Chapter 3
Facility Type – Road

Legend

(solid border box)	Multimodal Application Example
(dotted border box)	Context-Sensitive Solutions Application Example
(dashed border box)	Performance-Based Practical Design Application Example
(cyclist icon)	Multimodal (MM)
(mountain icon)	Context-Sensitive Solutions (CSS)
(light bulb icon)	Performance-Based Practical Design (PBPD)
(globe icon)	Web link for additional information
(AASHTO seal)	AASHTO-Specific Information

Chapter
3

3 Facility Type – Road

Road
Context Classifications: C1 Rural Mountainous Environment, C2 Rural Places, C3 Suburban Places.
A facility generally characterized as a two or more-lane roadway with shoulders and roadside ditches, mainly found in a rural, low-density settings.

3.1 Introduction

The guidelines in this chapter apply to facilities defined as Roads, consistent with the definitions in Chapter 1 of this Guide and Chapter 5 of the American Association of State Highway and Transportation Officials (AASHTO) *A Policy on Geometric Design of Highways and Streets* (the Green Book) (2018 AASHTO GDHS) (AASHTO, 2018). Guidelines for Streets and Freeways, Expressways, and Interstates are described in Chapters 4 and 5, respectively.

A road facility type (Road) is typically found in low-density and rural areas, such as the Rural Mountainous Environment, Rural Places, and Suburban Places context classifications, and are characterized as a two or more-lane roadway with shoulders and roadside ditches. A Road can be any functional classification—Arterial, Collector Road and Street, or Local Road and Street. Low-volume facilities may provide access to a farm, a residence, a business, or other abutting property. Low-volume facilities include forest, recreational, and resource development roads. High-volume facilities may connect communities.

Refer to Chapter 1 of this Guide for definitions of functional classifications, facility types, and context classifications that are used in this chapter.

3.2 Highway Capacity (Transportation Facility Operations)

3.2.1 Highway Capacity Manual

When a Road is being scoped for improvements, the designer needs to know current and projected traffic volumes and level of service (LOS) for the future design year. A 20-year capacity design project for what is a Road in current year might need to be designed as a Street facility type with additional lanes in the future year if there are projected traffic volume increases and lower levels of service. If capacity improvements for future conditions can be addressed by adding a passing lane to the facility, the Road may be appropriate.

The *Highway Capacity Manual, Seventh Edition: A Guide for Multimodal Mobility Analysis* (*Highway Capacity Manual*) (TRB, 2022) has tools for the designer to quickly evaluate and compare multimodal operational effects of concepts, performance measures, and analysis techniques to determine the appropriate facility type.

Along with the operational and capacity analysis presented in the *Highway Capacity Manual*, the considerations presented in this chapter will help determine the appropriate context classification (C1 through C3) for design of a Road. Decisions regarding which context classification to apply to a Road should be discussed with the Resident Engineer and Region Traffic Engineer so that there is agreement on the appropriate project outcome and scope.

3.2.2 Factors Other Than Traffic Volume That Affect Operating Conditions

There are many factors that can affect the operating conditions of a Road. Some examples the designer should consider are:

- Design speed of the existing road.
- Weaving sections of the road.
- Intersection type or types.
- Number of side road accesses.
- Vertical and horizontal sight distances.
- Mixture of vehicle types using the road.

Refer to Chapter 2, Section 2.4.4, of the 2018 AASHTO GDHS for information on these factors.

3.2.3 Multimodal Considerations

Because a Road is often in a rural environment, design considerations for pedestrian, bicycle, and transit activity may be minimal. However, the designer needs to understand the context and potential multimodal trip generators in the area. This requires the designer to consider the facility's ability to support these multimodal elements. The guidance in the following resources can help determine how to accommodate alternative modes of transportation in Road design.

Use this link to access FHWA's Small Town and Rural Multimodal Networks publication (FHWA, 2016): Small Towns - Publications - Bicycle and Pedestrian Program - Environment - FHWA (dot.gov)

Use this link to access FHWA's Guidebook for Measuring Multimodal Network Connectivity (FHWA, 2018): https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_connectivity/

Use this link to access the National Association of City Transportation Officials (NACTO) Transit Street Design Guide (NACTO, n.d.): https://nacto.org/publication/transit-street-design-guide/transit-system-strategies/

3.2.4 Design Service Flow Rates

In general, the design service flow rate is defined as, the maximum hourly vehicular volume that can pass through a Road element at the selected level of service for the facility. Refer to Chapter 2, Section 2.4.3.1, of the 2018 AASHTO GDHS for information on design service flow rates.

