide typical sections for an urban freeway with concrete median barriers (CMB).

fig19-2a

**TYPICAL RURAL/URBAN FOUR-LANE DIVIDED FREEWAY**

**(Depressed Median)**

###### Figure 19.2A

\*In rural areas, a wider median may be desirable to accommodate future widening.

fig19-2b

**TYPICAL SECTION FOR FOUR-LANE FREEWAY**

**(Flush CMB Median)**

# Figure 19.2B

**TYPICAL RURAL/URBAN SIX-LANE DIVIDED FREEWAY**

**(CMB Median)**

###### Figure 19.2B

fig19-2c

**TYPICAL RURAL/URBAN SIX-LANE DIVIDED FREEWAY**

**(CMB Median)**

###### Figure 19.2C

# Tables of Design Criteria

Figures 19.3A and 19.3B present the Department’s design and alignment criteria for freeway projects. The designer should consider the following when using these figures:

1. Applicability. Note that some of the cross-section elements included in the figures (e.g., flush CMB) are not automatically warranted in the project design. The values in the figures only apply after the decision has been made to include the design element in the highway cross section.
2. Manual Section References. These figures are intended to provide a concise listing of design values for easy use. However, the designer should review the *Manual* section references for more information on the design elements.
3. Footnotes. The figures include many footnotes, which are identified by a number in parentheses (e.g., (3)). The information in the footnotes is critical to the proper use of the design tables.
4. Controlling Design Criteria. The figures provide an asterisk to indicate controlling design criteria. If the designer cannot meet the criteria provided in the tables, see the Program Manager for alternatives. Section 9.2 discusses this in more detail and presents the process for approving design exceptions to controlling criteria.

**GEOMETRIC DESIGN CRITERIA FOR FREEWAYS**

**(New Construction/Reconstruction)**

**Figure 19.3A**

Revised: 10-2005

\*Controlling design criteria (see Section 9.2)

**GEOMETRIC DESIGN CRITERIA FOR FREEWAYS**

**(New Construction/Reconstruction)**

Footnotes to Figure 19.3A

(1) Design Speed. In mountainous terrain, a minimum design speed of 55 miles per hour may be considered.

(2) Shoulder Width (Right). Where the directional distribution of trucks exceeds 250 DDHV, consider providing a 12-foot paved shoulder.

(3) Shoulder Width (Left). Where there are three or more lanes in one direction, provide a 10-foot left paved shoulder. If the directional distribution of trucks exceeds 250 DDHV, consider providing a 12-foot paved left shoulder.

(4) Travel Lane Cross Slope. On a six-lane highway crowned at the center line with CMB, use 2.08 percent for first two travel lanes adjacent to inside shoulder, use 2.78 percent for third lane breaking away from outside edge of second travel lane. See Figure 19.2B.

(5) Auxiliary Lane Cross Slope. For auxiliary lanes adjacent to two travel lanes sloped in the same direction, use a cross slope of 2.78 percent.

(6) Depressed Median Widths. In urban areas, existing 36-foot medians may be allowed to remain in place.

1. Flush Median Widths (CMB). In urban areas, existing 12-foot to 14-foot medians may be allowed to remain-in-place. Where adding travel lanes to an existing median less than 48 feet, the left-shoulder may be less than 10 feet.
2. Side Slopes (Cut Section). Cut rock slope may vary based on a detailed geotechnical investigation.
3. Clear Zone. The clear zone will vary according to design speed, traffic volumes, side slopes and horizontal curvature.
4. New and Reconstructed Bridge Widths. Clear roadway bridge widths are measured from face to face of parapets or rails. Bridge widths are normally defined as the sum of the approach traveled way width plus total shoulder width right and left.
5. Existing Bridge Widths to Remain in Place. Clear roadway bridge widths are measured from face to face of parapets or rails. Bridge widths are normally defined as the sum of the approach traveled way width plus total shoulder width right and left.
6. Vertical Clearance (Freeway Under).
7. The clearance must be available over the traveled way, shoulders, and any anticipated future widening.
8. Table value includes allowance for future overlays.

