MEDIAN

HANDBOOK

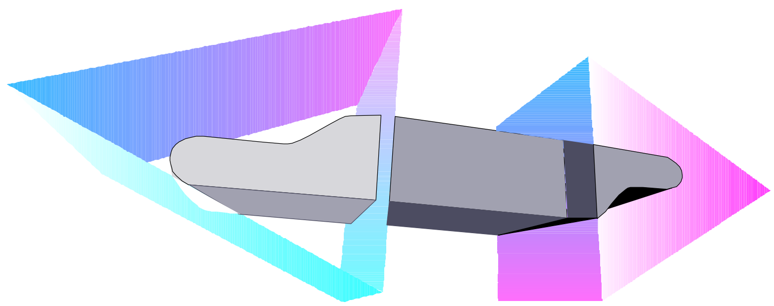


Table of Contents

IMPORTANT CONCEPTS IN UNDERSTANDING MEDIANS AND MEDIAN OPENING PLACEMENT (CONTINUED)

SIGHT DISTANCE AS IT RELATES TO MEDIANS AND MEDIAN OPENING DESIGN

MEDIAN WIDTH

SPECIAL U-TURN CONSIDERATIONS

WHERE THE TURNING VEHICLE GOES

CHAPTER 1

INTRODUCTION AND OVERVIEW OF MEDIANS AND THEIR BENEFITS

NOTES:

INTRODUCTION - WHY DO WE USE MEDIANS?

Why do we use medians?

Vehicular Safety — to prevent accidents caused by crossover traffic, headlight glare distraction and traffic turning left from through lanes.

Pedestrian Safety — to provide a refuge for pedestrians crossing the highway.

Vehicular Efficiency — to remove turning traffic from through lanes thereby maintaining/increasing highway operating speed. This reduces fuel consumption and emissions which is an environmental benefit.

Restrictive medians and well designed median openings are known to be some of the most important features in a safe and efficient highway system. The design and placement of these medians and openings is an integral part of the Access Management practice.

What are the Benefits of Medians?

- **Safety**
  - Fewer / less severe accidents
  - Less auto / pedestrian conflict
- **Efficiency**
  - Higher levels of service
  - Less stop and go traffic
- **Aesthetics**
  - More room for landscaping and pedestrians
  - More attractive corridors
  - Less roadway pavement

Restrictive medians help in both low and high traffic situations, but where traffic is high, the benefits are greater.

Properly implemented median management will result in improvements to traffic operations, minimize adverse environmental impacts, and increase highway safety. As traffic flow is improved, delay is reduced as are vehicle emissions. In addition, roadway capacity and fuel economy are increased, and most importantly, accidents are less numerous and/or less severe.

See Section 1.2 for a more complete treatment of the studies on the benefits of good median design and placement practices.

WHAT IS Access Management?

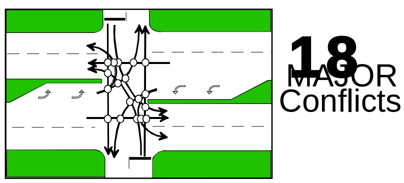
The Control and Regulation of the Spacing and Design of:

- DRIVEWAYS/INTERSECTIONS
- MEDIANS
- MEDIAN OPENINGS
- TRAFFIC SIGNALS
- FREEWAY INTERCHANGES

1.1 MEDIAN OPENINGS DEFINED — WHAT IS THE FUNCTION OF A MEDIAN OPENING?

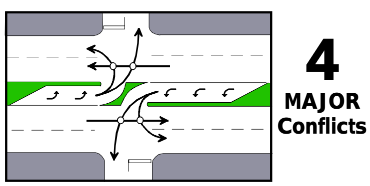
- **Median openings provide for cross traffic movement.**
- **Median openings allow left and u-turns from the highway.**

NORMAL MEDIAN OPENING



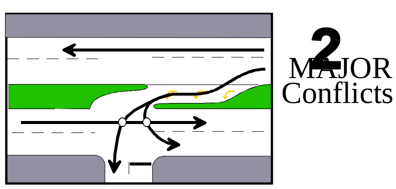
A typical median opening that allows all turns has 18 major conflict points.

DIRECTIONAL MEDIAN OPENING



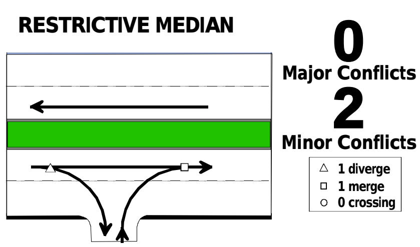
One way to limit the number of conflicts is through the design of median openings. This is a "directional" median opening serving a side street, a design which greatly reduces the conflict points by limiting the number of allowed turning movements.

LEFT-IN ONLY



By providing a restrictive median along arterial roads, we can assure that the number of conflict points is kept to the minimum. Through use of restrictive medians, almost every driveway along the corridor essentially becomes a right-in and right-out driveway with only two conflict points.

RESTRICTIVE MEDIAN

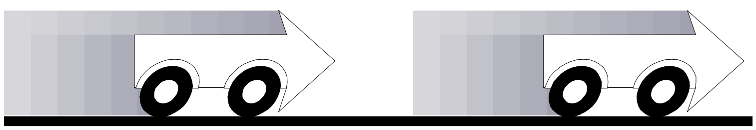


• The location of median openings has a direct relationship to highway efficiency and traffic progression

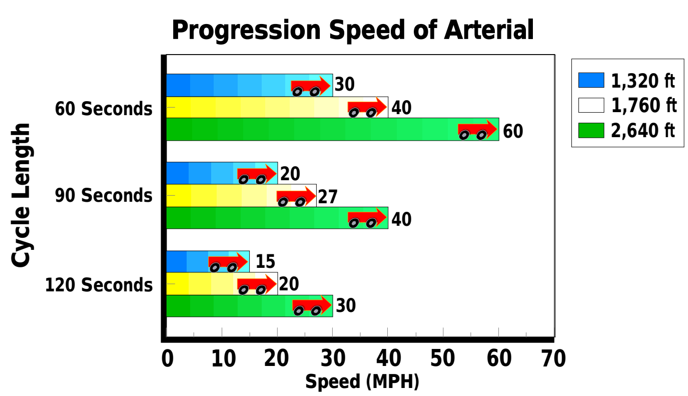
To assure efficient traffic operation full median openings should only be at locations which are uniformly spaced along the highway. Thus, if these locations are properly signalized, traffic can be progressed at efficient and uniform operating speeds.

