CHAPTER 7
RURAL AND URBAN ARTERIALS

7.0 INTRODUCTION

This chapter provides the general information needed to establish the basis of design for rural and urban arterials.

Consult Chapter 3 and Chapter 4 for details on the basic design elements applicable to this classification of roadway.

7.1 RURAL ARTERIALS

A major part of the rural highway system consists of rural arterials, which range from two-lane roadways to multilane, divided controlled-access arterials.

The appropriate design geometrics for an arterial may be determined from the selected design speed and the design traffic volumes, with consideration of the type of terrain, the general character of the alignment, and the composition of traffic.

7.1.1 General Design Considerations

7.1.1.1 Design Speed

Rural arterials, except for freeways, are normally designed for speeds of 40 to 75 mph depending on terrain, driver expectancy, and whether the design is for new construction or reconstruction of an existing facility. Normal design speeds are shown in Table 3-4.

7.1.1.2 Design Traffic Volume

Check with the Region Traffic Engineer to determine the best source of data for design traffic volumes. The Division of Transportation Development (DTD) website presents base data including Annual Average Daily Traffic (AADT) and design hourly volumes (DHV) **(1)**. Traffic counts may supplement the data. For further information on determining design traffic volumes, see Chapter 2 of the *PGDHS* **(2)**. Base data and additional information such as seasonal variation, directional split, and local-area growth can be obtained from the DTD.

AADT values used to design low-volume rural arterials should be projected to the design year, normally 20 years into the future. DHV is used to design high-volume rural arterials.

7.1.1.3 Levels of Service

Check with the Region Traffic Section for present and future levels of service. Procedures for determining levels of service are presented in the *Highway Capacity Manual* **(3)**. For acceptable degrees of congestion, rural arterials and their auxiliary facilities (i.e., turning lanes, passing sections, weaving sections, intersections, and interchanges) should generally be designed for level of service B except in mountainous areas where level of service C is acceptable.

7.1.1.4 Sight Distance

Sight distance is a direct function of the design speed which greatly influences the level of service on rural arterials. Minimum stopping sight distance must always be provided as a safety requirement. See Chapter 3 for a comprehensive discussion on the subject of sight distance and for tables suitable for the design of arterials.

Ideally, intersections and railroad crossings should be grade-separated or provided with adequate sight distance. Intersections should be placed in sag and/or tangent locations, where practical, to allow maximum visibility of the roadway and pavement markings.

Special consideration should be given to providing adequate decision sight distance at locations such as high-volume intersections and at transitions of roadway widths or numbers of lanes. See Table 3-1.

7.1.1.5 Grades

Table 3-4 gives recommended maximum grades for rural arterials. When vertical curves for stopping sight distance are considered, there are seldom advantages to using the maximum grade values except when grades are long. Grades below the maximum are always desirable, but a grade of 0.5 percent should be considered the minimum.

7.1.1.6 Number of Lanes

The number of lanes required is determined by volume, level of service, and capacity conditions. A multilane arterial refers to four or more lanes. The required number of lanes is determined by procedures in the *Highway Capacity Manual* **(3)**.

7.1.1.7 Superelevation

When the use of curves is required on a rural arterial alignment, a superelevation rate compatible with the design speed must be used. Adjustments in design runoff lengths may be necessary for smooth riding, drainage, and appearance. See the CDOT *Standard Plans - M & S Standards* **(4)** for superelevation rates. Chapter 3 provides a detailed explanation of superelevation rates and runoff lengths for design speed.

7.1.1.8 Cross Slope

See section 4.1.2.

7.1.1.9 Vertical Clearances

New or reconstructed structures shall provide a minimum of 16.5 feet of clearance over the entire roadway width, which includes 6 inches for future resurfacing of the underpassing road. Existing structures that provide 14 feet of clearance, if allowed by local statute, may be retained. In highly urbanized areas, a minimum clearance of 14 feet may be allowed only if there is an alternate route with 16 feet of clearance. Additional information on vertical clearances is given in Table 3-3.

7.1.1.10 Structures

Bridges to remain in place shall have adequate strength and be at least the width of the traveled way plus 2 feet of clearance on each side, but should be considered for ultimate widening or replacement.

Consult with Staff Bridge on all new and existing structures.