Bullets 3, 10, 11, and 12a – Revised: 10-2004

Figure 19

**ALIGNMENT CRITERIA FOR FREEWAYS**

**(New Construction/Reconstruction)**

**Figure 19.3B**

\* Controlling design criteria (see Section 9.2).

1. Stopping Sight Distance. Table values are for passenger cars on level grade.
2. Vertical Curvature. The K-values are based on stopping sight distances. See Section 19.2.4.
3. Maximum Grade.

a. Rural. With wide medians where two roadways are on independent alignments, downgrades may be 1 percent steeper.

b. Urban. Grades 1 percent steeper may be used for restricted conditions.

(4) Minimum Grade. Check flow lines of the outside ditches to insure adequate drainage.

# Interchanges/Grade Separations

Where there is a need to provide for the safe and efficient movement of traffic through a series of intersecting roads, it can most effectively be accomplished by providing grade separations and/or interchanges. This allows for the greatest capacity and level of service that can be achieved by providing continuous uninterrupted travel for highway users. On fully access-controlled facilities, each intersecting highway must be terminated, rerouted or provided with a grade separation or interchange. The importance of the continuity of the crossing road, the feasibility of alternative routes, traffic volumes, construction costs, environmental impacts, etc., must be evaluated to determine which option is the most cost effective.

## Interchanges

Section 16.2 discusses several guidelines that must be considered in determining whether or not an interchange should be provided. In general, interchanges are provided at all freeway-to-freeway crossings and other major highways based on the anticipated demand for regional access.

Section 16.2 also discusses the procedures for adding or revising an interchange access point to the freeway system.

## Grade Separations

Grade separations are provided to allow for two transportation facilities to cross at different elevations (e.g., highways, railroads, pedestrian crossings, bicycle paths). Separations are defined in terms of the major highway crossing over (overpass) or under (underpass) the less major facility.

The type of bridge structure provided at overpasses and underpasses is based upon site conditions and span lengths required to obtain the necessary horizontal and vertical clearances.

### Justification

For each crossroad along the freeway, which is not an interchange, a determination must be made whether the crossroad should be closed, rerouted or provided with a grade separation. Primarily comparing the respective cost and social factors for each alternative makes this justification. Although cost is a primary factor, the designer should review the following additional considerations:

1. Operations. Grade separations should be of sufficient number and adequate capacity to accommodate the crossroad traffic, traffic diverted to crossroads from other roads and streets terminated by the freeway and the traffic generated by access connections to and from the mainline.
2. Locations. The location of grade separation structures is determined by assessing the need to provide for community and commercial continuity and traffic demand.
3. Site Topography. There are some sites where existing topography creates a condition in which the only rational design approach is to provide for grade separations.
4. Local Considerations. Closing the crossroad can have a significant impact on local users and the overall local road system integrity due, primarily, to changes in travel patterns. These may include:
   1. School Bus Routes. The effect of a road closure on the bus route system can be two-fold. There may be an increase in the operating cost due to longer bus routes and an increase in the travel time for school children.
   2. Emergency Personnel. The financial effect of the longer detour route on emergency vehicles is generally not a concern. However, the extra response time could adversely affect the health and safety of local citizens.
   3. Businesses/Farms. Access to businesses and farms must be evaluated to insure that these operations can continue without severe economic hardship. For businesses, the road closure can significantly affect their deliveries and the number of customers they receive (e.g., customers may be unwilling to travel the extra distance). For farmers, the road closure may require the transportation of large, slow-moving farm equipment along busy alternative facilities.
   4. Social Factors. Parks, churches, cemeteries, public facilities, and other areas or buildings of social concern generally cannot be relocated. Limited access to these facilities may create undue hardship.
   5. Land Use Planning. Consider future land use within a suburban environment to insure adequate access and reciprocation factors are available.

