Access Management Report

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16. Abstract

This report serves as a source of guidelines to assist TDOT in its efforts to regulate access management in transportation projects throughout the State of Tennessee. The focus of this document is on recommended practices for access spacing and access design. A comprehensive review of TRB manuals, NCHRP reports, FHWA guidelines and State manuals illustrates current applications of access management regulations to help preserve the functional integrity of the state highway system, promote safe and efficient movement of people and goods and provide reasonable access. Recommendations are provided for access management standards on signalized access spacing, unsignalized access spacing (intersection, driveway and corner clearance), median opening spacing and interchange spacing. Furthermore, best practices are presented on driveway and median geometrics, u-turns and turning lanes design and on retrofitting techniques.

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Executive Summary

Access management is the coordinated planning, regulation, and design of access between roadway and land development. It includes a range of methods that promote the efficient and safe movement of people and goods by reducing conflicts on the roadway system. Without access management, the function and character of major roadway corridors can deteriorate quickly. Access management strategies are critical components in transportation plans designed to improve overall safety, protect roadway capacity, improve streetscape appearance, and attract economic development. Transportation agencies are encouraged to preserve the ability of a roadway to perform its function.

This report provides guidelines to assist TDOT in its efforts to regulate access management in transportation projects throughout the State of Tennessee. Initially, a review of TDOT's functional classification for Tennessee roadways was presented and subsequently, the development of five (5) Access Management Classes was proposed, where the functional classes in the urban and rural systems were analyzed and grouped into categories based on common characteristics such as speed limits, roadway function, and AADT's traffic volumes.

A chapter on the principles of access management illustrates the fundamental needs of protecting the intersection functional areas, providing appropriate sight distance to drivers and understanding the use of medians for safety and operational efficiency. The remainder of the report presents an applicable review of TRB manuals, NCHRP reports, FHWA guidelines and State manuals on current access management techniques used by a variety of transportation engineers and planners in different parts of the United States. It provides access management standards recommendations for Tennessee based on the proposed Access Management Classes for signalized access spacing, unsignalized access spacing (intersection, driveway and corner clearance), median opening spacing and interchange spacing. Furthermore, it provides best practices on access design, more specifically on driveway and median geometrics, u-turn design and turning lanes design and on retrofitting techniques.

Finally, the techniques described in this document are a synthesis of access management strategies from research studies or from transportation agencies experiences. The recommendations herein should be used as guidelines and should recognize the need for adaptation in situations where they may not be feasibly suitable.

DISCLAIMER

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CHAPTER 1 - INTRODUCTION

1.1 Purpose of this Report

The purpose of this report is to offer Access Management guidelines to TDOT to assist in the planning and design of transportation projects throughout the State of Tennessee.

Access regulations are necessary in order to preserve the functional integrity of the State Highway System and to promote the safe and efficient movement of people and goods while providing reasonable access to adjoining property owners. Reasonable access means that a property owner will have access to the public highway system, but it does not mean that potential patrons are guaranteed the most direct or convenient access from a specific roadway to the owner's property.

Every access point constructed on the state highway system increases the crash risk. The cumulative impact of closely spaced access points over time is one of the largest contributors to high crash rates and congestion on state highways. It is the Department's intent to adopt national best practices that better preserve the safe and efficient movement of people and goods while also helping property owners make better decisions regarding access needs.

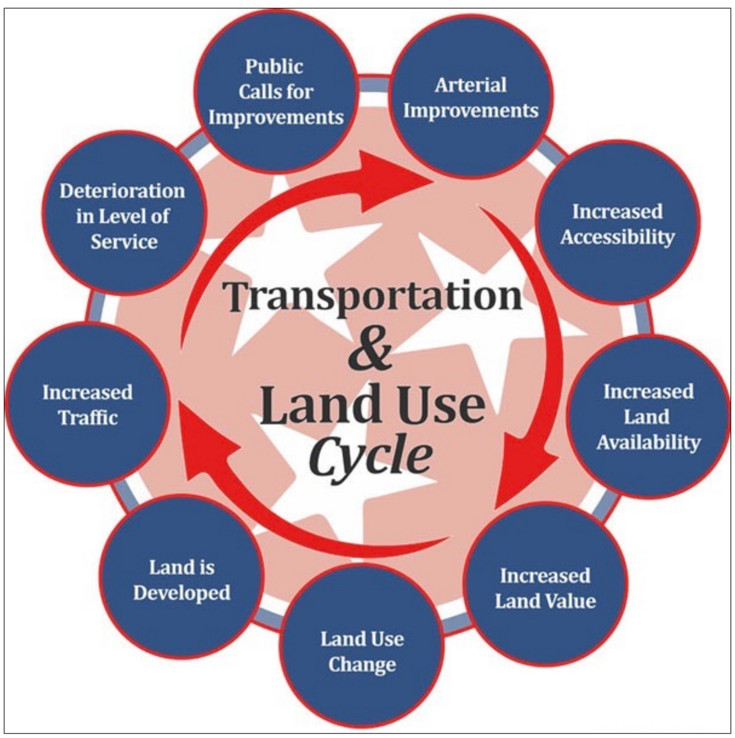


Figure 1: Transportation and Land Use Cycle [TDOT]

Without access management, the function and character of major roadway corridors can deteriorate rapidly. The result is a cycle of events demonstrated in Figure 1 that begins with arterial improvements that increase the accessibility of developable land. Transportation projects, especially those that increase capacity or provide access to new areas, can affect the growth rate and development patterns of those areas. Land values increase as greater regional accessibility stimulates real estate interest. Land use changes occur as commercial or industrial uses seek locations on arterials and near highway interchanges, and as developers of low density subdivisions build on nearby land made more accessible to job centers.

In the absence of proactive planning and access management on major roads, conflicts soon emerge between transportation and development objectives.

Some adverse effects of the failure to manage roadway access:

- Increase in vehicular crashes and collisions involving pedestrians and cyclists
- Accelerated reduction in roadway efficiency and increased delay and travel times for private and public transportation
- More frequent need for roadway reconstruction and right-of-way acquisition
- Reduced aesthetics from frequent driveways, cluttered signage, and inadequate area for landscaping
- Increased fuel consumption and vehicular emissions as numerous driveways and traffic signals intensify congestion and delay

1.2 References Used

This report encompasses a review of practices of states that have implemented access management programs, a review of nationally recognized research on access management best practices and a review of pertinent TDOT documentation. Standards, specifications, and references referred to within this Access Management Report include, but are not limited to, the following sources:

- TRB Access Management Manual – 2003 Edition / 2014 Edition
- TRB Access Management Application Guidelines - 2016
- NCHRP 348 – Access Management Guidelines for Activity Centers
- NCHRP 420 – Impact of Access Management Techniques
- NCHRP 659 – Guide for Geometric Design of Driveways
- FHWA Highway Functional Classification Concepts, Criteria and Procedures
- TDOT Manual for Constructing Driveway Entrances on State Highways 2015
- TDOT Roadway Design Guidelines
- TDOT Landscape Design Guidelines
- TDOT State Industrial Access Program Agreement
- TDOT SR 109 Access Management Study
- TDOT SR 60 Corridor Management Agreement
- Alabama DOT Access Management Manual
- Florida Median Handbook
- Florida Driveway Information Guide
- Kentucky Access Management Report and Implementation

- Massachusetts Access Management
- Mississippi DOT Access Management Manual
- Nevada DOT Access Management System and Standards
- Ohio State Highway Access Management Manual
- Oregon Access Management Standards (Vergil Stover)
- Pennsylvania DOT Access Management Best Practices
- South Carolina DOT Access & Roadside Management Standards
- Urbana-Champaign Access Management Guidelines
- Virginia Access Management Design Standards

1.3 Benefits of Access Management

Extensive research has been conducted concerning the effects of access management techniques. The Transportation Research Board (TRB) Access Management Manual provides a comprehensive description of the benefits of access management related to safety, operations, economics, land use and environment. The following sections depict a summary of findings.

1.3.1 Effects on Safety

The increase in safety is attributable to the reduction in traffic conflicts resulting from properly managing access to and from a roadway. Traffic conflict points occur where vehicle paths cross, merge, or weave. Different types of connections result in different levels of traffic conflicts. The following illustration shows different types of intersections and its conflict points.

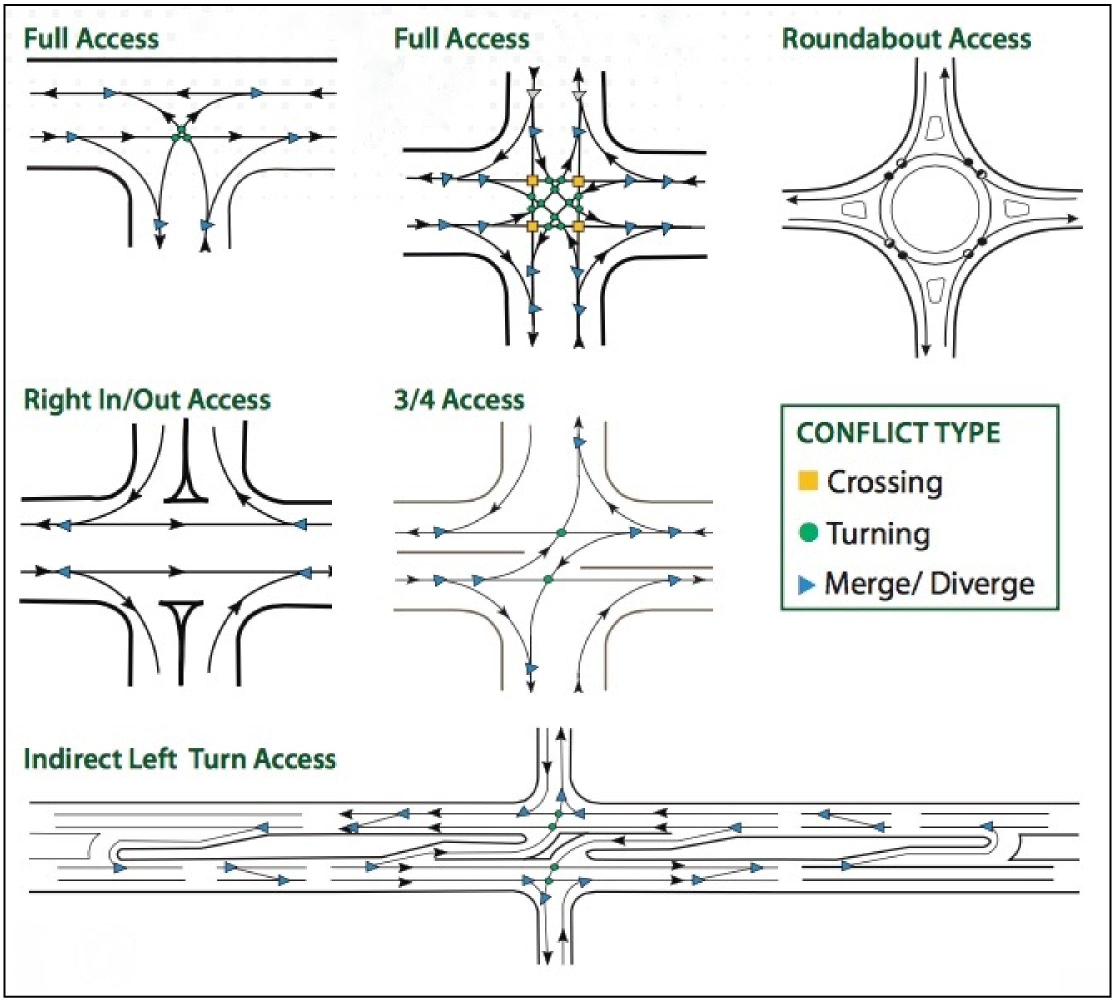


Figure 2: Conflict Types at Intersections

Data indicates that minor street crossing movements and left turns on a major street are the most hazardous. Left turns from the major street are less hazardous than the minor street movements, and right turn movements are the least hazardous. Analysis of crash data has proven that the most frequent type of severe intersection crash is the right-angle crash.

Crash rates at restricted access intersections (3/4 access design and right-in/out) are typically lower than at similar four-legged intersections.

Table 1: Number of Conflict Points by Intersection Type					
	Crossing	Turning	Merge/ Diverge	Total	Typical Crash Rate*
Full Access (+)	4	12	16	32	0.3
Full Access (T)	0	3	6	9	0.3
¾ Access	0	2	8	10	0.2
Right-in/out Access	0	0	4	4	0.1
Roundabout	0	0	8	8	0.2
Indirect Left Turn	0	4	20	24	0.1

** Crashes per million entering vehicles*

Minnesota Department of Transportation. Minnesota's Best Practices and Policies for Safety Strategies on Highways and Local Roads. September 2011.

As access density increases, crash rates increase. The following diagram from TRB's Access Management Manual (2014) shows the relationship between access density and crashes. It shows the composite crash rate indexes that were derived from an analysis of 37,500 crashes and compared with a synthesis of the literature. The indexes were developed by correlating crash rates with access density – the crash rate for 10 access points per mile was used as a base – and then averaging crash rates for each access density threshold. The indexes suggest that an increase from 10 driveways to 20 driveways per mile would increase crash rates by roughly 30%. *[TRB. Access Management Manual. 2014. P.26].*

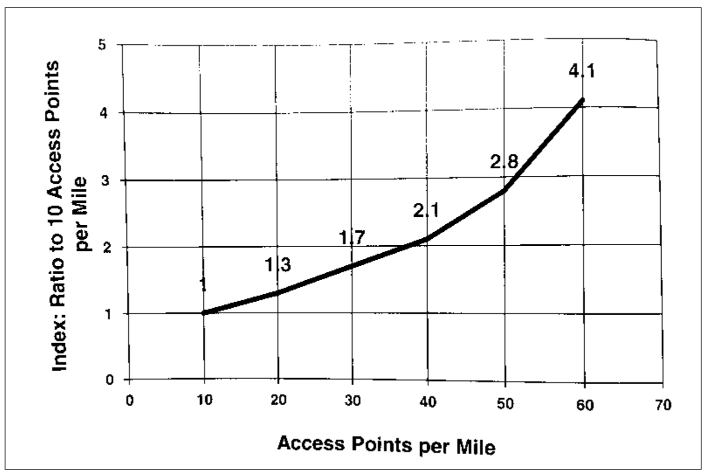


Figure 3: Composite Crash Rate Indexes

The use of shared common access drives between adjacent properties abutting major roadways helps to reduce the number of conflict points and separate the conflict areas, thus increasing roadway safety.

Eliminating or restricting turning maneuvers by providing channelization or closing median openings is considered a proven strategy. Medians are also measures to achieve a reduction of conflicts. The average crash rate on roadways with a two-way left-turn lane design guide (TWLTL) is less than that for undivided roadways. Roadways with non-traversable medians have been found to have lower average crash rates than those with a TWLTL. *NCHRP Report 420* found the crash rate for a roadway with a non-traversable median to be about 30% less than a two-way left turn lane configuration. Research indicated that the safety advantage of a non-traversable median over a TWLTL increases when the ADT exceeds 24,000 to 28,000 VPD. *[TRB. Access Management Manual. 2014].*

The following table summarizes common access management techniques and their associated safety and operational effects.

Table 2: Summary of Research on Effects of Access Management Techniques

Treatment	**Effect**
Add continuous TWLTL	35% reduction in total crashes 30% decrease in delay 30% increase in capacity
Add nontraversable median	> 55% reduction in total crashes 30% decrease in delay 30% increase in capacity
Replace TWLTL with nontraversable median	15% to 17% reduction in crashes on four-lane roads 25% to 50% reduction in crashes on six-lane roads
Add left-turn bay	25% to 50% reduction in crashes on four-lane roads Up to 75% reduction in total crashes at unsignalized access 25% increase in capacity
Type of left-turn improvement - Painted - Separator or raised divider	 32% reduction in total crashes 67% reduction in total crashes
Add right-turn bay	20% reduction in total crashes Limit right-turn interference with platooned flow,

	increased capacity
Increase driveway speed from 5 to 10 mph	50% reduction in delay per maneuver; less exposure time to following vehicles
Visual cue at driveways, driveway illumination	42% reduction in crashes
Prohibition of on-street parking	30% increase in traffic flow 20% to 40% reduction in crashes
Long signal spacing with limited access	42% reduction in total vehicle hours of travel 59% reduction in delay 57,500 gal of fuel saved per mile per year
TRB. Access Management Manual. 2014. PP. 29-30	

1.3.2 Effects on Operations

Studies of the effects of access management on roadway operations have assessed the influence of access spacing on travel time through the use of a variety of analysis techniques. The studies indicate that access management helps to increase capacity, maintain desired free-flow speed, and reduce delays.

Increasing the number of access points and signals along a roadway result in increased delay. Analysis of capacity techniques indicates that the typical reduction in free-flow speed (for one direction) is approximately 0.25 mph per access point and 0.005 mph per right-turning movement per hour per mile of road *[TRB Access Management Manual. 2014. P.32*]. For example, a Colorado Access Control Demonstration Project compared average travel speeds, ADT volume per lane, total crashes, rear-end crashes, and angle crashes for various roadways in Denver. It found that total vehicle hours of travel per hour decreased by more than 40% on access-controlled roadways, as compared with those with uncontrolled access, and that total delay decreased by about 50%.

Minimizing the number of traffic signals and promoting uniform signal spacing significantly improves travel times. Each traffic signal per mile added to a roadway reduces speed by 2 to 3 mph [*TRB. Access Management Manual. 2014. P.32*].

1.3.3 Effects on Economics

Studies of the economic effects of access management on businesses have largely focused on medians and the potential impacts of left-turn restrictions on business activity. Most studies have focused on business owner perceptions of impacts before and after a median project or on generalized comparisons of business activity across corridors. Studies to date indicate that median projects generally have little overall adverse impact on business activity. Business owner perceptions of potential impacts of changes in access tend to be much worse than the actual impacts.

- A North Carolina study in 2010 was conducted in response to business owner opposition to access management and a perception that access management would negatively affect profits. The study included 16 sites in North Carolina and surveyed 789 businesses. It was found that access management treatments, particularly the installation of medians, did not affect businesses as much as initially perceived.
- In Florida, researchers conducted a study in 1991 of merchants along a major boulevard after the closure of several median openings and reconstruction of the raised median. Approximately 70% of the merchants indicated that the median changes had no adverse effect on truck deliveries, and more than 60% perceived no change in business activity after the project. More than half (57%) of the merchants reported that they favored the median changes, and 80% of those traveling on the corridor favored the project.
- A 1999 study of the economic impacts of left-turn restrictions in Texas found the following:
  - About 93% of business owners reported that their regular customers were at least as likely or more likely to continue patronizing their businesses after the median installations. Business owners reported no change in the number of customers stopping by on their way to another destination.
  - Most business types (specialty retail, fast-food restaurants, and sit-down restaurants) reported increases in the numbers of customers per day and gross sales. However, gasoline stations and automotive repair shops reported decreases in the numbers of customers per day and gross sales.
  - Most negative impacts were realized during the construction phases of the median installations.
  - Business owners’ perceptions were more pessimistic before the installation of a median than after project completion.
  - With some exceptions during the construction phases, employment within the corridors experienced upward trends overall.

- Business owners generally ranked “accessibility to store” as less important than customer service, product quality, and product price. They ranked accessibility as more important than store hours and distance to travel.
- With only a few exceptions along corridors where property values were studied, most land values stayed the same or increased.

➢ In Iowa, a statewide study was conducted in 1996 to measure the effects off access management on business vitality. Before and after data were collected on a series of corridor case studies. Results indicated that:

- Corridors with completed access management projects performed better in terms of retail sales than the surrounding communities. Business failure rates along access managed corridors were at or below the statewide average for Iowa.
- About 80% of businesses surveyed in Iowa along access managed corridors reported sales at least as high after the project was in place. Relatively few businesses reported sales declines associated with the access management project.
- About 80% of businesses reported no customer complaints about access to their business after project completion. Those businesses that tended to report most complaints were highly oriented toward automobile traffic.
- In all cases, 90-100% of motorists surveyed had a favorable opinion of improvements made to roadways that involve access management. The vast majority of motorists thought that the improved roadways were safer and that traffic flow had improved.

In conclusion of these studies it can be stated that median projects have little overall adverse impact on business activity. The majority of businesses report no change in business activity following a median project. Destination type businesses, such as certain restaurants and specialty stores, appear less sensitive to access changes than businesses that primarily rely on pass-by traffic, such as gas stations or convenience stores.

However, such projects tend to invoke anxiety among affected business owners. One solution is direct and meaningful involvement of affected businesses in median issues. It has been shown that public involvement leads to greater success in achieving access management objectives with projects. *[Williams, Kristine M., Center for Urban Transportation Research, University of South Florida. Economic Impacts of Access Management. 2000.]*

1.3.4 Effects on Land Use

Minimizing the number of curb cuts, consolidating access drives, constructing landscaped medians, and buffering parking lots from adjacent thoroughfares can create a visually pleasing and more functional corridor which can help attract new investment. The use of fewer access connections increases the area for landscaping. Landscaping at the margin of the roadway and in the median of divided roadways enhances the appearance of major corridors. Proper landscaping also helps to provide a visual cue for driveways and median openings.

Requirements for well-designed road and access systems further the orderly layout and use of land and help improve the design of residential subdivisions and commercial circulation systems.

1.3.5 Effects on Environment

The minimum consumption of fuel for passenger cars occurs at speeds ranging from 35 to 55 mph. Energy consumption increases by about 20% for every additional stop per mile. Access management helps save fuel. For example, ½-mile signal spacing with left-turn and right-turn bays at all intersections can provide substantial fuel savings over ¼-mile signal spacing with left and right turns midway between signals.

Effective access management of major roadways leads to smoother traffic flow, which results in reduced generation of air pollutant emissions. Any access management situations that increase average travel speed or smooth traffic flow by minimizing excessive stopping will typically affect fuel economy and emissions levels directly. Aggressive driving and stop-and-go traffic conditions result in frequent braking and acceleration, with higher levels of air pollutant emissions than under uniform speed conditions. Access management strategies and designs that increase capacity or eliminate conflicts between road users will typically yield more uniform speeds and lower emission levels.

Another aspect is that access management designs reduce the need for new major roadways or bypass facilities and their associated adverse environmental impacts.

CHAPTER 2 - PRINCIPLES OF ACCESS MANAGEMENT

The TRB Access Management Manual states that contemporary access management programs focus on functional design, aligning transportation plans, access policies, and design standards with the desired function of each roadway in the transportation network. More specifically, access management coordinates planning, regulation, and design of access between roadways and land development. It encompasses a range of methods that promote the efficient and safe movement of people and goods by reducing conflicts on the roadway system and at its interface with other modes of travel.

Techniques for managing access involve the application of established traffic engineering and planning principles. The following are typical principles:

- Provide a specialized roadway system
- Promote intersection hierarchy
- Preserve the functional area of intersections and interchanges
- Locate signals to favor through movements
- Limit the number of conflict points
- Separate conflict areas
- Remove turning vehicles from through traffic lanes
- Use nontraversable medians on major roadways
- Provide a supporting street network
- Provide unified access and circulation systems

The application of these principles promotes a roadway that functions safely and efficiently for its useful life.

2.1 Functional Classification and Access Management Categories

Access management is necessary for achieving the roadway functional hierarchy implicit in state, regional, and local transportation plans. Roadways are classified by function on the basis of the relative priority given to land access or through movement (Figure 4).

