CHAPTER 6
AT-GRADE INTERSECTIONS

6.1 GENERAL

An intersection is a critical part of a highway because the efficiency, safety, speed, cost of operation and the capacity of the facility depend on the intersection design. The main objective of intersection design is to reduce the severity of potential conflicts between passenger cars, buses, trucks, bicycles and pedestrians. In addition, the intersection design should facilitate the convenience, ease and comfort of people traveling through the intersection. Chapter 9 of the AASHTO Green Book provides an in-depth discussion of at-grade intersection design and criteria. Chapter 4, Section 4.1 provides further discussion of sight distance required at intersections.

6.2 INTERSECTION GEOMETRICS

The alignment of the intersecting roadways should be as straight as possible. In addition, profile gradients should be as flat as practical. Cross roads intersecting at angles greater than 135º should be realigned using one of the methods shown in Figure 6-1. Additional discussion of intersection geometry can be found in Section 6.4 of this manual and in the section titled 'Alignment and Profile' in Chapter 9 of the AASHTO Green Book.

The safety at an intersection and traffic flow through an intersection can be enhanced by applying several design elements such as right-of-way flares, turn lanes, and channelization, which are further described in the following sub-sections.

6.2.1 Right-of-Way Flares

To improve sight distance at intersections, right-of-way flares are obtained at all corners of the intersection where practical. The right-of-way flare enhances safety by providing better sight conditions inside the flare. The flare may be reduced or eliminated at one or more corners if a substantial amount of property damage would result, and if sufficient stopping sight distance is maintained on the main roadway. Stopping sight distance, not intersection sight distance, is the controlling factor in setting required right-of-way at intersections.

The standard right-of-way flare used at rural intersections is 100 ft x 100 ft, as shown in Figure 6-2. In special cases, flares larger than 100 ft x 100 ft may be considered in order to provide intersection sight distance as outlined in Section 4.1 or for other considerations.

Additional right-of-way for large flares is rarely considered in urban areas due to slower speeds, greater development at intersections, and more expensive property costs. Right-of-way flares typically used in urban areas are shown in Figure 6-3.

6.2.2 Turn Lanes

On new four-lane highways, left turn lanes are usually provided at all intersecting side roads that have dedicated right-of-way. Right turn lanes, left turn lanes on divided roadways (both depressed and raised median sections), and dedicated left turn lanes on five-lane urban roadways are considered based on:

- traffic volumes
- turning movements
- reduced accident potential
- and increased operational efficiency

Upon request, the Traffic Engineering Development Section provides recommendations for turn lane locations, lengths of storage, and taper lengths.

To develop left turn lanes on two-lane roadways for new construction or reconstruction projects, the pavement is widened using reverse curves and/or nearby horizontal curves on the mainline. The degree of curve should be limited so that no more than a reverse crown superelevation of 2.5 percent is required through the widening curves. Figure 6-4 shows geometry for left turn lane development. The minimum length required to obtain the widening is the greater of that required by the geometry and curve superelevation, or as shown by the following formulas:

- $L = (w)(s)$, for design speeds of 45 mph or higher
- $L = \frac{(w)(s)^2}{60}$, for design speeds less than 45 mph

where: L = distance needed to develop widening (ft)
w = width of widening (ft)
s = design speed (mph)

For isolated intersection improvement projects, the pavement is typically widened for left turn lanes using straight-line transitions or by using curvature of the existing alignment. Where possible, the minimum length should be as calculated in the above formulas.

Once the full widening for left turn lanes is attained, a straight-line turn lane taper of 8:1 is used for design speeds up to and including 30 mph, and 15:1 for design speeds of 50 mph (see Figure 6-4). The 30 mph design speed is used for urban highways, while the 50 mph design speed is used for rural highways. Storage lengths should be long enough to store the number of vehicles likely to accumulate during a critical period without blocking through lanes. Typically, a minimum storage length of 150 ft is required for left turn lanes.

Right turn lanes are generally developed using straight-line tapers based on the 8:1 and 15:1 ratios.

6.2.3 Channelization

Channelization is included at intersections to reduce excessive pavement areas, to regulate traffic, and to indicate proper intersection use. Channelization can consist of pavement markings and/or raised islands. When raised islands are used to channelize traffic, islands less than 150-square feet should be paved. However, the District or local municipality may request that larger islands be paved as well, due to maintenance considerations. Section 5.5.6 contains additional discussion of raised channelizing islands. Chapter 9 in the AASHTO Green Book provides an in-depth discussion of islands. EDSM II.2.1.7 provides guidance on curb use.