When interchanges cannot be justified by traffic demands and economics, grade separations along freeways may be provided when the following conditions are met:

* decrease in traffic and/or road user costs,
* route continuity,
* when the intersecting road cannot be cost effectively re-routed through the use of frontage or other local roads,
* a critical need exists to maintain local access, and
* a critical need exists at railroad crossings for safety or special crossings for pedestrians or bicycle users.

### General Design Considerations

Often the proposed highway grade separation (i.e., carrying the mainline over or under the crossroad) is based on topography features or highway classification. When designing grade separations, consider the following guidelines:

1. Over versus Under. The decision on whether the freeway should be over or under the crossroad is normally dictated by topography and cost. If the topography does not favor one profile over the other, use the following guidelines to decide which highway should cross over the other:
   1. Cost Effectiveness. The designer should consider which alternative will be more cost effective to construct. Some elements to consider are the amount of embankment and excavation required, span lengths, angle of skew, gradients, sight distances, alignment, vertical clearances, constructability, traffic control, right of way, access, drainage, soil conditions and construction costs.
   2. Classification. Select the alternative that provides the highest design for the mainline road. Typically, the crossroad has a lower design speed and, therefore, the minor road can be designed with steeper gradients, lesser roadway widths, steeper side slopes, etc.
   3. Future Crossings. If any crossings and/or structures are planned for a future date, the mainline should be under these future crossings. Overpasses are easier to install and will be less disruptive to the freeway when they are constructed in the future.
   4. Aesthetics. Through traffic is given aesthetic preference by a layout in which the more important road is the overpass. A wide overlook can be provided from the structure and its approaches, giving drivers a minimum feeling of restriction.
   5. Turning Traffic. Where turning traffic is significant, the ramp profiles are best fitted when the major road is at the lower level. The ramp grades then assist turning vehicles to decelerate as they leave the major highway and to accelerate as they approach it. In addition, for diamond interchanges, the ramp terminal is visible to drivers as they leave the major highway.
2. Horizontal Distance. The distance required for adequate design of a grade separation depends on the design speed, the roadway gradient and the amount of rise or fall necessary to affect the separation. Figure 19.4A can be used during preliminary design to quickly determine whether a grade separation is feasible for a given set of conditions, what gradients may be involved and what profile adjustments may be necessary on the crossroad. Also, carefully study the sight distance requirements because these will often dictate the required horizontal distance along the crossroad. When using Figure 19.4A, consider the following:
   1. Minimum Horizontal Distances. The plotted lines on Figure 19.4A are derived assuming the same approach gradient on each side of the structure. However, values of “D” from the figure also are applicable to combinations of unequal gradients. Distance “D” is equal to the length of the initial vertical curve, plus one-half the central vertical curve, plus the length of tangent between the curves. Lengths of vertical curves are based on stopping sight distances. However, longer vertical curves are desirable from an aesthetic and safety standpoint. Conversely, longer curve lengths may be costlier due to increased earthwork quantities. However, these additional costs may be a less important consideration if crossroads or access points exist near the grade separation structure.
   2. Maximum Gradient. The lower terminal point of each gradient line on Figure 19.4A, marked by a small symbol, indicates the distance where the tangent between the curves is zero and below which a design for the given grade is not feasible (i.e., a profile condition where the minimum central and end curves for the gradient would overlap).
   3. Restricted Gradients. For the usual profile rise or fall required for a grade separation (“H” of 25 feet or less), do not use gradients greater than 3 percent for a design speed of 70 miles per hour, 4 percent for 60 miles per hour, 5 percent for 50 miles per hour and 6 percent for 40 miles per hour. For values of “H” less than 25 feet, use flatter gradients.
   4. Relationship. For a given “H” and design speed, distance “D” is only shortened a negligible amount by increasing the gradient. However, the distance “D” varies to a greater extent for a given “H” and “G” with respect to the design speed.
   5. Elevation. Considering the vertical clearance and structural depth, an elevation distance of “H” is typically between 23 and 25 feet for the grade separation of two highways. “H” is typically the same for a freeway under a railroad. For a railroad facility under a freeway, “H” is typically 30 to 31 feet.

fig19-4a

**GRADE SEPARATION DETERMINATION**

**Figure 19.4A**

* 1. Design Speed. To provide additional safety at rural grade separations where the crossroad passes over the freeway, consider designing the crest vertical curve with a design speed of 55 miles per hour or greater.

