Intersection Geometric Design II

Course Number: CE-03-915

PDH: 3

Approved for: AK, AL, AR, FL, GA, IA, IL, IN, KS, KY, LA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, SC, SD, TN, TX, UT, VA, VT, WI, WV, and WY

New Jersey Professional Competency Approval #24GP00025600
North Carolina Approved Sponsor #S-0695
Maryland Approved Provider of Continuing Professional Competency
Indiana Continuing Education Provider #CE21800088
Florida Provider #0009553 License #868
NYSED Sponsor #274

This document is the course text. You may review this material at your leisure before or after you purchase the course. In order to obtain credit for this course, complete the following steps:

1) Log in to My Account and purchase the course. If you don't have an account, go to New User to create an account.

2) After the course has been purchased, review the technical material and then complete the quiz at your convenience.

3) A Certificate of Completion is available once you pass the exam (70% or greater). If a passing grade is not obtained, you may take the quiz as many times as necessary until a passing grade is obtained (up to one year from the purchase date).

If you have any questions or technical difficulties, please call (508) 298-4787 or email us at admin@PDH-Pro.com.

INTRODUCTION

This course is the second of two that summarizes and highlights the geometric design process for modern roadway intersections. The contents of this document are intended to serve as guidance and not as an absolute standard or rule.

When you complete this course, you should be familiar with the general guidelines for at-grade intersection design. The course objective is to give engineers and designers an in-depth look at the principles to be considered when selecting and designing intersections.

Subjects include:

General intersection design considerations

Roundabout design – elements, single-lane, multilane, mini-roundabouts

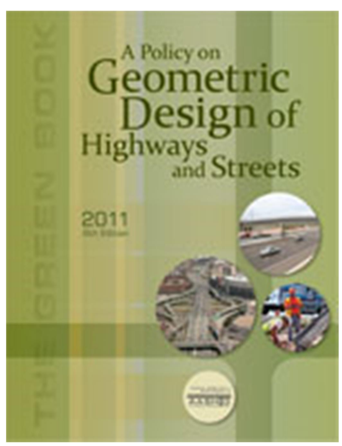
Frontage roads

Pedestrian facilities

Bicycle considerations

Railroad crossings – alignments, sight distance

For this course, Chapter 9 of **A Policy on Geometric Design of Highways and Streets** (also known as the "Green Book") published by the American Association of State Highway and Transportation Officials (AASHTO) will be used primarily for fundamental geometric design principles. This text is considered to be the primary guidance for U.S. roadway geometric design.



This document is intended to explain some principles of good roadway design and show the potential trade-offs that the designer may have to face in a variety of situations, including cost of construction, maintenance requirements, compatibility with adjacent land uses, operational and safety impacts, environmental sensitivity, and compatibility with infrastructure needs.

Geometric design is the assembly of the fundamental three-dimensional features of the highway that are related to its operational quality and safety. Its basic objective is to provide a smooth-flowing, crash-free facility. Geometric roadway design consists of three main parts: **cross section** (lanes and shoulders, curbs, medians, roadside slopes and ditches, sidewalks); **horizontal alignment** (tangents and curves); and **vertical alignment** (grades and vertical curves). Combined, these elements provide a three-dimensional layout for a roadway.

The practice of geometric design will always be a dynamic process with a multitude of considerations: driver age and abilities; vehicle fleet variety and types; construction costs; maintenance requirements; environmental sensitivity; land use; aesthetics; and most importantly, societal values.

Despite this dynamic character, the primary objective of good design will remain as it has always been – **to provide a safe, efficient and cost-effective roadway that addresses conflicting needs or concerns.**

BASICS

Intersections are unique roadway elements where conflicting vehicle streams (and sometimes non-motorized users) share the same space. This area encompasses all modes of travel

- *pedestrian*
- *bicycle*
- *passenger vehicle*
- *truck*
- *transit*

as well as auxiliary lanes, medians, islands, sidewalks and pedestrian ramps. These may further heighten the accident potential and constrain the operational efficiency and network capacity of the urban street system. However, *the main objective of intersection design is to facilitate the roadway user and enhance efficient vehicle movement.* The need to provide extra time for drivers to perceive, decide, and navigate through the intersection is central to intersection design controls and practices.

Designing to accommodate the appropriate traffic control are critical to good intersection design. Warrants and guidelines for selection of appropriate intersection control (including stop, yield, all-stop, or signal control) may be found in the MUTCD.

Basic Elements of Intersection Design

Human Factors

Driver habits, decision ability, driver expectancy, decision/reaction time, paths of movement, pedestrian characteristics, bicyclists

Traffic Considerations

Roadway classifications, capacities, turning movements, vehicle characteristics, traffic movements, vehicle speeds, transit, crash history, bicycles, pedestrians

Physical Elements

Abutting properties, vertical alignments, sight distance, intersection angle, conflict area, speed-change lanes, geometric design, traffic control, lighting, roadside design, environmental factors, crosswalks, driveways, access management

Economic Factors

Improvement costs, energy consumption, right-of-way impacts

A range of design elements are available to achieve the functional objectives, including horizontal and vertical geometry, left- and right-turn lanes, channelization, etc.

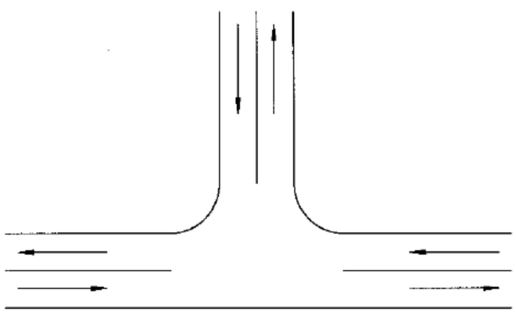
Level of service analysis and roadway capacity are critical considerations in intersection design. Capacity is determined by constraints at intersections. Vehicle turns at intersections interrupt traffic flow and reduce levels of service.

AASHTO defines intersection capacity as “the maximum hourly rate at which vehicles can reasonably be expected to pass through the intersection under prevailing traffic, roadway, and signalization conditions”. The Highway Capacity Manual (HCM) provides various analysis techniques for comparing different conditions at intersections.

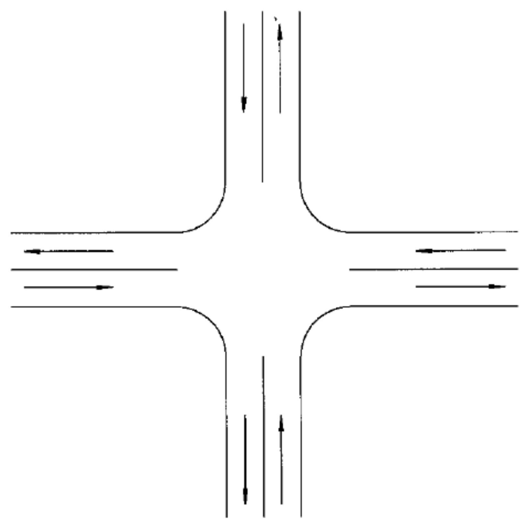
A well-designed intersection is clear to the driver with design dimensions supporting operational requirements, traffic control devices functioning as intended, and nonmotorized vehicle users operating safely through the intersection.