Each functional class of roadway must perform its function. Arterials must serve mobility first and access secondarily, and each segment of roadway must operate effectively and efficiently to serve travel demand at an acceptable quality of service.

Arterial highway and other primary roads require a higher level of access control to move vehicular traffic safely and efficiently over longer distances at the desired operating speed.

Local streets and other minor roads provide frequent, direct property access. Here, the movement function is curtailed to increase safety for low-speed local circulation by pedestrians, bicyclists, and motorized vehicles.

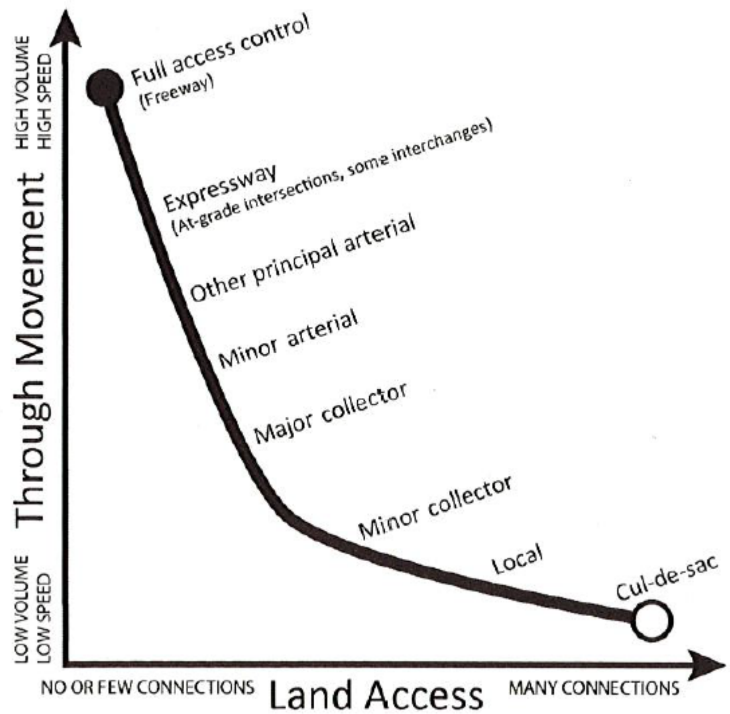


Figure 4: Conceptual Roadway Functional Hierarchy [TRB. Access Management Manual. 2014]

2.1.1 Functional Classification in Tennessee

TDOT differentiates between interstate, other freeway and expressway, urban and rural principal arterials, urban and rural minor arterials, urban and rural major collectors, urban and rural minor collectors, and local roads.

Definitions and characteristics of the functional classes are listed below according to the Federal Highway Administration’s guidelines.

<table>
<tr><th colspan="2">Table 3: Characteristics of Functional Classes</th></tr>
<tr><th colspan="2">Interstate</th></tr>
<tr><td colspan="2">Interstates are the highest classification of arterials and are designed and constructed to provide mobility and long-distance travel. The interstate network provides limited access, and divided highways offer high levels of mobility while linking the major urban areas of the U.S.</td></tr>
<tr><th colspan="2">Other Freeways / Expressways</th></tr>
<tr><td colspan="2">Roads with this classification have directional travel lanes are usually separated by some type of physical barrier, and their access and egress points are limited to on- and off-ramp locations or a very limited number of at-grade intersections. Like interstates, these roadways are designed and constructed to maximize their mobility function, and abutting land uses are not directly served by them.</td></tr>
<tr><th colspan="2">Principal Arterials</th></tr>
<tr><td>Urban</td><td>Rural</td></tr>
<tr><td>• Serve major activity centers, highest traffic volume corridors and longest trip demands
• Carry high proportion of total urban travel in minimum of mileage
• Interconnect and provide continuity for major rural corridors to accommodate trips entering and leaving urban area and movements through the urban area
• Serve demand for intra-area travel between the central business district and outlying residential areas</td><td>• Serve corridor movements having trip length and travel density characteristics indicative of substantial statewide or interstate travel
• Connect all or nearly all Urbanized Areas and a large majority of Urban Clusters with 25,000 and over population
• Provide an integrated network of continuous routes without stub connections (dead ends)</td></tr>
<tr><th colspan="2">Minor Arterials</th></tr>
<tr><td>Urban</td><td>Rural</td></tr>
<tr><td>• Interconnect and augment the higher-level Arterials
• Serve trips of moderate length at a somewhat lower level of travel mobility than Principal Arterials
• Distribute traffic to smaller geographic areas than those served by higher-level</td><td>• Link cities and larger towns (and other major destinations such as resorts capable of attracting travel over long distances) and form an integrated network providing interstate and inter-county service
• Be spaced at intervals, consistent with population density, so that all developed areas</td></tr>
</table>

Arterials • Provide more land access than Principal Arterials without penetrating identifiable neighborhoods • Provide urban connections for Rural Collectors	within the State are within a reasonable distance of an Arterial roadway • Provide service to corridors with trip lengths and travel density greater than those served by Rural Collectors and Local Roads and with relatively high travel speeds and minimum interference to through movement
Major Collectors	
Urban	Rural
• Serve both land access and traffic circulation in higher density residential, and commercial/ industrial areas • Penetrate residential neighborhoods, often for significant distances • Distribute and channel trips between Local Roads and Arterials, usually over a distance of greater than three-quarters of a mile • Operating characteristics include higher speeds and more signalized intersections	• Provide service to any county seat not on an Arterial route, to the larger towns not directly served by the higher systems and to other traffic generators of equivalent intra-county importance such as consolidated schools, shipping points, county parks and important mining and agricultural areas • Link these places with nearby larger towns and cities or with Arterial routes • Serve the most important intra-county travel corridors
Minor Collectors	
Urban	Rural
• Serve both land access and traffic circulation in lower density residential and commercial/ industrial areas • Penetrate residential neighborhoods, often only for a short distance • Distribute and channel trips between Local Roads and Arterials, usually over a distance of less than three-quarters of a mile • Operating characteristics include lower speeds and fewer signalized intersections	• Be spaced at intervals, consistent with population density, to collect traffic from Local Roads and bring all developed areas within reasonable distance of a Collector • Provide service to smaller communities not served by a higher-class facility • Link locally important traffic generators with their rural hinterlands
Local	
Urban	Rural
• Provide direct access to adjacent land • Provide access to higher systems • Carry no through traffic movement	• Serve primarily to provide access to adjacent land • Provide service to travel over short distances as

• Constitute the mileage not classified as part of the Arterial and Collector systems	compared to higher classification categories • Constitute the mileage not classified as part of the Arterial and Collector Systems
FHWA. Highway Functional Classification: Concepts, Criteria and Procedures. 2013	

According to FHWA's *Functional Classification Guidelines,* an important principle of access management is to avoid connecting a roadway of low classification directly to a roadway of much higher classification. A desirable practice is to allow direct connection to the next higher or lower functional classification, as shown in Figure 5.

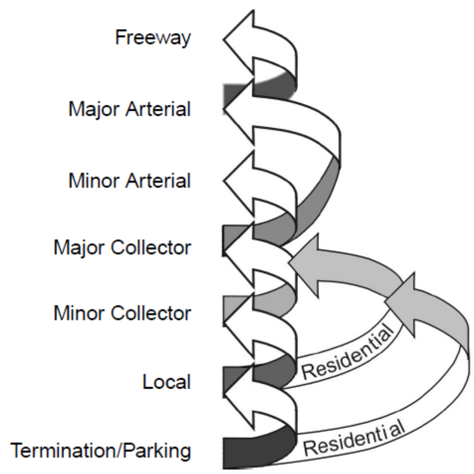


Figure 5: Access Relationship between Functional Categories [TRB. Access Management Manual. 2014]

In order to identify any potential major discrepancies on TDOT's classification of roadways, this research compared the current AADT's by functional classification in the State of Tennessee to FHWA's typical AADT's by functional class. TDOT's AADT's by functional class are within FHWA's recommended ranges, as shown in the following Table. Only exceptions are rural interstate AADT's which are slightly higher in Tennessee compared to guidance.

Table 4: AADT Guidelines by Functional Classifications from FHWA compared to TDOT				
	Rural Area		Urban Area	
	AADT - FHWA	AADT - TDOT	AADT - FHWA	AADT - TDOT
Interstate	12,000 – 34,000	35,613	35,000 – 129,000	73,565

Other Freeways & Expressway	4,000 – 18,500	N/A	13,000 – 55,000	38,539
Other Principal Arterial	2,000 – 8,500	7,641	7,000 – 27,000	19,132
Minor Arterial	1,500 – 6,000	3,974	3,000 – 14,000	9,369
Major Collector	300 – 2,600	1,508	1,100 – 6,300	3,881
Minor Collector	150 – 1,110	627		1,826
Local	15 – 400	159	80 – 700	1,059

2.1.2 State Practices on Access Management Categories

Several states have developed access classes or categories to which roadways are assigned. Those categories are different from functional classification as they specifically address accessibility.

Ohio DOT

The Ohio DOT has five "Access Categories" to which all sections of state highways have been assigned as shown in Table 5.

Table 5: Ohio DOT's Access Categories		
Access Categories	**Function**	**Operational Standards**
Category I	• Highways providing mobility for high traffic volumes at high speeds over long distances • They serve major interstate, intrastate, and interregional travel demand for through traffic • Includes all interstate and freeway facilities	• Opposing traffic movements separated by grade separations and medians • Public access provided by interchanges • No direct private access • Minimum posted speed of 55 mph
Category II	• Highways providing mobility for relatively high speed, high volume, long distance, and through traffic • Typically includes principal rural arterials, major urban expressways, and facilities intended to become Category I highways	• Public access provided by interchanges or public street intersection • Signalized intersections should be based on one mile spacing • Minimum speed of 50 mph in areas

		without signals and 45 in areas with signals • Direct private access not permitted (exceptions)
Category III	• Highways providing mobility at moderate to high speeds and volumes • Typically includes rural arterials, most urban arterials, and some urban collectors	• On rural highways, signalized intersections should be based on one mile spacing; On urban highways, signalized intersections should be based on one-half mile spacing • Minimum speed of 45 mph in areas without signals and a minimum of 35 mph in areas with signals • Direct private access not permitted
Category IV	• Highways provide access and mobility at moderate to high speeds and volumes for moderate to short distances in rural areas and low to moderate speeds in urban areas • Includes most rural collectors, some low and moderate speed urban arterials, and most urban collectors	• On rural highways, signalized intersections based on one mile spacing; On urban highways, signalized intersections should be based on one-half mile spacing • Minimum posted speed of 35 to 55 mph in undeveloped areas and 25 to 45 mph in developed areas • One direct private access permitted per parcel
Category V	• Roads providing local land access, including frontage roads • Mostly low volume rural highways, rural and urban streets and roads	• One direct private access permitted per parcel • All turning movements allowed subject only to safety considerations
Ohio Department of Transportation. State Highway Access Management Manual. 2001.		

<u>Florida DOT</u>

Florida DOT differentiates between seven access classes called “Access Control Classification” in their access management standards.

- **Access Class 1** consists of limited access facilities, which roadways do not provide direct property connections.

- **Access Class 2** roadways are highly controlled access facilities distinguished by the ability to serve high speed and high-volume traffic over long distances in a safe and efficient manner.
- **Access Class 3** roadways are controlled access facilities where direct access to abutting land is controlled to maximize the operation of the through traffic movement.
- **Access Class 4** roadways are controlled access facilities where direct access to abutting land is controlled to maximize the operation of the through traffic movement
- **Access Class 5** roadways are controlled access facilities where adjacent land has been extensively developed and where the probability of major land use change is not high.
- **Access Class 6** roadways are controlled access facilities where adjacent land has been extensively developed, and the probability of major land use change is not high.
- **Access Class 7** roadways are controlled access facilities where adjacent land is generally developed to the maximum feasible intensity and roadway widening potential is limited.

Figure 6 shows Florida's Access Management Standards. Access Class 1 applies specifically to freeways and is not included in that table. It is important to know what access classification and posted speed limit has been assigned to the highway/ road segment under consideration and to determine what roadway features and access connection modifications are appropriate to adhere to the access management process.

Class	Medians	Median Openings		Signal	Connection	
		Full	Directional		More than 45 mph Posted Speed	45 mph and less Posted Speed
2	Restrictive w/Service Roads	2,640	1,320	2,640	1,320	660
3	Restrictive	2,640	1,320	2,640	660	440
4	Non-Restrictive			2,640	660	440
5	Restrictive	2,640 at greater than 45 mph Posted Speed 1,320 At 45 mph or less Posted Speed	660	2,640 at greater than 45 mph Posted Speed 1,320 At 45 mph or less Posted Speed	440	245
6	Non-Restrictive			1,320	440	245
7	Both Median Types	660	330	1,320	125	125

Figure 6: Florida DOT Access Management Standards

Kentucky DOT

Kentucky DOT created a set of four classes for urban and rural roadways to maintain a reasonable number of classes and some resemblance to the functional classification system.

Interstates, parkways and other freeways have full access control and are assigned into two individual categories: rural (Rural F) and urban (Urban F). The other classes are: Rural I, II, III, IV and Urban I, II, III, IV

The correspondence between functional class and these categories for both urban and rural roadways is as follows:

I – Principal Arterial
II – Minor Arterial
III – Collector (both Major and Minor in rural)
IV – Local

The use of 45 mph for both rural and urban categories will be used to indicate roadways that might be shifted to a restrictive access class than initially established by the functional classification. This speed is considered as the upper design speed for urban design, i.e. cross section with curb and gutter.

Table 6: Kentucky DOT – Definition of Access Management Classes

Class	Location	
	Urban	Rural
F	Freeways, expressways, parkways with full access control	Freeways, expressways, parkways with full access control
I	Roads with high volumes and high speeds, placing a high priority on mobility, long distance travel through urban areas, typically including principal arterials, multi-lane facilities often with median.	Roads with high volumes and high speeds, placing a high priority on mobility, long distance travel between urban areas, typically including principal arterials, multi-lane facilities.
II	Roads with moderate volumes and speeds, placing priority on mobility, used for intra-city travel, typically including minor arterials, often multi-lane facilities.	Roads with moderate volumes and speeds, placing priorities on mobility, used for intercity and interregional travel, typically including minor arterials, often two-lane facilities.
III	Roads with low volumes and speeds, balancing access and mobility, short	Roads with low volumes and speeds, balancing access and mobility, short

	distance travel within urban centers, typically including collectors, often two-lane facilities.	distance travel in rural areas, typically including collectors, two-lane facilities.
IV	Roads with very low volumes and speeds, placing a high priority on access, travel for local access, typically including local streets.	Roads with very low volumes, placing a high priority on access, travel for local access, typically including local streets.
Kentucky Access Management Report 2004.		

<u>State Route 109 in Middle Tennessee</u>

The State Route 109 Access Management Study was completed by a consultant team in cooperation with the Nashville MPO, TDOT, and local partners.

The SR 109 study recommends the application of five access management classifications to SR 109. These range from highly restrictive (Class I) to highly permissive (Class V). The classifications incorporate various components of roadway design and operation, including median, signal, and access spacing.

The access classifications are based on the "Transect" concept. Land use intensity transitions from rural to compact/urban from Class I to V. Consequently, mobility decreases and accessibility becomes less restrictive the higher the classification as shown on Figure 7.

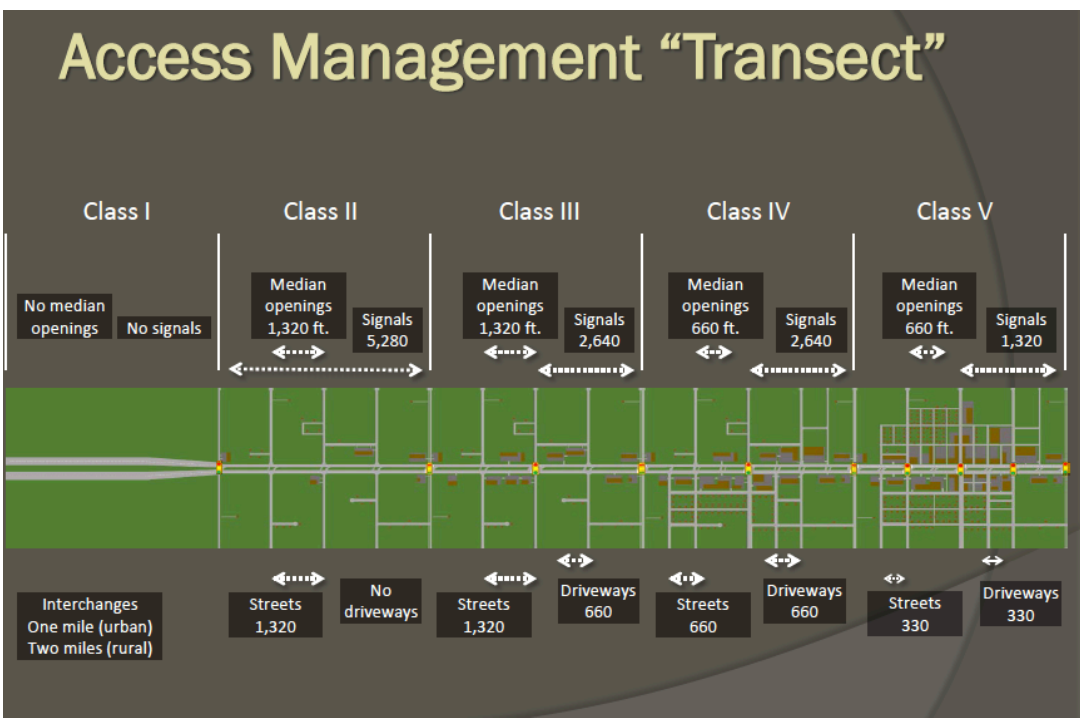


Figure 7: Transect Classes I - V

The five access categories are further described in Table 7:

Table 7: Transect Access Categories

Access Category	Mobility and Safety	Access Spacing	Driveways	Traffic Signals and Street Spacing	Median
Class I	Most restrictive with access Mobility is only priority Speeds ≥ 55 mph With proper access design provides the safest travel Lower crash rate	Access only by grade-separated interchanges	No direct public or private access	No traffic signals Interchange spacing should be one mile (urban) and two miles (rural) Consider interchange ramp roundabouts	A non-traversable median is required
Class II	Restrictive with access Mobility is priority Speeds ≥ 45 mph With proper access design provides the safest travel Lower crash rate	Access only by public street	No private driveways Temporary driveways would be allowed until local network alternatives are available	Street spacing: 1,320 ft. Consider roundabouts in place of traffic signals Traffic signal spacing: 5,280 ft.	Non-traversable median preferred Median openings: 1,320 ft.
Class III	Transition to suburban area Mobility and safety are priorities Speeds ≥ 40 mph	Full movement at one-half mile spacing Spacing is more flexible	Driveways should only be built by necessity until alternative is available Driveway spacing: 660 ft.	Street spacing: 1,320 ft. Consider roundabouts in place of traffic signals Traffic signal spacing: 2,640 ft.	Non-traversable median is preferred Median openings: 1,320 ft.

Class IV	Suburban Area Balance between mobility and adjacent land use access allowances Lower mobility Speeds = 35 mph Higher crash rate than in Class III	Full movement at one-half mile spacing Spacing is more flexible	Driveway spacing: 660 ft.	Street spacing: 660 ft. Consider roundabouts in place of traffic signals Traffic signal spacing: 2,640 ft.	Non-traversable median is preferred Median openings: 660 ft.
Class V	Urban / Compact Areas More accommodation of abutting access needs Lowest mobility Speeds < 35 mph Highest crash rate of the five classes	Full movement at quarter mile spacing Spacing is more flexible	Driveway spacing: 330 ft.	Street spacing: 220 ft. Consider roundabouts in place of traffic signals Traffic signal spacing: 1,320 ft.	Non-traversable median still preferred Median openings: 660 ft.

The Access Categories developed for the SR 109 Access Management Study are similar to the classification systems established by peer states, such as Florida DOT, Ohio DOT, and Kentucky DOT.

2.1.3 Development of Access Management Classes for Tennessee

One finding in the review of other states Access Management Manuals is that the core element of a comprehensive access management system is a roadway classification system. Such a system allows for the identification of strategies for access management that can be related directly to roadway function.

Many of the systems used by other states utilize existing functional classification as a basis for their roadway classification system. Some states use speed limit for defining a roadway classification system. Operating speed along a section of roadway affects the speed differential between through vehicles and those turning from or onto the roadway. Thus, the level of access management necessary to attain a desired level of safety is highly dependent on speed considerations. For example, Florida used 45 mph speed while Ohio uses qualitative measures such as high and low speeds.

The first step in the development of an access management classification system is an understanding of the current roadway network and its mileage for various combinations of speed limits and traffic volumes within each functional class.

The analysis of Tennessee's network of functional classified roads by speed limits has found most of the urban interstates and freeways/expressways have speed limits above 45 mph, whereas roads classified as urban principal arterials and below, have speed limits equal to or less than 45 mph. In rural areas, there are more functional classes with speed limits of more than 45 mph, such as rural minor and principal arterials. Most arterials in urban areas are subject to stricter speed limits. See Table 8 (Tennessee's Functional Classified Roadway Mileage by Speed Limits).

This report differentiates between roads functional classes with a speed limit greater than 45 mph and roads with speed limits of equal or less than 45 mph. According to AASHTO, the upper limit for low-speed design is 45 mph and lower limit for high-speed design is 50 mph *[AASHTO. Geometric Design of Highways and Streets. 2011]*.

Table 8: Tennessee's Functional Classified Roadway Mileage by Speed Limit

	Functional Class	15 mph	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph	60 mph	65 mph	70 mph	Total miles	<= 45 mph	> 45 mph
Class I	Urban Interstate	/	/	/	/	/	/	2	/	139	11	138	257	547	2	545
	Urban Freeway/Expressway	/	/	/	/	/	1	11	5	79	3	74	9	182	12	170
Class II	Urban Principal Arterial	1	/	4	87	140	373	617	164	458	2	25	13	1,884	1,222	662
Class III	Urban Minor Arterial	3	12	54	424	437	705	622	150	143	/	1	2	2,553	2,257	296
	Urban Major Collector	7	41	93	816	653	358	282	41	62	/	0	1	2,354	2,250	104
Class IV	Urban Minor Collector	2	9	54	336	228	111	120	8	7	/	/	/	875	860	15
Class V	Urban Local	209	1,077	1,541	2,529	547	197	115	1	17	/	/	/	6,233	6,215	18
Class I	Rural Interstate	/	/	/	/	/	/	/	5	32	18	67	513	635	0	635
	Rural Freeway/Expressway	/	/	/	/	/	/	/	1	8	/	14	/	23	0	23
Class II	Rural Principal Arterial	/	0	4	32	22	69	242	47	1,009	15	321	32	1,793	369	1,424
	Rural Minor Arterial	/	1	9	113	81	139	575	169	1,815	/	20	16	2,938	918	2,020
Class III	Rural Major Collector	2	10	26	259	283	622	1,658	449	1,570	/	8	30	4,917	2,860	2,057
Class IV	Rural Minor Collector	7	35	133	665	1,172	686	1,912	62	154	/	/	/	4,826	4,610	216
Class V	Rural Local	349	736	1,266	1,676	1,252	518	684	138	51	/	/	2	6,672	6,481	191

For the development of Access Management Classes, the functional classes in the urban and rural systems were analyzed and grouped into categories based on common characteristics such as speed limits, roadway function, and AADT's. The roadway characteristics directly correlate to the level of access.