Islands delineated with pavement markings should follow the same guidance as curbed islands, except the offsets for the noses and edge lines would not be required.

6.3 SIGNALIZATION

6.3.1 Warrants

The Traffic Engineering Development Section is required to perform a detailed study of the geometric design and traffic flow of an intersection before a signal can be installed or included in a construction project. Warrants for traffic signals are contained in EDSM VI.3.1.6 and in the Manual on Uniform Traffic Control Devices.

6.3.2 Installation

New signal equipment shall be installed at intersections by, or under the direction of, Traffic Operations (see EDSM IV.7.1.5). A contractor can install signal equipment during a DOTD construction project or a municipality can install equipment with a permit.

6.3.3 Addition or Replacement

Signal plans and quantities will be requested from the Traffic Engineering Development Section after the decision has been made to include signals in a construction project and the warrant analysis has been performed according to Section 6.3.1. Once available, the details and quantities will be incorporated into the construction plans (see Section 8.2.20).

If geometric modifications at an intersection require that an existing signal be replaced, it will be replaced according to the warrant analysis and the new geometric configuration of the intersection. If the warrant analysis concludes that a signal is required at a location that previously had no signal, the signal plans will likewise be prepared based on the intersection geometric layout.

6.4 TURNOUTS

Simple connections to intersecting roadways are commonly referred to as turnouts. To expedite construction, turnouts typically utilize the same pavement type and thickness as the main roadway. The typical section at the back of the turnout should match the width required in the Design Guidelines for the highway classification and traffic volume of the intersecting roadway. For most projects, turning radii that accommodate a single unit (SU) design vehicle are provided. Transitions from the back of the turnout to the existing roadway are typically constructed of full depth asphalt.

For drainage and aesthetic purposes, attention should be paid to the edge profiles at intersecting roadways. Smoothness of flow and clarity of crossings and connections are required while satisfying the design criteria. See Section 5.3.4 for additional discussion of slope breaks allowed at intersections.

The proper intersection design can be achieved most accurately and rapidly through a graphic procedure. These graphics can be transferred onto plan sheets, as graphical grades, to aid in the intersection construction (see also Section 8.2.14).

Where significant lengths of side roads are reconstructed, vertical curves should be used, where necessary, to provide smooth profiles from the existing side road to the main roadway.

6.4.1 Rural

Typical turnouts for intersecting roadways are shown in Figure 6-5. For high volume intersections, a higher type design may be required, such as a channelized intersection with dedicated turn lanes, a grade separation, or an interchange.

Side roads (paved or gravel) that intersect the main roadway at an angle greater than 135° should be realigned. The portion of realigned roadway behind the turnout should meet the Design Guidelines for its class of roadway and should be paved. An intermediate design speed can be used for curves adjacent to a stop-controlled intersection.

6.4.2 Urban

Turnouts for urban and suburban areas are also shown in Figure 6-5. Values in parenthesis () are those typically used for urban and suburban locations where vehicles will be traveling at lower speeds. In addition, Figure 6-5 also shows typical treatment of curbs and/or shoulders at turnouts. These details have been developed using the required turning radii for the single-unit (SU) design vehicle. When the intersecting roadway serves a facility where larger vehicles are expected, the turnout radii may be adjusted based on criteria in Chapter 9 of the AASHTO Green Book.

6.5 INTERSECTION JOINT LAYOUT

Transverse and longitudinal joints are placed in the concrete slabs of all concrete pavements except continuously reinforced concrete pavements to help control cracking. Standard Plan CP-01 provides general guidance on the location of joints required. However, because requirements at each site vary, it is often necessary to include joint layouts in the construction plans. A good jointing plan when developed as part of the final plans will ease construction by providing clear guidance and by avoiding width changes along the edge of the mainline or primary paving lane(s).

Joints are usually classified as longitudinal or transverse, as shown in Figure 6-6. Longitudinal joints are typically placed at lane lines. However, an intermediate longitudinal joint is required when the width of the pavement slab exceeds 15 ft.