Basic Types of Intersections

- Three-leg (T)
- Four-leg
- Multi-leg
- Roundabout



THREE-LEG INTERSECTION



FOUR-LEG INTERSECTION

ROUNDABOUT DESIGN

The “modern roundabout” was a British solution to the problems associated with rotary intersections. The resulting design is a one-way, circular intersection with traffic flow around a central island. The U.K. adopted a mandatory “give-way” rule for entering traffic at all circular intersections to yield to circulating traffic. This rule greatly reduced the number and severity of vehicle crashes.

Basic Principles for Modern Roundabouts

1) **Yield control at all entry points** – All approaching traffic is required to yield to vehicles on the roundabout’s circulatory roadway before entering the circle. Yield signs are used primarily as entry control. Weaving maneuvers are not considered a design or capacity factor.
2) **Traffic deflection** – Entering vehicles are directed to the right (in the U.S.) by channelization or splitter islands onto the roundabout’s circulating roadway avoiding the central island. No entrance traffic is permitted to travel a straight route through the roundabout.
3) **Geometric curvature** – Entry design and the radius of the roundabout’s circulating roadway can be designed to slow the speeds for entering and circulating traffic.

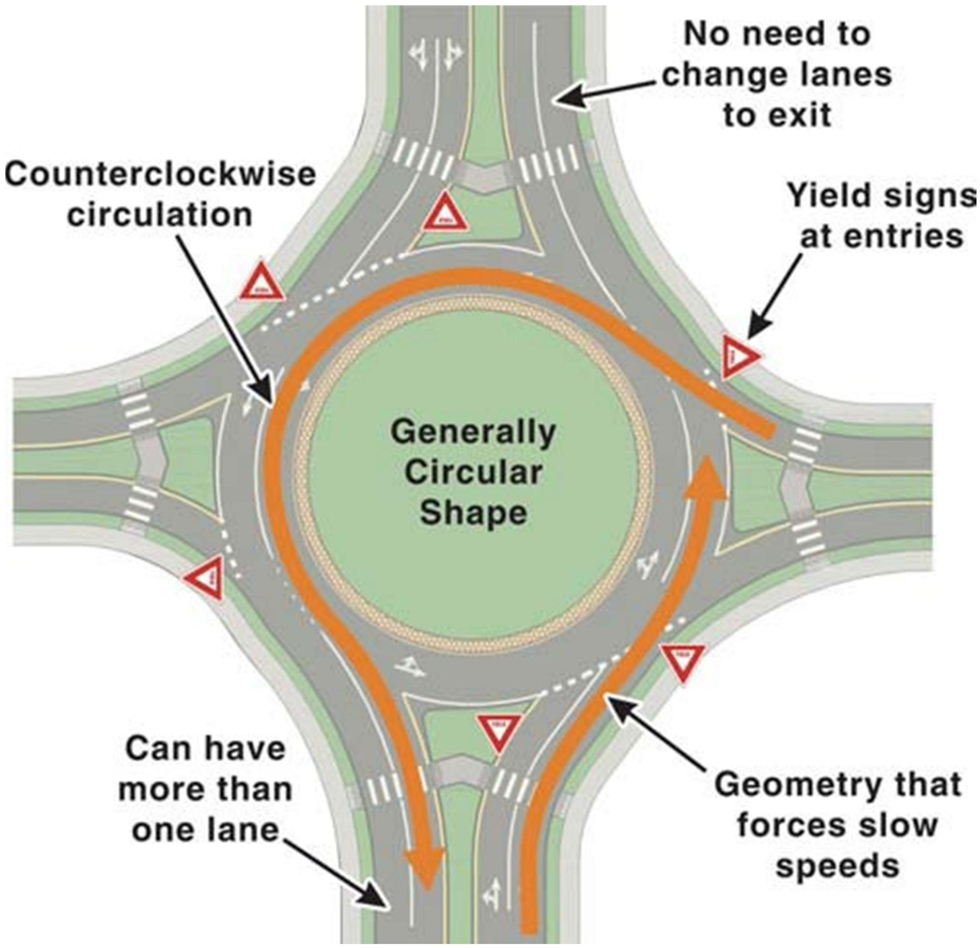


Exhibit 1-1

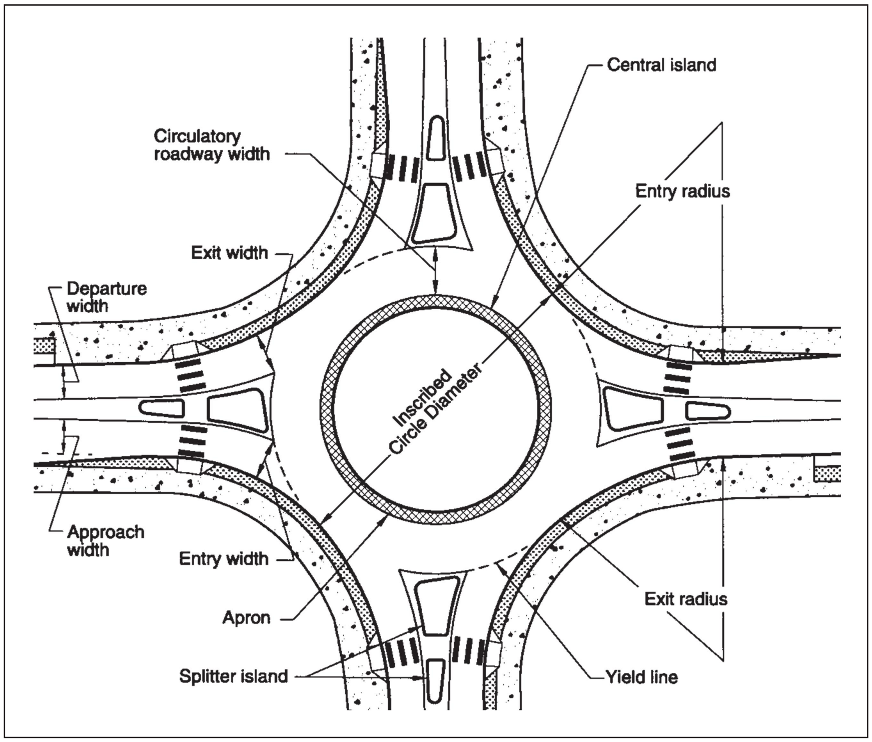
Key Roundabout Characteristics

(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

Roundabout geometric design is a combination of balancing operational and capacity performances with the safety enhancements. Roundabouts operate best when approaching vehicles enter and circulate at slow speeds. By using low-speed design elements (horizontal curvature and narrow pavement widths for slower speeds) the capacity of the roundabout may be negatively affected. Many of the geometric criteria used in design of roundabouts are also governed by the accommodation of over-sized vehicles expected to travel through the intersection.