Another Benefit of Longer Opening Spacing

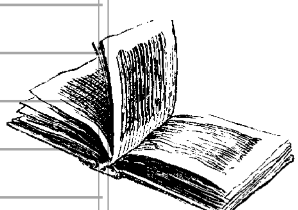
Better speed and progression



Signal Spacing and Speed



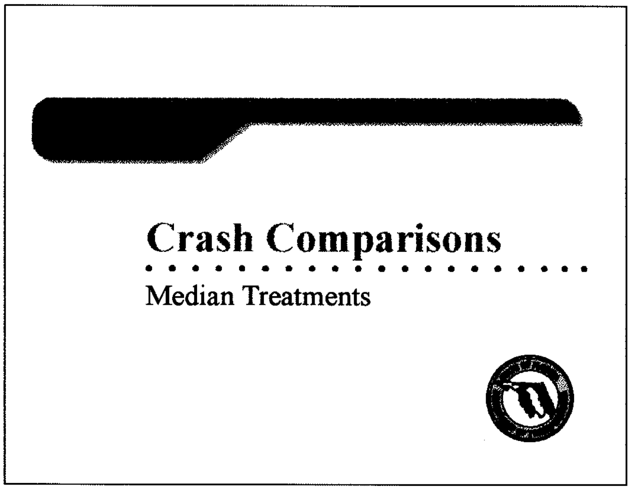
Source: Stover, Demosthenes, Weesner (1991)

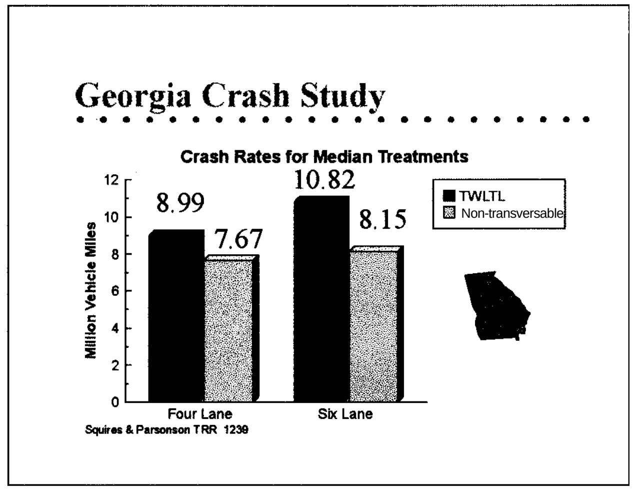


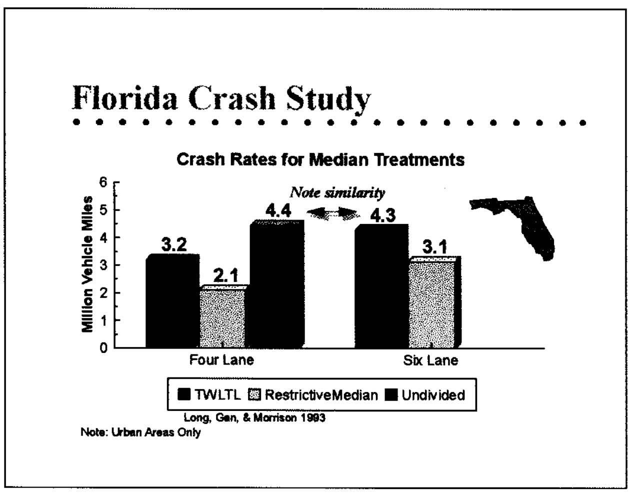
For More Information On Signal Spacing and Progression:

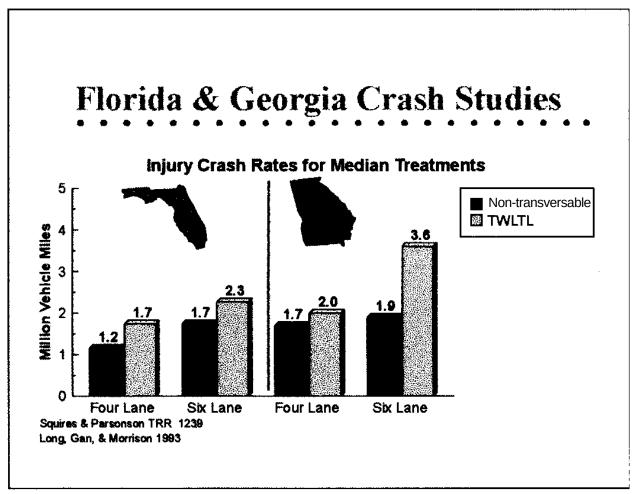
- NCHRP Report # 348 - **Access Management Guidelines for Activity Centers** (Section 7-3)
- V.G. Stover, P.B. Demosthenes and E.M. Weesner, **"Signalized Intersection Spacing: An Element of Access Management,"** Compendium of Papers, 61st Annual Meeting of the Institute of Transportation Engineers, September 1991.

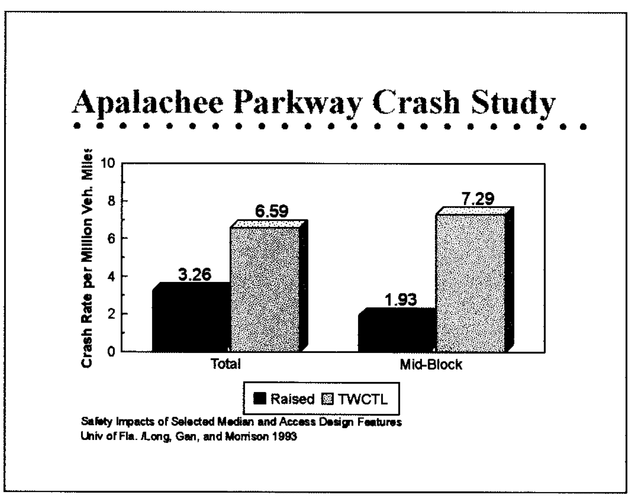
1.2 CRASH COMPARISON AND PUBLIC OPINION OF ROADS WITH AND WITHOUT MEDIANS

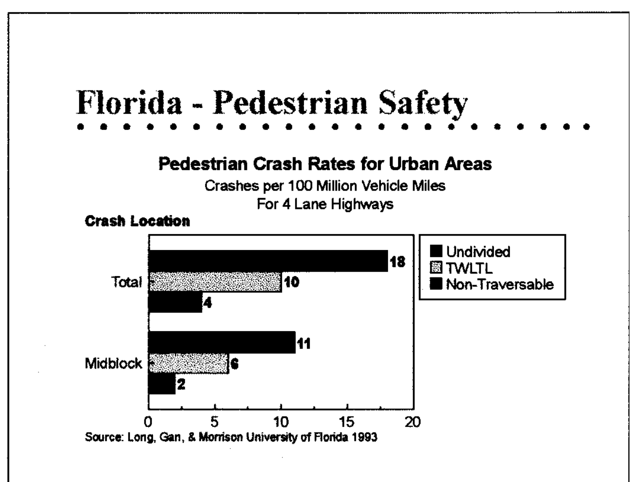






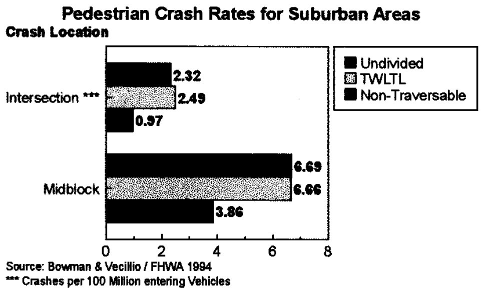




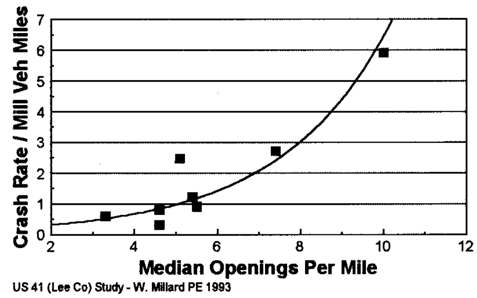


CRASH COMPARISON AND PUBLIC OPINION OF ROADS WITH AND WITHOUT MEDIANS

Pedestrian Safety - *Atlanta, Phoenix, Los Angeles*



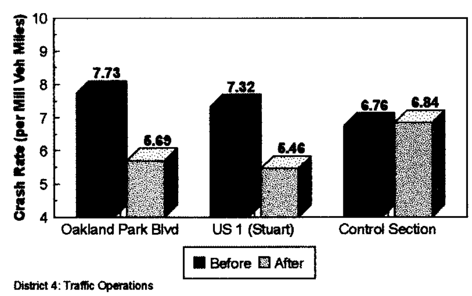
Median Openings and Crashes US 41 - Lee County, Florida