1. Sight Distance. In rolling topography or in rugged terrain, major-road overcrossings may be attainable only by a forced alignment and rolling gradeline. Where there is no pronounced advantage to the selection of either an underpass or an overpass, the design that provides the better sight distance on the major road (desirably passing distance if the crossroad is two lanes) should be preferred.
2. Hydrology Considerations. Carrying the major highway over without altering the crossroad grade may reduce troublesome drainage problems. In some cases, the drainage problem alone may be sufficient reason for choosing to carry the major highway over rather than under the crossroad.

\* \* \* \* \* \* \* \* \* \*

**Example 19.4(1)**

It is proposed that an existing crossroad be provided with an overpass over a new freeway.

Given: Crossroad Design Speed – 50 miles per hour.

Difference between the proposed crossroad profile grade line and the proposed freeway profile grade line is 25.0 feet.

Problem: Determine where along the crossroad the profile grade line will need to be adjusted to provide a 25-foot profile rise.

Solution: Assume a longitudinal gradient of 4 percent. Reading into Figure 19.4A, the minimum distance required to provide the 25-foot height distance is approximately 940 feet. Note that when using a 5 percent longitudinal gradient the distance will be approximately 900 feet.

\* \* \* \* \* \* \* \* \* \*

### Underpass Roadway

For each underpass, the dimension, load, foundation and general site needs should determine the type of structure used for that particular location. Only the dimensional details are reviewed in this Section.

An underpass is only one component of the total facility and should be consistent with the design criteria of the rest of the facility to the extent practical. It is desirable that the entire roadway cross section, including the median, traveled way, shoulders and roadside clear zone areas, be maintained through the structure. Possible limitations may require some reduction in the basic roadway cross section (e.g., structural design limitations, lateral clearance limitations, controls on grades and vertical clearance, limitations due to skewed crossings, appearance or aesthetic dimension relations, cost factors). However, where conditions permit a substantial length of freeway to be developed with desirable lateral dimensions, an isolated overpass along the section should not be designed as a restrictive element. In these cases, the additional structural costs are strongly encouraged to insure consistency throughout the facility.

Desirable lateral clearances for freeway underpasses are illustrated in Figure 19.4B. For a two-lane roadway or an undivided multilane roadway, the cross section width at underpasses will vary, depending on the design criteria appropriate for the particular functional classification and traffic volume. The minimum lateral clearance from the edge of the traveled way to the face of the protective barrier should be the normal shoulder width.

On divided highways, the clearances on the left side of each roadway are usually governed by the median width and clear zone. For a roadway with six or more lanes, the minimum median width should be 22.5 feet to provide 10-foot shoulders and a CMB. Figure 19.4C(a) shows the minimum lateral clearances to a continuous median barrier for the basic roadway section and for an underpass where there is no center support. The same clearance dimensions are applicable for a continuous wall on the left.

Figure 19.4C(b) shows the minimum lateral clearance on the right side of the roadway as applicable to a continuous wall section. For this situation, the lateral clearance on the right should be measured to the base of the barrier.

fig19-4b

*Notes:*

1. Locate median piers, when required, on the median centerline when the median width provides less than the required clear zone width.
2. Locate the minimum clearance point at the least clearance point above the usable roadway under, including stabilized shoulders.

**CLEARANCES FOR BRIDGES OVER FREEWAYS**

**Figures 19.4B**

fig19-4c

**LATERAL CLEARANCES FOR MAJOR ROADWAY UNDERPASSES**

**Figure 19.4C**

# Miscellaneous Elements

## Freeway Lane Drops

Lane reductions occur when there is a sufficient change in traffic volume in which the basic number of lanes can no longer be justified. Lane drops may occur as the result of:

* the introduction of auxiliary lanes at interchanges,
* in areas where there are multiple interchanges, and/or
* collector-distributor roads necessitating multiple lanes that no longer are required to handle existing or projected traffic volumes.