Access Class I is typically comprised of rural and urban interstates and freeways having the most restricted level of access. Those highways are designed and intended to provide mobility for high traffic volumes and traffic at high speeds over long distances. This report does not give specific access management recommendations to this class since access is not allowed other than through interchanges.

Access Class II is typically formed by urban / rural principal arterials and rural minor arterials. Rural minor arterials are generally characterized by higher speeds and are similar in characteristics as the principal arterials. Highways in this category are designed and intended to provide mobility for relatively high speed, high volume, long distance, through traffic. Access is permitted but adherent to strict spacing standards on those highways.

Access Class III is typically composed of urban minor arterials, as well as urban and rural major collectors. This class is characterized by moderate speeds, volumes, and distances. Access by public and private roadways is permitted.

Access Class IV typically includes urban and rural minor collectors. Those roads provide balanced service for access and mobility at moderate to high speeds and volumes in rural areas and low to moderate speeds and volumes in urban areas. Public and private roadway access is permitted on these roads and spacing occurs in close distances.

Access Class V is typically comprised of roads and streets designed and intended to provide local land access. Typically, this category would not include any state highways. This report does not make specific access management recommendations for Class V since it includes only local roads.

Table 9 shows the recommended Access Management Classes.

Table 9: Functional Classified Road Mileage by Access Class

Access Class	Typical Functional Class	Miles ≤ 45 mph	Miles > 45 mph
Class I	Urban Interstate	2	545
	Rural Interstate	0	635
	Urban Freeway/ Expressway	12	170
	Rural Freeway/ Expressway	0	23
Class II	Urban Principal Arterial	1,222	662
	Rural Principal Arterial	369	1,424
	Rural Minor Arterial	918	2,020
Class III	Urban Minor Arterial	2,257	296
	Urban Major Collector	2,250	104
	Rural Major Collector	2,860	2,057
Class IV	Urban Minor Collector	860	15
	Rural Minor Collector	4,610	216
Class V	Urban Local	6,215	18
	Rural Local	6,481	191

This report gives recommendations for access management standards for each functional class (except for those in Access Class I and V), and differentiates standards by speed (≤ 45 and > 45 mph).

2.2 Intersection Functional Area

Intersections are comprised of physical and functional areas, as shown in Figure 8 below. The physical extent of an intersection is the area bound by the intersection legs. The functional area extends upstream and downstream of the intersection, and includes the roadway length required for vehicle storage and maneuvering. The upstream functional area of an intersection depends on the vehicle queuing (storage length), driver perception-reaction time, and the distance required for decelerating or stopping. The downstream functional area of an intersection is the distance required by the driver to clear the intersection, and be able to perceive and react to a conflict downstream of the intersection.

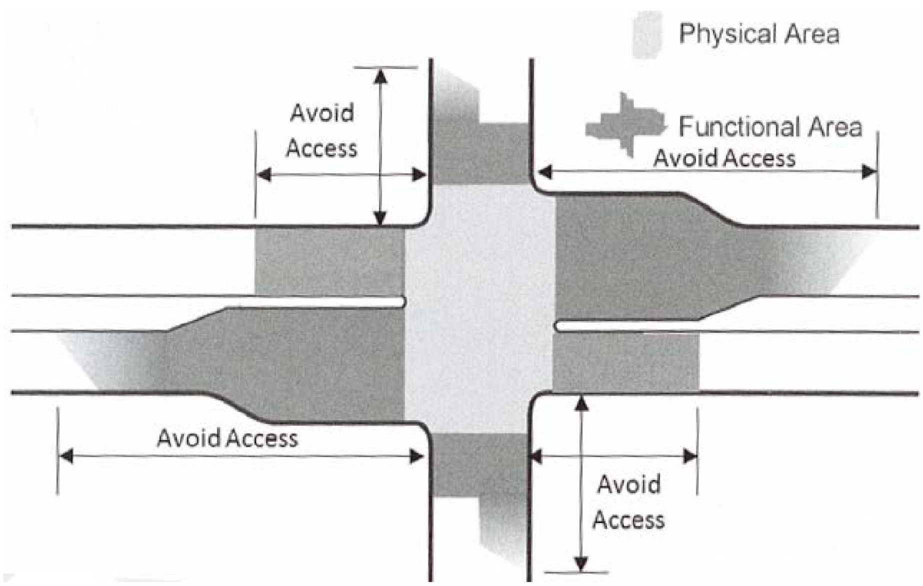


Figure 8: Functional Area in which Access should be avoided [TRB. Access Management Manual. 2014]

Access connections are **not** recommended in the intersection functional area. Driveways or median openings within the functional area create conflict points, which the driver approaching or exiting an intersection may not be able to negotiate safely. The functional area of an intersection should be considered when evaluating potential driveway locations. Ideally, the functional areas of adjacent intersections should not overlap. The integrity of the intersection functional area is maintained by intersection spacing, median spacing, driveway spacing, and corner clearance. It is also necessary to understand that calculated values for functional areas are ideal values that may not be feasible for implementation, especially in consolidated urban areas.

2.2.1 Upstream Functional Distance

The upstream functional area of an intersection is based on the stopping sight distance and the queueing requirements. Figure 9 illustrates the elements used to estimate the upstream functional area.

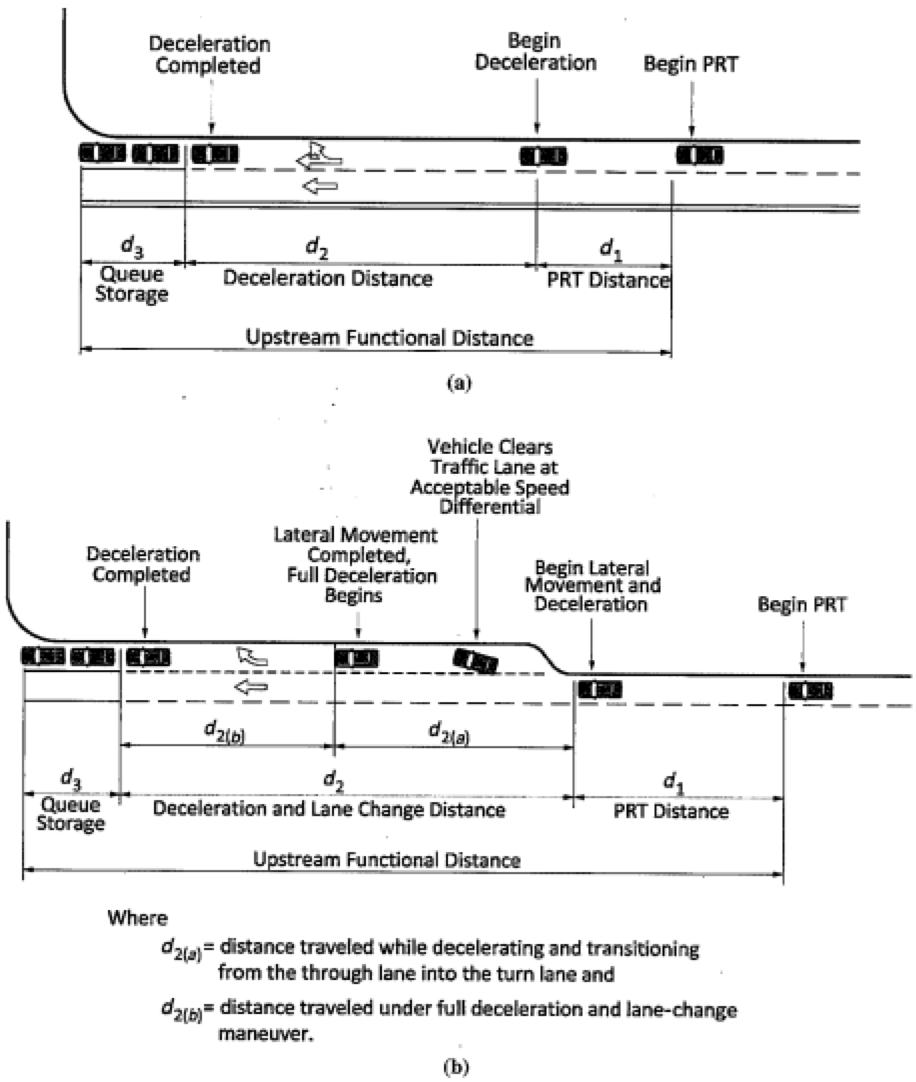


Figure 9: Upstream Functional Intersection Area: (a) without a turn bay and (b) with a turn bay [TRB Access Management Manual. 2014]

The upstream functional area includes the following three components:

• *Perception-Reaction Distance (PRT)* (d1): This is the distance travelled during the perception-reaction time as a driver approaches the intersection, based on the vehicle speed. According to TRB 2014 a value of 1.5 sec is often used as the perception-reaction time for urban and suburban conditions, and 2.5 sec is often used for rural situations. Table 10 presents the perception-reaction time distances for a variety of speeds.

Table 10: Distance traveled during Driver's Perception-Reaction

Speed (mph)	Perception – Reaction Distance (d_1) (ft) by Perception – Reaction Time						
	1.0 s	1.5 s	2.0 s	2.5 s	3.0 s	3.5 s	4.0 s
20	30	45	60	75	90	105	120
25	35	55	75	90	110	130	145
30	45	65	85	110	130	155	175
35	50	75	105	130	155	180	205
40	60	90	120	145	175	205	235
45	65	100	130	165	200	230	265
50	75	110	145	185	220	255	295
55	80	120	160	200	240	285	325
60	90	130	175	220	265	265	355
65	95	145	190	240	285	335	380
70	105	155	205	255	310	360	410
75	110	165	220	275	330	385	440

Note: Distances rounded to 5 ft.
TRB. Access Management Manual. 2014.

•*Deceleration/Maneuver Distance* (d2): This is the additional distance travelled while the driver maneuvers to bring a vehicle to a complete stop. The maneuver distance can vary depending on the existence of a turn-lane. For turning lanes, it is separated into the distance traveled while braking and moving laterally into a turn bay and the distance traveled to come to a complete stop at the end of the storage queue. Table 11 presents the deceleration/maneuver distances based on average deceleration rate. The "Most Drivers" column is recommended for locations with left-turn or right-turn lanes and the "Limiting Conditions" column can be applied to through lanes or shared-right turn lanes. The *TRB Access Management Manual* presents additional tables for estimation of these values. Notice that TDOT has a slightly more conservative table in its *Roadway Design Guidelines 2-170.00* for deceleration lengths.

Table 11: Deceleration – Maneuver Distance based on Average Deceleration Rate		
Speed (mph)	Deceleration – Maneuver Distance	
	Most Drivers[a]	Limiting Conditions[b]
20	60	45
25	95	70
30	135	100
35	185	135
40	240	175
45	305	220
50	375	275
55	455	330
60	540	395
65	635	460
70	735	535
75	840	610

Note: Deceleration while steering straight ahead. Distances rounded to 5 ft.

[a] Eighty-five percent of drivers traveling at a speed of 40 mph or less were reported to use a deceleration rate of 7.2 ft/s^2 or less. Thus, the distance for d_2 given in the table accommodates 85% of drivers; only 15% will require a longer distance.

[b] Based on 50th percentile of drivers using a deceleration rate of 9.9 ft/s^2, yielding a shorter deceleration – maneuver distance. Braking distances to determine AASHTO stopping sight distance are based on 11.2 ft/s^2.

TRB. Access Management Manual. 2014.

• *Queue Storage Length* (d3): This is the length where vehicles are stored on the approach of an intersection. In urban areas, different traffic conditions are encountered throughout the day. In peak periods, traffic volumes are high while speeds are typically slow in comparison to off-peak periods. Therefore, the upstream functional area for urban areas should be calculated for both scenarios with the selected result yielding the greater sum of $d_1 + d_2 + d_3$. The TDOT Roadway Design Guidelines 2-170.00 presents the procedures for calculation of queue storage lengths.

2.2.2 Downstream Functional Distance

After exiting the intersection, the driver requires adequate distance to safely negotiate any potential conflict. The downstream functional area depends on geometric features, operational effects and human factors. Adequate downstream acceleration distance (Table 12) and downstream sight distance are typically used to determine a downstream functional distance.

Table 12: Ideal Downstream Functional Distance Based on Acceleration

Speed (mph)	Acceleration Distance[a] (ft)	Typical Taper Distance[b] (ft)	Downstream Functional Distance[c] (ft)
20	100	60	160
25	150	80	230
30	220	100	320
35	320	120	440
40	440	140	580
45	580	160	740
50	770	180	950
55	1,000	200	1,200
60	1,300	220	1,520
65	1,750	240	1,990
70	2,320	260	2,580

[a] Based on AASHTO (7, Figure 2-24)
[b] Based on AASHTO (7, Figure 9-49 and p. 9-127)
[c] Acceleration lane length
TRB. Access Management Manual. 2014.

Stopping sight distance provides perception-reaction time plus braking distance to a single clearly discernable hazard in the middle of the roadway. The downstream functional distance often must provide sight distance to more complex situations within the traffic stream and along the roadway. Therefore, decision sight distance to a stop recognizes the added complexity and is a logical minimum downstream functional distance for arterials. Also, multilane arterials may use decision sight distance for a change in speed, path, or direction as presented on Table 13. The larger of acceleration distance versus decision sight distance should be used to determine the downstream functional distance.

Table 13: Ideal Downstream Functional Distance Based on Decision Sight Distance to Stop and for Change in Speed, Path, or Direction						
Speed (mph)	Decision Sight Distance to Stop (ft)			Decision Sight Distance for Change in Speed, Path, or Direction (ft)		
	Rural[a]	Suburban[b]	Urban[c]	Rural[d]	Suburban[e]	Urban[f]
20	130	215	305	305	340	430
25	180	280	400	375	400	525
30	220	350	490	450	535	620
35	275	425	590	525	625	720
40	330	505	690	600	715	825
45	395	590	800	675	800	930
50	465	680	910	750	890	1,030
55	535	775	1,030	865	980	1,135
60	610	875	1,150	990	1,125	1,280
65	695	980	1,275	1,050	1,220	1,365
70	780	1,090	1,410	1,105	1,275	1,445
75	875	1,200	1,545	1,180	1,365	1,545

[a]Stop on a rural road with perception-reaction time (PRT) = 3.0s.
[b]Stop on a suburban road with PRT = 6.0 s.
[c]Stop on an urban road with PRT = 9.1 s.
[d]Change in speed, path, or direction on a rural road, PRT = 10.2 to 11.2 s.
[e]Change in speed, path, or direction on a suburban road, PRT = 12.1 to 12.9 s.
[f]Change in speed, path, or direction on a rural road, PRT = 14.0 to 14.5 s.

TRB. Access Management Manual. 2014.

2.2.3 Locating Access Connections

The *TRB Access Management Manual* states that to identify where access can best be located, it is helpful to first identify where access should not be located. The steps in determining the access location with the least interference to the connecting roadway and with the most benefit and flexibility for the site are:

- Locate nearby intersections (streets and driveways connections);
- Arrange these intersections in descending order of importance;
- Define the upstream and downstream functional area of each intersection;

- Identify if the functional areas are overlapping or if there is space between the functional areas;
- Locate access connections outside the functional areas.

Although it is desirable to avoid access within the functional area, this is not always possible in urban areas, where short street spacing and small property frontages are common. When an alternative reasonable access connection is not available and locating it within the functional area becomes unavoidable, including the following conditions in the access permit can minimize the adverse impacts of the connection:

- Require that the access connection be located as far as possible from the intersection;
- Limit movements to right in, right out;
- Require the applicant to agree to close the access connection if and when alternative access becomes available.

2.3 Sight Distance

The driver's ability to see ahead is the utmost importance in the safe and efficient operation of a vehicle on a highway. Sight distance is the length of the roadway that is visible to the driver.

The following sight distances are most relevant in access management:

- **Stopping Sight Distance**: The distance necessary for the driver to safely bring a vehicle to a stop.
- **Intersection Sight Distance**: The distance necessary for drivers to safely approach and pass through an intersection.

2.3.1 Stopping Sight Distance

Stopping sight distance is the length of the roadway ahead that is visible to the driver. The sight distance should be sufficiently provided so that drivers can control the operation of their vehicles to avoid striking an unexpected object in the traveled way. The sight distance at every point along the roadway should be at least that needed for a driver to stop the vehicle.

Stopping sight distance is the sum of two distances: (1) the distance traversed by the vehicle from the instant the driver sights an object necessitating a stop to the instant the brakes are applied; and (2) the distance needed to stop the vehicle from the instant brake application begins.

Table 14: Stopping Sight Distance	
Design Speed (mph)	Minimum Stopping Sight Distance (ft)
25	155
30	200
35	250
40	305
45	360
50	425
55	495
60	570
65	645
AASHTO. Geometric Design of Highways and Streets. 2011.	

2.3.2 Intersection Sight Distance

The provision of stopping sight distance at all locations along each roadway, including intersections, is essential to intersection operation. Sight distance is provided at intersections to allow drivers to perceive the presence of potentially conflicting vehicles. The driver of a vehicle approaching an intersection should have an unobstructed view of the entire intersection, including any traffic-control devices, and sufficient lengths along the intersecting roadway to allow the driver to anticipate and avoid potential collisions.

The methods for determining the sight distances needed by drivers approaching intersections are based on the same principles as stopping sight distance, however assumptions based on observed driver behavior at intersections are incorporated.

The *TDOT Roadway Design Guidelines Standard Drawings* provide detailed information on the calculation of intersection sight distance for different types of facilities. The information can be found at URL: *https://www.tn.gov/tdot/article/transportation-chief-engineer-engineer-library-design-roadway-design-standa*

2.3.3 Sight Distance for U-Turns

U-turns are more complicated than simple turning or crossing maneuvers [*Florida DOT Median Handbook. 2014*]. Figure 10 illustrates an example of a U-turn maneuver sight distance requirement. Table 15 presents calculated values for U-turns based on the following assumptions:

- "P" vehicle (Passenger vehicle)
- 2.0 seconds reaction time
- Additional time required to perform the U-turn maneuver
- Begin acceleration from 0 mph only at the end of the U-turn movement (this is conservative)
- Use of speed/distance/and acceleration figures from AASHTO Green Book.
- 50 ft clearance factor

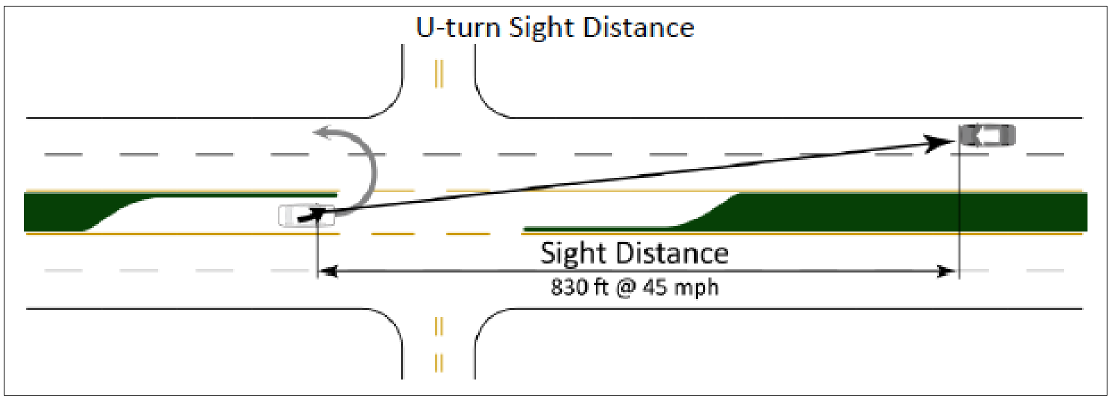


Figure 10: Example of U-Turn Sight Distance [Florida DOT. Median Handbook. 2014]

Table 15: Sight Distance for U-turn and Unsignalized Median Opening	
Design Speed (mph)	Intersection Sight Distance (ft)
35	520
40	640
45	830
50	1,040
55	1,250
60	1,540
FDOT. Florida Median Handbook. 2014.	

2.3.4 Landscaping Sight Distance Issues

Landscaping shall not cause a sight distance or clear zone conflict. TDOT's Environmental Division – Beautification Office's has produced a *Landscape Design Guidelines* for roadside landscaping details. The document may be view at URL*: http://www.tn.gov/tdot/article/beautification-landscape-design*. In addition, the Florida DOT Median Handbook provides important direction on areas that should never have any landscaping except low groundcover. At a minimum, low groundcover should be used in areas to allow for clear stopping sight distance or to the start of the turn lane taper (whichever is the longest measure). Figure 11 demonstrates special areas limited to ground cover. FDOT also states that no trees shall be permitted within 100 ft (< 50 mph) or 200 ft (≥ 50 mph) of the restrictive median traffic separation nose. (Additional information on landscaping including tree spacing tables is available at URL:
http://www.fdot.gov/roadway/DS/18/IDx/00546.pdf)

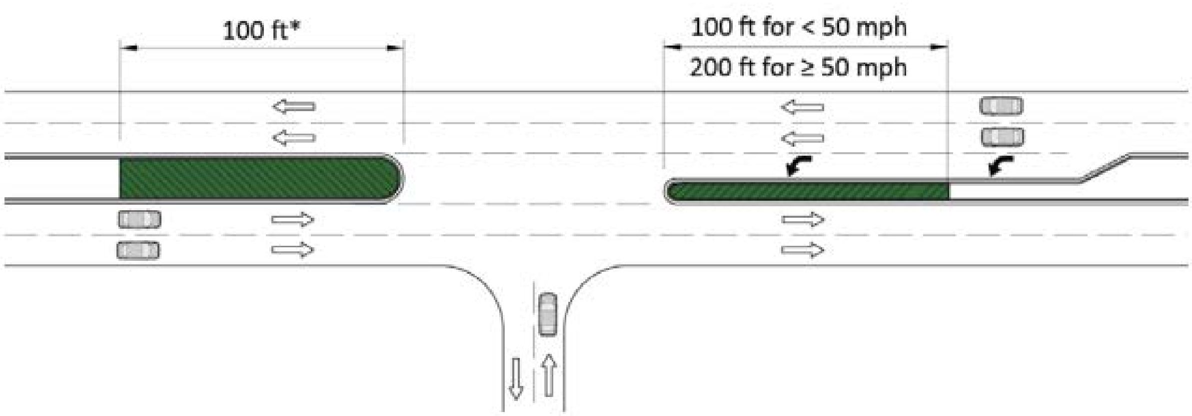
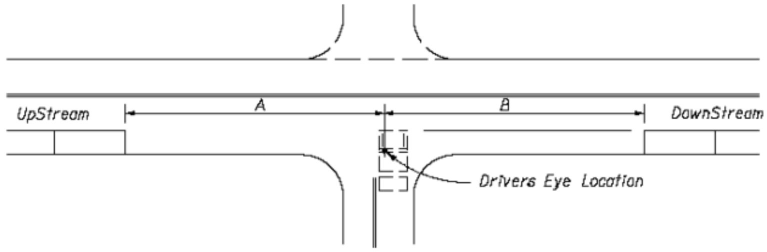


Figure 11: Special areas limited to ground cover [FDOT. Florida Median Handbook. 2014]

2.3.5 On-Street Parking Sight Distance Issues

Location of a driveway close to on-street parking can seriously impact visibility. This situation is most common on urban developed areas. FDOT also provides best practice guidance (Figure 12) on the placement of driveways in relation to on-street parking.