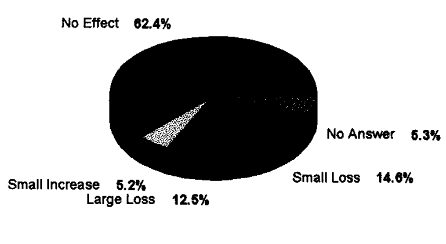
Memorial Drive - Atlanta Area

- ***Data***
  - 4.3 Miles
  - 6 Lanes
  - 40,000 to 48,000 Vehicles per Day
  - Speed Limit 45 MPH
- ***Before***
  - Two way left turn Lane
- ***After***
  - Raised Median (14 ft width)
  - 14 Median Openings Provided
  - 7 public streets were not given median openings
  - U turns allowed at all openings but one (r-t-o-r restrictions)

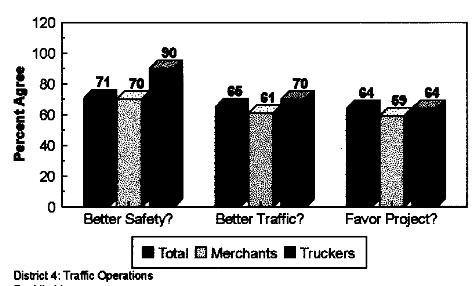
Effects of Median Retrofit
on 2 South Florida Arterials



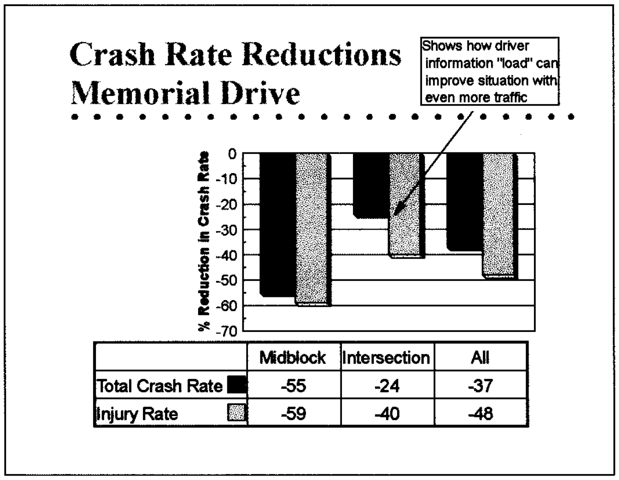
Most Businesses Saw No Loss in Profits - District 4 Retrofit



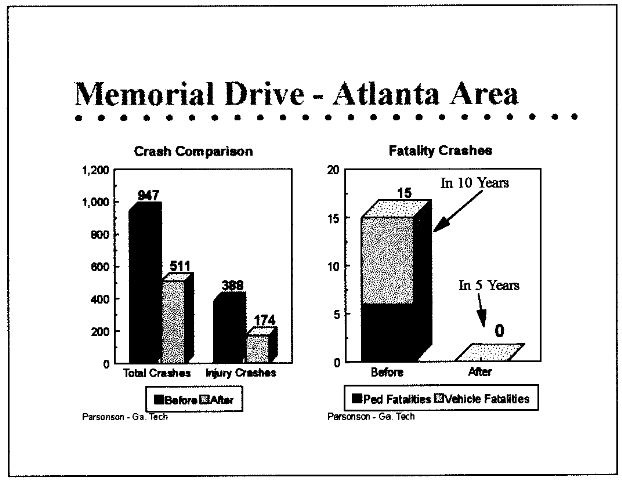
Public Attitude - District 4 Retrofit Projects

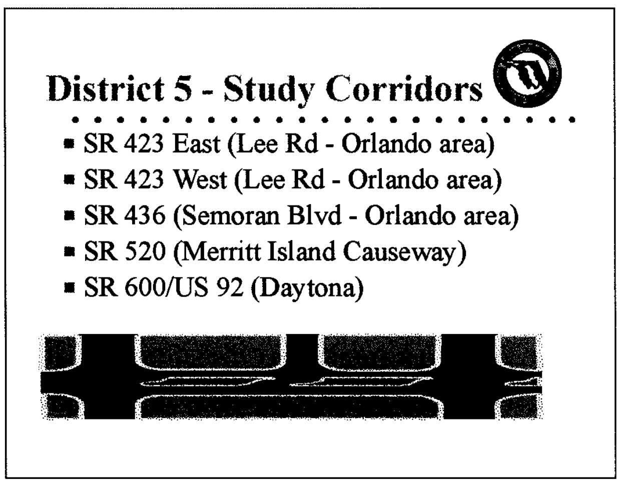


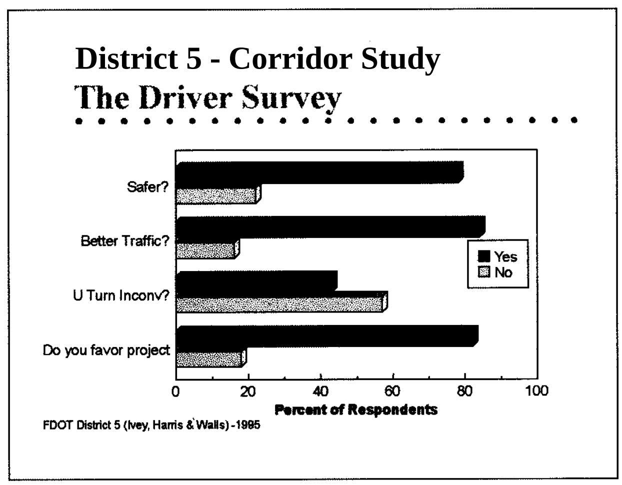
CRASH COMPARISON AND PUBLIC OPINION OF ROADS WITH AND WITHOUT MEDIANS

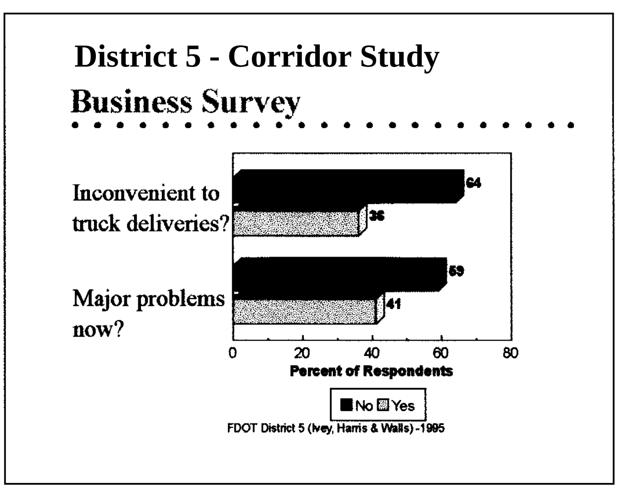


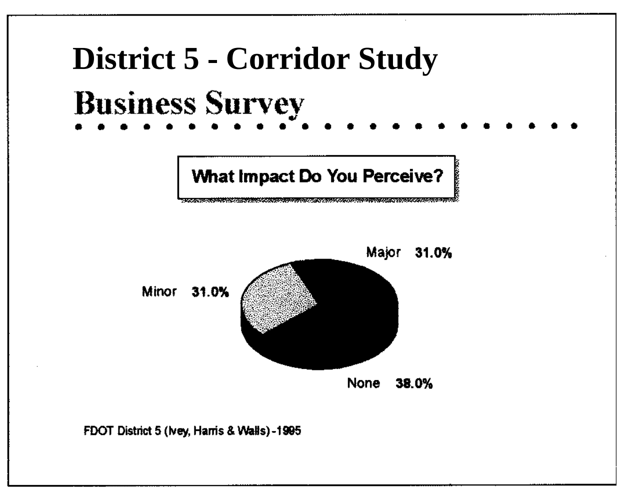
	Midblock	Intersection	All
Total Crash Rate	-55	-24	-37
Injury Rate	-59	-40	-48