Freeway lane drops should normally occur on the freeway mainline away from any other turbulence (e.g., interchange exits and entrances). Figure 19.5A illustrates the recommended design of a lane drop beyond an interchange. In addition, consider the following criteria when designing a freeway lane drop:

1. Location. The lane drop should occur approximately 2,500 feet beyond the previous interchange ramp. The 2,500 feet allows for adequate signing and driver adjustments from the interchange, but yet is not so far downstream that drivers become accustomed to the number of lanes and are surprised by the lane drop. In addition, do not drop a lane on a horizontal curve or where other signing is required (e.g., an upcoming exit).
2. Transition. Lane drops that involve pavement width changes should be transitioned over a length equal to the product of the change in lane width (W) times the design speed (S). Figure 19.5B provides lane drop transition lengths for 12-foot lanes. Maximum transition taper rate will be 70:1.
3. Sight Distance. Decision sight distance should be available to any point within the entire lane transition. See Section 10.3 for applicable decision sight distance values. These criteria would favor, for example, placing a freeway lane drop within a sag vertical curve or at a location where the freeway lies on an upgrade but not just beyond a crest.
4. Right-side Versus Left-side Drop. Right-side freeway lane drops are preferred due to the merging of slower vehicles and normal driver expectations. For the situation where the left lane is to be continued in the median in the future, the right-side lane drop is still preferred. If a left-side lane drop is used, provide advance supplemental signing, longer taper lengths and 12-foot wide paved left- shoulders beyond the area of the proposed lane drop.
5. Shoulders. Maintain the full-width right shoulder through a right-side lane drop.

fig19-5a

**TYPICAL FREEWAY LANE DROP (RIGHT SIDE)**

**Figure 19.5A**

|  |  |
| --- | --- |
| Design Speed (mph) | Transition Length (feet) |
| 55 | 660 |
| 60 | 720 |
| 65 | 780 |
| 70 | 840 |
| 75 | 840 |

**TRANSITION LENGTH FOR 12-FOOT FREEWAY LANE DROP**

**Figure 19.5B**

## Weaving

Weaving sections should be designed so that the LOS within the area of weaving is consistent with the remainder of the highway. The design LOS of weaving sections depends upon their length, number of lanes, acceptable degree of congestion and relative volumes of individual traffic movements. Weaving sections may be considered as single or multiple. Detailed discussions of freeway weaving sections, relating to the operation and analysis, are contained in the *Highway Capacity Manual*.

## Frontage Roads

### General

Frontage roads are parallel roads adjacent and outside the controlled access lines of freeways and other controlled access highways. It is preferable that frontage roads be located generally parallel to freeways on an independent right of way. For example, if the typical freeway right of way is 150 feet from the centerline of the median, then an additional 66 to 90 feet of right of way should be provided for the frontage road. Alternatively, frontage roads can be located a distance of 300 to 400 feet from the freeway right of way, allowing for industrial and/or commercial development to occur on both sides of frontage roads.

At rural interchanges, frontage roads should intersect with crossroads at a distance of approximately 500 feet (desirable) from ramp terminals. In urban areas, these distances may be reduced to 300 feet (desirable). Providing adequate distance between ramp/crossroad and frontage road/crossroad intersections avoids operational and safety problems. Where right of way restrictions are not a consideration, the distance between the ramp terminal and frontage road should be as liberal as practical.

Where freeways sever existing low-volume roads, the designer must determine if the road is to be closed, provided with a cul-de-sac, rerouted, provided with a grade separation or provided with a frontage road. This decision should be based on economics and, if necessary, through a benefit/cost study. Desirably, a freeway should be located so that a minimum number of properties are severed by its location. Realizing that this is not always practical or feasible, frontage roads are provided for access to severed properties. The designer, with the assistance of the Right of Way Office, should conduct an economic justification study to determine if it is more economical to construct the frontage road or pay severance damages for loss of access.