Exhibit 6-1. Basic Geometric Elements of a Roundabout.

(FHWA. Roundabouts: An Informational Guide. 2000)



Roundabout Geometric Elements

Central Island

Raised area (not necessarily circular) in the center of the roundabout which is bordered by circulating traffic.

Splitter Island

Raised or painted approach area for delineating, deflecting and slowing traffic. It also permits non-motorist crossings.

Circulatory Roadway

Curved vehicle path for counterclockwise travel around the central island.

Apron

Optional mountable part of the central island for accommodating larger vehicle wheel tracking.

Yield Line

Pavement marking for entry point to the circulatory roadway. Entry vehicles must yield to circulating traffic before crossing the yield line onto the circulatory path.

Accessible Pedestrian Crossings

Non-motorist access that is setback from the entrance line and cut through the splitter island.

Landscape Strip

Optional areas for separating vehicle/non-motorist traffic, designating crossing locations, and providing aesthetic improvements.

Roundabout design is a creative process that is specific for each individual intersection. No standard template or “cookie-cutter” method exists for all locations. Geometric designs can range from easy (mini-roundabouts) to moderate (single lane roundabouts) to very complex (multi-lane roundabouts). How the intersection functions as a single traffic control unit is more important than the actual values of the individual design components. It is crucial that these individual geometric parts interact with each other within acceptable ranges in order to succeed.

Speed Management

The design speed of vehicles is a critical factor for roundabout design. Speed management is often a combination of managing speeds at the roundabout plus the approaching legs. Forecasting these vehicular speeds when traveling through a proposed roundabout is fundamental for attaining good safety performance.

Maximum entering design speeds of 20 to 25 mph are recommended for single-lane roundabouts. For multi-lane roundabouts, these maximum entering design speeds increase to 25 to 30 mph (based on the theoretical fastest path). Exhibit 6-4 shows the recommended design speeds for different types of roundabouts.

Exhibit 6-4. Recommended maximum entry design speeds.

(FHWA. Roundabouts: An Informational Guide. 2000)

Site Category	Recommended Maximum Entry Design Speed
Mini-Roundabout	25 km/h (15 mph)
Urban Compact	25 km/h (15 mph)
Urban Single Lane	35 km/h (20 mph)
Urban Double Lane	40 km/h (25 mph)
Rural Single Lane	40 km/h (25 mph)
Rural Double Lane	50 km/h (30 mph)

Another important objective is to produce consistent speeds for all roundabout movements which along with overall speed reduction can help to minimize the crash rate between conflicting traffic. For any design, it is desirable to minimize the relative speeds between consecutive geometric elements and conflicting traffic streams.

Lane Arrangements

The entry movements assigned to each lane within a roundabout are critical to its overall design. An operational analysis can help determine the required number of entry lanes for each approach. Pavement marking may also be used in the preliminary phase to ensure lane continuity through the various design iterations.

Roundabouts are typically designed to accommodate design year traffic volumes (normally projected 20 years in the future). This design may produce more entering, exiting, and circulating lanes than needed at the start of operation. It may be necessary to use a phased design that initially uses fewer entering and circulating lanes while maximizing potential safety. In order for lane expansion at a later phase, an optimal roundabout configuration (including horizontal and vertical design) needs to be considered as early as possible in the initial design. Lanes may then be removed from the optimal roundabout design to provide the necessary initial capacity. This phased method ensures that adequate right-of-way is acquired and any revisions to the original roundabout are minimized.

Appropriate Path Alignment

The fastest speed path is a basic principle in the geometric design of roundabouts. This path is the fastest and smoothest path possible for a single vehicle to travel through the entry, around the central island, and out the exit of a roundabout. Its purpose is to restrict operating speed by deflecting the paths of entering and circulating vehicles. Typically, the through movement will be the **critical fastest path**. However, in some cases it may be a right turn movement.

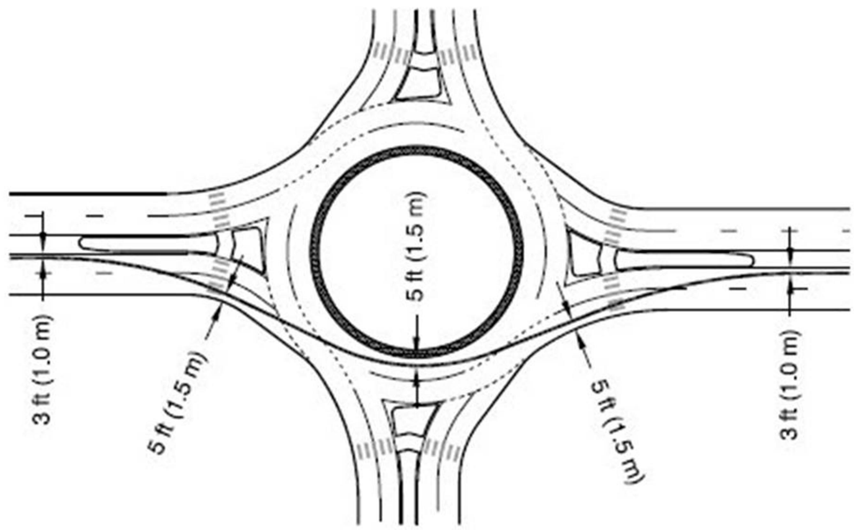


Figure 7: Fastest Vehicle Path Through a Single-Lane Roundabout

(FHWA. Roundabouts: Technical Summary. 2010)

A good entry and exit design permits appropriate lane alignment throughout the roundabout. Engineers may improve the operations and safety of a roundabout design by analyzing the traffic path alignments. Approaching traffic will be channelized by lane markings to the roundabout's entry and then continue onto the circulatory roadway. Natural path interference or overlap reduces the safety and efficiency of the roundabout. Exit geometry also affects the natural travel path and possible vehicle overlap.

Design Vehicle

A primary factor in determining the design of a roundabout is the choice of the largest vehicle (design vehicle) that will use the facility. Turning path requirements will have a direct effect on many of the dimensions of the roundabout (inscribed circle diameter, approach re-alignment, etc.).

Appropriate design vehicle consideration is dependent on the following criteria:

- Roadway classification
- Input from local authorities
- Surrounding environmental characteristics

For rural areas, agricultural machinery may determine design vehicle requirements while emergency, mass transit and delivery vehicles should be considered in urban environments. Local emergency agencies need to be involved in any plans for designing a roundabout in their area.

The AASHTO Green Book recommends using the following guidelines when choosing a design vehicle:

Design Vehicle	Location
Passenger Car (P)	*parking lots or series of parking lots*
Single-unit Truck (SU)	*residential streets and park roads*
City Transit Bus (CITY-BUS)	*highway intersections with city streets designated bus routes*
Large or Conventional School Bus (S-BUS36 or 40)	*highway intersections with local roads under 400 ADT*
Interstate Semitrailer (WB-65 or 67)	*freeway ramps with arterial crossroads or high volume traffic roadways*

For most cases, the *Intermediate Semi-trailer (WB-50)* is the largest design vehicle for urban collectors/arterials. Its also considered to be the minimum design vehicle for all turning movements for roundabouts on the state highway system.