Speed MPH	Upstream (A)	Downstream (B)	
		2 Lane	4 Lane
0-30	85 ft	60 ft	45 ft
35	100 ft	70 ft	50 ft

Figure 12: On-street parking sight distance [FDOT. Florida Median Handbook. 2014]

2.4 Medians

By definition, a median is the portion of a highway separating opposing traffic flows. Medians can be depressed, raised, or flush with the traveled way. Medians are also typically classified as traversable or nontraversable. Properly designed medians provide many benefits including *[FDOT. Florida Median Handbook. 2014]*:

- *Vehicular safety* – medians reduce crashes caused by traffic turning left, head-on and crossover traffic, and headlight glare, resulting in fewer and less severe crashes;
- *Pedestrian safety* – restrictive medians provide a refuge for pedestrians crossing the highway. Fewer pedestrian injuries occur on roads with restrictive medians.
- *Operational efficiency* – medians help traffic flow better by removing turning traffic from through lanes. A roadway with properly designed medians can carry more traffic, which can reduce the need for additional through lanes.
- *Aesthetics* – in addition to safety and operations, medians can improve the appearance of a corridor. If landscaped, the median can lessen water runoff and enhance air quality.

Properly implemented medians and median openings will result in improvements to traffic operations, minimize adverse environmental impacts, and increase highway safety. The location and design of medians and their openings will depend on the function of the roadway, to provide appropriate access to the driveways, intersections, traffic signals and freeway interchanges that connect. Medians openings can provide for cross traffic movement or allow left-turns and U-turns from a highway. Figure 13 demonstrates the use of a median to reduce the number of conflicts by serving a side street that allows for left-turns from the major street but prohibits left-turns from the minor street (directional median opening). This design yields right-in/right-out side street access.

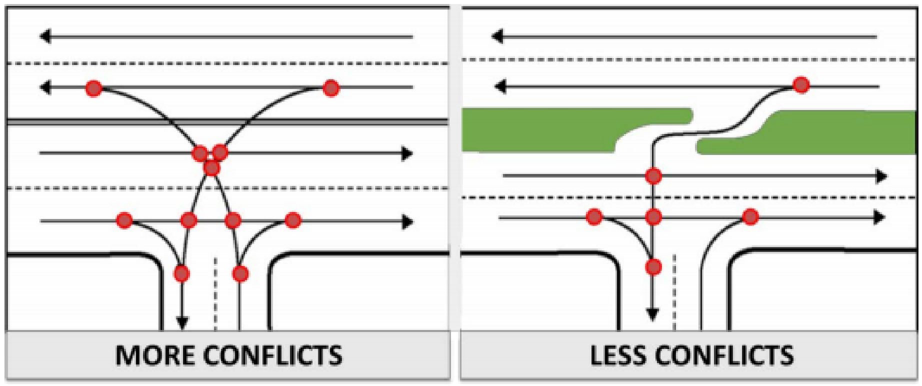


Figure 13: Use of a directional median opening to restrict the number of conflicts.
[FDOT. Florida Median Handbook. 2014]

2.4.1 Traversable Medians

A traversable median does not physically discourage or prevent vehicles from entering upon or crossing over it. Painted medians and TWLTLs are examples of traversable medians. Traversable medians are typically referenced as non-restrictive medians.

Continuous TWLTLs have typically been used to improve traffic flow on two and four-lane undivided roadways. When compared to undivided roadways, roadways with continuous TWLTL:

- Are generally safer, with 35% lower average crash rates;
- Have increased capacity;
- Experience less delay.

In contrast, TWLTLs do not provide the safety benefits of nontraversable medians and have the potential for overlapping left-turn movements. TWLTLs do not provide positive control over left-turns encouraging frequent access points in commercial strip developments. Therefore, research indicates that TWLTL may be most appropriate for the following roadways, according to the 2014 TRB Access Management Manual:

- Roadways in urban and suburban areas with a projected average daily traffic (ADT) of fewer than 24,000 vpd;
- Collector streets in developing residential areas in which residences front onto local streets that intersect with the collector street;
- Collector streets in developing suburban areas on which direct access is to be provided to small abutting properties;
- Collector streets in developed urban and suburban areas on which there is no crash pattern that would be correctable by a raised-curb median;

- Roadways having a maximum of 2 through lanes in each direction.

Also, research suggests that TWLTL should not be used on:

- Two-lane roadway that has and ADT greater than 17,000 vpd or at any access connection at which the left-turn ingress volume exceeds 150 vehicles per hour (vph);
- Multi-lane roadway that has an ADT greater than 24,000 vpd or at an access connection at which the ingress volume exceeds 100 vph.

2.4.2 Nontraversable Medians

A nontraversable median provides a physical barrier in the roadway, such as a concrete barrier or landscaped island that separates traffic traveling in opposite directions. This type of median also provides space for left-turn lanes, which in turn increase roadway capacity, reduce delay, decrease fuel consumption, and decrease vehicular emissions. Nontraversable medians are typically referenced as restrictive medians.

A nontraversable median is more desirable than a TWLTL in the following situations:

- All new multilane urban arterial roadways;
- Existing multilane urban arterial roadways with an ADT in excess of 24,000 to 28,000 vpd, depending on local conditions;
- Rural multilane roadways;
- Bypasses of urban areas;
- Between closely spaced roundabouts in areas with moderate or greater commercial development;
- Roadways on which aesthetic considerations are a high priority;
- Multilane roadways with a high level of pedestrian activity; and
- High-crash locations or areas in which it is desirable to limit left turns to improve safety.

2.4.3 Median Openings Concepts

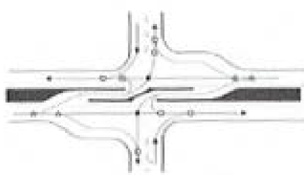
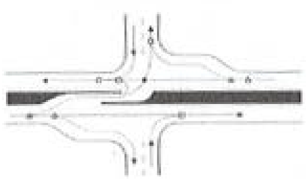
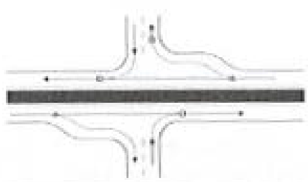
In keeping with the principles of roadway functional design adopted by the *AASHTO Green Book*, it is necessary to carefully consider the availability and design of median openings. Median openings can be categorized as full median openings or directional median openings.

Full median openings should be designed with adequate deceleration lanes and adequate left-turn storage and be limited to the following locations, according to best practices around the country:

- Signalized intersections;

- Intersections that conform to the adopted signal spacing interval (not yet signalized);
- In undeveloped areas, access connections (midblock median openings) associated with low turning volumes and located far enough away from signalized intersections to avoid the possibility of interference with intersection queues.

In urbanized and developing areas, the provision of directional median openings is recommended. It is important to ensure that the opening does not interfere with the operation of adjacent signalized intersections or compromise the design of the signalized intersections. The *TRB Access Management Application Guidelines 2016* provides a relevant analysis procedure on Section 16.4. Figure 14 demonstrates the advantages of directional median design in respect to the number of conflicts.

Median Opening Type		Number of Conflict Points				
		Crossing, Through[a] ○	Crossing, Turn[b] ●	Diverge △	Merge □	Total
Full median opening		4	12	8	10	34
Directional opening for both directions		0	2	4	6	12
Directional opening for one direction		0	1	3	4	8
No median opening		0	0	2	2	4

[a]Vehicle goes straight through the intersection.
[b]Vehicle enters the median and turns left.

Figure 14: Conflict points by Median Opening Type [FDOT. Florida Median Handbook. 2014]

Median openings should not encroach on the functional area of another median opening or intersection. A median opening within the physical length of a left-turn lane or lanes as illustrated in Figure 15 can create a safety issue. Such an opening violates driver expectancy. Median openings allowing movements across exclusive right turn lanes and/or across regularly forming queues from neighboring intersections should be avoided (see Figure 16).

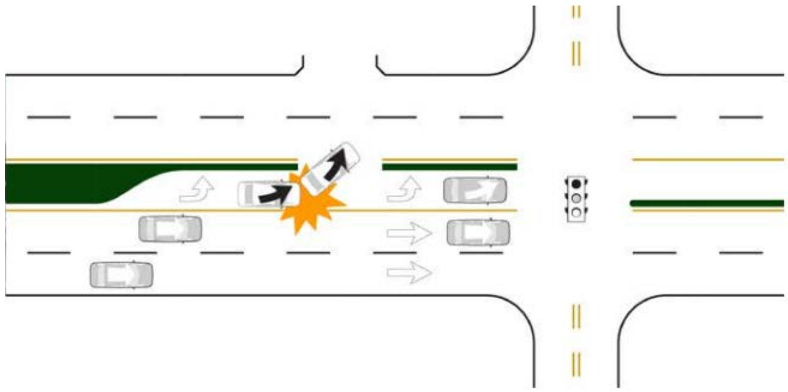


Figure 15: Median openings that allow traffic across left-turn lanes should not be allowed. [FDOT. Florida Median Handbook. 2014]

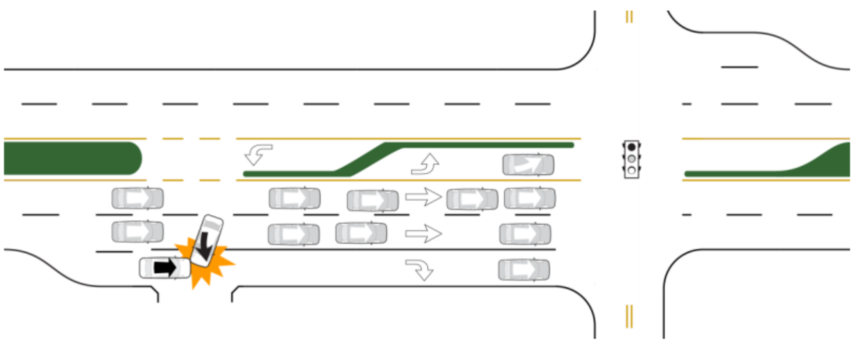


Figure 16: Median openings that allow traffic across right-turn lanes should not be allowed. [FDOT. Florida Median Handbook. 2014]

CHAPTER 3 – RECOMMENDATIONS FOR ACCESS MANAGEMENT STANDARDS

A variety of access management techniques can be applied to maintain and enhance roadway safety and its operational characteristics. For example, it is essential to observe ***access spacing*** standards to minimize the number of conflicts and friction introduced by new access points. Furthermore, adherence to ***access design (Chapter 4)*** criteria facilitates the ingress and egress for the development and minimizes potential adverse impacts caused by the access on the roadway.

The following sections present guidelines on Access Spacing.

3.1 Access Spacing

By definition, an access connection is any driveway, street or other means of providing for the movement of vehicles to or from the public roadway system. Each access connection introduces conflicts and friction. This interaction increases the chance for crashes and reduces the operational efficiency of the roadway system. To address these issues, it is recommended to establish minimum access spacing standards consistent with the intended function of the roadways. Access management spacing standards also involve a compromise between engineering principles and the access needs of the surrounding land use. It will not always be practical to provide the desirable access separation distances but access opportunities should be coordinated with critical operational and safety principles.

Typically, Access Management literature suggests a 1 mile spacing of urban principal arterials, with a minor arterial or a major collector midway between the principal arterials, arranged in a grid pattern, as illustrated on Figure 17.

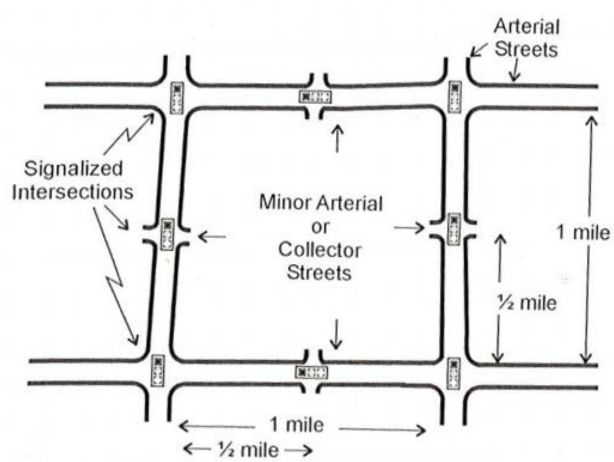


Figure 17: Urban Arterial Spacing Guidelines. [TRB. Access Management Manual. 2014]

According to the Access Management Manual (TRB 2014), some of the advantages for this arrangement include:

- Potential for residential streets to be designed to discourage cut-through traffic, providing a safer environment for users;
- Local bus service available within a reasonable (1/4 mi) walking distance of a bus line;
- Reduction of VMT on local streets and minor residential collectors;
- Improvement in emergency response time;
- Potential for better traffic signal progression.

Topographical features, landholding patterns, rural and urban population density and expansion may influence the final location of the primary and supporting roadway network.

Access spacing should be measured between the near edges of successive connections. This approach directly addresses the underlying concerns that prompt spacing criteria.

The following sections present guidelines on spacing of signalized intersections, unsignalized intersections, median opening spacing and interchange spacing.

3.2 Signalized Access Spacing

Ideally, intersections should be uniformly spaced resulting in a system that when signalized, allow timing plans to efficiently accommodate two-way vehicular progression. Moreover, the actual spacing (distance) between intersections dictates the ability of the signal system to accommodate varying traffic conditions during peak and off-peak periods (different times of the day). Longer signalized intersection spacing provides more signal timing flexibility increasing the range of cycle lengths that can produce efficient traffic progression for different speeds. Closely spaced intersections restrict signal timing flexibility and typically results in more frequent stops, unnecessary delay and higher potential for crashes.

As mentioned before (Section 2.1), transportation agencies classify roadways by function on the basis of the relative priority given to land access or through movement. Each functional class of roadway has a desired operating speed that supports the safe and efficient movement of vehicles. <u>Transportation agencies are encouraged to preserve the ability of a roadway to perform its function.</u> It is therefore necessary to understand the relationship of access spacing, cycle length and speed to allow a system of signalized intersections to operate properly.

This relationship is expressed by:

$$\text{Signal spacing (ft)} = \frac{\text{Speed (ft/sec) x Cycle length (sec)}}{2}$$

The formula takes in account an optimal split for two-way progression as half the cycle length. Table 16 presents the optimal signal spacing based on various progression speeds and cycle lengths.

Table 16: Signalized intersection spacing for various progression speeds and cycle lengths

Cycle Length	Speeds (mph)						
	25	**30**	**35**	**40**	**45**	**50**	**55**
60	1,100	1,320	1,540	1,760	1,980	2,200	2,420
70	1,280	1,540	1,800	2,050	2,310	2,570	2,820
80	1,470	1,760	2,050	2,350	2,640	2,930	3,230
90	1,630	1,980	2,310	2,640	2,970	3,300	3,630
120	2,200	2,640	3,080	3,520	3,960	4,400	4,840

Notes: Spacing distances are in feet. Where the recommended spacing in the table exceeds ½ mile (2,640 ft), designers can limit the actual spacing to 2,640 ft.

NCHRP Report 659. Guide for the Geometric Design of Driveways. 2010.

Another way to review this relationship is looking at progression speed as a function of signal spacing and cycle length, as presented on Table 17.

Table 17: Progression speed as a function of signal spacing and cycle length

	Progression Speed (mph)			
Cycle Length (s)	**1/8-mi (660 ft)**	**¼ mi (1,320 ft)**	**1/3 mi (1,760 ft)**	**½ mi (2,640 ft)**
60	15	30	40	60
70	13	26	34	51
80	11	22	30	45
90	10	20	27	40
100	9	18	24	36
110	8	16	22	33
120	7.5	15	20	30

TRB. Access Management Manual. 2014.

Morning and evening peak periods are typified by high traffic volumes and require longer cycle lengths to accommodate the extra volume of the roadway. Off-peak periods are typified by lower traffic volumes that can be handled by shorter cycle lengths. It is well documented that flow rates, fuel consumption and emissions are optimized when traffic progression is operating at the 30-45 mph range. Therefore, roadways with higher functional classification need to have longer signal spacing intervals in order to accommodate traffic volumes variations throughout the day while maintaining mobility with efficient operational speeds. For example, arterial roadways with signalized intersections spaced at ½ mi (2,640 ft) are able to provide efficient operational conditions for a variety of traffic conditions (short and long cycle lengths). The same arterial roadways would lack operational efficiency, especially during peak periods, if signalized intersections are spaced at ¼ mi (1,320 ft), leading to much lower operational speeds, increasing congestion, delay, and the potential for crashes. On the other hand, signalized intersections spaced at ¼ mi (1,320 ft) perform adequately for roadways with lower functional classification (not intended for mobility), where lower speeds and lower traffic volumes are expected.

As mentioned on the *TRB Access Management Manual* (2014), long and uniform traffic signal spacing is especially important on principal arterials in urbanized areas. Because of the volumes that urban principal arterials are expected to carry and the intense traffic demand during peak periods, efficient progression (coordination) is necessary on these roadways. Signalized intersection spacing based on optimal location permits a through band to be equal to the green time, facilitating two-way progression. (The through bandwidth indicates the amount of traffic that can pass through a series of signalized intersections during the green phase). As the signals are placed away from the optimum location, there is a corresponding reduction in time during which progression is maintained (through band), leading to less efficient operations. Roadways with lower functional classification accept a larger degree of deviation from an ideal uniform signal spacing. Efficient progression on one-way streets are not dependent on long and uniformly spaced intersections since a through bandwidth equal to the green time can be provided regardless of the block spacing.

Developed areas typically present intersections that are already established at short or irregularly spaced intervals or that cannot be ideally spaced due to natural barriers, street location, or land ownership constraints. When considering signalization of an intersection that deviates from ideal spacing, an analysis of the progression bandwidth necessary to maintain operational efficiency is recommended. The analysis should demonstrate that the additional signal still provides a progression bandwidth as large as that required or as presently exists for through state highway traffic at the critical intersection of the arterial signal system.

Table 18 presents the recommended signalized access spacing for Tennessee.

Table 18: Recommended Signalized Access Spacing (ft)*	
URBAN	
CLASS II	
> 45 mph	5,280
≤ 45 mph	2,640
CLASS III	
1,320	
CLASS IV	
1,320	
RURAL	
CLASS II	
	Principal Arterial – Minor Arterial
> 45 mph	5,280 – 2,640
≤ 45 mph	2,640 – 1,320
CLASS III	
> 45 mph	2,640
≤ 45 mph	1,320
CLASS IV	
1,320	

**Spacing measured between near edges*

3.3 Unsignalized Access Spacing

Ideally, unsignalized access connections should be spaced in a manner to minimize the number of conflicts introduced in the traffic stream by each new connection. As the distance between unsignalized access connections increase, the driving task becomes simpler leading to fewer crashes while improving travel time and preserving the capacity of the roadway. Whereas signalized intersections are spaced basically on the operation of traffic signal control devices, unsignalized connections have multiple factors that justify analysis of the dynamics of vehicles entering and leaving the through traffic lanes. In summary, some of the factors influencing the selection of unsignalized connection spacing include the functional area, sight distances, egress capacity (ability of vehicles to enter the roadway), the existence of exclusive right-turn lanes, the need for a driver to monitor more than one access connection at a time while driving in a through traffic lane, the existence of restrictive medians, etc. The *2016 TRB Access Management Application Guidelines* provides a summary of spacing distances based on the above criteria (see Table 19.

Table 19: Summary of Spacing Distances

	Spacing (ft)					
Operating Speed (mph)	Right-Turn Entry Overlap[a]	Stopping Sight Distance[b]	Intersection Sight Distance[c]	Right-Turn Exit Influence Distance[d]	Functional Area[e]	Egress Capacity[f]
30	100-185	200	335	380	325	315
35	150-245	250	390	405	425	450
40	185-300	305	445	460	525	625
45	230-350	360	500	530	630	870
50	-	425	555	620	750	1,140
55	-	495	610	725	875	1,470

NOTE: - = no value given.
[a] Participant Notebook for National Highway Institute Course 133078: Access Management, Location and Design (p. 3-70)
[b] AASHTO, level terrain, rounded up to nearest 5 ft.
[c] AASHTO, assumes both left and right turns, rounded up to the nearest 5 ft.
[d] Gluck et al. (pp. 6, 55); limited to 2% spillback rate (i.e. percentage of through vehicles in right lane and positioned at least one upstream driveway per quarter mile that is affected by vehicle turning right into a downstream driveway with 30 to 60 vehicles per hour turning right into driveway); will have shorter distances for higher percentage of spillback.
[e] *Transportation Research Circular 456*: Driveway and Street Intersection Spacing (p.18)
[f] Participant Notebook for National Highway Institute Course 133078: Access Management, Location and Design (p.3-73)

TRB. Access Management Application Guidelines. 2016

Due to the interrelation between these factors, literature provides **no** specific, universal method of establishing spacing criteria for unsignalized connections. Nevertheless, in addition to the understanding of how the aforementioned factors influence the spacing of unsignalized connections, there are common guidelines that should be considered in the selection and application of unsignalized access connection:

- Consideration must be given to the impact that excessively large spacing could have on economic development;

- Functional classification of a roadway should be considered, longer connection spacing is desired for roadways that are designed for mobility, typically with higher operational speeds;
- Spacing of unsignalized connections should complement those for signalized access to preserve the ability of efficient traffic progression due to potential need of signalization at some future date.

The *2016 TRB Access Management Application Guidelines* defines unsignalized access spacing as the distance along a roadway between two successive unsignalized connections, such as intersecting driveways and streets. This definition can be expanded to include the closely related topic of spacing between an unsignalized connection and a signalized connection. Therefore, spacing criteria should apply both to distances between successive driveways and to distances between driveways and roadways.

Another important factor on unsignalized access connections spacing is the existence and type of medians. If a restrictive median is in place on the subject roadway, then the spacing on one side of the roadway does not affect spacing on the other side of the roadway (unless a median opening exists). Also, full median openings require longer unsignalized access connections spacing than directional median openings.

As previously defined, an access connection is any driveway, street or other means of providing for the movement of vehicles to or from the public roadway system. For the purpose of this report, a distinction will be made between intersection spacing and driveway spacing. An intersection is a public street or other access serving large area or major traffic generator(s) where full access is typically provided. Driveway spacing will be categorized in nontraversable median and traversable median. A driveway is defined as an improved area between a public road and private property used to provide ingress and egress of vehicular traffic from the public road to a definite area of private property.

3.3.1 Intersection Spacing

In this report, unsignalized intersection spacing is referred to the distance between two successive streets. Ideally, the spacing between unsignalized streets should complement those for signalized access connections, looking to preserve the ability of traffic progression at some future date. In urban areas, intersection spacing should be consistent with the established street spacing along the state highway facility.

Table 20 presents the recommended unsignalized intersection spacing for Tennessee.

Table 20: Recommended Unsignalized Intersection Spacing (ft)*	
URBAN	
CLASS II	
1,320	
CLASS III	
Minor Arterial – Major Collector	
1,320 – 660	
CLASS IV	
660	
RURAL	
CLASS II	
	Principal Arterial – Minor Arterial
> 45 mph	2,640 – 1,320
≤ 45 mph	1,320
CLASS III	
> 45 mph	1,320
≤ 45 mph	660
CLASS IV	
330	

**Spacing measured between near edges*

3.3.2 Driveway Spacing

Driveways should be located to minimize interruption with the through traffic flow. According to the Florida Driveway Information Guide, intersection sight distance is the most appropriate criteria for driveway operations. Applying intersection sight distance at driveways allows the drivers both on the driveway and the roadway to adjust speeds and position to merge into traffic rather than requiring someone to make an emergency stop.