1.3 DEPARTMENT POLICY ON MEDIANS AND MEDIAN OPENINGS

1.3.1 Rule 14-97

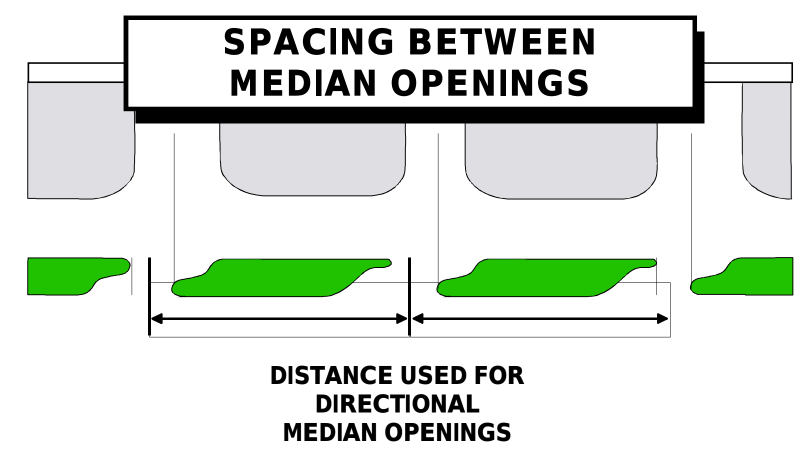
Administrative Rule Chapter 14-97 establishes the seven classifications for state highways and the criteria and procedures for assigning these classifications to specific roads. These classifications contain separation standards for access features. Essentially, the Department of Transportation determines which roads are the most critical to providing high speed, high volume traffic, and these end up with the highest of standards.

Medians and median openings are regulated through the requirement for a restrictive median in certain classes. For those classes, spacings between median openings are regulated. The Median Opening Spacing Standards and how these are measured are found in the following Figures.

Spacing Standards from Rule 14-97

Access Class	**Facility Design Features** (median treatment and access roads)	**Minimum Median Opening Spacing** (Directional)		**Minimum Median Opening Spacing (Full)**		**Minimum Signal Spacing**	
2	Resitrictive - with service roads	1,320 ft	400m	2,640 ft	800m	2,640 ft	800m
3	Restrictive	1,320 ft	400m	2,640 ft	800m	2,640 ft	800m
5	Restrictive	660 ft	200m	2,640 ft over 45 mph* 1,320 ft 45 mph or less	800m over 70km/h* 400m 70 km/h or less	2,640 ft over 45 mph* 1,320 ft 45 mph or less	800m over 70 km/h* 400m 70 km/h or less
7	Both	330 ft	100m	660 Feet	200m	1,320 ft	800m

* Based on posted speed



1.3.2 Multi-lane Facility Median Policy

The 1993 Multi-lane Facility Policy essentially directs all Department multi-lane projects over 40 mph (60 km\h) in design speed to have a restrictive median (see next figure). It also directs our designers to find ways to use restrictive medians in all multi-lane projects, even those below the 40 mph (60 km/h) design speed. An example of a small pedestrian refuge that could be used on a 5-lane section is shown in the following Figure.

NOTES:

FLORIDA DEPARTMENT OF TRANSPORTATION

LAWTON CHILES
GOVERNOR

605 Suwannee Street, Tallahassee, Florida 32399-0450

BEN G. WATTS
SECRETARY

POLICY STATEMENT

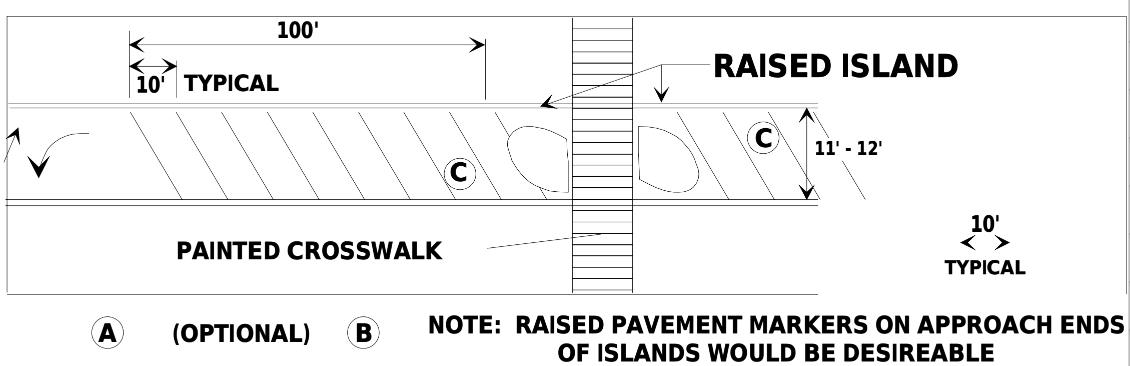
Effective: January 29, 1993
Responsible Office:
Roadway Design
Topic No.: 000-625-015-a
References: Sections 334.046, 336.045, Florida Statutes

MULTILANE FACILITY MEDIAN POLICY

All multilane facilities shall be designed with a raised or restrictive median except four-lane sections with design speeds of 65 km/h (40 mph) or less. Facilities having design speeds of 65 km/h (40 mph) or less are to include sections of raised or restrictive median for enhancing vehicular and pedestrian safety, improving traffic efficiency, and attainment of the standards of the Access Management Classification of that highway section.

Ben G. Watts, P.E.
Secretary

The department's metric policy has changed the 65 km/h to 60 km/h.



Source: Pedestrian Design Standards Development Project, FDOT Traffic Operations, 1988.

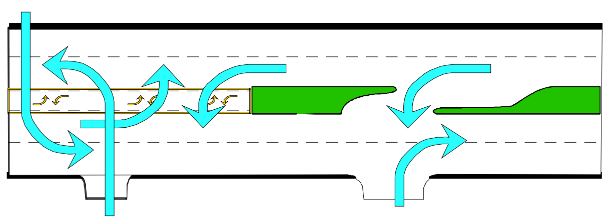
What is the impact of these Standards?

One of the impacts of these standards is the concentration of more left turn and more U-Turns. These are things that need to be handled by careful planning and design. In response to this, the Department created the Median Opening Decision Process.

What is the impact of these standards ?

Greater Concentration of Left and U-Turns

How do we deal with the concentration of left and U-Turns ?



Well designed, well placed median openings

1.3.3 Median Opening Decision Process (FDOT Procedure 625-010-020)

Meeting the median opening spacing standards of Rule 14-97 can, at times, pose a practical problem. Therefore the Department created a process to analyze deviation from the standards found in the rule.

The process allows Project Managers a 10% deviation from the standards for full median openings and gives complete flexibility to Project Managers on decisions involving directional median openings as long as they meet minimum traffic engineering standards for storage, deceleration, sight distance and maneuverability. All deviations greater than this must go to a district Median Opening Review Team for further study and recommendation.