Non-motorized Design Users

Roundabouts are designed to meet the needs of all facility users. The safe and efficient accommodation of all non-motorized users (bicyclists, drivers, pedestrians, disabled or impaired persons, strollers, skaters, etc.) is as important as the considerations made for vehicles. The potential for any conflicting traffic or severe crashes is substantially reduced by forcing roundabout traffic to enter or exit only through right turns . The low speeds through roundabouts allow more user reaction time resulting in fewer crashes involving pedestrians.

Exhibit 6-7. Key Dimensions of Non-Motorized Design Users

(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

User	Dimension	Affected Roundabout Features
Bicyclist		
Length	5.9 ft	Splitter island width at crosswalk
Minimum operating width	4 ft	Bike lane width on approach roadways; shared use path width
Pedestrian (walking)		
Width	1.6 ft	Sidewalk width, crosswalk width
Wheelchair user		
Minimum width	2.5 ft	Sidewalk width, crosswalk width
Operating width	3.0 ft	Sidewalk width, crosswalk width
Person pushing stroller		
Length	5.6 ft	Splitter island width at crosswalk
Skaters		
Typical operating width	6 ft	Sidewalk width

Pedestrian Design

Pedestrian needs should be addressed and controlled to maximize safety and minimize conflicts with other traffic flows. Pavement marking inside the crosswalk area is recommended to improve safety.

Many cities and suburban areas have gone to the next level by adding aesthetic treatments to their crosswalk designs.

Pedestrian Crosswalk Considerations

Should be located at intersections

Have appropriate curb ramps for accessibility

Should be highly visible

Pedestrians are accommodated by crosswalks and sidewalks around the perimeter of the roundabout. Sidewalks (5 ft minimum, 6 ft recommended) should be set back from the edge of the circulatory roadway (2 ft minimum, 5 ft recommended) with a landscape strip. Low shrubs or grass may be planted in the strip between the sidewalks and curb. This setback discourages pedestrians from cutting across the roundabout's central island and guides visually-impaired pedestrians to the designated cross-walks. Fencing or other barriers may be necessary in heavy pedestrian traffic areas to guide users to the appropriate crossings.

The *Americans with Disabilities Act* requires that all new or modified roundabouts be accessible to and usable by disabled individuals. Visually impaired pedestrians may have more difficulty crossing roundabouts since these intersections do not typically include the normal audible and tactile cues used to successfully maneuver crosswalks.

Pedestrian signals should be coordinated with traffic lights at all signalized intersections with pedestrian activity. Push buttons can be used for isolated intersections or locations where traffic warrants maximum vehicle travel time through the intersection. Fixed time traffic signals with short cycle lengths are more appropriate for urban or downtown environments.

Bicycle Design Considerations

Research has shown that bicyclists are the most vulnerable users of roundabouts with over 50 percent of bike crashes at roundabouts involving entering vehicles and circulating bicycles.

Modern roundabouts are typically designed to accommodate bicyclists of different skills and experience levels.

When designing a roundabout for bicycle safety and travel, the following general methods may be used to accommodate bicyclists:

1) **Motor Vehicle Method** - *mixed flow with regular traffic*

Typical bicycle (12 – 20 mph) and design vehicle entry (20 – 30 mph) speeds are similar and compatible for low-speed, single-lane roundabouts with low potential conflicts.

2) **Pedestrian Method** - *shared use paths*

Bicycle safety tends to deteriorate at high-speed, multiple lane roundabouts and many cyclists may be more comfortable and safer using bike ramps connected to a sidewalk or shared use path around the outside of the roundabout. The typical sidewalk width should be a minimum of 10 ft in order to accommodate both pedestrians and bicyclists. Bicycle lanes or shoulders used on approach roadways, should end at least 100 feet before the edge of the circulatory roadway. A taper rate of 7:1 is recommended to transition the combined travel/bike lane width down to the appropriate width for the desired vehicle speeds on the approach. Bicycle ramps may be provided to allow access to the sidewalk or a shared use path at the roundabout. These ramps should only be used where the design complexity or vehicle speed is incompatible for some cyclists. AASHTO's *Guide for Development of Bicycle Facilities* provides specific details for designing shared-use paths.

Sight Distance and Visibility

Adequate visibility and sight distance for approaching vehicles is crucial for providing safe roundabout operation. For roundabouts, the two most relevant parts of sight distance are *stopping sight distance* and *intersection sight distance.*

Stopping sight distance is the distance required for a driver to see and react to an object in the roadway and then brake to a complete stop. Stopping sight distance should be provided within a roundabout and on each entry and exit leg. The required distance is based on speed data from the fastest path speed checks.

Exhibit 6-54

Computed Values for Stopping Sight Distance

(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

Speed (km/h)	Computed Distance* (m)	Speed (mph)	Computed Distance* (ft)
10	8.1	10	46.4
20	18.5	15	77.0
30	31.2	20	112.4
40	46.2	25	152.7
50	63.4	30	197.8
60	83.0	35	247.8
70	104.9	40	302.7
80	129.0	45	362.5
90	155.5	50	427.2
100	184.2	55	496.7

* Assumes 2.5 s perception–braking time, 3.4 m/s^2 (11.2 ft/s^2) driver deceleration

AASHTO recommends using an assumed height of **driver's eye of 3.5 ft** and an assumed **object height of 2 ft** for stopping sight distances. Three critical roundabout locations should be checked for sight distance:

approaches;

circulatory roadway;

and *exit crosswalks.*

<u>Intersection sight distance</u> is the distance required for a driver to anticipate and avoid conflicting vehicles. Adequate intersection sight distance ensures drivers can safely enter the circulatory roadway without impeding traffic flow. Entry roadways are the only roundabout locations requiring evaluation of intersection sight distance.

Sight triangles are used to measure intersection sight distance. This triangle consists of a boundary defining a distance away from the intersection on each approach and by a line connecting those two limits. The distance between the entering vehicle and the circulatory roadway is fixed while the other legs of the sight triangle are based on two conflicting approaches:

1. Entering stream of vehicles from the immediate upstream entry. The approximate speed can be calculated using the average values for the entering and circulating speeds.

2. Circulating stream of vehicles entering the roundabout prior to the immediate upstream entry. The speed can be approximated from the speed of left turning vehicles.

In both cases the distance is a function of vehicular speed and a reasonable design value of the critical headway for the drivers. These sight triangle legs should follow the curvature of the roadway, and not be measured as straight lines but as distances along the vehicle path.

In some cases, sight distance at the roundabout may be increased at the expense of the roundabout's visibility. Normally, it is desirable to allow no more than the minimum required intersection sight distance for each approach. Excessive visibility may result in higher speeds and safety reduction for the roundabout.