If sufficient intersection sight distance cannot be achieved, and there are no other driveway location alternatives, stopping sight distance can be used. This distance will allow the through traffic driver to avoid a hazard at the driveway.

The *AASHTO A Policy on Geometric Design of Highways and Streets 2011* states that "Driveways should not be situated within the functional boundary of at-grade intersections. This boundary would include the longitudinal limits of auxiliary lanes."

Intersections are a major control of the highway system, so it is important to consider the placement and design of driveways, especially in proximity to intersections. Driveways close to an intersection create a situation where the road user must negotiate conflicts too close to an area that has been designed to manage large volumes of traffic and its own inherent conflicts. Proper driveway placement can also help the business operator because today's traffic queues are so long that traffic exiting driveways may be blocked for long periods of time.

Table 21 presents the recommended driveway spacing for Tennessee.

Table 21: Recommended Driveway Spacing (ft)*

	Nontraversable Median		Traversable Median
	Full Access	**Partial Access**	
URBAN			
CLASS II			
	Not recommended	Not recommended	Not recommended
CLASS III			
	Minor Arterial – Major Collector	660	660
	1,320 - 660		
CLASS IV			
	660	330	330
RURAL			
CLASS II			
	Principal Arterial – Minor Arterial	Principal Arterial – Minor Arterial	Principal Arterial – Minor Arterial
> 45 mph	Not recommended – 1,320	Not recommended – 1,320	Not recommended – 1,320
≤ 45 mph		Not recommended – 660	Not recommended – 660
CLASS III			
> 45 mph	1,320	660	660
≤ 45 mph	660		
CLASS IV			
	330	330	330

**Spacing measured between near edges*

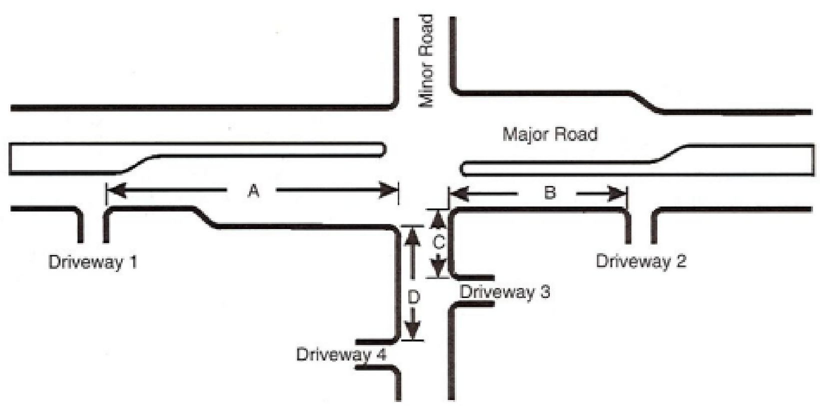
3.3.3 Corner Clearance

Corner clearance is a form of unsignalized access connection spacing that can be defined as the minimum distance required from an intersection of a public or private road to the nearest access connection.

Adequate corner clearance is important to preserve adequate sight distance at intersections and avoid conflicts between the access connection traffic and vehicles turning at the roadway intersection. Inadequate corner clearances can result in traffic operation, safety, and capacity problems. These issues can be caused by blocked driveway ingress and egress, conflicting and confusing turns at intersections, insufficient weaving distances, and backups from a downstream access connection into an intersection. Therefore, driveways should be as far as possible from major intersections. This allows for the best operations of traffic exiting the driveway and positioning itself in the intersection.

From a traffic operations perspective, corner clearance should be measured from the near edge of the driveway connection to the near edge of the parallel roadway.

Figure 18 presents sample criteria for minimum corner clearances.



Clearance Type	Description	Sample Clearance Criteria
A	Upstream on the major roadway	Minimum corner clearance should equal or exceed the functional distance of the intersection $d_1 + d_2 + d_3$ in Exhibit 14-2 (i.e., the sum of distances d_1 from Exhibit 14-3 and d_2 from Exhibit 14-4 plus queue storage).
B	Downstream on the major roadway	Separation should equal or exceed (*a*) the upstream functional dimensions of the driveway or (*b*) the influence distance. Minimum separation is no less than the stopping distance.
C	Approach side on the minor roadway	Maximum queue
D	Departure side on the minor roadway	Separation of the intersection from entering and exiting maneuvers at the driveway

Figure 18: Corner Clearance Criteria. [TRB. Access Management Manual. 2014]

Best practices around the country recommend that where minimum corner clearance cannot be met in accordance to Figure 18, the driveway should be located as far as possible from the parallel road. In these cases, it is most important to prohibit (or limit) left turns from these driveway locations.

The 2016 Access Management Application Guidelines developed several analysis spreadsheets to facilitate the application of corner clearance for different scenarios at signalized intersections. Tables are provided as guidance on selection of key input variables. The use of this tool is recommended in Tennessee. The following Figures 19-21 present screenshots from the analysis spreadsheets.

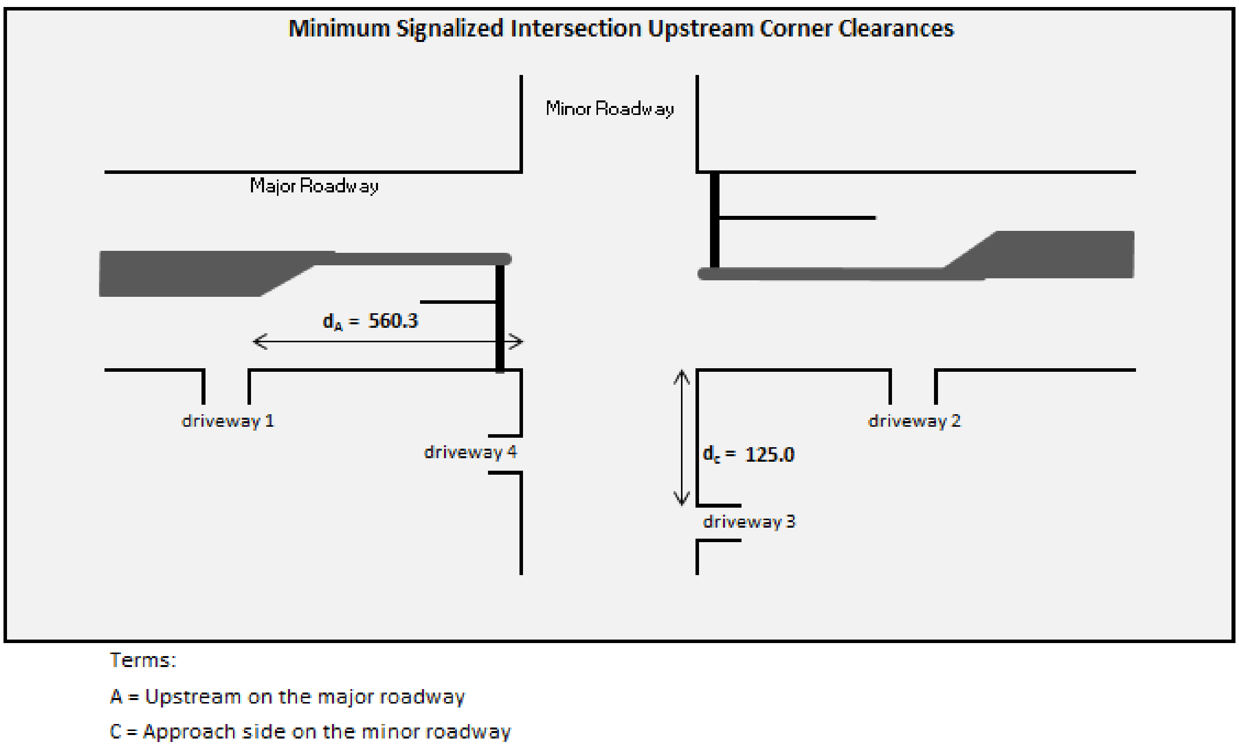


Figure 19: Screenshot of Corner Clearance Analysis Spreadsheet. [TRB Access Management Application Guidelines. 2016]

Upstream Intersection Corner Clearances

General Input Variables	Values
Average Vehicle Length (ft)	25
(Refer to Table A for Vehicle Length Recommendations)	
Major Roadway Design Speed (mph)	45
Level of Development	Urban
PR Time (sec.) -- AMM2, Section 14.2.1 = 1.5	
Note: PR Time based on stopping sight distance for an alert driver approaching the intersection.	
Intersection Cycle Length (seconds)	80

Functional Distance on Minor Roadway Approach (C)

Input Variables	Values
Minor Approach Volume in Lane Adjacent to Driveway (vph)	230
Minor Street Red Phase (seconds)	45
Maximum Acceptable Blockage of Driveway (percent)	40%
Note: Blockage rates change based on volume and red phase length. Refer to Table B for recommendations.	
Minimum d_C (ft) -- calculated =	**125.0**

Figure 20: Screenshot of Corner Clearance Analysis Spreadsheet. [TRB Access Management Application Guidelines. 2016]

Functional Distance Upstream on the Major Roadway (A)

Input Variables	Values
Does the major approach have a left-turn bay?	No
Does the major approach have a right-turn bay?	No
Perception-Reaction Distance (ft) -- 1.47 x speed x PRTime	99.0
Braking + Maneuver Distance (ft) -- AMM2, Exhibit 14-5, p. 335	360.0
Stopping Sight Distance (ft) -- AASHTO Green Book, Eqn. 3-2, p. 3-4	293.6
Left-Turn Storage Calculations	
Not Applicable	
Right-Turn Storage Calculations	
Not Applicable	
Through Lane Storage Length	
Is the 85th-Percentile Queue Length Known?	No
Peak Through Volume, Per Lane (vphpl)	640
(Refer to Table D for Recommendations)	
Major Approach Red Phase Length (seconds)	40
Vehicles Per Cycle -- calculated = 7.1	
Through Lane Storage Length (ft) -- calculated	266.7
Through Lane Functional Area (ft) -- calculated	560.3
Minimum d_A (ft) -- calculated =	**560.3**

(Note: d_A is equal to the sum of PRT distance, braking+maneuver distance, and the larger of the left or right turn storage length, OR, the sum of the thru storage length and stopping sight distance, whichever is larger.)

Figure 21: Screenshot of Corner Clearance Analysis Spreadsheet. [TRB Access Management Application Guidelines. 2016]

3.4 Median Opening Spacing

As mentioned in Chapter 2.4.3, median opening spacing is dependent on the location and type of median. Full median openings are common in rural, undeveloped areas while directional medians are recommended for more developed areas. Furthermore, median opening spacing is also dependent on roadway function, and speed. Unsignalized directional openings between signalized intersections provide convenient access to abutting properties and reduce U-turns and left turns at signalized intersections.

The 2016 Access Management Application Guidelines reports that few state highway design policies have formal provisions for the minimum spacing between median openings. It continues by discussing that although some agencies may consider adequate space between unsignalized openings to be the sum of the turn lane taper length and the storage length, this perspective ignores the operational and safety problems that arise from closely spaced connections. Table 22 presents some absolute minimum distances as reported on older research studies.

Table 22: Median Opening Spacing

Speed (mph)	Spacing Recommendations* (ft)	
	Absolute Minimum	Desirable Minimum
30	190	370
35	240	460
40	300	530
45	360	670
50	430	780
55	510	910

*For each car to be stored, add 25 ft to the spacing shown.

TRB. Access Management Application Guidelines. 2016.

Koepke and Levinson proposed the following unsignalized median opening spacing for use on all types of facilities in the NCHRP Report 348 [*Access Management Guidelines for Activity Centers. TRB, National Research Council, Washington D.C. 1992*]

- Urban setting: 330 – 660 ft.
- Suburban settings: 660 ft.
- Rural settings: 1,320 ft.

Table 23 presents the recommended median opening spacing for Tennessee.

Table 23: Recommended Median Opening Spacing (ft)*		
	Full Access	**Partial Access**
	URBAN	
	CLASS II	
> 45 mph	1,320	1,320
≤ 45 mph	1,320	660
	CLASS III	
	Minor Arterial – Major Collector	Minor Arterial – Major Collector
	1,320 - 660	660 - 330
	CLASS IV	
	660	330
	RURAL	
	CLASS II	
	Principal Arterial – Minor Arterial	Principal Arterial – Minor Arterial
> 45 mph	2,640 – 1,320	1,320
≤ 45 mph	1,320	660
	CLASS III	
> 45 mph	1,320	660
≤ 45 mph	660	330
	CLASS IV	
	330	330

**Spacing measured between near edges*

3.5 Interchange Spacing

Access connections in the vicinity of an interchange present a complex challenge. The effective access management of interchange areas requires sound guidelines and rules for the spacing, location, and design of access facilities that are uniform, consistent, and logical. According to *TRB Access Management Application Guidelines*, there are five critical locations for access facilities:

- The first intersection with a crossroad downstream of the last interchange exit ramp terminal,

- The first driveway downstream of the ramp terminal,
- The first signalized intersection from the last access drive,
- The last driveway before a freeway entrance ramp, and
- The first median opening after the freeway exit ramp or before the entrance ramp.

The location and spacing requirements depend if the ramp is controlled by a signalized or unsignalized intersection, a free-flow exit ramp, or a roundabout. On a signalized ramp terminal, traffic alternates between uninterrupted through flow and stop-and-go flow. On a free-flow exit ramp terminal, traffic on the crossroad does not stop for the ramp traffic. The ramp traffic must merge and weave with the trough traffic. On a roundabout ramp terminal, the crossroad traffic and ramps enter a roundabout at reduced speeds. This terminal treatment is characterized by normal roundabout design and operation.

3.5.1 Spacing Standards for Signalized Ramp Terminal Intersections

The operation of a signalized ramp terminal intersection is essentially the same as that of other signalized street intersections. Figure 22 and Table 24 present *TRB's* recommendation as typical spacing for signalized ramp terminals for two-lane and four-lane crossroads, on urban, suburban and rural areas.

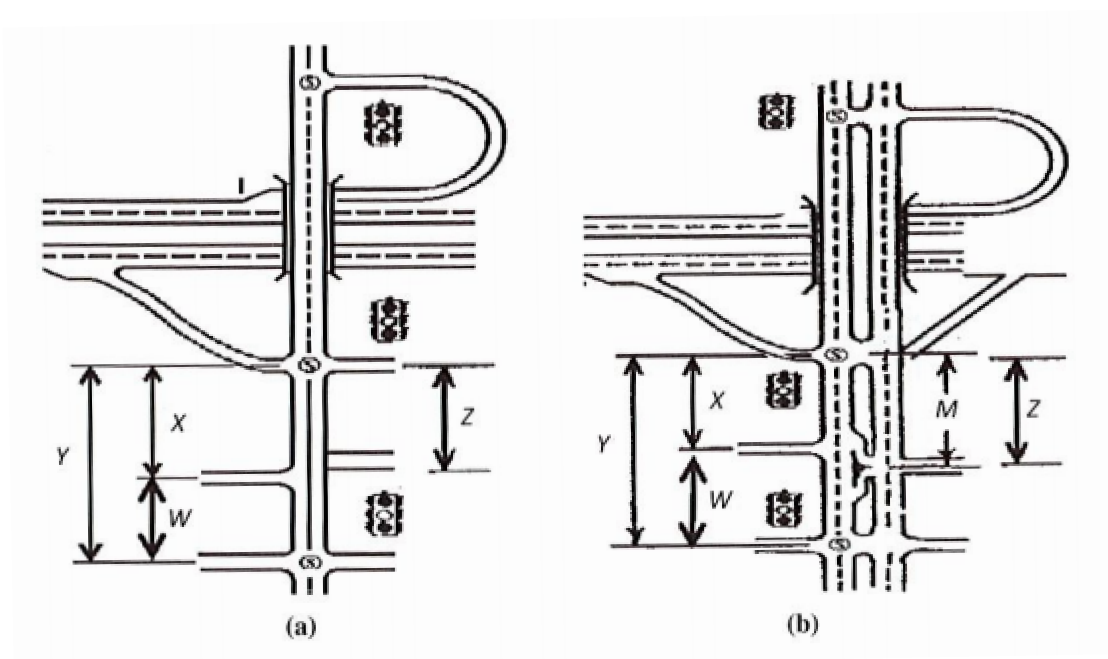


Figure 22: Typical Spacing for Signalized Ramp Terminals

Table 24: Typical Spacing for Signalized Ramp Terminals with (a) two-lane and (b) four-lane crossroads						
Arterial Width (no. of lanes)	Spacing Dimension[a] (ft)					
	X	W	Y	Y^1	Z	M
Urban Area (35mph)						
2	590	1,100	1,100	1,320	660	-
4	590	1,100	1,100	2,640	750	600
Suburban Area (45 mph)						
2	590	1,100	1,100	1,320	660	-
4	590	1,100	1,100	2,640	800	600
Rural Area (55 mph)						
2	535	750	750	1,320	560	-
4	535	750	750	2,640	865	550

NOTE: It is recommended that no four-legged intersection be placed between ramp terminals and the first major intersection.
[a]Dimensions as follows:
X = distance to first driveway on right (right in, right out only). Criterion = decision sight distance
W = distance from last driveway to first major intersection. Criterion = decision sight distance plus queue.
Y = distance to first major intersection. Criterion = decision sight distance plus queue. Y must be greater than or equal to X + W if a driveway is allowed between a ramp terminal and the first major intersection. If the area could be fully developed and urbanized, 1,320 ft should be used for urban, suburban, and rural areas and 2,640 ft should be used for a future coordinated multilane arterial.
Y^1 = distance to the first major intersection in coordinated signal network for two-way progression. Criterion = signal progress.
Z = distance between last driveway and on-ramp signalized intersection. Criterion = decision sight distance plus queue. Z can be reduced significantly if an added free right-turn lane is provided.
M = distance to first directional median opening for left turns from crossroad. Criterion = decision sight distance plus small queue. No full median openings are allowed in nontraversable medians to the first major intersection.

It is recommended that the location and spacing standards for unsignalized ramp terminals be the same as for signalized ramp terminals due to the possibility for the location to become signalized at some time in the future.

3.5.2 Spacing Standards for Free-flow Exit Ramp Terminals

On a free-flow exit ramp terminal, traffic on the crossroad does not stop for the ramp traffic. The ramp traffic must merge and weave with the trough traffic. Figure 23 and Table 25 present *TRB's* recommendation as typical spacing for free-flow exit ramp terminals for two-lane and four-lane crossroads, on urban, suburban and rural areas.

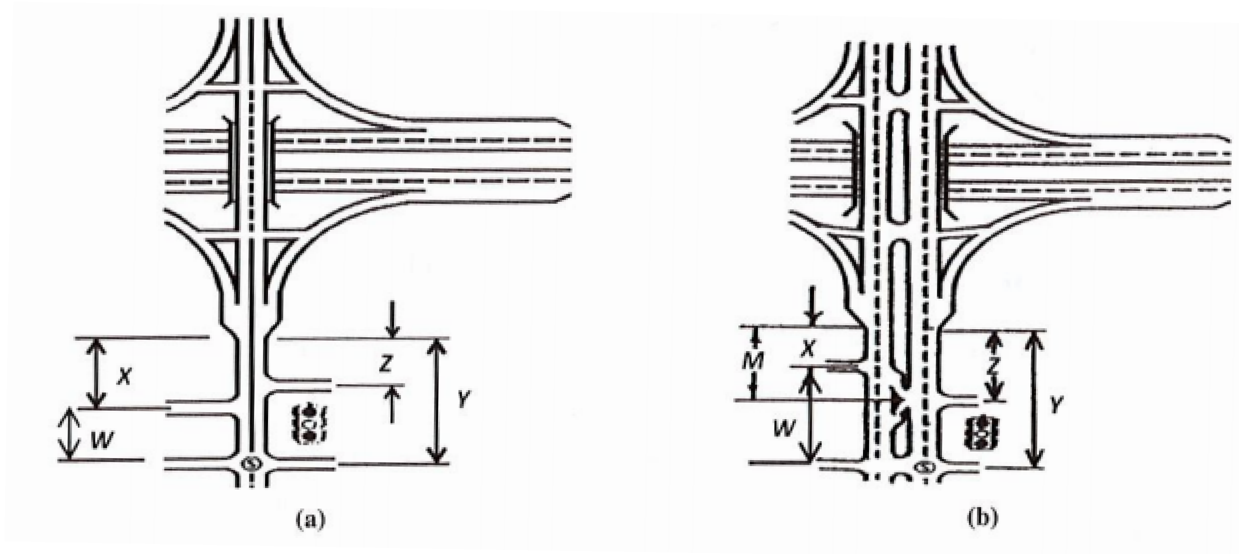


Figure 23: Typical Spacing for Free-flow Exit Ramp Terminals

Table 25: Typical Spacing for Free-Flow Exit Ramp Terminals with (a) two-lane and (b) four-lane crossroads

Arterial Width (no. of lanes)	Spacing Dimension[a] (ft)					
	X	W	Y	Y[1]	Z	M
Urban Area (35mph)						
2	590	1,100	1,100	1,320	1,100	-
4	590	1,100	1,320	2,640	1,100	600
Suburban Area (45 mph)						
2	590	1,100	1,100	1,320	1,100	-
4	590	1,100	1,100	2,640	1,100	600
Rural Area (55 mph)						
2	535	750	750	1,320	800	-
4	535	750	750	2,640	800	550

NOTE: It is recommended that no four-legged intersection be placed between ramp terminals and the first major intersection.

[a] Dimensions as follows:

X = distance to first driveway on right (right in, right out only). Criterion = decision sight distance

W = distance from last driveway to first major intersection. Criterion = decision sight distance plus queue.

Y = distance to first major intersection. Criterion = decision sight distance plus queue. Y must be greater than or equal to X + W if a driveway is allowed between a ramp terminal and the first major intersection. If the area could be fully developed and urbanized, 1,320 ft should be used for urban, suburban, and rural areas and 2,640 ft should be used for a future coordinated multilane arterial.

Y[1] = distance to the first major intersection in coordinated signal network for two-way progression. Criterion = signal progress.

Z = distance between last driveway and start of taper for on-ramp. Criterion = decision sight distance plus queue. Z can be reduced significantly if an additional free right-turn lane is provided.

M = distance to first directional median opening. Criterion = decision sight distance plus small queue. No full median openings are allowed in nontraversable medians to the first major intersection.

3.5.3 Spacing Standards for Roundabout Diamond Interchanges

The use of roundabouts that function as ramp terminals can benefit corridor access management. Lower speeds in the roundabout yield the possibility of reduced spacing to the first access point. The following factors should be considered before using roundabouts terminals:

- Roundabouts do not support coordinated signal timing,
- Unbalanced volumes can leave some approaches poorly served, and
- Pedestrians and bicyclists may have some difficulties with roundabouts.

Figure 24 and Table 26 present *TRB's* recommendation as typical spacing for roundabout diamond interchanges terminals for two-lane and four-lane crossroads, on urban, suburban and rural areas.