3.3 General Design Considerations

In the rural parts of Colorado, a Road may be a State Highway. In some instances, the Road can be the "main street" as it passes through a town. In this situation, the facility can transition from a Road to a Street facility type, which means there would be two sets of design criteria for the project—one for the rural context (C1 and C2) and one for the higher-density context that may have a mix of pedestrian, bicycle, and transit uses (C3 through C6). This needs to be acknowledged and discussed during project scoping and design.

Local agencies desiring to use federal funds must design projects to meet the design standards or the minimums presented in the 2018 AASHTO GDHS and in this Guide. The use of federal funds also requires that the National Environmental Policy Act (NEPA) process be followed. Historic districts require special consideration that may require consultation with the State Historic Preservation Office (SHPO).

3.4 Design Speed

Design speeds ranging from 25 to 45 mph are typically considered for a Road, depending on available right of way, terrain, adjacent development, and other area controls. When a Road is also a highway the design speeds could be as high as 65 mph. For new and reconstructed facilities, the designer should strive to design the segment to the appropriate standards to maintain the designated design speed. Refer to Table 5-1, Minimum Design Speeds for Roads, in the 2018 AASHTO GDHS to determine appropriate design speeds while considering traffic volumes and context.

A designer needs to recognize conditions when actual operating speeds may exceed the posted speed or even the design speed and consider those nuances in the overall design of a segment. For example, a rural Road (C1) with relatively low traffic volumes may create a sense of confidence in the driver to drive faster than the posted speed. Another common example is an older Road that may have terrain or a roadway curve that requires a design and posted speed below the general operating speed. The common practice is to post an advisory speed sign in advance of the varying terrain or curve to alert drivers to adjust to a lower safe operating speed if the design cannot easily accommodate the design speed for the corridor.

For new and reconstructed facilities, the designer should strive to design the Road segment to the appropriate standards to maintain the designated design speed. Refer to Table 5-1, Minimum Design Speeds for Roads, in the 2018 AASHTO GDHS to determine appropriate design speeds taking into consideration traffic volumes and terrain.

Designing a Road to too high a design speed may inadvertently become a barrier and/or increase crash potential for non-motorized uses, such as people and bicyclists, along the corridor. See Chapter 13 of this Guide for more information on the design of bicycle facilities.

When designing a Road, the surrounding natural and built environment can directly influence the design considerations for a specific Road segment. The designer needs to recognize how the physical setting will influence the design speed and consider what measures can be used to influence driver expectations to maintain appropriate speeds. For example, a driver will operate at the posted speed or faster if the Road is designed for 45 mph as a straight, two-lane Collector with 10-foot shoulders. When that same Road transitions from a Rural Places to Mountainous Environment context and begins to curve, a driver can enter a curve at too high a speed if traffic calming features are not considered.

The designer may use the current posted speed as a logical governing design criterion, but a better practice is to use performance-based practical design (PBPD). The designer can drive the road and observe what drivers are doing. It may also be appropriate to request a traffic and safety analysis to determine the 85th percentile speed and safety performance to determine if there are crash patterns to potentially mitigate.

3.5 Design Traffic Volume

Current and future traffic volumes are important design considerations. The basis of traffic design is to calculate the anticipated Design Hour Volume (DHV) of traffic projected to a future design year. During the planning stage of a project, the Region Traffic Engineer can provide current traffic volumes, predict future traffic volumes, and determine the future design year that is appropriate for the project. Design traffic volume should be estimated for at least 10 years, and preferably 20 years, from the date of completion of construction. A simple resurfacing project may only need a future DHV of 10 years, while a major rehabilitation or reconstruction project may require a future DHV of 20 years.