Minor Deviations **(median opening spacing)**

- **Decision can be made by responsible engineer**
- **10% for "Full" openings**
  - **District can be more strict**
- **Directional openings - "case-by-case"**

✓ **Remember:**
even less than 10% deviations might be a problem

District Median Opening Review Teams

Each District has a Median Opening Review Team to consider deviations from Rule 14-97 standards but, safety, traffic efficiency and functional integrity of the highway system must be taken into account.

Guiding Principles

The decisions of the District Median Opening should be made with the following principles of the process:

Safety of the entire system

Traffic Efficiency

Functional Integrity

Recommended Queue Storage

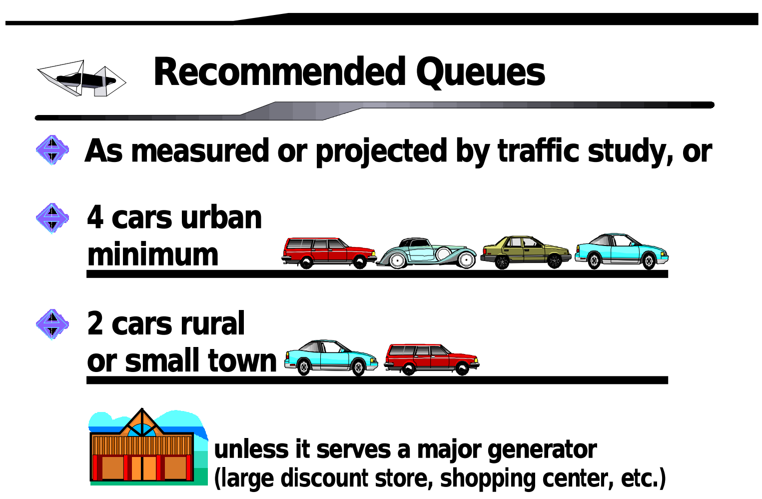
- A critical measure for good median opening design is left turn queue storage.

- Site or project specific projections of queue storage should be use at all major or critical intersections. (Due to the variable nature of left turn demand, actual turn volumes should be reviewed in many cases. Designs should also be conservative enough to handle some of the uncertainty in demand.)

  Where left turn volume is unknown and expected to be minor

  - Urban/suburban minimum = 4 cars or 100 ft. (30 m)
  - Rural/small town minimum = 2 cars or 50 ft. (15 m)

Source: Median Opening Decision Process (FDOT) Topic No.: 625-010-020



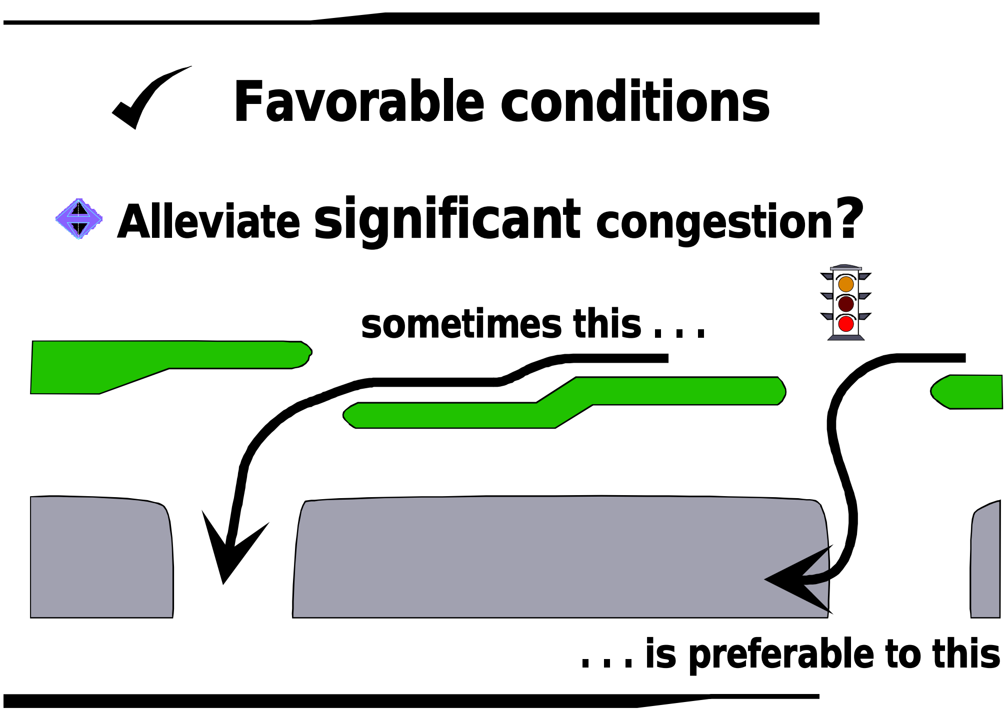
Conditions for More Flexibility

The process also gives guidance for where more flexibility (or less) should be considered.

Conditions that may be viewed favorably in evaluating a proposed median opening deviation include:

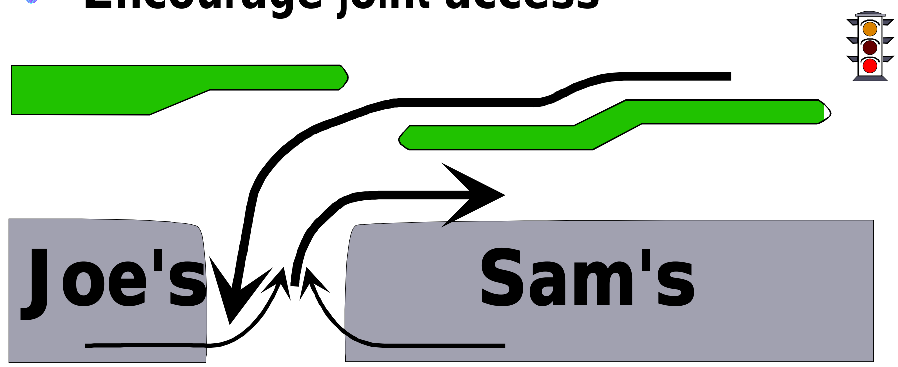
- ✔ opportunities to alleviate significant traffic congestion at existing or planned signalized intersections
- ✔ opportunities to accommodate a joint access serving two or more traffic generators
- ✔ existence of un-relocatable control points such as bridges, waterways, parks, historic or archaeological areas, cemeteries, and unique natural features
- ✔ where strict application of the median opening standards in 14-97.003(1) Figure 2, would result in a safety, maneuvering, or traffic operational problem
- ✔ where directional opening would replace existing full service median opening.

Source: Median Opening Decision Process (FDOT)



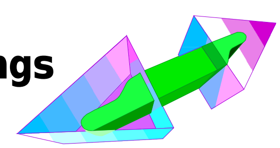
✓ Favorable Conditions

- Alleviate significant congestion?
- Encourage joint access



Other Considerations

- ✓ Un-relocatable or unique historic features
- ✓ Where strict adherence would cause safety problem
- ✓ Where a directional would replace a "full" opening
- ✓ Emergency vehicle openings



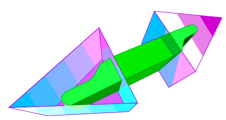
Conditions for Less Flexibility or Greater Scrutiny

- ✔ Florida Intrastate Highway System facilities(FIHS)
- ✔ Access Class 2 or 3
- ✔ Full median openings and signal spacings
- ✔ Median openings in a high accident corridor or location, unless a safety benefit can be clearly shown
- ✔ Situations where circulation can be provided through other alternatives.