7.1.1.11 Widths

Table 7-1 provides values for the width of traveled way and shoulder that should be considered for the volumes indicated. Shoulders should be usable at all times regardless of weather conditions. On high-volume highways the shoulders shall be paved. The shoulder should be constructed to a uniform width for relatively long stretches of roadway. For additional information regarding shoulders, refer to section 4.3.

Design Speed (mph)	**Minimum width of traveled way (ft) [a] for specified design volume (veh/day)**			
	Under 400	400 to 1500	1500 to 2000	Over 2000
40	22	22	22	24
45	22	22	22	24
50	22	22	24	24
55	22	22	24	24
60	24	24	24	24
65	24	24	24	24
70	24	24	24	24
75	24	24	24	24
All speeds	**Width of shoulder (ft) [b]**			
	4	6	6	8

[a] On roadways to be reconstructed, an existing 22-ft traveled way may be retained where alignment and safety records are satisfactory.

[b] Shoulders on arterials shall be paved; however, where volumes are low or a narrow section is needed to reduce construction impacts, the paved shoulder may be reduced to 2 ft.

Table 7-1 Minimum Width of Traveled Way and Shoulder

7.1.1.12 Horizontal Clearance to Obstructions

When fixed objects or non-traversable slopes fall within the roadside clear zones discussed under Horizontal Clearance to Obstructions in Chapter 4 of the *PGDHS* **(2)**, refer to the AASHTO *Roadside Design Guide* **(5)** for guidance in selecting the appropriate treatment. For guardrail installations, see CDOT *Standard Plans - M & S Standards* **(4)**.

7.1.1.13 Right of Way

A uniform width of right of way may be convenient, but there are special cases where additional right of way may be desirable. These cases include locations where the side slopes extend beyond the normal right of way, where greater sight distance is desirable, at intersections and junctions with highways, at-grade railroad crossings, and for environmental considerations.

Consider the following when determining right of way widths:

- Local conditions such as drainage and snow storage.
- Rounding of the slopes.

- Extending right of way 10 to 15 feet from the bottom of the toe or the top of the cut for level terrain, 15 to 20 feet for mountainous terrain.
- Utility corridor or easement.
- Irrigation features.
- Future capacity improvements.
- Transit alternatives.
- Additional needs for maintenance and utility purposes.

On staged construction, it may be desirable to construct the initial two lanes off-center so that the future construction will not interfere with the traffic or waste the investment in the initial grading and surfacing stage.

See Table 4-1.

7.1.1.14 Ultimate Development of Four-Lane Divided Arterials

Where it is anticipated that a DHV for the design year will be in excess of the design capacity of the two-lane arterial, the initial improvement should be patterned to the ultimate development of a four-lane divided arterial and provisions made for acquisition of the necessary right of way. Even where right of way is restricted, some form of separator should be used in the ultimate facility, with a median at least 4-feet wide, but preferably wider.

In the ultimate development of a four-lane divided arterial, the initial two-lane surfacing should be constructed to form one of the two-lane one-way surfaces.

7.1.2 Multilane Undivided Arterials

The minimum required sight distance at all points is the stopping sight distance, because passing is accomplished without the necessity of using an opposing traffic lane. Longer than minimum required stopping sight distance is desirable, as it is on any type of arterial.

Adequate shoulders, which encourage drivers to use them in emergencies, are essential on multilane undivided arterials.

If traffic volumes require the construction of multilane arterials in rural areas where speeds are apt to be high, it is generally considered that opposing traffic should be separated by a depressed median or barrier. All arterials on new locations requiring four or more lanes should be divided. Improvement of an existing two-lane arterial to a multilane facility should include a depressed median or barrier.

Undivided arterials with four or more lanes are most applicable in urban and suburban areas where there is concentrated development of adjacent land.

7.1.3 Divided Arterials

7.1.3.1 General Features

A divided arterial is one with separated lanes for traffic in opposite directions. It may be situated on a single roadbed or two widely separated roadways. The width of the median may vary and is governed largely by the type of area, character of terrain, intersection treatment, and economics. An arterial is not normally considered to be divided unless two full lanes are provided in each direction of travel and the median is 4 feet or wider and constructed or marked in a manner to preclude its use by moving vehicles except in emergencies or for left turns. A four-lane rural facility should have adequate median width to provide for protected left turns.