Basically, the idea is to eliminate triangles or circles left intact with a rectangular portion of a slab, and to eliminate acute angles between joints, especially angles less than 60°. These areas, if allowed to exist, will create a plane of weakness that will break during temperature movements of the slab. The procedure outlined in the appendix describes typical steps used in developing a joint layout plan. Examples are shown for both right angle and angled intersections.

Figure 6-7 shows alternate joint layouts for a skewed intersection. The layout shown in Detail (b) of Figure 6-7 is useful for simple curve radii greater than 36 feet and compound curves (2 or 3-centered curves). It can simplify field construction when the contractor builds the curve area in a single pour (indicated by the shaded area). As shown in the diagram, it is necessary to add an additional joint near the center of the slabs that exceed the maximum allowed width (15 feet).

Figure 6-8 shows a completed joint layout along a highway with multiple intersections. This figure illustrates only one of the many possible joint layouts.

Joints are required around utility structures in the pavement because otherwise, movement of the pavement will be restricted and cracking will result. At such locations, box-outs are required, as shown in Figure 6-9. Where a joint must be located within 4 feet of a catch basin or manhole, it is desirable to adjust the joint so that it will intersect the structure or box-out surrounding the structure as shown in Figure 6-10.

6.6 MEDIAN OPENINGS

EDSM IV.2.1.4 contains requirements for median openings. The following two subsections provide additional discussion of applying the EDSM to median design in rural and urban locations.

6.6.1 Rural

Median openings on rural, divided highways are located at all street and highway intersections. At intermediate locations, the preferred spacing of median openings is 0.25 to 0.50 miles. Fixed spacing is not necessary, nor does it fit in all cases, because of variations in terrain and local service requirements. Median openings in rural locations should be designed as shown in Figures 6-11 and 6-12, and in Chapter 9 of the AASHTO Green Book. Typically, the larger radii shown in Figure 6-11 are used at rural locations. Adjustments to the design should be made for locations with dedicated left turns.

6.6.2 Urban

For urban divided highways, median openings should be provided at street intersections and major developed areas, such as mall entrances, etc. Special situations may also warrant median openings. Median openings in urban areas should be designed similar to rural highways, as shown in Figure 6-11 and in Chapter 9 of the AASHTO Green Book. The smaller radii shown in Figure 6-11 are typically used at urban and suburban locations.

6.7 DRIVEWAYS

Driveways are essentially low-volume intersections and merit special consideration in their design and location. New driveways and modifications to existing driveways are regulated through the use of permits. Driveway regulations generally control:

- right-of-way encroachment
- driveway location
- driveway design
- use of curbs
- parking
- setback, etc.

Driveways are a means of controlling access to the roadway from adjacent properties. In order to achieve this, large graded or paved areas adjacent to the traveled way should be eliminated so that vehicles gain access to the facility only at driveway locations.

6.7.1 Criteria for Driveway Locations

1. Existing Access: Driveway approaches are provided to restore existing access to abutting property.

2. Safe Operation: Additional driveway approaches are provided when they would result in safer operation, particularly when more approaches would substantially reduce the distance traveled by agricultural equipment on the main roadway or on other roadways.

3. Opposite Median Crossovers: On divided highways, approaches should not be located or relocated to fall opposite median cross-overs.

4. Severed Property: If property is cut in two, so that the owner has property remaining on both sides of the highway, the following criteria are used:

   a. Both Sides: At least one approach is provided to the property on each side of the road.

   b. Existing Field Roads: Approaches are located at existing field roads when possible, or continuous headlands are provided to connect the approach and field roads.

   c. Lateral Ditches: Approaches are provided for access on each side of lateral ditches or streams, unless a crossing is available to the owner within a short distance.

5. New Frontage: When a roadway is located on new alignment and creates new frontage for adjacent properties, new driveway approaches may be recommended by the plan-in-hand party.

6. At Intersections: Driveways will not be allowed within the limits of the turnout radii at an intersection. The driveway should be located as far away from the intersection as practical, and desirably outside the limits of turning lanes and other auxiliary lanes.

6.7.2 Application of Criteria

1. Undivided Highways on Existing Location: The plan-in-hand party locates driveway approaches based on criteria in Sections 6.7.1.1 and 6.7.1.2.

2. Divided Highways on Existing Location: The plan-in-hand party locates driveway approaches based on criteria in Sections 6.7.1.1, 6.7.1.2, and 6.7.1.3.