The AASHTO "Green Book" recommends that intersection sight distance should be measured using an assumed height of **driver's eye of 3.5 ft** and an assumed **object height of 3.5 ft.**

Angles of Visibility

The intersection angle at roundabouts is measured between the vehicular alignment at the entry and the sight line required. This angle must allow drivers to comfortably turn their heads to view oncoming traffic upstream. Current guidelines recommend using an **intersection angle of 75˚** to design for older driver and pedestrian needs.

Size, Position, and Alignment of Approaches

The design of a roundabout involves optimizing the following design decisions to balance design principles and objectives:

size

position

and **the alignment of the approach legs.**

Creating the best design will often be based upon the constraints of the project site balanced with the ability to control traffic speeds, accommodate over-sized vehicles, and meet other design criterion.

	Normal Capacity
Single-lane circulatory road	*1400 to 2400 vehicles/hour*
Two-lane circulatory road	*2200 to 4000 vehicles/hour*
	Maximum Capacity
Single-lane entry	*1300 vehicles/hour*
Two-lane entry	*1800 vehicles/hour*

Inscribed Circle Diameter

The inscribed circle is the entire area within a roundabout between all approaches and exits. Its diameter consists of the distance across the central island (including the truck apron) bordered by the outer curb of the circulatory roadway. A number of design objectives determine the inscribed circle diameter and designers often have to experiment with varying dimensions before determining the optimal roundabout size.

For single-lane roundabouts, the inscribed circle's size depends on the design vehicle's turning requirements – circulatory roadway width, entry/exit widths, radii and angles.

For multilane roundabouts, the size is dependent on balancing deflection with aligning natural vehicle paths.

Capacity

A roundabout's capacity and size depends on the number of lanes required to handle future traffic. Exhibit 3-12 illustrates a simple, conservative way to estimate roundabout lane requirements. It is applicable for the following conditions:

Ratio of peak-hour to daily traffic (K) *0.09 to 0.10*

Acceptable volume-to-capacity ratio *0.85 to 1.00*

Ratio of minor street to total entering traffic *0.33 to 0.50*

Direction distribution of traffic (D) *0.52 to 0.58*

Alignment of Approaches

The entry alignment of the approaching legs to a roundabout affects the deflection and speed control achieved, accommodation for the design vehicle, sight angles to drivers, and property impacts/costs.

Although it is desirable for these alignments of the roundabout approaches to pass through the center of the inscribed circle, it is not mandatory for a successful design.

SINGLE-LANE ROUNDABOUTS

Single-lane roundabout design consists of single-lane approaches at all legs and a single-lane circulatory roadway around a central island. This design permits slightly higher operation speeds for the entry, exit and the circulatory roadway. Like all roundabouts, the size of single-lane design is largely dependent on the type of design vehicle and available right-of-way.

Single-lane Geometric Design Characteristics

Larger inscribed circle diameters

Raised splitter islands

Non-traversable central island

Crosswalks

Truck apron

Exhibit 1-12 illustrates the distinguishing features of typical single-lane roundabouts.

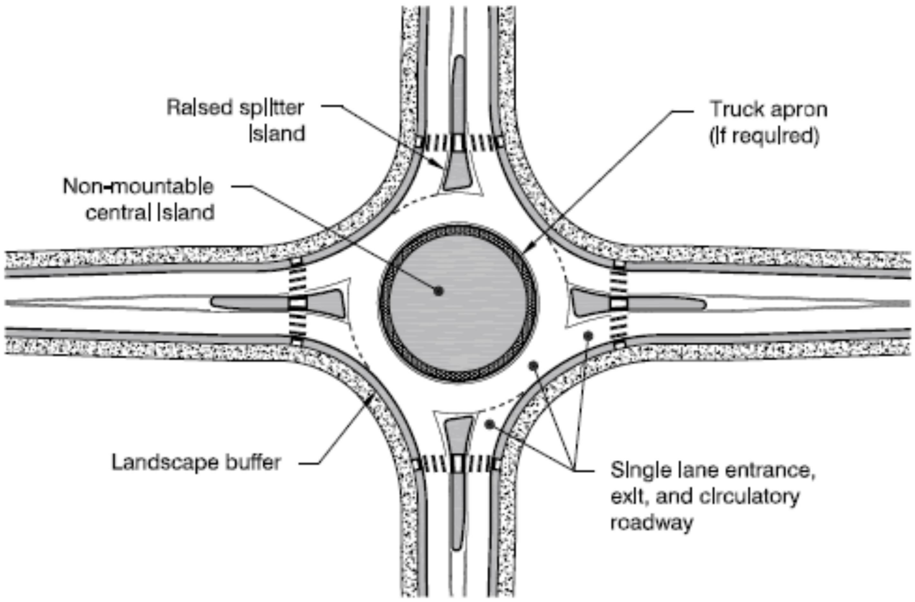


Exhibit 1-12

Features of Typical Single-Lane Roundabout

(FHWA. NCHRP Report 672 Roundabouts: An Informational Guide. 2010)

MULTILANE ROUNDABOUTS

Multilane roundabouts contain a minimum of one entry (two or more lanes) and require wider circulatory roadways to accommodate more than one vehicle traveling side by side. The roundabouts may have a different number of lanes or transitions on one or more legs. The number of lanes should be the minimum needed for the anticipated traffic demand. The design speeds at the entry, on the circulatory roadway, and at the exit may be slightly higher than those for single-lane roundabouts. Multilane roundabouts include raised splitter islands, truck aprons, a non-traversable central island, and appropriate entry path deflection.

The size of a multilane roundabout is typically determined by balancing two critical design objectives:

the need to achieve deflection;

and **providing sufficient natural vehicle path alignment.**

To achieve both of these objectives, a diameter larger than those used for single-lane roundabouts is required. Generally, the inscribed circle diameter of a multilane roundabout ranges from 150 to 220 ft (two-lane) and 200 to 300 ft (three-lane) for achieving adequate speed control and alignment. Truck aprons are recommended to accommodate larger design vehicles and keep the inscribed circle diameter reasonable.

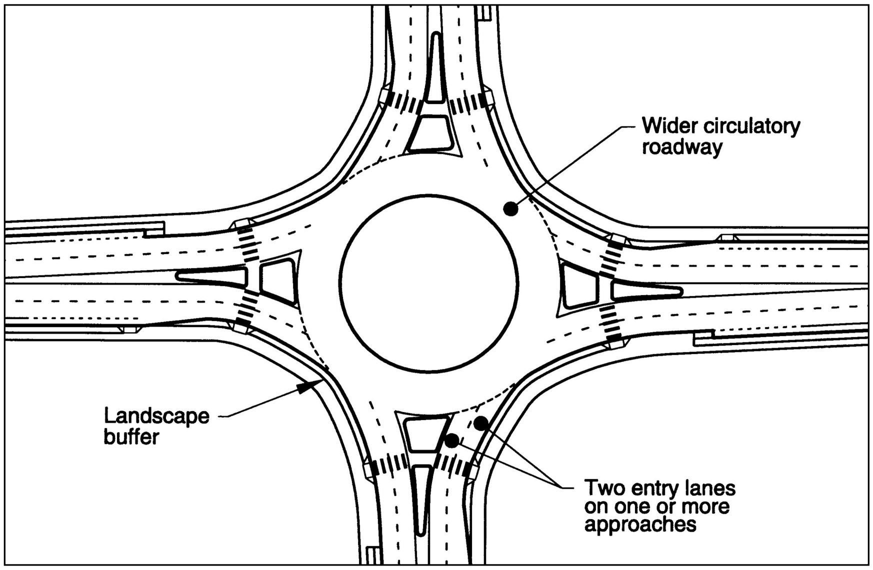


Exhibit 1-11

Typical Urban Double-Lane Roundabout

(FHWA. Roundabouts: An Informational Guide. 2000)