In determining the design traffic volume, it is important to understand the perceptions of the local community regarding traffic growth and congestion. In rural parts of Colorado, three cars stopped at an intersection may be perceived as congestion. The designer must consider the local context of the traffic impacts and determine if something can be done differently. Understanding the perception of traffic volumes and their impacts, no matter how large or small, helps to make the design context-sensitive and appreciated by the local users.

3.6 Level of Service

Understanding level of service (LOS) and how it impacts design must take several factors into consideration. Consider that a stop-controlled intersection on a Road may target a LOS C rather than an LOS D or LOS E for a signalized intersection. Discussions with the local traffic engineer and individuals who have a good working knowledge of the conditions at the project location can determine what an acceptable LOS target should be for the design.

Generally, the side friction of the road will meter traffic progression and speed that determine LOS. Traffic activity at an intersection is what most likely impacts overall LOS for a rural Road; therefore, the intersection LOS plays a more important role in the general traffic progression of a Road. Refer to the *Highway Capacity Manual* (TRB, 2022) for further information on LOS.

3.7 Multimodal Accommodations

Road facility types are more commonly found in rural areas where bicycle, pedestrian, and transit activities are less prevalent than on Street facility types. When there are multimodal activities, it may be related to recreation and/or tourism attractions where bicyclists, transit patrons, and pedestrians may be using a Road simultaneously.

3.7.1 Transit

While transit systems most commonly operate on Street facility types in medium to large cities, such as Grand Junction, Pueblo, Boulder, and Denver, they can also operate on a Road in more rural contexts. For example, the VelociRFTA Bus Rapid Transit, serving the Roaring Fork Valley, is the first rural bus rapid transit system in the nation. While most of the VelociRFTA route operates on Roads in a Rural Places (C2) context, it passes through several Downtown Places (C5) areas with Streets. The designer needs to coordinate with the local and regional agencies, such as school districts, cities, counties, and Metropolitan Planning Organizations, to identify where transit systems exist and where they may be planned in the future. This will help determine what accommodations need to be incorporated into the Road design.

The single largest public transit service in the state is the school bus system. It is important to coordinate with the local school district to identify whether a roadway is a school bus route, to identify the location of the bus stops, and to discuss roadway design that will make school pick-up and drop-off safe.

3.7.2 Bicycles

In Colorado, bicycles are considered a vehicle. They are allowed on most roadways but generally not on interstates unless there is no alternate route available. Colorado has 26 Scenic & Historic Byways, which are also popular bicycle routes on Roads in rural areas. The designer should investigate whether there are bicycle facilities on the Road and consult with local agencies to understand policies and plans related to current and to future bicycle infrastructure and accommodations.

Use this link to access information about Colorado's Scenic & Historic Byways: https://www.codot.gov/travel/colorado-byways

Use this link to access the Colorado Bicycle & Byways Map: https://www.codot.gov/programs/bikeped/information-for-bicyclists/colorado-bicycling-maps

Use this link to access the Colorado's High Demand Bicycle Corridors Map: https://www.codot.gov/programs/bikeped/high-demand-bicycle-corridors

Bicycle facility design is largely dependent on the physical surroundings (context classification) and functional classification, namely speed and motorized traffic volume; and preferred facilities vary by local or regional agencies. Often, agencies have plans and recommendations for facility types, but, if none exist, the CSS process can help determine the appropriate facility, using Chapter 13 of this Guide as a reference.

"Sharrow" markings can be used on Roads with restricted roadway width and posted speeds of 35 mph or less. Sharrows should be only used where no other alternative is possible to accommodate the bicycle activity. The use of sharrows could be appropriate where the Road is making its final transition from a Rural Places context to more urban environment. The appropriate use of a sharrow markings should be discussed with the Region Traffic Program.

3.7.3 Pedestrians

A Road in a C1 or C2 context classification typically does not have pedestrian activity, but the designer should exercise due diligence to identify if there are pedestrian trip generators and activity. If pedestrian activity is occurring, the designer needs to consider ways to make that activity safe, particularly on Roads with a higher functional classification where vehicular speeds tend to be higher. Refer to Chapter 13 of this Guide for more information on shared-use paths.

Crash histories show that pedestrians are most vulnerable at crossings, designers should consider street design elements that reduce pedestrian exposure at these locations.