3. Undivided Highways on New Location: The plan-in-hand party locates driveway approaches based on criteria in Sections 6.7.1.1, 6.7.1.2, and 6.7.1.4. After the right-of-way base maps showing property lines and owners are available, the designer can use the maps to locate additional approaches based on criteria in Sections 6.7.1.1, 6.7.1.2, and 6.7.1.4. A set of prints showing all approach locations is then transmitted to the District Administrator for review and suggestions. These prints show the following information:

   - property lines
   - property owners' names
   - location of proposed vehicular approaches
   - location of proposed headlands (including drainage structures under headlands)
   - location of cross drains

4. Divided Highways on New Location: The same procedures are used for divided highways on new location as for undivided highways on new location (No. 3 above).

The location of median crossovers is also shown on the prints transmitted to the District for review.

5. Right-of-Way Considerations: Additional approaches may be added during right-of-way negotiations as part of the offer made for the required property. The designer and District construction personnel should review the placement of these approaches before final agreement is reached to avoid creating traffic hazards and to maintain Department standards.

6. Changes During Construction: If requested by a property owner during construction, the Project Engineer may move the location of approaches within the limits of the property, subject to consideration of criteria 6.7.1.2 and 6.7.1.3.

7. Approaches Added During Construction: Additional approaches may be added during construction using normal plan change procedures. However, each one must be justified individually.

6.7.3 Driveway Typical Sections and Materials

Standard Plans DW-01 and DW-02 provide details on length and width of drives, as well as the type and thickness of surfacing material. Figures 6-13 through 6-20 were developed for use in the DOTD permitting process, but are generally applicable to construction projects as well. They provide additional guidance on the location of driveways.

Existing driveways on highway projects are replaced with a new drive of similar material and width, up to the maximum width shown on the Standard Plans. Maximum driveway widths are not to be exceeded. If more driveway width is needed, two drives can be included at the discretion of the plan-in-hand party, provided sufficient frontage exists.

6.7.4 Horizontal Geometry of Driveways

1. Rural Residential Drives: For aggregate driveways, a triangular flare is used on each side of the driveway at the edge of the shoulder. The same size flare is used for all shoulder widths. This provides a slightly larger turning radius for roadways with wide shoulders, as compared to roadways with narrow shoulders. This practice is desirable since wider shoulders are typically used on roadways with higher classification. The driveway is terminated at the right-of-way line, or as otherwise directed by the Project Engineer, based on field conditions.

   For paved rural driveways, horizontal geometric details should be similar to those used for urban driveways.

2. Urban Residential Drives: The desirable size of the triangular flare is shown in Figures 6-13 through 6-17. For special cases, the size of the flare may be reduced, as necessary. The flares for adjacent driveways may be overlapped if a minimum is not obtainable.

3. Commercial Drives: Geometric guidelines for various types of commercial driveways are shown in Figures 6-13 through 6-20. Commercial driveways range in width from a minimum of 12 feet to a maximum of 35 feet. The type of driveway used should be as indicated on the appropriate standard plan. The designer should consider using a turnout connection at drives with very heavy traffic, or at locations where the existing drive has a turnout configuration.

6.7.5 Vertical Geometry of Driveways

In order to prevent vehicles from dragging or scraping at driveway entrances and connections, special attention should be given to driveway profiles. It is not necessary to show mathematical grades on the plans for each driveway. However, a check of all driveways (both urban and rural) should be made by the designer to determine whether a satisfactory grade can be provided within the available right-of-way. Generally, problems with driveway grades are encountered in urban areas where right-of-way is restricted, or in rural areas with rolling or hilly terrain. If a satisfactory grade cannot be provided within the available right-of-way, the plans should note that a right-of-way agreement will be required to extend the driveway. If this is impractical, either a realignment of the driveway or an adjustment in the main roadway grade may be required.

For special cases where it appears unfeasible to extend the driveway or adjust the grade of the main roadway, driveway grades as steep as 25 percent for passenger cars may be used. Otherwise, driveway grades should not exceed 20 percent, positive or negative, for passenger cars (see Figure 6-21). At entrances to trailer parks, the maximum grade should not exceed 10 percent in a fill section, and 13 percent in a cut section (see Figure 6-22). In all cases, an appropriate transition grade or vertical curve must be used to tie the reconstructed portion of the driveway to the existing drive.