MINI-ROUNDABOUTS

Mini-roundabouts are small intersection designs with a fully traversable central island that are commonly used in low-speed urban environments (average operating speeds of 30 mph or less). The small footprint of a mini-roundabout (inscribed circle diameter less than 90 ft) can be useful in such environments where conventional roundabout design is limited by right-of-way constraints. The small diameter is made possible by using a fully traversable central island for accommodating heavy vehicles. Passenger cars should be able to exit the mini-roundabout without running over the central island. The overall design should naturally guide entering vehicles along their intended path and minimize traversing the central island.

Mini-roundabouts are very popular for retrofit applications due to their low cost from requiring minimal additional pavement at the intersecting roads and minor widening at the corner curbs. Small, mini-roundabouts are also seen as pedestrian-friendly with short crossing distances and very low vehicle entry/exit speeds.

Limitations of mini-roundabouts are due to the reduced ability to control speeds with the traversable central island. Therefore, it is important to consider the advantages and limitations of mini-roundabouts versus the larger-diameter roundabouts and intersection designs based upon site-specific conditions.

Figure 1 (Mini-Roundabouts Technical Summary) shows the distinctive features for a typical mini-roundabout.

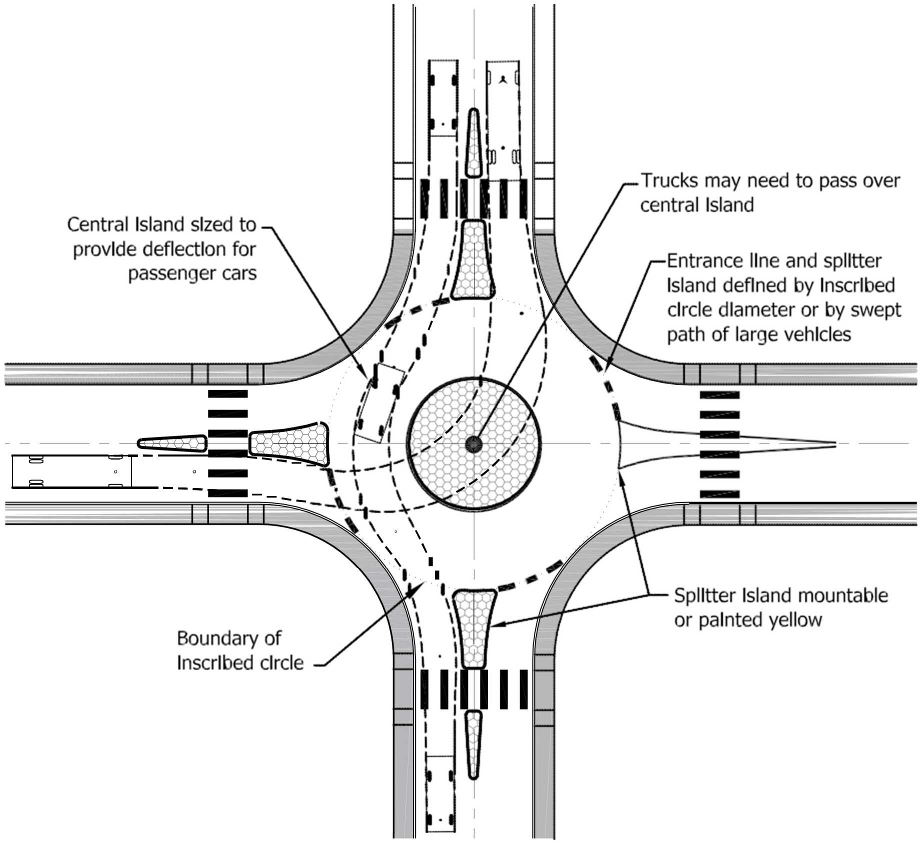


Figure 1.

Design Features of a Mini-Roundabout

(FHWA. Mini-Roundabouts Technical Summary. 2010)

FRONTAGE ROADS

Frontage roads preserve the character of the highway and prevent impacts of road development. These roads are used most frequently on freeways to distribute and collect roadway traffic between local streets and freeway interchanges. Frontage roads are typically used adjacent to arterials/freeways where property owners are denied direct access.

A minimum spacing of 150 feet between arterial and frontage roads is recommended in urban areas to lengthen the spacing between successive intersections along the crossroads. This dimension is based on the following criteria:

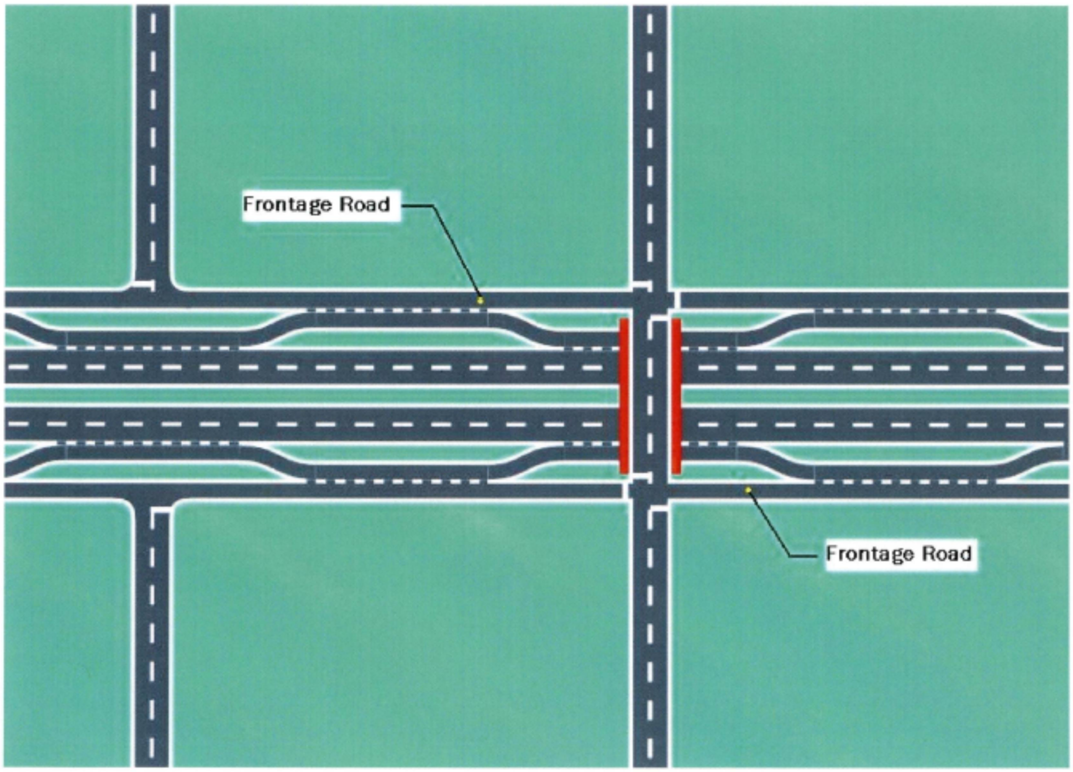
- Shortest acceptable length needed for signs and traffic control devices
- Acceptable storage space on crossroad in advance of main intersection
- Enables turning movements from the main road onto frontage road
- Facilitates U-turns between main lanes and two-way frontage roads
- Alleviates potential wrong-way entry onto highway