### Outer Separations

The area between the traveled way and a frontage road or street is referred to as the outer separation. If there are no adjoining frontage roads or local streets, then these areas are referred to as borders. Basically, outer separations or borders provide areas for shoulders, slopes, drainage facilities, controlled access fencing, walls, ramps and noise abatement barriers. Outer separations may also serve as recovery areas for errant vehicles. In urban areas, the outer separation may require a reduced width due to certain restrictions (e.g., retaining walls, right of way restrictions). Typical outer separations between freeways and frontage roads are shown in Figure 19.5C.

### Functional Classification

The normal design elements of pavement width, cross slope, horizontal and vertical alignment, etc., should be provided consistent with the functional operation of the frontage road. That is, the same considerations relative to functional classification, design speed, traffic volumes, etc., apply to frontage roads as they apply to any other highway. The functional classification of the frontage road will be determined on a case-by-case basis.

### Design

In the design of frontage roads, consider the following:

1. Design Criteria. The selection of the appropriate design criteria is based on the functional classification of the frontage road. Once the frontage road classification has been determined, the appropriate design elements (e.g., design speed, lane and shoulder widths) can be selected. For freeways, the frontage road design criteria can be found in Chapters 20 and 21.

fig19-5c

**TYPICAL OUTER SEPARATIONS**

**Figure 19.5C**

1. One-Way/Two-Way. Two-way frontage roads are used in suburban or rural areas where the adjoining street system is so irregular or so disconnected that one-way operation would introduce considerable added travel distance and cause undue inconvenience. Two-way frontage roads are also used in many urban situations. From an operational and safety perspective, one-way urban frontage roads are preferred to two-way. One-way operations may inconvenience local traffic to some extent, but the advantages in reducing vehicular and pedestrian conflicts at intersecting streets often fully compensates for this inconvenience. Two-way frontage roads at high-volume, urban intersections may complicate crossing and turning movements. Off ramps (e.g., slip ramps) joining two-way frontage roads should not be used because of the potential for wrong-way entry.
2. Outer Separation. See Section 19.5.3.2 for discussion on outer separation.
3. Access to Freeways. Connections between the main highway and the frontage road are an important design element. On facilities with lower operational speeds and one-way frontage roads, slip ramps or simple openings in a narrow outer separation may work reasonably well. Slip ramps from one-way frontage roads and freeways are acceptable. Because slip ramps from a freeway to two-way frontage roads tend to induce wrong-way entry onto the freeway and may cause crashes at the intersection of the ramp and frontage road, the access to the freeway must be provided with interchanges.

## Pedestrians

Where planned freeway construction will divide established communities, resulting in the termination of streets and sidewalks, designers should investigate the spacing of the remaining crossing streets and sidewalks. This should be done in conjunction with the volume of diverted pedestrian traffic and associated distances that pedestrian traffic is required to travel to determine the need for intermediate pedestrian grade separation crossings. FHWA’s, *A Pedestrian Planning Procedures Manual*, outlines a method of converting walking distance, time and safety into dollars for use when comparing relative cost versus benefits with and without pedestrian structures.

## Noise Barriers

As part of the continuing assessment of human reaction to construction and maintenance of highways and in accordance with established environmental assessment procedures, noise barriers may be provided. If a decision is made that noise barriers are required, insure their construction will not compromise the highway safety. Major design considerations should include the following:

* Insure that adequate lateral clearances are obtained in accordance with clear zone requirements in Section 14.3. Noise barriers should be located at or near the right of way line.
* Insure that adequate stopping sight distance is not impaired.
* Design noise barriers, to the greatest extent feasible, so that they will not appear obtrusive to drivers. Alternatives (e.g., landscaped earthen berms) should be considered.

# references

*1. A Policy on Geometric Design of Highways and Streets*, AASHTO, 2001.

2. *A Policy on Design Standards ⎯ Interstate System*, AASHTO, draft, 2002.

3. *Highway Safety Design and Operations Guide*, AASHTO, 1997.