6.8 RAILWAY - HIGHWAY GRADE CROSSINGS

Like any other intersection, railway-highway grade crossings are a potential source of conflict. When accidents occur at these intersections, they usually have catastrophic results. Therefore, the designer should carefully analyze the crossings with personnel from the Railroad Construction Unit, who coordinate with the railroad company. This is done to determine the type of crossing that will be provided. If a structure over the railroad cannot be provided, or is not warranted, signals and gates may need to be installed to properly warn motorists of an approaching train. EDSM II.2.1.2 contains information on DOTD policy for the construction of at-grade railway-highway crossings.

6.8.1 General

Railway-highway grade crossings on roadway projects are to be in accordance with American Railway Engineering Association (AREA) specifications, railway company requirements, and DOTD specifications. The owner of each railway is responsible for the actual construction of the crossing and payment of all associated costs. Construction

details and items for the crossing are not included in the projects plans. However, the cost to construct the crossing is included in the overall project costs.

If a crossing is required on a privately owned spur, such as to a plant or mill, DOTD is typically responsible for the construction and cost of the crossing. In this case, appropriate details and items for the crossing will be included in the project plans.

When a proposed construction project involves a railroad, the project title sheet and plan sheet (showing the location) should be sent to the Railroad Construction Unit. This should be done as early as possible in the plan development process so the necessary agreements can be obtained from the railroad company.

6.8.2 Materials

When DOTD is responsible for construction of the grade crossing, materials used will be those noted in DOTD Supplemental Specifications for Railway-Highway Grade Crossing.

6.8.3 Traffic Control Devices

Traffic control devices required for grade crossings will conform to Part VII of the Manual on Uniform Traffic Control Devices and to Standard Plan PM-07.

6.8.4 Roadway Vertical Geometry at Railway Crossings

In most cases, the grade of the proposed roadway must be set to match the elevation of any intersecting railroad tracks, particularly mainline tracks. The intersection should be made as level as possible to improve:

- sight distance
- rideability
- braking and acceleration distances

In some instances, the roadway vertical alignment may not meet acceptable geometrics for a given design speed because of restrictive topography or limitations of right-of-way. The crossing surface should be set at the same plane as the top of the rails for a distance of two feet outside the rails to prevent low-clearance vehicles from becoming caught on the tracks. Also, the highway surface should not be more than 3 inches higher or 6 inches lower than the top of the nearest rail, at a point 30 feet from the rail, unless track superelevation dictates otherwise.

6.8.5 Plan Procedures

Railway-highway grade crossings are noted on the title sheet and plan/profile sheet in the same manner as bridge sites and equations. When the crossing is to be constructed by others, it should be considered as an exception to the paving table.

Typically, all railway companies require pre-cast concrete crossing units. Most companies use a ten foot crossing.

6.9 ROUNDABOUT DESIGN

A roundabout is an intersection with a curbed central island around which traffic must travel counterclockwise and in which entering traffic must yield to circulating traffic. Roundabouts are characterized by a generally circular shape and geometric features that create a low speed environment (see Figure 6.23).

6.9.1 General

1. For this section only, the use of "Shall" designates mandatory conditions, and the designer will make every practical effort to follow the criteria. If it is impractical to follow these criteria, authorization for a design waiver will need to be obtained from the Traffic Engineering Division Administrator.

2. The roundabout design shall conform to the results in the roundabout study as defined in EDSM VI.1.1.5. If this changes, a new analysis shall be required.

3. All movements including u-turns shall be accounted for in the design.

4. Roundabouts should be designed for future traffic volumes. However, constructing a roundabout with more lanes than are needed can result in increased crashes. For this reason, multi-lane roundabouts may need to be built in stages. The initial stage should be designed for the build year which, can be assumed to be 3 years from the date of the study. The final stage should be designed for full build, measured from the build year.

5. Roundabouts should be designed so that as traffic volumes warrant additional circulating lanes, the center island of the roundabout can be reduced to accommodate the additional lanes. Another way to do this is to build the splitter islands to only allow one circulating lane and then reduce them to allow additional lanes as traffic volumes increase. By carefully planning the construction of the roundabout for the initial and full build stages, the designer can acquire the full build required right of way, design a permanent drainage plan, complete final utility relocations, and final sidewalks location. This is to accommodate any future expansion without completely rebuilding the roundabout.

6.9.2 Operational

1. Commercial driveways located within 50 ft. of the yield point shall require a waiver approved by the Traffic Engineering Division Administrator.