Frontage roads are typically parallel to the freeway

- *Either one or both sides*
- *Continuous or non-continuous*

Arterial and frontage road connections are a crucial element of design. For slow-moving traffic and one-way frontage roads, simple openings may be adequate. On high-speed roadways, ramps should be designed for speed changes and storage.

Frontage road design is also impacted by its intended type of service – it can assume the character of a major route or a local street.



Typical Frontage Road Example

Outer Separations

The “outer separation” is the buffer area between through traffic on a roadway and local traffic on a frontage road. The wider the separation → the lesser the influence on through traffic. Wide separations are particularly advantageous at intersections with cross streets to minimize vehicular and pedestrian conflicts. Separations of 300 feet allow for minimal vehicle storage and overlapping left-turn lanes.

The cross-section of an outer separation is dependent on:

width

type of arterial

frontage road type

The AASHTO “Green Book” provides further information for these types of separations.

PEDESTRIAN FACILITIES

Sidewalks

The safe and efficient accommodation of pedestrians along the traveled way is equally important as the provisions for vehicles. By separating pedestrians and vehicles, sidewalks increase pedestrian safety and help vehicular capacity. Sidewalks are typically an integral part of the transportation system in central business districts. Data suggests that providing sidewalks along highways in rural and suburban areas results in a reduction in pedestrian accidents.

Early consideration of pedestrian needs during the project development process may also streamline compliance with accessibility requirements of the *Americans with Disabilities Act Accessibility Guidelines (ADAAG)*. Intersections designed with proper curb ramps, sidewalks, pedestrian signals, and refuge islands can also aid in furnishing a pedestrian-friendly environment.

Sidewalks are typically placed along roadways without shoulders – even at locations with light pedestrian traffic. For sidewalk locations along high-speed roads, buffer areas may be utilized to distance the sidewalk from the traveled way.

Sidewalks should be wide enough for the volume and type of expected pedestrian traffic. Typical residential sidewalks vary in width from 4 to 8 feet. The *Americans with Disabilities Act Accessibility Guidelines (ADAAG)* require passing sections for sidewalks with widths less than 5 feet spaced every 200 feet. An optional planted strip may be provided between the sidewalk and the curb (2 ft minimum width) to allow for maintenance activities. At locations with sidewalks adjacent to the curb, the width should be 2 feet wider than the minimum width required.

Advantages of Buffer Areas

Increased pedestrian distance from moving

Aesthetics of the facility

Reduced width of hard surface space

Space for snow storage

A major disadvantage of buffers or plant strips is the possibility of requiring additional right-of-way.

The wider the sidewalk, the more room there is for street furniture, trees, utilities, and pedestrians plus it is easier to maneuver around these fixed objects. It is important not to overlook the need to maintain as unobstructed a pathway as possible.

Grade-Separated Pedestrian Crossings

A grade-separated pedestrian facility (either over or under the roadway) permits pedestrian and vehicle crossings at different levels without interference. These structures may be used at locations where pedestrian/traffic volumes, intersection capacity, etc. encourage their construction. Governmental regulations and codes can provide additional design guidance when considering these facilities. The *AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities* provides more specific information for these structures.

Pedestrian walkways should be a minimum of 8 feet wide. Wider walkways may be used for tunnels, high pedestrian traffic areas, and overpasses with a tunnel effect (from screens).

Vandalism is a legitimate concern for pedestrian/vehicle overpass structures – where individuals drop objects onto oncoming traffic. While there is no universal deterrent, options have been developed to deal with this problem, including:

solid plastic enclosures

screens

<u>Possible Overpass Locations (with screens)</u>

- Schools, playgrounds, etc. – where children may be unaccompanied
- Large urban pedestrian overpasses – not under police surveillance
- Where history indicates a need

Curb Ramps

Curb ramps provide access between sidewalks and streets at pedestrian crossings. Basic curve types have been developed for use according to intersection geometric characteristics.