The principal advantages of dividing the multilane arterial are increased safety, comfort, and ease of operation. Of significance is the reduction of head-on collisions and virtual elimination of such accidents on sections with wide medians or with a median barrier. Pedestrians crossing the divided arterial are required to watch traffic in only one direction at a time and are provided a refuge at the median, particularly if a raised island is provided. Where the median is wide enough, crossing and left-turning vehicles can slow down or stop between the one-way pavements to take advantage of breaks in traffic and cross when it is safe to do so.

7.1.3.2 Lane Widths, Cross Slope, and Shoulders

See Chapter 4.

7.1.3.3 Medians

On highways without at-grade intersections, the median may be as narrow as 4 to 6 feet under restricted conditions but wider medians should be provided wherever feasible. A wide median allows the use of independent profiles. Median widths of more than 60 feet are undesirable at intersections that are signalized or may need to be signalized in the future.

Medians should be designed for the appropriate design vehicle such as buses.

While medians as narrow as 4 to 6 feet may be required under restricted conditions, medians 12 to 30 feet wide provide protection for left-turning vehicles at intersections. If urban situations are expected in the future, consider a median of 18 feet which accommodates a 12-foot turn lane and 6 feet for curb, gutter, and signage.

Median widths from 30 to 50 feet should be carefully considered from an operational standpoint at intersections. These widths do not provide median storage space for larger vehicles crossing the median. Also, these widths may encourage the driver to attempt the crossing independently leaving a portion of the vehicle unprotected from through traffic. These widths, even with these problems, normally operate quite well and apparently are within the realm of normal operational expectations of the driver.

For left-turn design, refer to Urban Arterials in Chapter 7 of the *PGDHS* **(2)**.

See Exhibit 7-7 **(2)** for typical medians on divided arterials. See also Chapter 3.

7.1.3.4 Climbing Lanes on Multilane Arterials

Climbing lanes generally are not as easily justified on multilane arterials as on two-lane arterials. A full discussion on the need for climbing lanes and their derivation is found in section 3.3.5.

7.1.4 Access Management

Consult the Region Access Manager, the *State of Colorado, State Highway Access Code* **(6)**, and Chapter 11 of this Guide.

7.2 URBAN ARTERIALS

7.2.1 General Considerations

Urban arterials carry large traffic volumes within and through urban areas. Their design varies from freeways with fully controlled access to two-lane streets.

The urban arterial system, which includes arterial streets and freeways, serves the major centers of activity of a metropolitan area, the highest traffic volume corridors, and the longest trips.

7.2.1.1 Design Speed

Design speeds for urban arterials generally range from 30 to 60 mph. Lower speeds apply in central business districts and in more developed areas, while higher speeds are more applicable to outlying suburban and developing areas.

7.2.1.2 Design Traffic Volume

See 7.1.1.2.

7.2.1.3 Levels of Service

Check with the Region Traffic Section for present and future levels of service. Procedures for determining levels of service are presented in the *Highway Capacity Manual* **(3)**. For acceptable degrees of congestion, rural and suburban arterials and their auxiliary facilities, i.e., turning lanes, weaving sections, intersections, interchanges, and traffic control systems (traffic signals, etc.), should generally be designed for level-of-service C for the particular design year. Heavily developed sections of metropolitan areas may necessitate the use of level of service D for the particular design year. When level-of-service D is selected, it may be desirable to consider the use of one-way streets or alternative bypass routes to improve the level of service.

7.2.1.4 Sight Distance

The sight distance values given in Table 3-1 are also applicable to urban arterial design.

7.2.1.5 Grades

The grades selected for an urban arterial may have a significant effect on its operational characteristics. For example, steep grades affect truck speeds and overall capacity. On arterials having large numbers of trucks and operating near capacity, flat grades should be considered to avoid undesirable reductions in speed. Steep grades also result in operational problems at intersections, particularly during adverse weather conditions. For these reasons, it is desirable to provide the flattest practicable grades while providing minimum gradients as required to ensure adequate longitudinal drainage in curbed sections. See Table 3-4.

7.2.1.6 Vertical Clearances

See section 7.1.1.9.

7.2.1.7 Curbs and Shoulders

Shoulders are desirable on any highway, and urban arterials are no exception. Shoulders contribute to safety by affording maneuver room and providing space for immobilized vehicles. They offer a measure of safety to the occasional pedestrian in sparsely developed areas where sidewalks are not appropriate. Shoulders serve as speed-change lanes for vehicles turning into driveways and provide storage space for plowed snow.