NOTES:

Unfavorable Conditions ✗

- ✗ **Intrastate system**
- ✗ **Where any openings unsafe**
  example: SR 436 near I-4
- ✗ **Openings in functional area of intersection**
- ✗ **High crash locations**
- ✗ **Where alternatives exist**



Source: Median Opening Decision Process (FDOT)

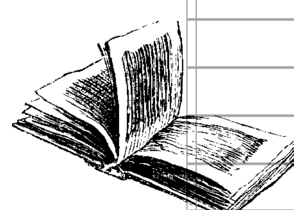
Retrofit to Restrictive Median

Existing 5 lane sections on the FIHS and all those over 28,000 daily traffic should be given the highest priority for retrofit. All 7 lane sections should be given a high priority for retrofit.

1.3.4 Other Department Criteria and Standards

Other Department documents containing important standards and criteria for medians and median opening design are:

- Plans Preparation Manual
- Standard Index
- Florida Highway Landscape Guide



CHAPTER 2

Important Concepts in Understanding Medians and Median Opening Placement

2.1 IMPORTANCE OF ROADWAY FUNCTIONAL CLASSIFICATION

NOTES:

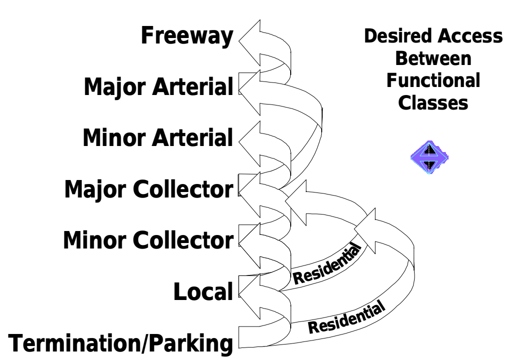
Highway functional classification means classifying highways with respect to the amount of access or movement they are to provide and then designing and managing each facility to perform that function.

"The failure to recognize and accommodate by suitable design each of the different trip stages of the movement hierarchy is a prominent cause of highway obsolescence." 1990 AASHTO Greenbook (Chapter 1)

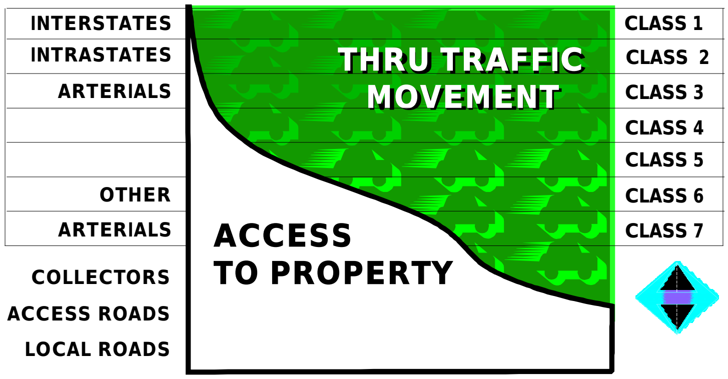
There is no definite dividing line between each of the classes or rigid rules defining what makes a street a local, collector, or arterial. The three basic functional classes represent a continuum of facilities that range from unrestricted access (no through traffic) to complete access control (no local traffic).

An important access management principle is that roads should not connect directly to another of a much higher classification. For instance, a local road may be connected to a major collector, and a major collector may be connected to a minor arterial, but a local road should not connect directly with a major arterial. See the following Figure for illustration of this principle.

Full median openings serve an "Major" transition function. This means that on arterial roads they should only be provided at arterial junctures of the road system as defined for the public street or internal circulation systems.

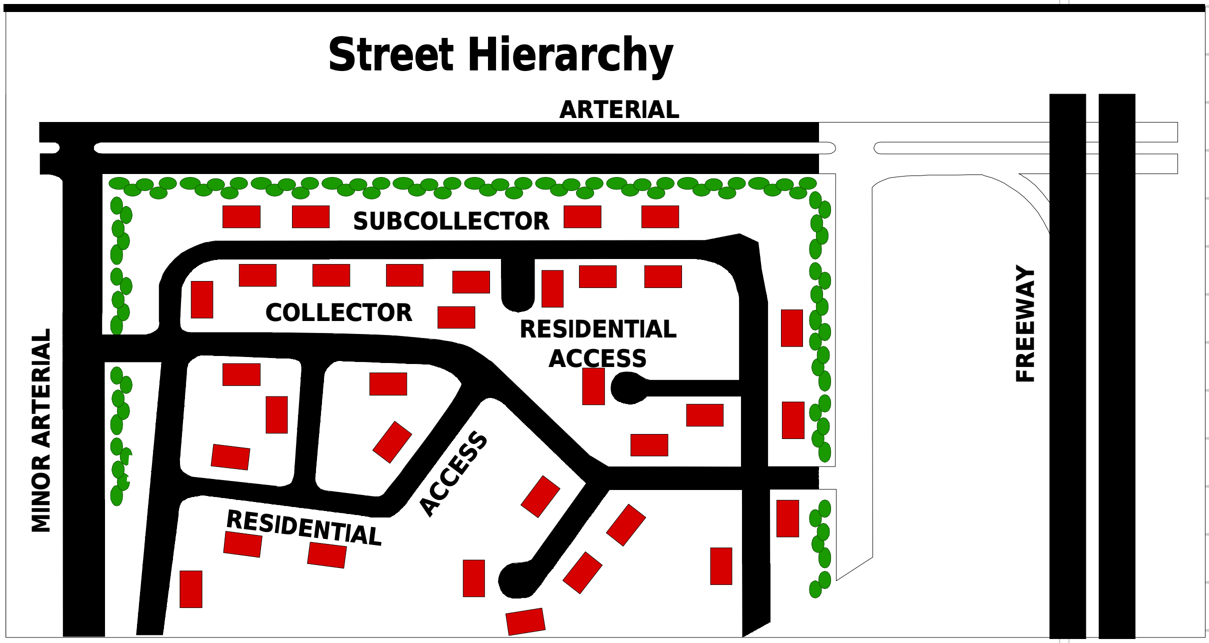


Roadway Function Classification



"Openings should only be provided for street intersections or for major developed areas" (AASHTO Greenbook pg. 528, emphasis added).

In keeping with the principles of functional design adopted by the AASHTO "Greenbook", the choice of which opening is to be closed in order to resolve the inadequate length of another requires that the hierarchy (importance) of the median openings be established. The following is a suggested hierarchy of median openings.



Hierarchal Priority of Median Openings

Priority of Median Openings

Priority of 1A and 1B are the same.

1A Intersection of freeway ramp and at-grade arterial

1B Major arterial-to-major arterial

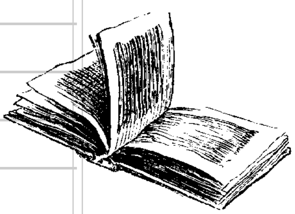
2 Other signalized intersections (public street or private access connection) which conform to the signalized intersection spacing standard

3 Other intersections on major arterials which conform to the signalized intersection spacing standard but which are not as yet signalized

4 Signalized intersections (public street or private access connection) which do not conform to the signalized intersection standard

5 U-turn or left-turn/u-turn opening serving 2 or more public and/or private connections. If two such conflicting openings each serve 2 or more connections, the one with the higher volume would typically be given the higher priority . If the volumes are similar, the median opening serving the larger public street volume would be given the higher priority.