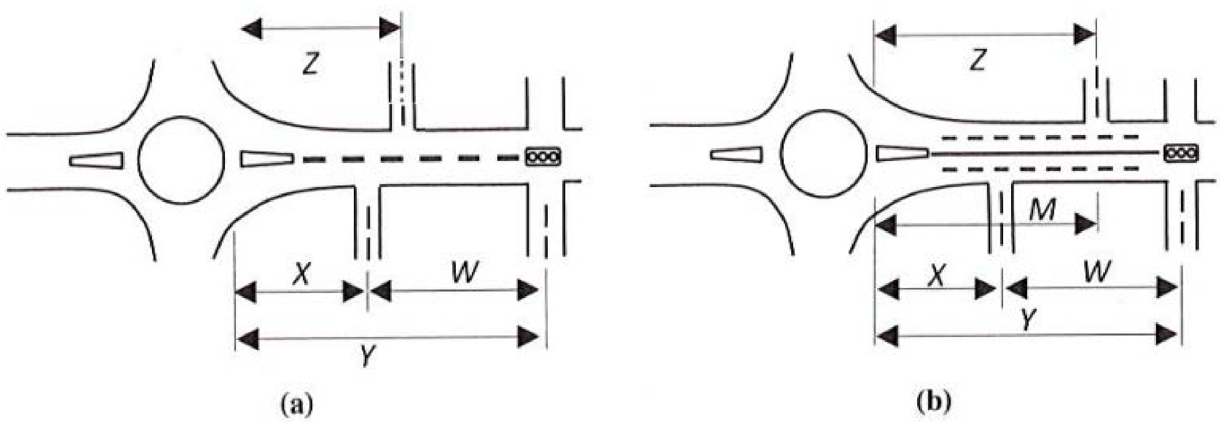


Figure 24: Typical Spacing for Roundabout Terminals

Table 26: Typical Spacing for Roundabout Terminals with (a) two-lane and (b) four-lane crossroads

Arterial Width (no. of lanes)	Roundabout Design Speed (mph)	Spacing Dimension[a] (ft)				
		X	W	Y	Z	M
Urban Area (35mph)						
2	25	400	1,000	1,000	400	-
	30	490	1,090	1,090	400	-
	35	590	1,140	1,140	400	-
4	25	400	1,000	1,000	450	475
	30	490	1,090	1,090	450	565
	35	590	1,140	1,140	450	665

Suburban Area (45 mph)						
2	25	400	925	925	460	-
	30	490	915	915	460	-
	35	590	965	965	460	-
4	25	400	925	925	510	340
	30	490	915	915	510	400
	35	590	965	965	510	475
Rural Area (55 mph)						
2	25	280	530	530	545	-
	30	350	525	525	545	-
	35	425	500	500	545	-
4	25	280	530	530	545	205
	30	350	525	525	545	245
	35	425	500	500	545	300

NOTE: It is recommended that no four-legged intersection be placed between ramp terminals and the first major intersection.

[a]Dimensions as follows:

X = distance to first driveway on right (right in, right out only). Criterion = decision sight distance to stop for roundabout design speed.

W = distance from last driveway to first major intersection. Criterion = decision sight distance to stop for roundabout design speed plus queuing.

Y = distance to first major intersection. Criterion = decision sight distance to stop plus queue at intersection. Y must be greater than or equal to X + W if a driveway is allowed between a ramp terminal and the first major intersection

Z = distance between last driveway and start of taper for on-ramp. (i.e. distance to last approach before terminal roundabout). Criterion = decision sight distance to stop plus queue at roundabout. Z can be reduced significantly if an entry bypass lane is provided.

M = distance to first directional median opening. Criterion = decision sight distance to stop plus queue of three vehicles, two vehicles or one vehicle.. No full median openings are allowed in nontraversable medians to the first major intersection.

When existing land use activities and their driveways do not allow acceptable spacing standards, a median barrier can be installed to eliminate left-turning movements.

Based on *AASHTO's A Policy on Geometric Design of Highways and Streets* there should be a minimum spacing between interchanges of 1 mile in urban areas and 2 miles in rural areas between crossroads.

CHAPTER 4 – ACCESS DESIGN

Access design criteria are also an important component of access management. Implementing access design standards helps preserve the public investment by limiting the conflict points and the interference between through and turning vehicles. Improper access design elements can greatly and negatively impact the traffic flow at intersections (*Urbana-Champaign Access Management Guidelines*). Providing proper access design helps:

- Improve safety by providing adequate sight distance at intersections;
- Reduce the speed difference between through and turning vehicles;
- Minimize the number of conflict points at an intersection;
- Provide adequate storage of turning vehicles;
- Facilitate the entry and exit of vehicles at a driveway.

Because of their effects on conflicts and interference between through and turning vehicles at intersections, elements such as driveway geometrics, median design and auxiliary lanes are the main elements detailed in this section.

4.1 Driveway Geometrics

NCHRP 659 – Guide for Geometric Design of Driveways identified more than 90 elements that can be related to or affect the geometric design of a driveway. The *2008 Florida Driveway Information Guide* provides a comprehensive discussion on critical dimensions and design features. Figure 25 presents typical driveway dimensions adapted from FDOT Design Standards.

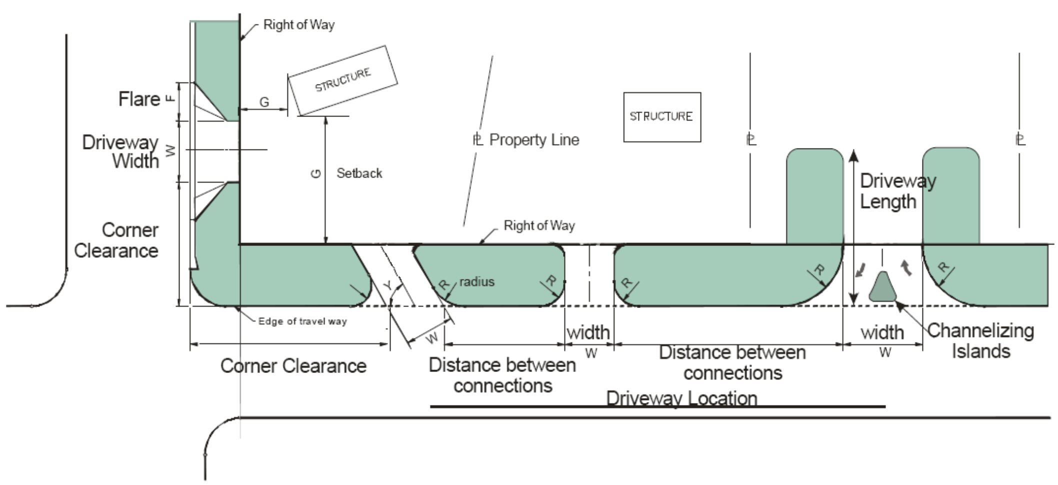


Figure 25: Typical Driveway Dimensions [FDOT Design Standards]

Driveways shall be designed to adequately handle the anticipated volume and type of traffic generated. Design shall be governed by the largest vehicle expected to regularly use the entrance. The following describe the most relevant driveway geometrics features and give recommendations for their proper design.

4.1.1 Driveway Alignment

Regarding horizontal alignment, the intersection angle between the roadway and the driveway is described in the *TDOT Manual for Constructing Driveway Entrances on State Highways 2015* (Urban and Rural):

Driveways for two-way operation:
90˚ to the centerline of the roadway.

Driveways for one-way operation:

1.) Driveways used by vehicles turning from both directions on the highway shall be the same as for two-way operation: 90˚ to the centerline of the roadway.
2.) Driveways used by vehicles traveling in one direction on the highway (right-in, right-out only): 60˚ to the centerline of roadway preferred; may be reduced to 45˚ (with the approval of the Department).

Regarding vertical alignment, the driveway should be free of any vertical discontinuities that adversely affect the flow of vehicles. The vertical alignment should include a sufficiently small rate of grade change to provide adequate ground clearance and avoid scraping or hanging-up the undersides of vehicles (see Figure 26). Driveway grade is important because turning vehicles must slow down to enter a driveway. The steeper the driveway, the greater the reduction in speed required to prevent hitting the bottom of the vehicle against the pavement.

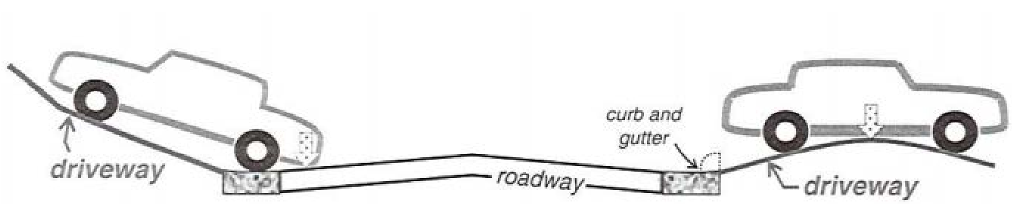


Figure 26: Problems that arise with excess in rate of grade change
[TRB. Access Management Application Guidelines. 2016]

Driveways should also conform to the requirements of the Americans with Disabilities Act (ADA), making pedestrian crossings accessible to people with disabilities. The *TDOT Manual for*

Constructing Driveway Entrances on State Highways 2015 Figure A.1 present the current requirements for driveway profile schematic.
Research performed by FDOT points to the maximum practical difference in grade being 12%. TDOT requirements states that the maximum allowable difference in grade between intersecting grade lines is 10% in crest and 9% in sags.

Regarding connections on opposite sides of a roadway, the location of a driveway should be carefully determined to minimize conflicts from undesirable maneuvers on the roadways. Closely spaced connections on opposite sides of an undivided roadway or on a roadway with a TWLTL result in jog maneuvers instead of separate and distinct turning movements. Figure 27 provides illustration of that.

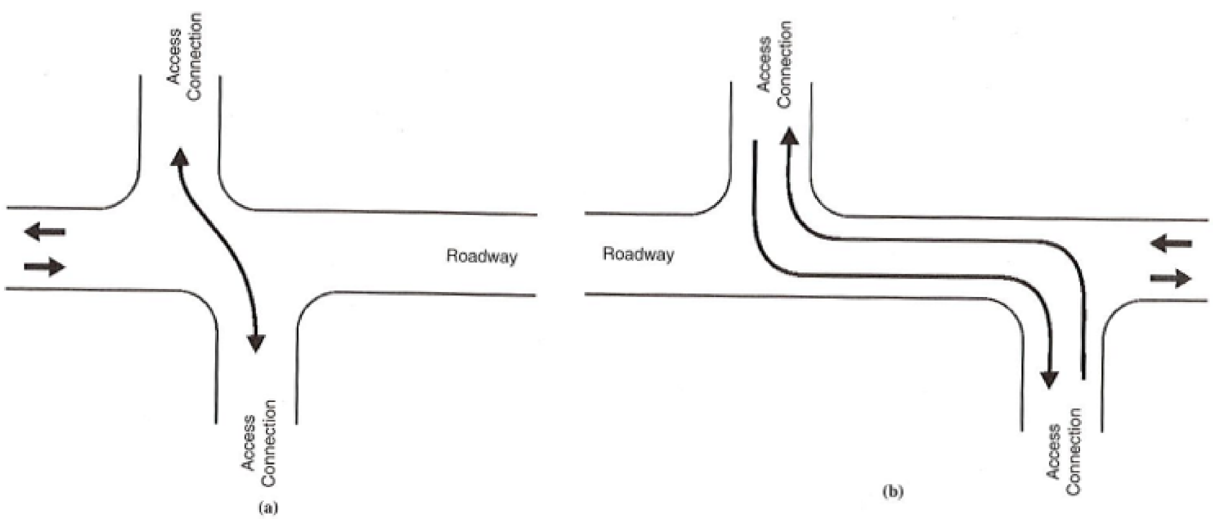


Figure 27: a) Jog maneuver and b) Separate and distinct left- and right-turn maneuver [TRB. Access Management Manual. 2014]

Closely spaced connections can also result in conflicting left-turns. Separation of the access connections to create two separately functioning T-intersections with relatively low crash potential is a possible solution (Figure 28).

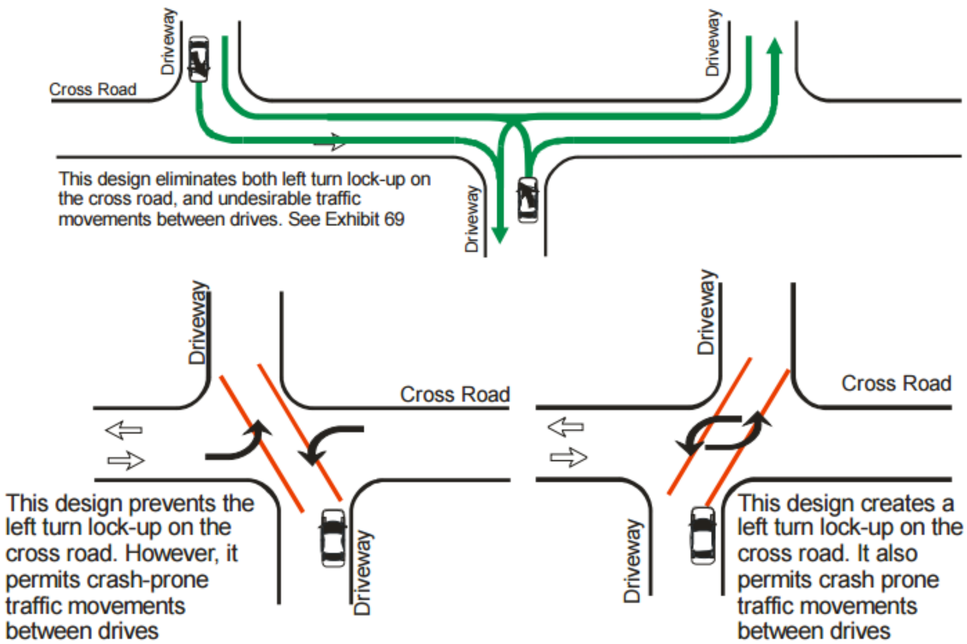


Figure 28: Separation of Access Connections [Source: Florida Driveway Information Guide 2008]

Furthermore, Figure 28 demonstrates the potential for overlapping left-turn movements and associated safety problems (head-on crash potential) when a TWLTL is present. Figure 29 presents a design that do not result in overlapping left-turn movements.

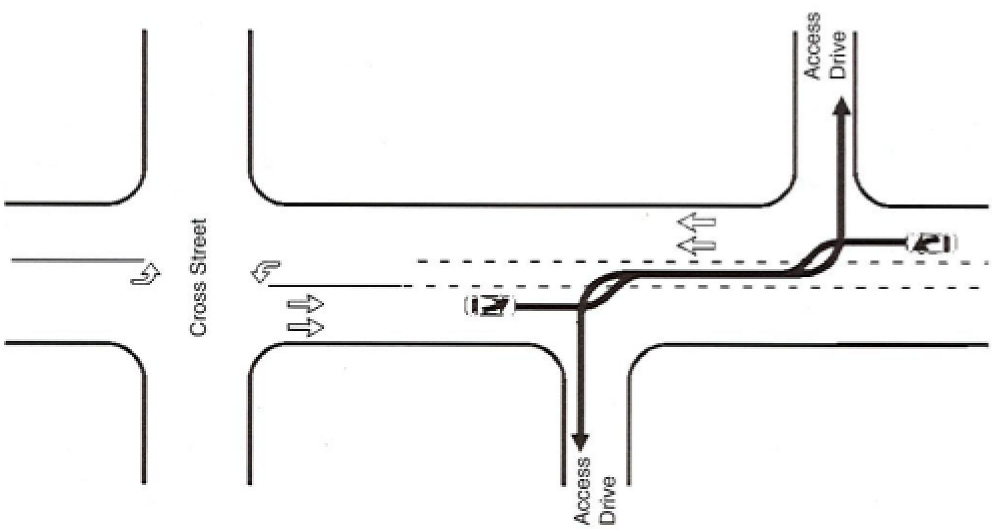


Figure 29: Access locations that typically result in overlapping left-turn movements [TRB. Access Management Manual. 2014]

Figure 30 presents a design that does not result in overlapping left-turn movements.

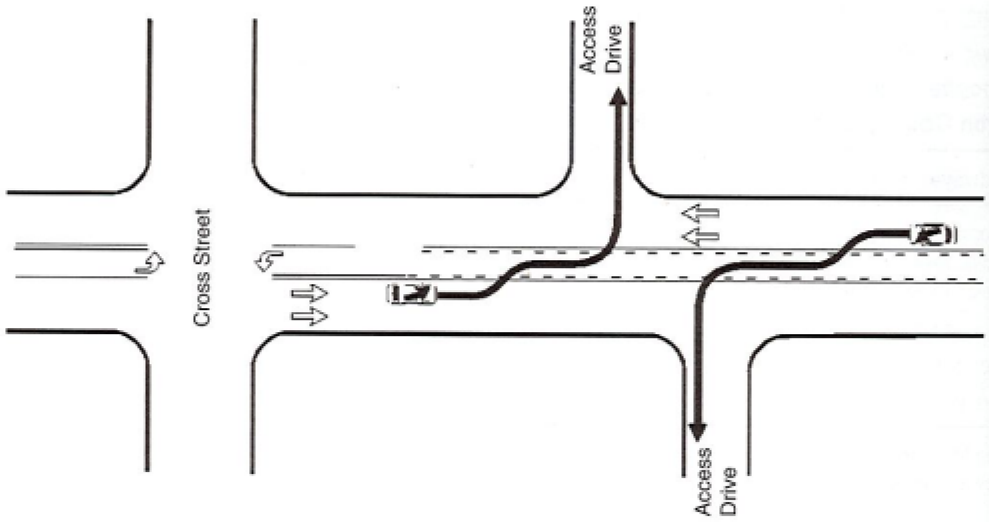


Figure 30: Access locations that do not result in overlapping left-turn movements
[TRB. Access Management Manual. 2014]

Table 27 from the *Michigan Access Management Guidebook* provides desirable offset distance between low to medium volume access points (such as residential streets) on opposite sides of the roadway on undivided or TWLTL highways (in feet).

Table 27: Offset Distance between Low to Medium Volume Access Points

Posted Speed (mph)	Offset Distance (feet)
25	255
30	325
35	425
40	525
45	630
50	750

Michigan DOT, Traffic & Safety Division Notes 7.9C

4.1.2 Turning Radius

An adequate driveway turning radius should be provided to allow safe entrance and exit of vehicles at a reasonable speed. This allows maintaining lower speed differential between through and turning vehicles. The edge of a driveway should be rounded to allow easy access of turning vehicles in and out of the driveway. Providing an appropriate turning radius prevents turning vehicles from encroaching onto the adjacent lane or the oncoming traffic when turning into the driveway (see Figure 31).

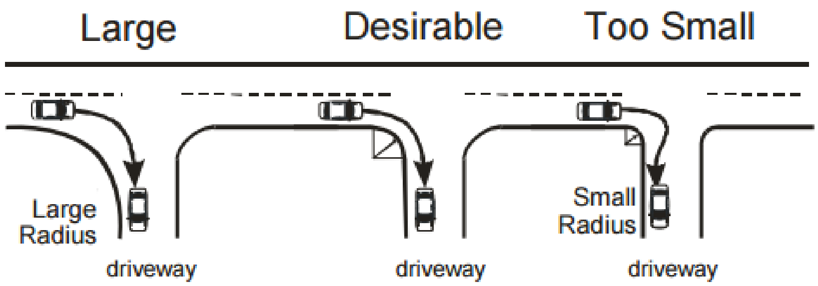


Figure 31: Impact of Driveway Radius [Florida Driveway Information Guide 2008]

The radii of driveways and street entrances will vary, depending on the type of establishment and the type of vehicle using the entrance. The driveway turning radii should be designed considering the largest design vehicle expected to access the property. Particular site characteristics, such as the speed of the adjacent roadway, should also be considered in determining entrance radii. The following are the requirements from the *TDOT Manual for Constructing Driveway Entrances on State Highways 2015:*

- Rural Driveways:
  - Residential - 10 ft. minimum; 20 ft. maximum
  - Commercial - 20 ft. minimum (larger radius may be required if design vehicle is a single-unit truck or tractor trailer)
- Urban Driveways:
  - Residential - 5 ft. minimum; 15 ft. maximum
  - Commercial - 20 ft. minimum (larger radius may be required if design vehicle is a single-unit truck or tractor trailer)
- Street-Type Entrances: For entrances servicing passenger cars almost exclusively - 25 ft. minimum, 30 ft. recommended.
- For entrances with a significant portion of single-unit trucks or WB-40 tractor trailers - 40 ft. minimum
- For entrances servicing WB-50 tractor trailers or larger - 40 ft. minimum, 75 ft. maximum, 50 ft. recommended.

The *2014 TRB Access Management Manual* provides recommendations on curb radius relevant to the type of establishment being served by the driveway and the typical speed of its roadway. It differentiates between higher, moderate, and lower-speed roads to determine the curb radius and driveway width. TRB also has four different land use categories, ranging from residential areas (lower intensity) to urban activity centers (very high intensity). Table 28 presents these recommendations.

Table 28: Guidelines for Driveway Width and Curb Radius

Category	Description of Common Application	Driveway Width	Driveway Curb Radius (ft)		
			Higher-Speed Road	Moderate-Speed Road	Lower-Speed Road
Standard Driveway					
Very high intensity	Urban activity center (constant driveway	Many justify two lanes in, two to three lanes out	30-50	25-40	na
Higher intensity	Medium-size office or retail	One entry lane (12-13 ft wide), two exit lanes (11-13 ft wide)	25-40	20-35	na
Medium intensity	Smaller office or retail	Two lanes (24-26 ft total width)	20-35	15-30	na
Lower intensity	Single-family or duplex residential	May be related to the width of the garage or driveway parking (single lane: 9-12 ft, double lane: 16-20 ft)	15-25	10-15	5-10
Special Situation Driveway					
Central business district	Building faces are close to the street	Varies greatly, depending on use	na	20-25	10-15
Farm or ranch, field	Mix of design vehicles, many very low volume	Minimum 16 ft, desirable 20 ft, but affected by field machinery	30-40	20-30	na
Industrial area	Driveways often used by large vehicles	Minimum 26 ft	50-75	40-60	40-60

Note: Widths shown do not include space for a median or a parallel bike lane or sidewalk. Additional width may be needed if the driveway has a curved horizontal alignment. For a flare-taper design, use the radius as the dimension of the triangular legs. For industrial or other driveways frequented by heavy vehicles, consider either a simple curve with a taper or a three-centered curve design. For skewed connection angles, check the radius design with turning templates. na = not applicable.

TRB. Access Management Manual. 2014.

The *2008 Florida Driveway Information Guide* present a slightly different approach, looking at turning radius as a function of both the daily trips at the driveway and the type of section, urban (curb and gutter) and rural (flush). Table 29 presents these recommendations.

Table 29: Driveway Turning Radius

	Trips/Day	1-20	21-600	601-4000
	Trips/Hour	1-5	6-60	61-400
RURAL SECTION Radius (feet)		15’ min	25’ min	25’ min
		25’ std	50’ std	50’ std
		50’ max	75’ max	(or 3-centerd curves)
URBAN SECTION Radius (feet)		N/A	10’ – 35’	25’ min
				50’ std
				75’ max

FDOT Driveway Information Guide. 2008

4.1.3 Driveway Throat Width

Narrow driveways can cause larger speed difference between through and turning vehicles. Driveways that are too wide may cause confusion and pose a safety risk for pedestrians. Commercial driveways are usually wider than residential driveways to accommodate larger traffic volume at higher speeds. In some cases, additional driveway width may be required to compensate for smaller driveway turn radii. The driveway should be designed to provide the shortest possible path for safe pedestrian access. When four lane driveways are planned, a median with pedestrian refuge should be considered.