6.9.3 Geometry

1. The design of a roundabout approach is independent of the design criteria for the corresponding roadway classification of the approaching roadways. For design purposes, the roundabout intersection design criteria begins 200 ft. prior to the intersection for approaching roadways posted 45 mph and below and 400 ft. prior to the intersection for approaching roadways posted greater than 45 mph.

2. All Roundabouts (see Figures 6.23 and 6.24)

    a. All speed control shall take place prior to the yield point on entry. A reverse curve on the approaches should be used to geometrically reduce the speed of vehicles entering the roundabout. The recommended design speed for all vehicles entering the roundabout is 15 mph.

    b. The offset alignment shall be to the left (see Figure 6.25).

    c. Approach legs should be designed as near to perpendicular to each other as possible.

    d. Entry width should be 18 ft. for a single lane roundabout unless a wider entry is needed due to a WB-67 or larger design vehicle. Entry widths for dual movements are to be designed using AutoTURN.

    e. Circulatory roadway width shall accommodate buses and fire trucks so that they do not use the truck apron. A minimum clearance of 1 ft. should be provided between the outside edge of a vehicle's tire track to the curb line.

    f. Appropriate entry radius are dependent upon other components of design: entry width, circulatory roadway width, entry deflection, design vehicle. Entry radius should be between 90 ft. and 130 ft.

    g. For designs using an offset left approach alignment, the exit radius should be between 400 ft. to 800 ft. For other alignments, the exit radius may be smaller.

    h. Roundabouts shall be designed for the WB-67 design vehicle.

    i. The cross slope for the circulating lane should not exceed 1.5%.

    j. Truck Aprons

        i. Typically range from 5 ft. to 20 ft. wide. A 0.5% -1.5% cross slope away from the center island is recommended. The exact width of the truck apron should be determined from AutoTURN.

        ii. Truck aprons shall be tinted (brick red – broom finish) to provide a visual distinction between the circulating traffic lane and the truck apron and to differentiate from nearby sidewalks. The truck apron shall not be stamped or textured.

k. The splitter islands shall have a minimum length measured along the approach as per the following table:

Posted Speed	Minimum Length of Curbed Splitter Island
≤ 35 mph	50 ft
35 mph < x ≤ 45 mph	75 ft
> 45 mph	150 ft

l. 3 in. sloping curb is preferred for the entire length of the splitter island. The approach nose of the splitter island should be tapered down according to AASHTO guidance and meet AASHTO guidance on offsets and minimum island area.

m. Sloping face curb should begin at the edge of the finished shoulder on the approach roadway, then taper inward using a shifting taper to the edge of the travel way. Continue the curb adjacent to the edge of the travel way through the roundabout entrance and along the outside diameter to the various exits.

n. The center island shall be earthen mounded to create increased conspicuity, obscure the headlight glare of oncoming vehicles, and promote lower speeds throughout the roundabout. Typically use a 6:1 slope on the central island for roadways with posted speeds of 45 mph or greater. The slope can level out once 2-3' of vertical height is achieved. This may need to be adjusted due to the size of the central island and if landscaping is installed at the time of construction.

o. Roundabouts on grade require special consideration. They should be constructed on relatively level terrain with a maximum of a 3% grade. Entry grade profiles should not exceed 3% within 50 ft. of the circulatory roadway. Additional grading may be necessary to achieve the desired terrain in order to maintain the safe operation of the circulating lane(s) while adequately achieving the required drainage of the intersection.

3. Single Lane Roundabouts

a. The inscribed circle shall be at least 110 ft. in diameter for a WB-67 design vehicle.

b. Circulatory widths shall be at least as wide as the maximum entry width and up to 120% of the maximum entry width. An 18 ft -20 ft. circulatory width is desirable.

4. Multi-Lane Roundabouts

a. The size for the inscribed circle shall be at least 175 ft. diameter.

b. Gore striping shall be used between entry lanes to keep 12 ft. lane widths for passenger vehicles.

c. If inner lane can exit, outer lane shall be an exit only.

d. The design vehicle may encroach into the adjacent lane, but a clear width of 11 ft. on the encroached lane must be maintained. A 30 ft. to 32 ft. circulatory width

is recommended. 30 ft. circulatory widths may be appropriate for roundabouts with inscribed circles that have larger than the minimum diameter.

e. Path overlap/Path intrusion

Vehicle path overlap is a type of conflict that occurs when the normal path of the adjacent lanes cross one another. Roundabout designs shall not have entry path overlap.

i. Striping shall not be used to mitigate path overlap or path intrusion.

ii. A diagram should be furnished illustrating that path overlap and path intrusion do not exist. Designers should determine the natural path overlap and path intrusion by assuming the vehicles stay within their lanes up to the yield point. At the yield point the vehicle maintains its natural trajectory into the circulatory roadway. The vehicle will then continue into the circulatory roadway and exit with no sudden changes in curvature or speed.