Refer to Chapter 2, Section 2.6.1, of the 2018 AASHTO GDHS for more information. Refer to Section 3.8 for information on accessible design.

3.7.4 Motorized Vehicles

Motorized vehicles that typically use a Road include passenger vehicles, freight transport, agricultural equipment, school buses, interregional transit, industrial machinery, trash trucks etc.

Knowing the type of vehicles that commonly use a Road and the land uses they access impacts design decisions regarding lane widths, shoulder widths, turning radii, and stopping sight distance. Typically, passenger vehicles and light trucks are the starting point for vehicle design considerations on a Road. Design standards for larger vehicles can be used based upon the specific project area and the local business needs and the types of vehicles that use the Road.

3.8 Accessible Design

When designing improvements to a Road, the designer should determine if existing Americans with Disabilities Act (ADA) accommodations are to standard or if they need to be added or upgraded. ADA elements are unique to each location and require a level of design detail that cannot be short-cut. CDOT follows design and construction guidance and standards found in the U.S. Department of Transportation ADA Standards for Transportation Facilities (USDOT, 2006), the U.S. Department of Justice 2020 ADA Standards for Accessible Design (U.S. Department of Justice, 2020), Americans with Disabilities Act Architectural Guidelines for Buildings and Facilities (ADAAG) (U.S. Access Board, 2002), and the *Manual on Uniform Traffic Control Devices for Streets and Highways* (FHWA, [2009] 2022). In addition, CDOT adopted the Proposed Right-of-Way Accessibility Guidelines (PROWAG) for curb ramps, which also provides design guidance for sign heights and pedestrian pushbuttons for traffic signals (U.S. Access Board, 2011). The designer should evaluate innovative ways to shorten pedestrian crossings at intersections to provide the greatest safety to the pedestrian. If the intersection is signalized, PROWAG guidance is highly recommended to provide the highest level of ADA accommodations.

Refer to Chapter 12 of this Guide for information on CDOT's design standards for ADA accessibility and PROWAG related to curb ramps.

Refer to Chapter 2, Section 2.6.7, of the 2018 AASHTO GDHS for more information.

Use this link to access CDOT's ADA resources for engineers, including CDOT's ADA Transition Plan: https://www.codot.gov/business/civilrights/ada/resources-engineers

3.9 Access Control and Access Management

Access control and management is critical to maintaining a safe facility. When access is managed and controlled, there is a safer environment for the public. Refer to Chapter 2, Section 2.5.1, of the 2018 AASHTO GDHS, the State Highway Access Code (2 CCR 601-1) (State of Colorado, 2002), and Chapter 11 of this Guide for further information on access control and management.

3.10 Horizontal and Vertical Geometry

The horizontal and vertical design elements for a Road are determined by the surrounding environment and context classification.

The designer must fully consider what horizontal and vertical design elements for a Road are required within a given context classification. A residential Road in a C3 or C4 context classification may have curb and gutter, storm sewer, sidewalks, buffer areas, bike lanes, and on road parking. A Road in a C1 or C2 context classification may have travel lanes, shoulders, and roadside ditches. A forest service road may be gravel, in steeper terrain, and may include elements to ensure proper drainage, while minimizing erosion and environmental impacts. A county road may need shoulders, z-slope, and ditches to contain surface runoff from adjacent properties. The designer must fully consider the different design requirements within a given context classification, understanding that a project may be located in more than one context classification.

Intersections on a Road may require special design considerations for safety. In more rural environments, even though crashes may be infrequent, the severity of crashes may be elevated. Minor improvements can provide major safety benefits. Design considerations should include:

- Avoid locating intersections on steep profile grades.
- Avoid locating intersections just before or after a crest vertical curve.
- Avoid locating intersections within horizontal curves.
- Design intersection approaches to be as close to perpendicular with the major roadway as possible.
- Design with adequate corner radii for the design vehicle.
- Stopping sight distances.
- Intersection sight triangles.

Refer to Chapters 6, 7, and 8 of this Guide for additional information on design calculations and considerations for Roads.

3.11 Alignments

Road alignments should fit closely with the existing topography to minimize the need for cuts or fills. The alignment should not reduce safety but may be altered to serve a special purpose if desired by the local planning officials.