A key consideration in the design of access connections is the relationship between throat width and driveway radius. Where a radius is less than the minimum inside turning radius of a vehicle, drivers are displaced to the left in the driveway throat when completing the entry maneuver. The *2008 Florida Driveway Information Guide* informs that one of the goals of good driveway design is to serve the entry and exit movements separately so the movements don’t encroach on each other (Figure 32 and 33). This allows a vehicle to enter the driveway without encroaching on the area needed for a vehicle to exit the driveway.

The entry area is probably the most critical portion of driveway width. The entry width should be sufficient to allow a vehicle to:

- Enter without having to slow down to nearly a stop in the through lanes
- Make a right turn into the driveway when an existing vehicle is waiting and not encroach on the exiting vehicle

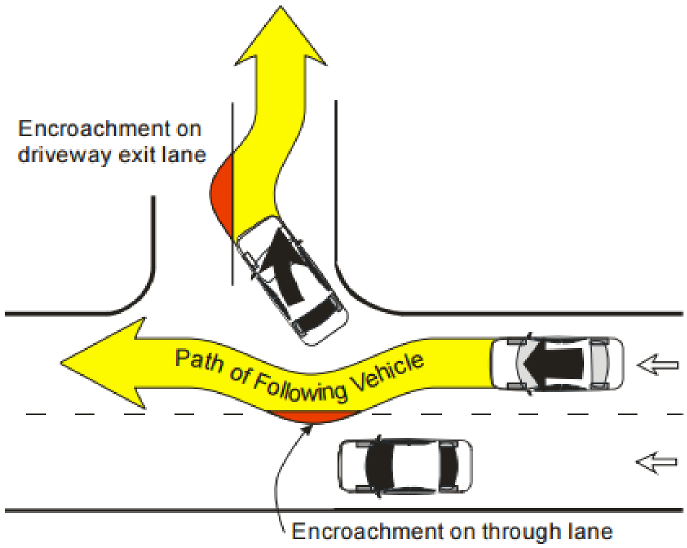


Figure 32: Encroachment due to Inadequate Driveway Design [Vergil Stover class notes]

The exit area lanes need to serve the operation of outbound driveway traffic. Vehicles may be turning right, left, or crossing the main roadway. This portion of the driveway needs to be wide enough to:

- Allow vehicles to turn right onto the public street or driveway without encroaching on the through lanes in the opposite direction
- Allow the number of exiting driveway lanes necessary for efficient outbound operation of the driveway. Driveways may need separate outbound lanes (usually a left turn lane) to prevent excessive queues in the driveway area
- Allow a right-turning vehicle to exit the access connection without encroaching upon the adjacent lane of a multi-lane highway or upon the opposing lane of a 2-lane highway

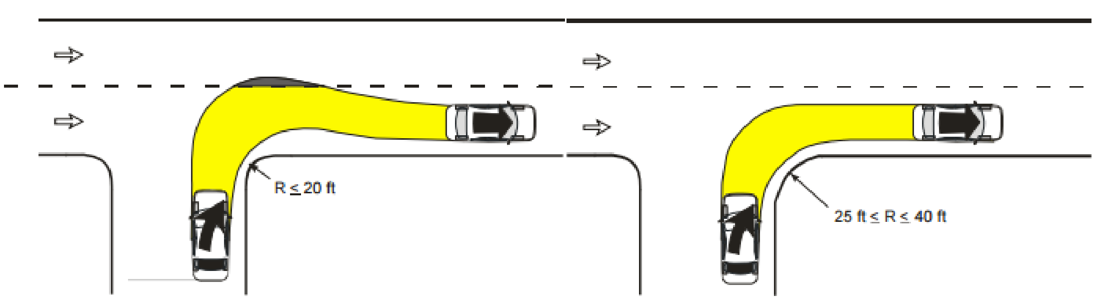


Figure 33: Encroachment due to Inadequate Driveway Design [Vergil Stover class notes]

Table 30 is recommended to substitute the current requirements for driveway width for urban and rural areas, as presented on the *TDOT Manual for Constructing Driveway Entrances on State Highways 2015.*

Table 30: Driveway Width Requirements for Urban and Rural Areas

Entrance Type	One-Way Driveways (Single lane)		Two-Way Driveways (Two lanes)	
	Minimum	Maximum	Minimum	Maximum
Single Family or Duplex	12 ft.	20 ft.	24 ft.	40 ft.
Multi Family	12 ft.	20 ft.	24 ft.	40 ft.
Commercial or Industrial	12 ft.	24 ft.	24 ft.	40 ft.*

*Note: Where developments are expected to serve a substantial volume of heavy vehicles (6 or more tires), this dimension may be increased to 50 feet.

TDOT. Manual for Constructing Driveway Entrances on State Highways. 2015

In addition, the TDOT Manual for Constructing Driveway Entrances on State Highways 2015 informs that street entrances shall be limited to 50 feet. The Department may elect to expand the entrance width if it is determined through a Traffic Impact Study that extra lanes are warranted. Regardless of entrance width, medians for street entrances may not be constructed within the right-of-way.

The *2008 Florida Driveway Information Guide* has the following width standards for basic driveways based on differing driveway traffic volumes, as presented on Table 31.

Table 31: Width Standards for Basic Driveways

	Trips/Day	1-20	21-600	601-4000
	Trips/Hour	1-5	6-60	61-400
RURAL SECTION (Flush Shoulder)		12’ min	24’ min	24’ min
		24’ max	36’ max	36’ max
URBAN SECTION (Curb and Gutter)		12’ min	24’ min	24’ min
		24’ max	36’ max	36’ max

FDOT Driveway Information Guide. 2008

4.1.4 Driveway Throat Length

Throat length is the distance measured along a driveway between the outer edge of the traveled way of the roadway to which the driveway connects and the first point along the driveway at which there are conflicting vehicular traffic movements.

An inadequate driveway throat length can lead to a variety of traffic problems (Figure 34). A desirable throat length will be long enough to eliminate or minimize traffic problems.

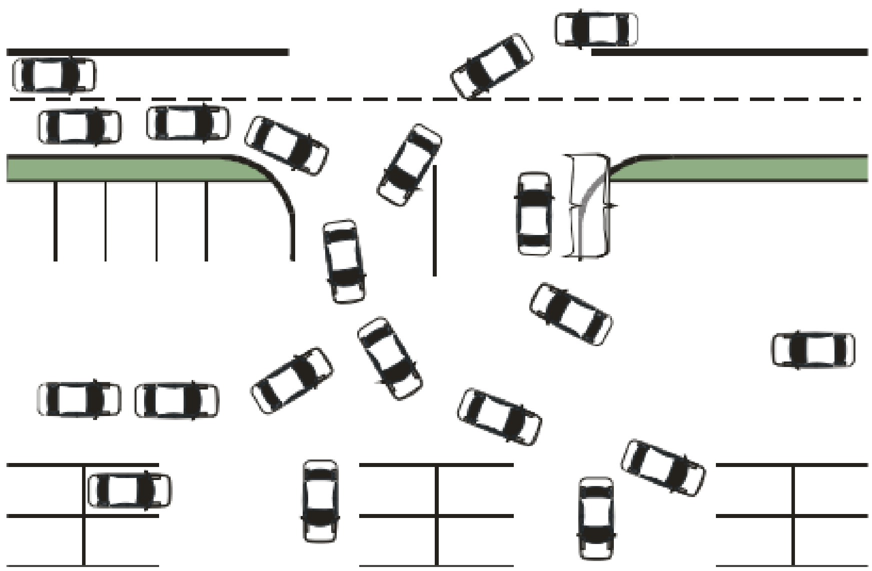


Figure 34: Impact of Driveway Throat Length [Florida Driveway Information Guide 2008]

The following guidance for throat length is likely to apply to most driveways:

- The length should be sufficient to keep vehicles that are maneuvering in the throat region from protruding into areas for other users
- The length should be sufficient to prevent queues in the throat from interfering with traffic (bicycle, motor vehicle, pedestrian) in the public roadway or within the site
- If activity on a site causes traffic to queue, the length of the throat should be sufficient to keep the queue from spilling back into the public roadway and a means to balk the queue should be provided.
- The throat length and distance between conflict points should be sufficient to allow users to react to individual conflicts ahead.

The needed minimum throat length will vary among sites. A basic component of throat length calculations involves estimating the length of the vehicle queue exiting the driveway. If a passenger vehicle is the design vehicle, a common assumption is 25 ft per vehicle. For example, if a single-lane queue should not exceed six vehicles, the following calculation can be made:

Throat length = 6 vehicles x 25 ft / vehicle
= 150 ft

If a setback distance is included, for example: 15 ft, the throat length would be 165 ft based on the previous calculation.

Table 32 - Recommended Throat Lengths	
Category	Throat Length (ft)
Regional shopping center	150 - 250
Community shopping center	80 - 15
Small commercial	20 - 60
Signalized, three exit lanes	200 - 250
Signalized, two exit lanes	75 - 150
TRB. Access Management Application Guidelines. 2016.	

4.2 Median Geometrics

A restrictive median with well-designed median openings is one of the most important tools to create a safe and efficient highway system. The design and placement of median openings is an integral component of a corridor that manages access and minimizes conflicts. The median width, the median end treatment, the median opening left-turn radius and the median opening length are important design components discussed below.

4.2.1 Median Width

The geometric design of the median opening should reflect and accommodate the dimensions and turning paths of the vehicles that can be expected to use the opening. *AASHTO's A Policy on Geometric Design of Highways and Streets* indicates that a median width of 20 ft or more is desirable when a simple left-turn lane is provided at intersections. Median width in most urban situations should accommodate turning lanes and a separator. The width of both the left-turn lane and separator are critical to the operations of the median opening.

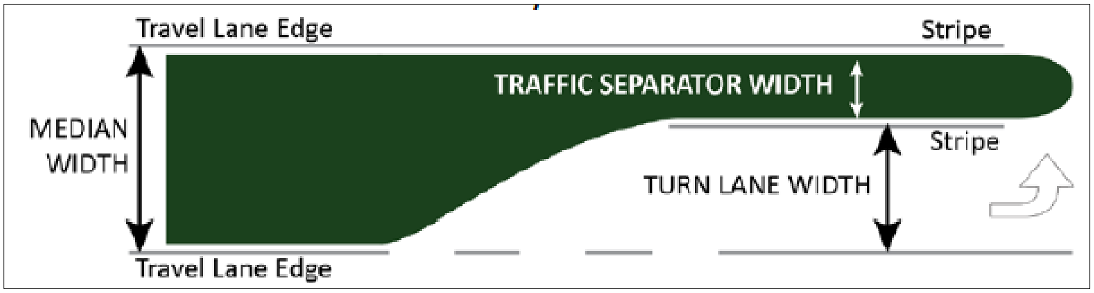


Figure 35: Drawing of Median Width [FDOT. Median Handbook. 2014]

The 2016 Access Management Application Guidelines indicates that the median must be wide enough that vehicles using the opening can completely remove themselves from the trough traffic lanes. The *TRB 2014 Access Management Manual* present median minimum width according to median function (Table 33).

Table 33: Minimum Median Width according to Median Function	
Median Function	Minimum Width (ft) Desirable
Separation of opposing traffic streams	10
Pedestrian refuge and space for signs and appurtenances	14
Left-turn deceleration and storage Single turn bay, no pedestrians Negative offset Positive offset Single turn bay, pedestrians present Negative offset Positive offset	 16 ≥ 20 18 ≥ 22
Dual left-turn bay	30
Protection for passenger vehicle crossing or turning left onto roadway	30
Directional opening for selected left-turn ingress or egress by passenger vehicle	30
TRB. Access Management Manual. 2014	

The minimum width of a median traffic separator or "nose" should typically be 4 ft. AASHTO recommends a minimum narrow median width of 4 ft and should be preferably between 6 and 8 ft wide.

The minimum median width for a pedestrian refuge should be 6 to 8.5 ft.

Narrow median traffic separator noses should be visible to drivers, especially during night or inclement weather. Options include using reflectorized paint, traffic buttons or pylons. The most effective way to provide good median visibility is landscaping.

Figure 36 presents the minimum median width for U-turn on a 4-lane road.

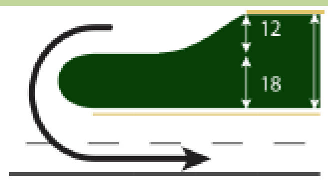
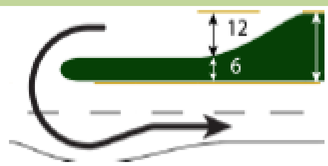
	Passenger P	Single Unit SU
	30	63
	18	53

Figure 36: Median Width for U-turn on 4-lane road [FDOT. Florida Median Handbook. 2014]

Vehicles turning left from opposing left-turn lanes restrict sight distance for both vehicles unless the lanes are sufficiently offset. Offset is defined as the lateral distance between the left edge of a left-turn lane and the right edge of the opposing left-turn. A positive offset as show in Figure 37 is recommended.

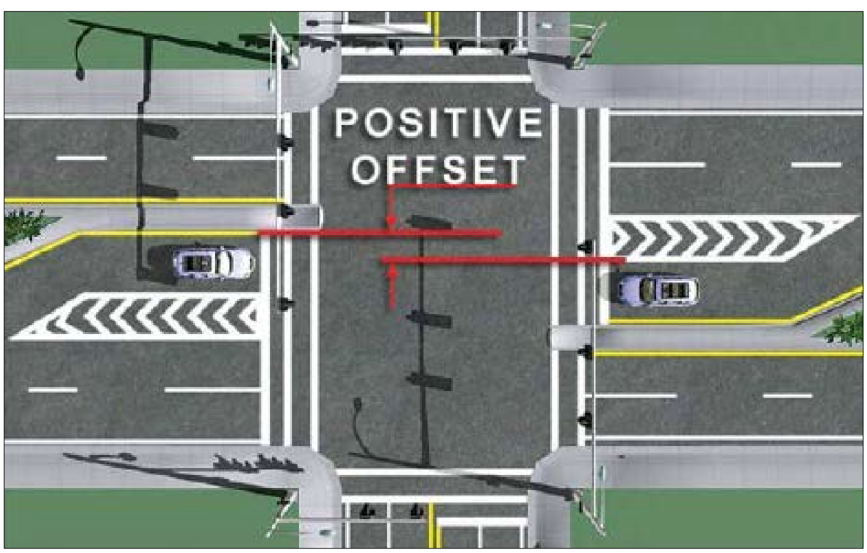


Figure 37: Offset Left-turn Lane [FDOT. Florida Median Handbook. 2014]

Desirable offsets should be at a minimum 2 ft when the opposing left turn vehicle is a passenger car and 4 ft offset when the opposing left turn vehicle is a truck.

On all urban designs, offset left-turn lanes should be used with median widths greater than 18 ft. Also recommended is to use a 4-foot-wide traffic separator to channelize the left-turn movement and provide separation from opposing traffic. In rural areas, where high turning movements occur, offset left-turn lanes should also be considered.

4.2.2 Median End Treatments

As a general recommendation, for medians with a width greater than 10 ft, the designer should use a bullet-nose end shape instead of a semicircular end shape [*TRB. Access Management Application Guidelines, 2016*]. The bullet nose end shape more closely conforms to the paths of vehicles turning left, which in turn reduces the distance of the offset needed from the median end to the projected edge of the cross street.

4.2.3 Median Opening Left-turn Radius

Typically a 60 ft left-turn radius is used in median openings and 75 ft when significant truck volumes are expected for left-turn or control radii.

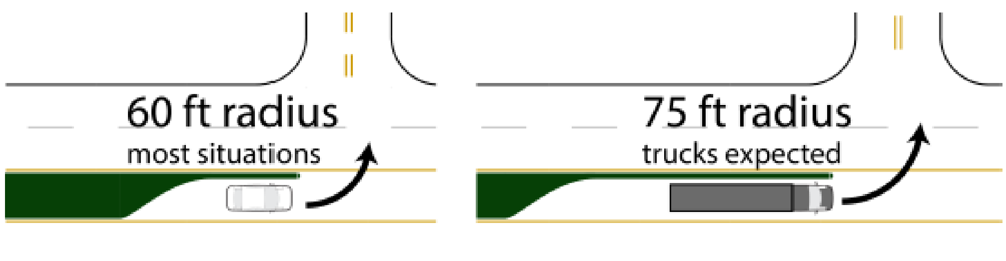


Figure 38: Typical Median Opening Left-turn Radius [FDOT. Florida Median Handbook. 2014]

4.2.4 Median Opening Length

The appropriate length of a median opening must be such that the median end does not interfere with the normal paths of allowable left-turn or through movements. *AASHTO* provides guidance on the length of a median opening in its *Green Book*. A rule of thumb is that the width of the opening is greater than or equal to the width of the crossroad traveled way plus the shoulder width.

4.3 U-Turns

U-turns can be used as alternatives to direct left turns. U-turns can reduce conflicts and improve safety. They create about 50% fewer conflicts than direct left turns. They make it possible to prohibit left-turns from driveway connections onto multi-lane highways and to eliminate traffic signals that would not fit into time-space patterns along arterial roads. When incorporated into intersection designs, they enable direct left-turns to be rerouted and signal phasing to be simplified. U-turns can prohibit left turns from driveway connections onto multi-lane highways and can eliminate traffic signals that would not fit into time-space (progression) patterns along arterial roads. [*NCHRP Report 420. Access Management Impacts*].

U-turns, coupled with two-phase traffic signal control, result in roughly a 15 to 20% gain in capacity over conventional intersections with dual left-turn lanes and multi-phase traffic signal control. In intersection designs, U-turns enable direct left turns to be rerouted and signal phasing to be simplified.

4.3.1 U-turn at Signalized Intersections

U-turns can be made at a signal when the median is of sufficient width and when there is low combined left-turn plus U-turn volume at signalized single left-turn lane.

If medians have sufficient width to accommodate dual left-turn lanes, a good option would be to allow U-turns from the inside (left-most) left-turn bays.

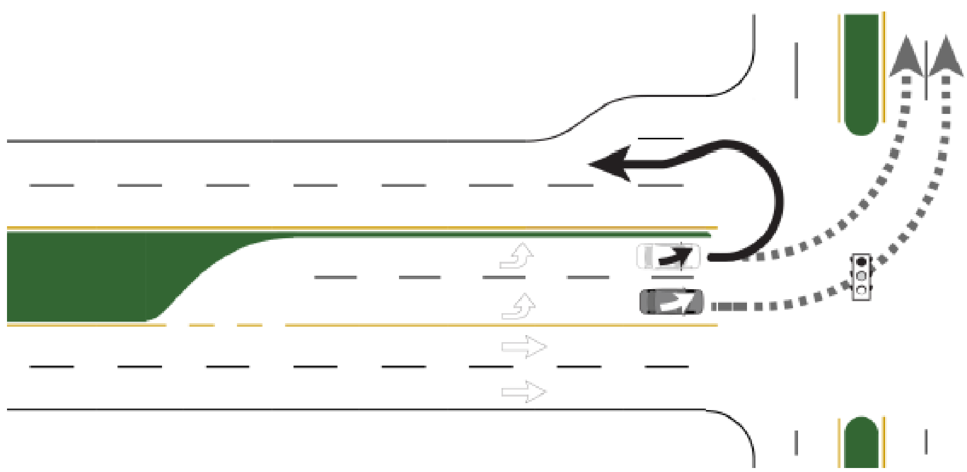


Figure 39: Dual Left Turn may provide U-Turn Option [FDOT. Florida Median Handbook. 2014]

4.3.2 U-turns in Advance of Signal

U-turns in advance of signalized intersections will result in two successive left-turn lanes. A problem is that drivers could mistakenly enter the U-turn lane when desiring to perform a left-turn at the downstream signalized intersection. Therefore, the median should be of sufficient length, for example a minimum of 100 ft. If that length is not possible, signage or other pavement markings can be used to guide motorists.

Indications for using a U-turn opening before a signalized intersection:

- High volume of left turns at a signalized intersection
- Many conflicting right turns
- Where a gap of oncoming vehicles would be beneficial at a separate U-turn opening
- Where there is sufficient space to separate the signalized intersection and U-turn opening

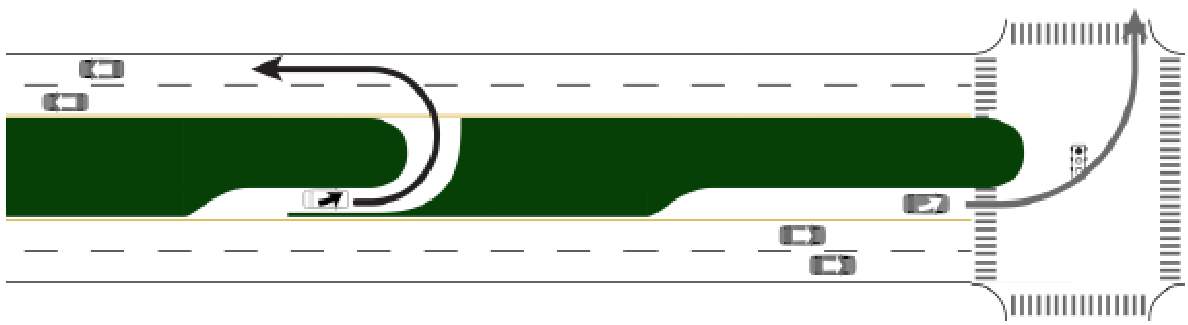


Figure 40: U-Turn before a Signal [FDOT. Florida Median Handbook. 2014]

4.3.3 U-turns after a Signal

U-turns located after a traffic signal is called a “Michigan” or directional crossover because Michigan has provided many such lanes along its divided “boulevard” arterials with wide medians. Potential benefits associated with the implementation of a Michigan U are that it allows for a 20 to 50 percent greater capacity than direct left-turns, which reduces average delays for left-turning vehicles and through-traffic [*FDOT. Florida Median Handbook. 2014*].

There is typically a ¼ mile spacing between the intersection and the left turn.

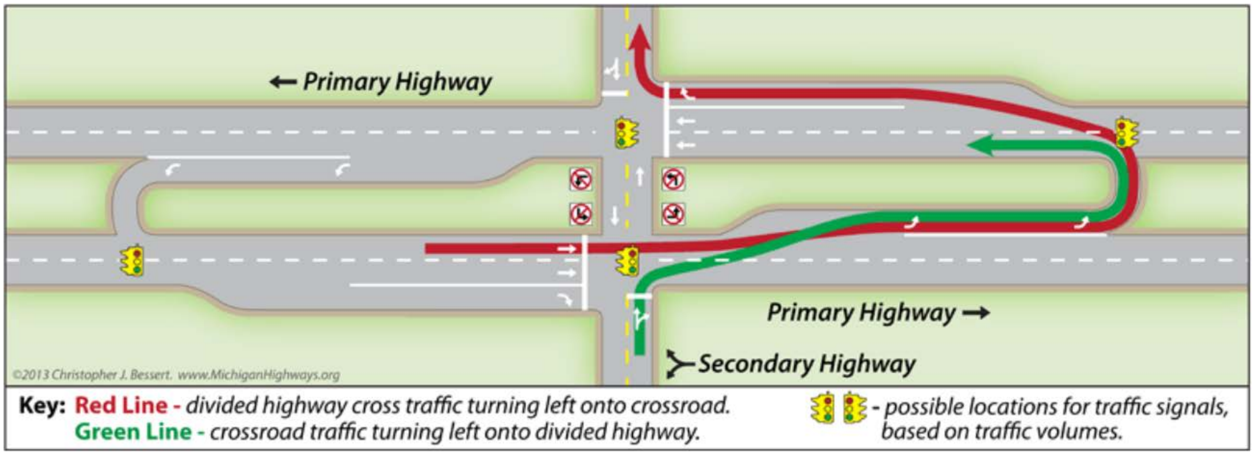


Figure 41: Illustration of a Michigan Left Turn [Michiganhighways.org]

4.3.4 U-turns in Relation to Driveways

Unsignalized access connections, such as driveways or minor roads should be located directly opposite or downstream from a median opening. It is recommended that the nearest driveway access should be located more than 100 ft upstream from the median opening to prevent wrong way maneuvers.