Despite the many advantages of shoulders on arterial streets, their use is generally limited by restricted right of way and the necessity of using the available right of way for traffic lanes. A raised curb at the outer edge of the shoulder is usually necessary in heavily developed areas as a means of controlling access and preventing deterioration of the shoulder. These requirements usually result in a cross section having a uniform pavement design with vertical-type curbs.

See Chapters 4 and 14 of this Guide and Chapter 4 of the *PGDHS* **(2)**.

7.2.1.8 Number of Lanes

A capacity analysis should be performed to determine the number of lanes.

7.2.1.9 Width of Roadway

Roadway width should be adequate to accommodate the traffic lanes, medians, curbs, and the required clearances from barrier faces. Parking on an arterial street should be considered only when provision is required because of existing conditions.

Lane widths may vary from 11 to 12 feet. Eleven-foot lanes are used quite extensively for urban arterial street designs. Twelve-foot lane widths are most desirable and are generally used on all higher speed, free-flowing, principal arterials. Under interrupted flow operating conditions at low speeds up through 40 mph, narrower lanes may be adequate.

The use of minimum requirements should be avoided if possible.

7.2.1.10 Geometric Design Type

Geometric design type wi1l be either Type B, Type A, or Type AA based on the number of lanes required for the facility. See Table 4-1.

7.2.1.11 Medians

Medians are a desirable feature of arterial streets and should be provided where space permits. Design of medians and median barriers is discussed in Chapter 4 of this Guide and the *PGDHS* **(2)**. Additional information on medians relative to urban arterials is given in Chapter 7 of the *PGDHS*.

7.2.1.11.1 Median Considerations

The designer should consider the possible future developments affecting the highway when selecting a median design. Two-lane highways, particularly in urban areas, may eventually require widening to four lanes. The ultimate use of the highway influences the selection of design criteria such as design speed, access openings, and whether rural or urban. Median design should be compatible with the eventual functional category of the highway.

Consider the following:

- Need for additional lanes in the future.
- Need for turning/storage lanes.
- Signalization.
- Improvements along outside lane (right turn provisions, curb and gutter, etc.).
- Need for parking.
- Pedestrian/bikeway requirements.
- Access requirements or controls.
- Clear zone requirements.

The above parameters compete with each other for available space and right of way. Even where right of way is restricted, some form of median should be provided on four-lane highways. The use of minimum requirements should be avoided if possible.

7.2.1.11.2 Width of Median

For rural and urban arterials:

- Four to 6-foot medians may be used under very restricted conditions.
- Twelve to 30-foot medians are desirable to provide protection for left turn lanes.
- Four to 8-foot medians should be avoided where left turns are common.

The width of median is the distance between inside edges of traveled ways. This width is dependent upon the type of facility, topography, and right of way considerations. For curbed medians, the gutter is not included in the traveled way, and the distance from face-to-face of curb should not be less than 2 feet.

Desirably, the median should be at least 18 feet wide for a 12-foot median turn lane and a 6-foot median separator. At restricted locations, a 10-foot lane with a 2-foot painted median separator may be used. The median width to accommodate left turning movements should be at least 12 feet. A median only 4 feet wide is better than none; however, each additional foot provides an added increment of safety and improved operation. Median widths less than 4 feet should be painted. Reasons for using distances less than those stated above shall be documented in a design decision letter.

At some locations, it may be necessary to forego the curbed median altogether and provide only pavement striping; e.g., a continuous two-way left turn lane. In these cases, the lane is not considered a median and should be designed as a separate lane (11 to 16 feet wide).

7.2.1.11.3 Width of Median Lanes

At commercial or business locations and where truck turning movements are high, the median turn lane should be 12 feet wide, and in no case less than the main line width. Turning movements with 5 percent or more of trucks should be studied for use of the 12-foot requirements. For a truck count of 10 percent or greater, it is recommended that 12-foot lanes be used. Buses should be treated in the same way as trucks.

When trucks and buses are not a consideration, auxiliary lanes may be reduced to a minimum of 10 feet if warranted. Conditions that may warrant the lesser width are:

- Narrow right of way.
- Narrow street widths.
- Narrow existing medians being modified at intersections.
- Safety improvements that furnish the minimum rather than nothing at all.