Other U-turn/left-turn ingress should normally be given priority over left turns out egress because ingress capacity is higher and produces less conflict than the left turn out movement.



For More Information On Roadway Hierarchy:

- AASHTO Greenbook (1990/1994), Chapter 1.
- Transportation and Land Development, Stover/ Koepke (1988), Chapter 4 (pgs. 80-86).

2.2 MEDIAN OPENING PLACEMENT PRINCIPLES

The basic concept used in median opening location and design is avoidance of unnecessary conflicts which result in crashes.

The unsignalized median opening is essentially an intersection. Properly designed it will have an auxiliary lane allowing the left turning vehicles to decelerate without interfering with the through movements of the leftmost through lane. **Remember, that the through lane is where the fastest traffic is.** This means that the potential of high speed crashes is the greatest there. Before any design of this area can be done, it is important to know what speed, maneuvering distances, and storage requirements you should design for.

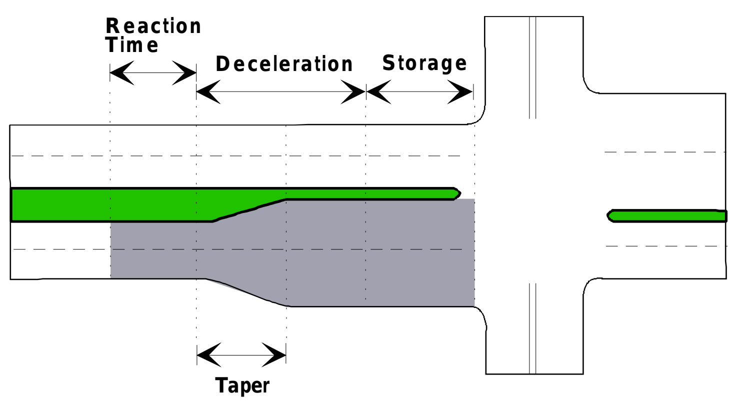
Median Opening Placement Principles

✔ **Follow the spacing criteria in Rule 14-97 as close as possible**.

✔ **Median openings should not encroach on the functional area of another median opening or intersection.**

See Section 2.2.2 for a complete discussion of this principle.

Median Openings Should not be in Functional Area

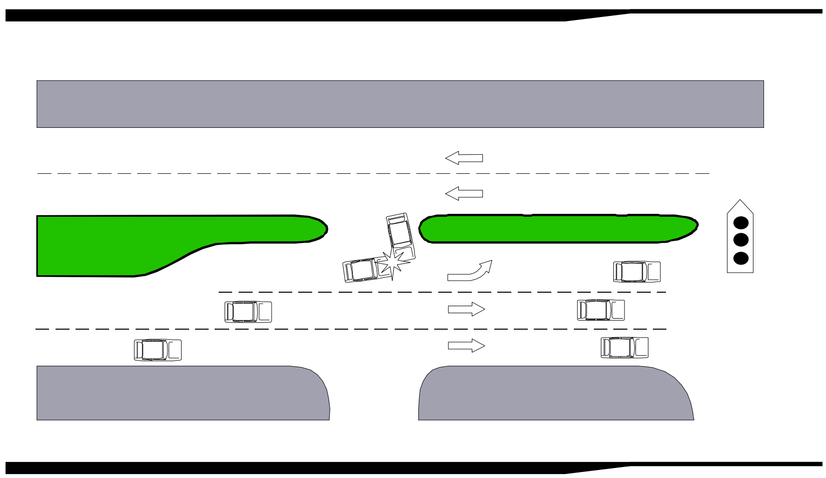


"Driveways should not be situated within the functional boundary of at-grade intersections. This boundary would include the longitudinal limits of auxiliary lanes." AASHTO Greenbook policy 1994, p. 841 and 1990, p. 841

✔ Median Openings That Allow Traffic Across Left-Turn Lanes Should Not Be Allowed

A median opening within the physical length of a left-turn bay as illustrated in Figure is potentially dangerous. Such an opening violates driver expectancy.

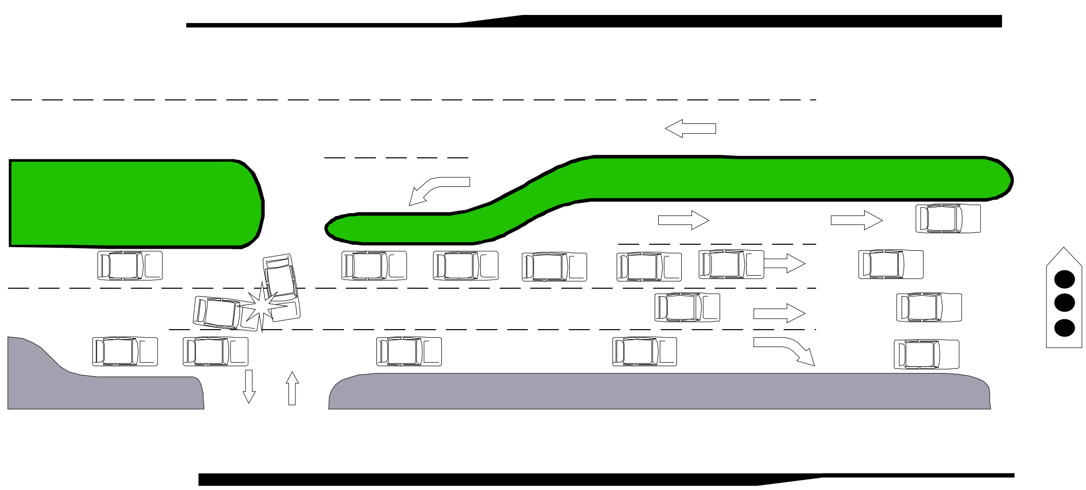
Remember: Exclusive right-turn lanes are most appropriate under the following conditions:
1. No median openings interfere,
2. The right-turn lane does not continue across intersections, and
3. No closely spaced high volume driveways.



✔ Median openings that allow the following movements should be avoided

- across exclusive right turn lanes
- across regularly forming queues from neighboring intersections

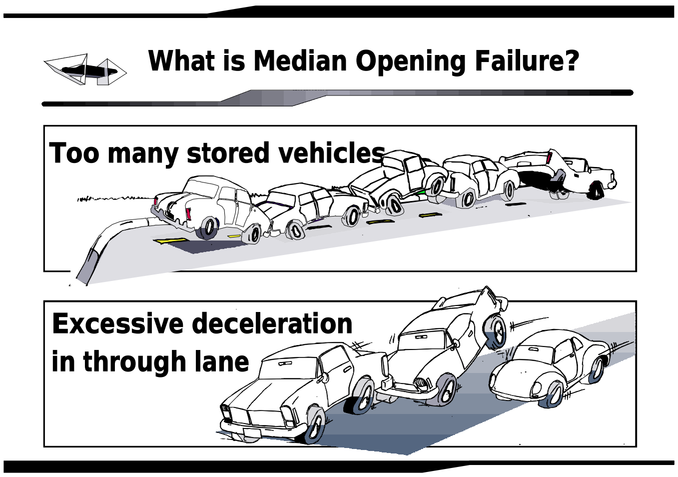
Avoid openings across right turn lanes due to the danger of queues building up across the opening area. The problem here is that when these queues build, "good Samaritans" might allow the left turner through only to crash with a vehicle moving freely in the separate right turn lane.