5. Mini Roundabouts

a. Mini roundabouts are a type of roundabout characterized by a small inscribed circle diameter (45 ft. to 90 ft.) and a traversable island (central island and splitter island). Mini roundabouts are primarily used on under capacity residential or collector streets.

Mini roundabouts shall only be installed on a state highway where the 85th percentile speed is 30 mph or less.

6.9.4 Pedestrians

1. Any pedestrian crosswalk must be justified by the District Traffic Operations Engineer (DTOE) before including pedestrians in the design of the roundabout.

2. Stopping sight distance to the crosswalk on the approach and exit shall be provided.

3. The pedestrian crossing shall be located at least 20 ft. from the yield point to the center of the crosswalk.

4. Sidewalk, ramp and crosswalk shall meet current DOTD guidelines.

5. Sidewalks shall be offset from the circulatory roadway by a minimum of 2 ft.

6.9.5 Bicycles

1. All shoulders and bike lanes shall be ended with a 7:1 min. taper 100 ft. in advance of the yield point. The bicycle lane should be dotted 50 ft. to 200 ft. in advance of the taper.

2. If applicable, curb ramps should be placed where the shoulder/bike lane terminates to allow cyclists to access the multi-use path.

6.9.6 Transit

1. Bus pullouts shall not be located on the circulatory roadway.

2. A bus stop is best situated:

   a. On an exit lane in a pull out just past the crosswalk.

   b. On an approach leg 60 ft. minimum upstream from the crosswalk, in a pullout.

6.9.7 Signing

1. Signing in roundabouts shall be an approved breakaway system. See Figures 6.26 and 6.27 for signing layouts.

2. Junction assemblies should be placed in advance of a roundabout.

3. Confirmation assemblies should be placed no more than 500 ft. beyond the intersection.

4. Signs placed in center island shall be 48 in. from bottom of sign to the elevation of the near edge of the travel way.

5. Fishhook arrows shall be used on signs.

6.9.8 Pavement Markings

1. Fishhook pavement markings shall be used on the approach lanes to multi-lane roundabouts.

2. Single lane roundabouts do not need lane arrows or circulatory roadway pavement markings except for edge line markings.

3. Bike lane markings shall not be permitted within the circulatory roadway.

4. Yield lines (shark teeth) should not be used.

6.9.9 Landscaping

1. Landscaping is not mandatory. If landscaping is provided, DOTD will not be responsible for the maintenance of the landscaping and a gateway permit/agreement with the local government to maintain the landscaping is required.

2. Sponsorship for landscaping is permitted, and may require placement of a sign that is visible to each approach. The sign shall have 2 in. lettering and must be retro-reflective. The sign shall be placed such that the ground clearance from the bottom of the sign is a maximum of 2 ft.

3. Provide two conduits to the central island, 1 for water and 1 for electrical.

4. No hard wall, benches, large spraying fountains, or any object that would encourage pedestrians shall be allowed in the center island.

5. Select plantings to ensure adequate sight distance and to minimize maintenance for the life of the project.

6. Splitter islands must not contain trees, planters or light poles.

7. Do not obstruct the sight triangle.

8. The perimeter portion of the central island may be landscaped with low-level vegetation so that stopping sight distances are maintained for vehicles within the circulatory roadway and at the entrance lines of the roundabout.

9. Avoid landscaping within 50 ft. in advance of the yield point.

10. Use low profile landscaping in the corner radii if a crosswalk is provided so as not to obstruct the pedestrians.

6.9.10 Lighting

Lighting is not mandatory. Where lighting is installed, illumination design shall comply with the current edition of the IES Design Guide for Roundabout Lighting. Right-of- way permits and the Certification for Permit Lighting Supplement must be obtained prior to design and/or installation. Liability, ownership, maintenance, electricity, and operation of the lighting and electrical system are the responsibility of the permit applicant.