It is not desirable to reduce median lane widths to the minimum on any type of arterial street or on the higher speed rural roads.

Auxiliary lane design varies between urban and rural applications. On urban streets, the lower speeds, driver expectancy of sudden movements and presence of pedestrians, traffic signals, lighting, and narrow right of way help to justify accepting lower standards (use of minimums), if needed. On rural roads, the driver is accustomed to higher speeds, and median design should meet the desirable standards. Auxiliary lanes desirably should have the same width as provided on the main travel lanes. On arterial highways this width would normally be 12 feet.

7.2.1.11.4 Cross Slope for Curbed Medians

Curbed medians normally should be crowned with a slope of 4 percent for self-cleaning and drainage.

7.2.1.11.5 Median Contrast

Pavement and median areas should contrast effectively in color, texture, or both, under wet and dry conditions. Surface types that contrast with the traveled way should be used for surfacing medians.

7.2.1.11.6 Median Configuration and Typical Design

The type of treatment used in a median configuration is usually dependent on local practice and available right of way widths. The type selected should always be compatible with drainage and required street appurtenances. It is desirable that the median be of uniform width; however, where intersections are widely spaced (e.g., 0.5 miles or more), the width of median may be varied. This can be accomplished by using a narrow width between intersections where necessary for economy and gradually widening on the approach to the intersection to accommodate the left-turn lane. Where possible, transitions between varying median widths should be made on curves in order to avoid reverse curvature.

7.2.1.12 Drainage

Inlets that are safe for bicycles should be located adjacent to and upstream of intersections, pedestrian facilities, and at intermediate locations where necessary. Additional inlets should be provided in sag locations to avoid ponding of water where the grade flattens to zero percent and to mitigate flooding should an inlet become clogged.

7.2.1.13 Parking Lanes

See Chapter 7 of the *PGDHS* **(2)**.

7.2.1.14 Borders and Sidewalks

Coordinate closely with the local agency and ensure ADA compliance. See sections 4.16, 5.2.13, 5.2.14, and 5.2.15 for a more thorough discussion.

7.2.1.15 Roadway Width for Bridges

See Chapter 4, Table 4-1.

7.2.1.16 Horizontal Clearance to Obstructions

AASHTO standards for clear zone design are recommended for urban arterials whenever feasible. On curbed street sections, this design is often impracticable, particularly in restricted areas. In those areas, a clearance from curb face to object of 1.5 feet or wider where possible should be the minimum. A 3-foot clearance will desirably be provided particularly near turning radii at intersections and driveways. This desirable offset provides the clearance required for overhang of trucks from striking the object. When pedestrians are not a factor, obstructions should be well set back, protected, or provided with breakaway features. Guardrail may be considered in special cases. Refer to the AASHTO *Roadside Design Guide* **(5)**.

7.2.1.17 Right of Way Width

The right of way should be wide enough to accommodate all of the cross-sectional elements throughout the project. This usually precludes a uniform right of way width since there are typically many situations where additional width is desirable. Such situations occur where the side slopes extend beyond the normal right of way, for clear areas at the bottom of traversable slopes, for wide clear areas on the outside of curves, where greater sight distance is desirable, at intersections and junctions with highways, at railroad-highway grade crossings, for environmental considerations, and for maintenance access.

Local conditions such as drainage and snow storage should be considered in determining right of way widths. Where additional lanes may be needed in the future, the initial right of way width should be adequate to provide the wider roadway section.

7.2.1.18 Intersection Design

Chapter 9 discusses intersection development in detail. It is recommended that each individual intersection be carefully evaluated in the early design phases.

7.2.1.19 Lighting

See section 3.7.

REFERENCES

1. CDOT. *CDOT Traffic Volume Maps.* [http://internal/App_DTD_DataAccess/index.cfm]

2. AASHTO. *A Policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C.: 2001.

3. Transportation Research Board, *Highway Capacity Manual*, Special Report No.209, National Academy of Sciences, National Research Council, Washington, D.C., 2000.

4. CDOT. *Standard Plans - M & S Standards* Colorado State Department of Transportation, 2000.

5. AASHTO. *Roadside Design Guide*, American Association of State Highway and Transportation Officials, Washington. D.C.: 2002.

6. Colorado Department of Transportation, Colorado State Transportation Commission, *The State of Colorado, State Highway Access Code*, 2 CCR 601-1.