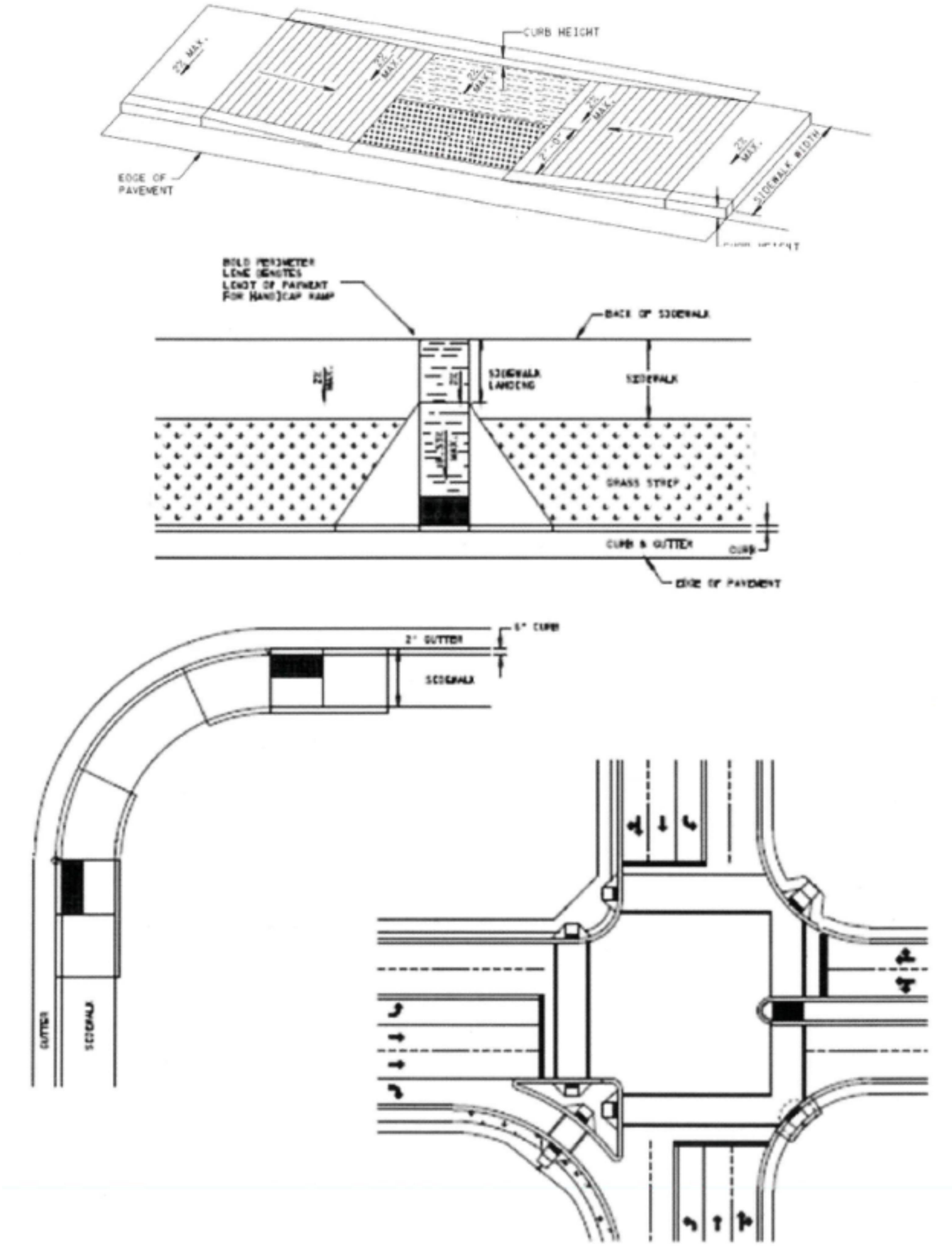
<u>Curb Ramp Design Considerations</u>

- Sidewalk width
- Sidewalk location
- Curb height & width
- Turning radius & curve length
- Street intersection angle
- Sign & signal locations
- Drainage inlets
- Utilities
- Sight obstructions
- Street width
- Border width

The *Public Rights-of-Way Accessibility Guidelines* provide the following guidance for curb ramps:

Minimum curb ramp width	4 feet
Maximum curb ramp grade	8.33%
Sidewalk cross slopes	2% maximum
Top level landing area	4 ft x 4 ft (with no obstructions, 2% maximum cross slope)

Curb ramp locations should be closely integrated with the pedestrian crosswalk by having the curb ramp bottom within the crosswalk's parallel boundaries, and perpendicular to the curb face. These ramps are typically placed within the corner radius or beyond the radius on the tangent section.



Curb Ramp Examples

BICYCLE FACILITIES

Due to the bicycle's popularity as a mode of transportation, their needs should be considered when designing roadways. The main factors to consider for accommodating bicycles include:

- Type of bicyclist being served by the route (experienced, novice, children)
- Type of roadway project (widening, new construction, resurfacing)
- Traffic operations & design characteristics (traffic volume, sight distance, development)

The basic types of bicycle facilities include:

Shared lane: typical travel lane shared by both bicycles and vehicles

Wide outside lane: outside travel lane (14 ft minimum) for both bicycles & vehicles

Bicycle lane: part of roadway exclusively designated (striping or signing) for bicycles, etc.

Shoulder: roadway paving to the right of traveled way for usage

Multiuse path: physically separated facility for bicycles, etc.

Transportation planners and designers list these factors that have a great impact on bicycle lanes – *traffic volume, average operating speed, traffic mix, on-street parking, sight distance, and number of intersections.*

RAILROAD-HIGHWAY GRADE CROSSINGS

The geometric roadway design for a railroad crossing should draw motorists' attention to roadway conditions. The major consideration is to enable highway traffic to move more efficiently.

Horizontal Alignment Guidelines

Intersect tracks at right angles and avoid nearby intersections or ramps

- Enhances sight distance
- Reduces conflicting vehicle movements
- Preferable for cyclists

Avoid locating crossings on highway or railroad curves

- Curvature inhibits driver's perception and sight distance
- Causes poor rideability and maintenance challenges (superelevation)

Where possible, the vertical alignment for a railroad-highway crossing should be as level as practical to enhance rideability, sight distance, acceleration, and braking. Limitations for the roadway surface include:

Being on the same plane as the rail tops for a minimum of 2 feet outside the rails

Limited to 3 inches higher or lower than the top of the nearest rail at 30 feet from the rail

Grade crossing geometric design consists of utilizing alignments (horizontal and vertical), sight distance, and cross-sections. This design may change with the type of warning devices used.

Railroad-highway grade crossing traffic control devices may consist of passive warning devices (signs, pavement markings) and/or active warning devices (flashing light signals, automatic gates). Guidelines regarding these devices are covered fully in the MUTCD.

At railroad-highway grade crossings without train-activated warning devices, the following two scenarios are typically used to determine sight distances:

- *Vehicle can see the approaching train with a sight line adequate to pass the crossing prior to the train's arrival (GO)*
- *Vehicle can see the approaching train with a sight line adequate to stop prior to crossing (STOP)*

The following texts provide a complete discussion of railroad-highway grade crossing sight distances:

NCHRP Report 288

Railroad-Highway Grade Crossing Surfaces

SUMMARY OF INTERSECTION DESIGN

Intersections are similar to other major infrastructure projects by consuming valuable resources and often adversely affecting the users or those in close proximity to them.

The various complex safety and operational relationships behind the design guidelines and criteria must be clearly understood. Designers must be prepared to present the reasons for a design, and be prepared to develop any alternatives. This is possible only if the designer understands how all elements of the roadway (horizontal and vertical alignment, cross section, intersections, and interchanges) contribute to its safety and operation.

This course is the last in a series that summarized and highlighted the basic elements of at-grade intersection design. There are clearly many considerations, including costs, maintenance, adjacent land uses, operational and safety impacts, environmental impacts, and infrastructure needs. Trade-offs must be balanced in order to provide safe, efficient, and cost-effective transportation of people and goods.

This course addressed the following specific knowledge and skills: basic elements of intersection design; types of intersections; basic roundabout design; frontage roads; outer separations; elements of pedestrian facilities; types of curb ramps; bicycle facilities; and railroad-highway grade crossings.

REFERENCES

A Policy on Geometric Design of Highways and Streets, 6th Edition

AASHTO. Washington, D.C. 2011.

Note: All figures, illustrations, tables, etc. contained within this course are from this text unless noted otherwise.

Handbook of Simplified Practice for Traffic Studies

Center for Transportation Research & Education – Iowa State University.

Ames, Iowa. 2002.

Mini-Roundabouts Technical Summary

FHWA. Washington, D.C. 2010.

NCHRP Report 672 Roundabouts: An Informational Guide, 2nd Edition

FHWA. Washington, D.C. 2010.

Roundabouts: An Informational Guide

FHWA. Washington, D.C. 2000.

Standard Roadway Drawings

Tennessee Department of Transportation.

Traffic Engineering Handbook, 5th Edition

Institute of Transportation Engineers. Washington, D.C. 1999.