Road alignments in industrial areas (in C2 and C3) should take into account the topography but should be as direct as possible. The choice of alignment, cross section, and right of way width may be based on avoiding and minimizing construction impacts to adjacent property associated with hazardous waste or petroleum product contamination.

Curvature for a Road should be designed with a radius appropriate for the design vehicle, design speed, and intended superelevation. Superelevation of a Road with a higher design speed is not uncommon. However, the designer needs to consider winter driving conditions and the effects of reduced friction factors on a superelevated roadway due to winter icing conditions.

Refer to Chapter 6 of this Guide and Chapter 3, Section 3.3.3.3, of the 2018 AASHTO PGDHS for additional information on superelevation considerations.

3.12 Grades

Maximum grades for a Road are a function of terrain and design speed. Refer to Table 5-2 in the 2018 AASHTO GDHS.

There are locations where grades cannot meet the 2018 AASHTO GDHS standards, and a PBPD analysis of the current roadway operations, crashes, etc. may reveal that the current condition is acceptable. The analysis could also indicate hot spots where a problem exists. Using PBPD may help the designer to better determine where necessary improvements are needed and to better maximize the project budget to improve those hot spots.

The grade for a residential Road in a C3 classification should be as flat and consistent with the surrounding terrain as possible. When grades are 4% or steeper, drainage design to manage water velocity may become more of a factor in design. For a Road in an industrial area with truck traffic (C2 or C3), grades should be less than 8% and desirably less than 5%. For a Road that is a state highway, the grades can be as high as 10%. Ideally, the grades should be less than 7% for long descents. Long, steep grades are problematic for heavy trucks to descend safely. The designer should carefully consider descent grades where trucks commonly use a Road. Refer to Table 6-4 in Chapter 6 of this Guide for maximum grades.

To provide for drainage, the minimum preferred grade used for a Road with curbs is 0.30% but as flat as 0.20% may be used when sufficient drainage can be provided. Where bikeways are present, there may be specific grade requirements to accommodate bicycles.

Approach grades to intersections should be reduced to less than 8% to accommodate improved stopping distances and to improve vehicle starts to efficiently cross the intersection quickly and safely. This is also beneficial in areas where winter conditions are common.

3.13 Vertical Curves

Design controls for vertical sag and crest curves are provided in Table 5-3 (stopping sight distance) and Table 5-4 (passing sight distance) of the 2018 AASHTO GDHS. Criteria for measuring stopping sight distance include an eye height of 3.5 feet and an object height of 2.0 feet. Passing sight distance criteria include an eye height of 3.5 feet and the object height of 3.5 feet.

3.14 Cross Slope and Superelevation

The cross slope for a Road is dependent on the Road's surface type, posted speed, and whether it has curb and gutter or shoulders and ditches. Cross slope can also be affected by topographic features. Adding superelevation to a Road may be necessary as the design speed increases.

Using PBPD principles may help to determine if superelevation is appropriate, as applied in the following scenario.

Example PBPD Application

A designer is considering whether superelevating a curve is warranted. The curve is not superelevated in the existing condition. The designer contacts the Region Traffic Representative with traffic engineering expertise in the area of Data Driven Safety Analysis (DDSA). The designer provides the Region Traffic Representative the estimated cost associated with superelevating the curve. The Region Traffic Representative examines the Road for the presence of correctable crash patterns and the potential for crash reduction at this specific curve location—if the curve is not superelevated versus if the curve were superelevated. This key analysis feeds into the benefit-cost analysis of the superelevated versus non-superelevated scenarios. The designer uses this analysis to inform the decision whether to superelevate the curve in conjunction with context-sensitive solutions (CSS) considerations and other factors.

Pavement cross slope should be adequate to provide proper drainage. A typical cross slope of 1.5% to 2.0% is acceptable for most paved roads. A steeper cross slope may be necessary for gravel or unpaved roadways. An example of a Road cross slope is shown in Figure 4-1 of the 2018 AASHTO GDHS. The designer should strive to maintain the same roadway cross slope on the shoulder.