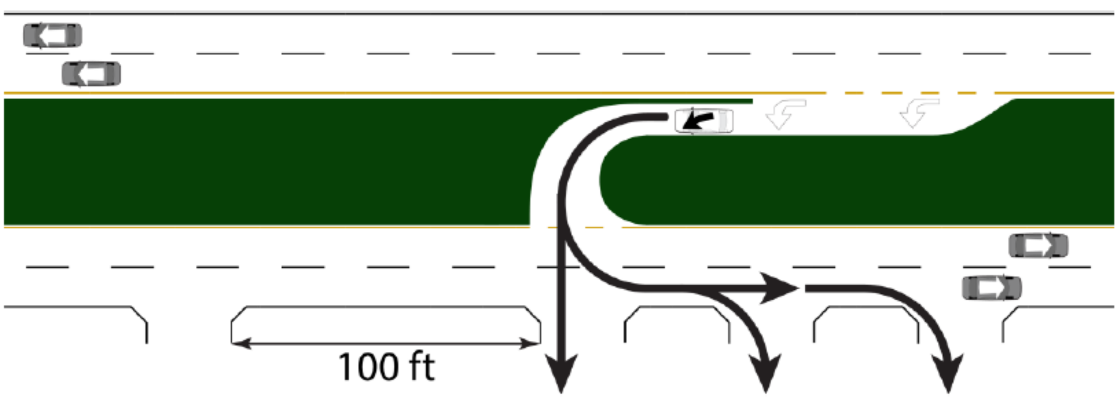


Figure 42: Entry Maneuvers [FDOT. Florida Median Handbook. 2014]

4.4 Turning Lanes

Turning lanes (left or right) improve traffic operations by increasing intersection capacity, decreasing delay, decreasing fuel consumption, and reducing vehicular emissions. A turning vehicle has to decrease speed to make a turn safely. If a turn lane is absent, drivers of through vehicles who are following the turning vehicle may also need to decelerate to a very slow speed. The deceleration can cause conflicts, reduce safety and capacity, and increase delay, fuel consumption, and vehicular emissions.

It is recommended that left-turn and right-turn lanes be provided for traffic in both directions in the design of intersections. Similarly, left-turn lanes should be provided for median crossovers.

4.4.1 Left-turn Lanes

According to the *TRB Access Management Application Guidelines*, a left-turn lane is a separate, full-width lane provided for vehicles that are making a left turn form a roadway. These lanes eliminate delay to vehicles in the adjacent through lane, which otherwise would have to stop behind the vehicle that was waiting to turn. Left-turn lanes also enhance safety by providing left-turning vehicles with a safe area in which to decelerate, to stop if necessary, and then to make the turn.

Left-turn lanes are the most effective way of limiting the speed differential between a left-turning vehicle and the following through vehicle (*Williams, Stover, Dixon and Demosthenes*). At unsignalized intersection locations, left-turn warrants are generally based on a combination of operating speed, left-turning traffic volumes, through traffic volumes, and opposing traffic volumes. The *AASHTO Green Book* provides warrants for unsignalized intersections on the *Harmelink* graphs. Crash history and sight distance can also be considered on the analysis. There are currently no national warrants for providing left-turn lanes at signalized intersections. Typically, an operational analysis will determine the benefit of left-turn lanes at signalized intersections.

TDOT's Roadway Design Guidelines section 2-170 presents specific information on the design of left-turn lanes. The 2016 *TRB Access Management Application Guidelines* developed analysis spreadsheets to facilitate the application of left-turn bay design for signalized intersections.

4.4.2 Right-turn Lanes

According to the *TRB Access Management Application Guidelines*, a right-turn lane is a separate, full-width lane provided for vehicles that are making a right turn from a roadway. These lanes eliminate delay to vehicles in the adjacent through lane that would otherwise have to slow, or perhaps stop, behind a vehicle that is waiting to turn. Right-turn lanes enhance safety by providing right-turning vehicles with a safe area to decelerate, to stop if necessary, and to make the turn.

The *AASHTO Green Book* does not include right-turn lane warrants. Many states provide their own warrants for unsignalized intersections on the basis of through and right-turning volumes and speed considerations. There are no national warrants for providing right-turn lanes at signalized intersections; right-turn lanes at traffic signals are generally provided when needed to meet operations standards or to address identified crash problems. For signalized intersections, the *ITE Traffic Engineering Handbook* says that an exclusive right-turn lane may be considered where a right-turn volume exceeds 300 vph plus the adjacent thru-lane volume also exceeds 300 vphpl, based on the *Highway Capacity Manual*.

TDOT's Roadway Design Guidelines section 2-170 presents information on the design of right-turn lanes. The 2016 *TRB Access Management Application Guidelines* developed analysis spreadsheets to facilitate the application of right-turn bay design for signalized intersections.

CHAPTER 5 - RETROFITS

Access management techniques can be applied to existing roadways as part of a “retrofit” process.

The application of access management guidelines on existing or developing roads is difficult and controversial. Challenges can be unavailable land needed for improvements, as well as property owners could perceive that their access would be restricted or/and their businesses hurt.

Reasons for implementing retrofit measures are:

- Increased congestion and accidents along a given section of road due to inadequate access
- Major construction or design plans for a road that makes access management and control essential
- Street expansions or improvements that make it practical to reorient access to a cross street and remove (or reduce) arterial access
- Coordinating driveways, on one side of a street, with those planned by a development on the other side.

Most retrofit actions involve the application of accepted traffic engineering techniques that limit the number of conflict points, separate basic conflict areas, limit speed adjustment problems, and remove turning vehicles from the through travel lanes.

Common retrofits improvements are:

Table 34: Common Retrofit Measures

Turn Lanes	• Provide right turn lanes • Provide left turn lanes (by widening, restriping or modifying median) • Provide two-way left turn lane
Medians	• Install median • Close median

Driveways	• Widen driveways and improve storage area • Consolidate driveways • Relocate or reorient access • Close driveway
Parking	• Redesign internal road and parking system • Replace curb parking with off-street parking
Frontage Roads	• Install frontage road
Traffic Signals	• Install or modify traffic signals

5.1 Turn Lanes

The removal of turning vehicles from through lanes can significantly improve traffic operations within a roadway segment. Also, fewer crashes are a result of such actions.

A simple and common treatment is to provide left-turn or right-turn lanes by restriping or widening the roadway. Continuity of the through-travel lanes can be achieved by installing alternating left-turn lanes or continuous two-way left-turn lanes. Retrofit designs may have to use less than optimum standards (i.e. 10 ft lanes instead of 12 ft lanes).

Left and right turn lanes are suitable where right-of-way width is not greatly limited because of existing land development or other constraints.

Providing right-turn lanes, by removing turning vehicles from the through traffic, helps to reduce the speed differences in the main travel lanes, thereby reducing the frequency and severity of rear-end collisions.

When left turns share the use of a through lane, they reduce both safety and capacity, in particular if the opposing traffic is heavy. The provision of left-turn storage lanes as a retrofit measure improves capacity and safety.

5.2 Medians

Methods to restrict access include (1) extending the median to physically prevent left turns from a driveway onto the arterial, (2) to prevent left turns from the arterial into driveways, and (3) close the median and preventing all left turns.

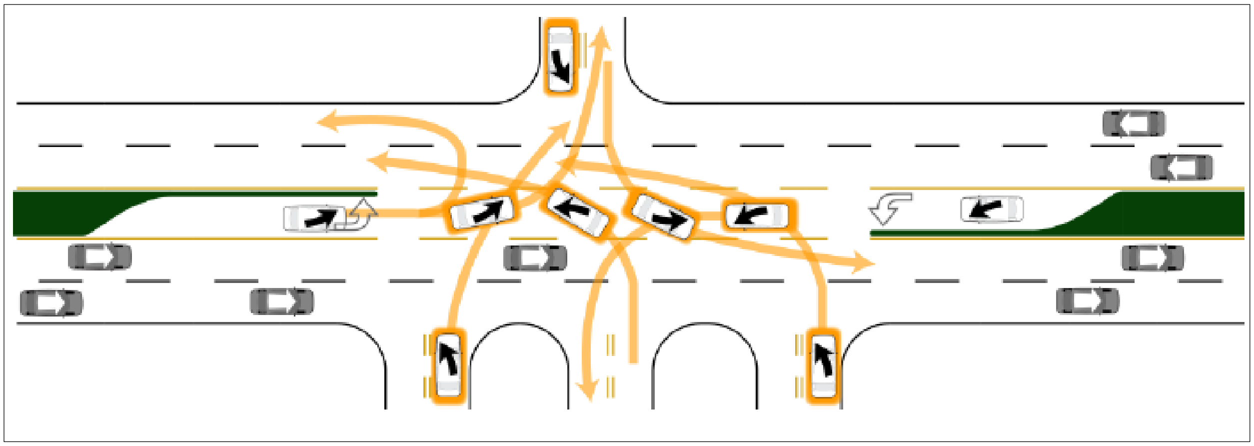


Figure 43: Issues of Wide Median Opening [FDOT. Florida Median Handbook, 2014].

5.2.1 Closing a Median

On many roadways, especially those with a narrow median, it may be desirable to close the median or to channelize openings to prevent left-turn ingress and egress movements. This technique is appropriate on arterial streets with at least 30 driveways per mile, travel speeds of over 30 mph, and an ADT of at least 5,000 vpd. *[NCHRP Report 348. Access Management Guidelines for Activity Centers. 1992]*. Closure is particularly appropriate where a few left-turn movements create safety problems.

The decision to close an existing median opening can be based on the following criteria, according to Florida's Median Handbook [*Florida Department of Transportation, 2014*]:

- Narrow median width (< 14 ft or less than length of design vehicle) where left turning vehicles cannot be protected during a two-stage left turn
- A combination of high volume left-turn out movements coupled with high through and left-turn in movements
- High volume of left-out movements onto the major roadway (AADT > 27,000 AADT)
- Disproportionate share of angled crashes involving the left-out turning movement
- Provision of an appropriate place for the displaced left-turn to make U-turns

5.2.2 Altering a Median

The decision to alter a median opening should be based on the following criteria:

- Narrow median (12 – 14 ft.): Replace a full median opening with a directional opening for left-turns from one direction only

- Median (> 14 ft.): Replace a full median opening with a directional opening for left-turns from both directions

5.2.3 Constructing a New Median on an Existing Roadway

On a 5-lane or 7-lane roadway with center turn lane:

- Replace the center turn lane with a raised median restrict movements to right-in/ right-out only
- Install a raised median with a directional median opening. Where the center turn lane width is 14 ft. or more, the directional opening may be designed for left-turns from both directions on the roadway. Where the center turn lane is less than 14 ft. wide, the directional opening should be designed for left-turns from one direction only.

5.3 Driveways

Retrofit measures regarding driveways aim to separate conflict areas.

Relocation - The simplest retrofit action is to close or relocate driveways that are poorly placed. For example, driveways that are too close to an intersection should be closed. In cases, where closely spaced driveways serve the same development, access should be consolidated and some driveways can be closed.
Access through driveways should be required on lower classified roadways in lieu of additional driveways on arterials where possible.

Consolidation – Driveway consolidation is desirable when driveways are spaced too closely together or the number of driveways per block becomes too large. Shared driveways are suggested in particular for commercial developments such as strip malls, regional shopping centers, and office parks. An internal roadway that connects adjacent developments and their parking areas usually makes possible the consolidation of access points.

Sharing driveways is most valuable when property frontages are short. According to some studies from the Iowa State University's Center for Transportation and Education *[Access Management Toolkit 2007]*, properties with less than 50 to 60 feet of frontage along an arterial street should have shared driveways. Three to four commercial driveways per block face is a desirable maximum standard for an urban and suburban arterial street.

5.4 Frontage Roads

Frontage roads run parallel to the mainline route and provide alternative access to property. Frontage roads can be considered to improve major thoroughfares as it reduces the number and density of conflict points associated with strip development. However, their provision can be costly and time consuming when right-of-way must be purchased. Care must be taken to ensure adequate separations between the arterial and the intersection of the frontage and cross roads.

5.5 Traffic Signals

Another retrofit measure is to remove unwarranted or poorly spaced traffic signals that interfere with efficient progression. In locations where signals are closely spaced, removal of signals that interfere with efficient progression will improve traffic flow on roadways.

Benefits are for example, smoother traffic flow, lower crash rates, reduced delay, reduced vehicular emissions, improved fuel economy, and reduced congestion. The removal of unwarranted and improperly spaced signals will improve safety and reduce maintenance costs.

Where traffic signals are closely spaced, removal of signals that interfere with efficient progression will improve traffic flow on roadways. The removal of unwarranted and improperly spaced signals will improve safety and reduce maintenance cost.

CHAPTER 6 - APPENDIX

A. Input from TDOT's Traffic Engineers in the Regional Offices

<u>TDOT Region 1: Nathan Vatter</u>

Current Practice:

- Used draft of TDOT Driveway Manual for years and now the adopted driveway guidelines.
- Other documents used include the NCHRP Report 659 "Guide for the Geometric Design of Driveways", which gives supporting information on where to place entrances from signalized and unsignalized intersections. This is helpful information to support recommendations for certain access constraints or restrictions.
- They try to encourage joint access between property owners, frontage roads and access management for larger scale developments. They run into issues when properties have limited roadway frontage which increases driveway densities and with competing commercial developments where they do not wish to work with adjoining properties.
- They are successful in implementing joint access driveways when planning larger developments without parcels. In that case parcels are plated with deed restrictions for their access. However, when there are separate owners for adjacent parcels it can be difficult since it would impact their property use. Since property owners do not have to give up their right for individual driveway access, when they share a driveway, they can change their mind at any point in time.
- They use a "Joint – Entrance Agreement" form to grant a Joint Highway Entrance Permit to property owners.
- They give recommendations regarding spacing of traffic signals to cities
- They encourage J-turns instead of full median openings
- TDOT Driveway Manual is sometimes vague and does not give much detail on entrance design. Also, insufficient regulation on the in- and out of entrances

Current Issues in Region:

- There are issues in several subdivisions, in which all the properties feed into one major collector. As the collector feeds into a state route, there is congestion due to the turning vehicles. Since there are no enforceable requirements for turn lanes, wide shoulders have to be provided. Developers avoid traffic impact studies by keeping the number of lots below the threshold.
- Some issues with the use of median openings (too many; in bad locations), especially near intersections

Recommendations for Access Management Manual:

- Details on driveway entrance design; standards for in- and out of entrances
- Stopping sight distance
- Standards for different types of interchanges, e.g. urban / rural
- In reference to unsignalized access connection: “temporary access/ entrance” should be addressed
- More details on median opening spacing near intersections; be more restrictive on median openings on multilane roads; encourage J-turns
- Corner Clearance standards are not clear (as brought up by Airton). Corner clearance distance is currently measured from ROW; maybe better to measure from traveled way.
- It would be good to differentiate between “minimum” and “desirable” standards

Region 2: Alan Wolfe, Landon Castleberry

Current Practice

- Have used the new the draft TDOT Driveway Manual (before it was adopted).
- Would be hesitant in using stricter standards than the TDOT Driveway Manual as they are unsure if directors at Regional Office would back them. However, probably support from the Commissioner and TDOT leaders.
- They use a similar “Joint – Entrance Agreement” form in Region 2, but lately they have been requiring copies of the property deed, which typically mentions the shared

driveway or any easement. The number of shared driveways has increased lately due to the new TDOT Driveway Manual, especially pertaining to corner clearances and distances from intersections.

Current Issues in Region:

- Difficulties to follow through with guidance on access management as the smaller cities often follow their own rules.
- Lack of coordination between local and state governments on new developments (placement of lots and accessibility)
- Traffic Impact Studies should be required for more developments; lower threshold to require a Traffic Impact Study.
- TDOT does not have much control over the placement of traffic signals. Therefore, many cities put up traffic signals wherever they want.

Recommendations for Access Management Manual:

- Statewide Access Management Guide is overdue. They want standards that are strict, but not so strict that they cannot abide with them. In addition to the minimum standards, some flexibility would be needed for case-by-case leniency, engineering judgement, or discretion.
- One thing to keep in mind is the lot/plat size. They need to make sure that lots/plats are divided in such way that they can meet our guidelines. But they also have to take into account the existing lots/plats that have been in existence for years.
- Include more detail on throat length/ throat design for driveways (not enough detail in Driveway Manual)
- With regard to large commercial developments, such as Walmart, those should have alley-type entrances, not just a lower curb and sidewalk (good example: Hwy 58)
- Corner clearance should not be measured from the ROW as it varies widely. For example, use Stop bar as a reference to measure corner clearance
- There should be warrants for turn lanes on median openings on higher speed roads (currently, there is nothing now on providing turn lanes for the openings).

<u>Region 3: Phil Trammel</u>

Current Practice:

- Using TDOT Driveway Manual for access management spacing. It gives clear policy on driveway spacing, interchange spacing, signalized and unsignalized intersection spacing, median design and opening spacing, corner clearance, etc.
- They also use Transect Standards from Phil Demosthenes (& GSP) who worked on the SR 109 Access Management Plan for Wilson and Sumner counties.
- Trying to apply Transect standards throughout the region. Though since it is not policy there are some difficulties with the implementation. It needs support from local governments as well, and sometimes they are more interested in the business coming to town than how the traffic it generates is managed. However, there is some support as well. Another issue is the already existing infrastructure in place.
- They use a "Joint – Entrance Agreement" form to implement shared driveway access.

<u>Region 4: Scott Pate, Stanley Sumner</u>

Current Practice:

- They use the TDOT Manual for Constructing Driveway Entrances on State Highways as the reference for any access management issues, for example, median opening spacing, corner clearance, and driveway spacing.
- They implement joint driveways in the region when needed.

Current Issues in Region:

- All new signals used to require a traffic impact study by locals or developers. Local agencies can put up a traffic signal whenever they want

Recommendations for Access Management Manual:

- Need to look at the distance from intersections and interchanges
- Need to make more divisions in route classifications, e.g. rural arterial and urban arterial classification

- Need to address signalized intersections with an understanding of TTI research
- More details on drainage and ROW
- Need a standard drawing for right-in/ right-out out to normalize these drive type use

B. Table of Tennessee's Roadways by Functional Class and Speeds

	Functional Class	15 mph	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph	60 mph	65 mph	70 mph	Total miles	<= 45 mph	> 45 mph
Class I	Urban Interstate	/	/	/	/	/	/	2	/	139	11	138	257	547	2	545
	Urban Freeway/Expressway	/	/	/	/	/	1	11	5	79	3	74	9	182	12	170
Class II	Urban Principal Arterial	1	/	4	87	140	373	617	164	458	2	25	13	1,884	1,222	662
Class III	Urban Minor Arterial	3	12	54	424	437	705	622	150	143	/	1	2	2,553	2,257	296
	Urban Major Collector	7	41	93	816	653	358	282	41	62	/	0	1	2,354	2,250	104
Class IV	Urban Minor Collector	2	9	54	336	228	111	120	8	7	/	/	/	875	860	15
Class V	Urban Local	209	1,077	1,541	2,529	547	197	115	1	17	/	/	/	6,233	6,215	18
Class I	Rural Interstate	/	/	/	/	/	/	/	5	32	18	67	513	635	0	635
	Rural Freeway/Expressway	/	/	/	/	/	/	/	1	8	/	14	/	23	0	23
Class II	Rural Principal Arterial	/	0	4	32	22	69	242	47	1,009	15	321	32	1,793	369	1,424
	Rural Minor Arterial	/	1	9	113	81	139	575	169	1,815	/	20	16	2,938	918	2,020
Class III	Rural Major Collector	2	10	26	259	283	622	1,658	449	1,570	/	8	30	4,917	2,860	2,057
Class IV	Rural Minor Collector	7	35	133	665	1,172	686	1,912	62	154	/	/	/	4,826	4,610	216
Class V	Rural Local	349	736	1,266	1,676	1,252	518	684	138	51	/	/	2	6,672	6,481	191

SUMMARY OF ACCESS MANAGEMENT SPACING STANDARDS

Recommended Signalized Access Spacing (ft)*	
URBAN	
CLASS II	
> 45 mph	5,280
≤ 45 mph	2,640
CLASS III	
1,320	
CLASS IV	
1,320	
RURAL	
CLASS II	
	Principal Arterial – Minor Arterial
> 45 mph	5,280 – 2,640
≤ 45 mph	2,640 – 1,320
CLASS III	
> 45 mph	2,640
≤ 45 mph	1,320
CLASS IV	
1,320	

*Spacing measured between near edges

Recommended Unsignalized Intersection Spacing (ft)*	
URBAN	
CLASS II	
1,320	
CLASS III	
Minor Arterial – Major Collector	
1,320 – 660	
CLASS IV	
660	
RURAL	
CLASS II	
	Principal Arterial – Minor Arterial
> 45 mph	2,640 – 1,320
≤ 45 mph	1,320
CLASS III	
> 45 mph	1,320
≤ 45 mph	660
CLASS IV	
330	

*Spacing measured between near edges

Recommended Driveway Spacing (ft)*			
	Nontraversable Median		Traversable Median
	Full Access	Partial Access	
URBAN			
CLASS II			
	Not recommended	Not recommended	Not recommended
CLASS III			
	Minor Arterial – Major Collector	660	660
	1,320 - 660		
CLASS IV			
	660	330	330
RURAL			
CLASS II			
	Principal Arterial – Minor Arterial	Principal Arterial – Minor Arterial	Principal Arterial – Minor Arterial
> 45 mph	Not recommended – 1,320	Not recommended – 1,320	Not recommended – 1,320
≤ 45 mph		Not recommended – 660	Not recommended – 660
CLASS III			
> 45 mph	1,320	660	660
≤ 45 mph	660		
CLASS IV			
	330	330	330

*Spacing measured between near edges

Recommended Median Opening Spacing (ft)*		
	Full Access	Partial Access
URBAN		
CLASS II		
> 45 mph	1,320	1,320
≤ 45 mph	1,320	660
CLASS III		
	Minor Arterial – Major Collector	Minor Arterial – Major Collector
	1,320 - 660	660 - 330
CLASS IV		
	660	330
RURAL		
CLASS II		
	Principal Arterial – Minor Arterial	Principal Arterial – Minor Arterial
> 45 mph	2,640 – 1,320	1,320
≤ 45 mph	1,320	660
CLASS III		
> 45 mph	1,320	660
≤ 45 mph	660	330
CLASS IV		
	330	330

*Spacing measured between near edges