Although superelevation is advantageous for traffic operations, such factors as wide pavements, abutting properties, drainage, intersections, and access points may make it impractical in more developed environments. Therefore, superelevation is not usually provided on low-speed and secondary Roads in residential and commercial areas (C2 or C3). It may need to be considered, however, in industrial areas (C2 or C3) or on a Road with operating speeds above 40 mph. A detailed discussion of superelevation is found in Chapter 6 of this Guide.

3.15 Cross Section Elements

Cross section elements of a Road (lane, shoulder, median, topographic impacts, parking, multimodal amenities, etc.) are varied and can be quite simple or complex. PBPD plays a key role in developing cross sections. Using good data analysis helps define the cross section elements that are needed and the widths that are appropriate to accommodate all users. Refer to Chapter 7 of this Guide for cross section elements.

When bicycle facilities are included as part of the design, refer to Chapter 13 of this Guide for bicycle facilities design, and refer to Chapter 12 of this Guide for accessible pedestrian design considerations.

3.16 Median Type

Medians on a low-speed Road are either raised or painted; justification is required to provide a continuous type median. Residential Roads (C2 or C3) rarely have medians. Roads that are state highways may have medians when there are passing lanes, auxiliary turn lanes, or an increased presence of accesses creating multiple turning movements on and off the highway. Median widths can vary from 4 feet to 20 or more feet. A raised median should be wide enough to accommodate the largest required signing width so that a sign does not extend beyond the median and become a striking hazard to vehicles. Median areas of 1 to 3 feet in width are considered" separators" or "dividers" and not medians and may not accommodate required sign widths.

3.17 Drainage

Proper drainage design minimizes high runoff and flooding potential. Drainage facilities, such as bridges, culverts, channels, curbs, gutter, and storm sewer systems, carry water across the right of way and are designed so that stormwater is removed from a Road surface.

The principal objective in drainage design is to control the presence and flow of water on a Road surface such that pedestrians, bicyclists, and vehicles are not placed in an unsafe situation during storm events.

It is desirable to use a minimum crown slope of 2.0% (0.02 foot/foot), particularly where the surrounding terrain is relatively flat. This reduces ponding areas that can contribute to deterioration of pavement and create safety problems. For additional information, refer to the CDOT *Drainage Design Manual* (CDOT, 2019).

Drainage requirements for a Road vary depending upon the context classification. County Roads and Roads in a C1, C2, or C3 classification may have a shoulder and a ditch that collects sheet flow off the Road. In this instance, drainage facilities need to accommodate runoff from the Road and the water that is intercepted by the ditch from adjacent properties. If a Road intercepts runoff from a specific drainage basin, the designer needs to ensure that the runoff makes its way back to the drainage basin it originated in. Diverting drainage away from a basin should be avoided as much as possible.

3.18 Pedestrian Facilities

Pedestrian facility design is largely dependent on the physical surroundings (context) and functional classification, namely speed and motorized traffic volume, and preferred facilities vary by local agency. Often, local agencies have plans and recommendations for facility types. If none exist, the CSS process can help determine the appropriate facility, using Chapter 13 of this Guide.

Pedestrian curb ramps must be compliant with PROWAG (U.S. Access Board, 2011). Other pedestrian facilities must be compliant with Americans with Disabilities Act Architectural Guidelines for Buildings and Facilities (ADAAG) (U.S. Access Board, 2002). Refer to Chapter 12 of this Guide for accessible pedestrian design.

3.19 Bicycle Facilities

Bicycle facility design is largely dependent on the physical surroundings (context) and functional classification, namely speed and motorized traffic volume, and preferred facilities vary by local agency. Often, local agencies have plans and recommendations for facility types. If none exist, the CSS process can help determine the appropriate facility using Chapter 13 of this Guide.

When bicycle facilities are also pedestrian facilities, such as shared-use paths, they must be compliant with PROWAG (U.S. Access Board, 2011). Refer to Chapter 12 of this Guide for accessible pedestrian design.

3.20 Transit Facilities

Transit facilities are becoming more common on Roads in both rural and urban settings. If there is a transit route or a school bus route with stops within the project limits, the designer needs to determine if there is adequate space within the Road cross section at the stops to accommodate the safe loading and unloading of passengers without impeding through vehicles.