NOTES:

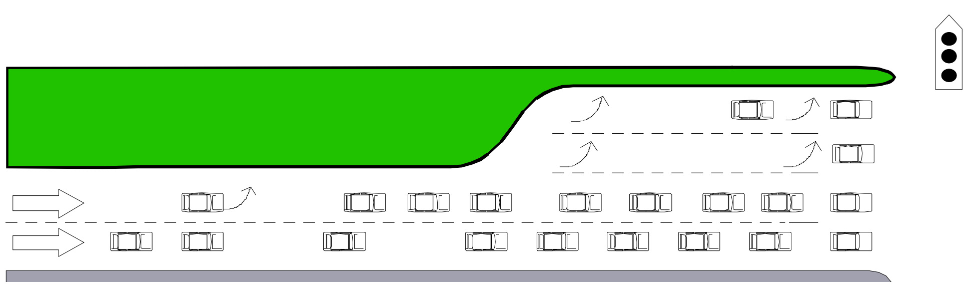
AVOID MEDIAN OPENING FAILURE

Median opening failure can occur when critical features of the functional area of the opening are not designed appropriately. This is usually due to the inadequate space for left turn storage. This can either result in excessive deceleration in the through lane, because cars are stored in the needed deceleration length of the functional area. Or, if it is critically underdesigned it can lead to cars “hanging out” in the through lane for an even more hazardous situation.



Watch out for this problem

THROUGH LANE QUEUE BLOCKS ENTRY INTO THE LEFT-TURN LANE



When the queue in the through traffic lane spills past the left-turn bay, turning vehicles are trapped in the queue, as illustrated in the previous Figure. The left-turning vehicles are not able to move into the turn bay until the queue advances. Dual left turn lanes are more prone to this problem.

2.2.1 PARTS OF THE FUNCTIONAL AREA

The functional area consists of distance traveled during perception reaction time, plus deceleration distance, plus queue storage.

Perception Reaction Time/Distance

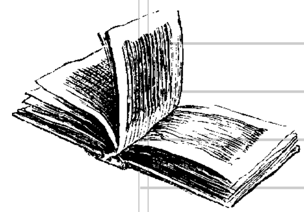
The perception-reaction time required by the driver varies. For motorists who frequently use the street this may be as little as one second or less. However, unfamiliar drivers may not be in the proper lane to execute the desired maneuver and may require three or more seconds.

Suggested Perception/Reaction distance may be used as follows:

Areas	Sec.	35 mph	60 km/h	45 mph	70 km/h	55 r
Rural	2.5	130 Feet	40 m	165 Feet	50 m	200
Suburban	2	100 Feet	35 m	130 Feet	40 m	160
Urban	1.5	75 Feet	25 m	100 Feet	30 m	120

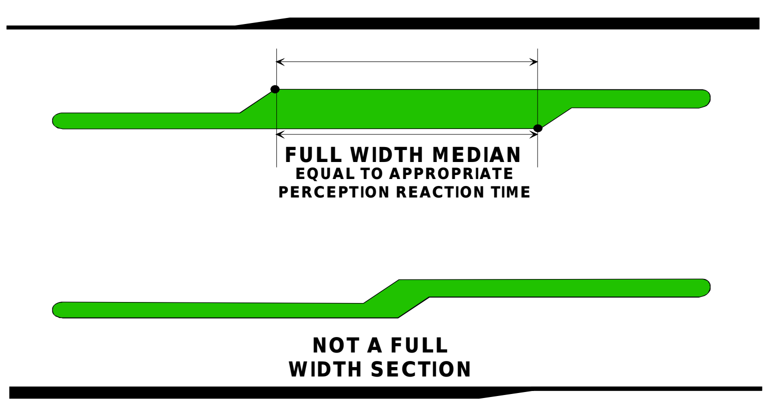
For More Information On Perception-Reaction Time:

- AASHTO Greenbook 1990 (pgs. 45-47).



Full Width Median

Where at all possible, you should try to get the perception-reaction distance as a full width of median. This allows a larger portion of median which will be more visible to the driver. This also gives more area for traffic signs and landscaping.

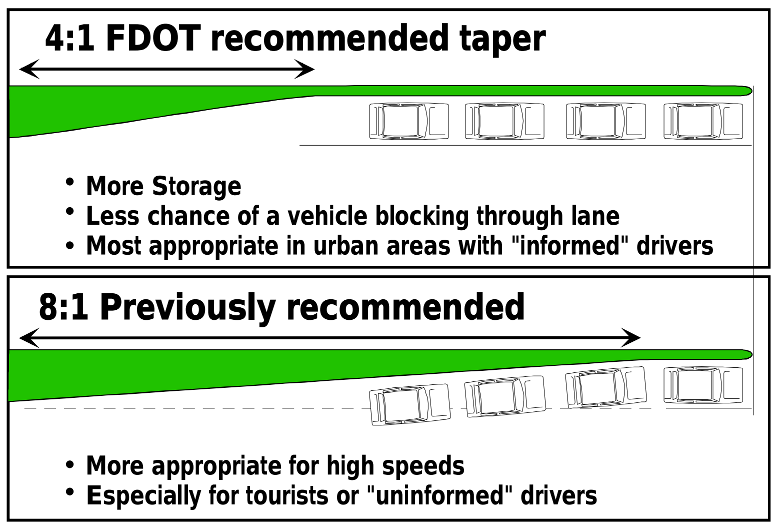


NOTES:

Deceleration and Length of the Left-Turn Lane

Taper — The Taper is the portion of the median opening that begins the transition to the turn lane. Standard Index #301 contains the standards for this feature.

Design standards for left turn lanes are available from several sources, most of which base their rate of taper on approach speed; the faster the speed, the longer the taper. The FDOT does offer standards for the design of left turn lanes. The FDOT Standards Index dictates the use of a 4:1 ratio for bay tapers on all multilane divided facilities regardless of speed. This may be an abrupt transition area, however, most urban areas will benefit from a longer storage area. Urban speeds are generally lower which lessens the need for gradual tapers.



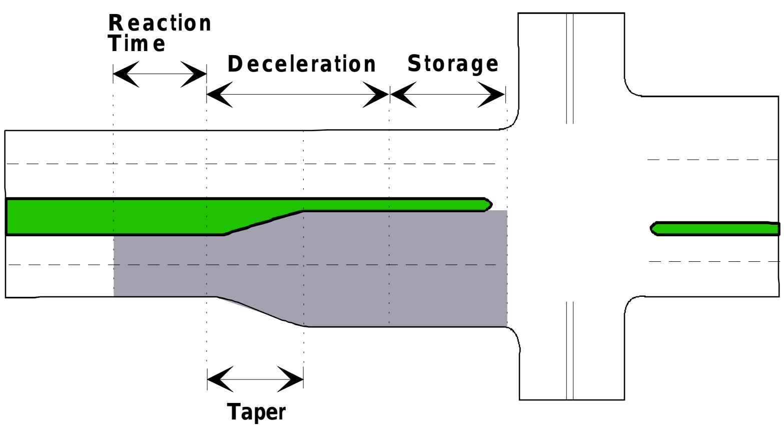
Total Deceleration Distance (Includes Taper)

Florida DOT Standard Index #301

Minimum standards for the distance needed to properly slow a vehicle down, and bring the vehicle to the storage portion of the median opening is found in Standard Index #301. This distance is measured from the beginning of the taper to the end of the queue storage portion.

The standards found in the Standard Index however should be considered a minimums because research has shown reactions vary considerably with drivers. And in many cases, more space may be needed.

Median Openings Should not be in Functional Area



2.2.2 Design Speed/Entry Speed

The design speed is the speed used to make critical decisions on the roadway design features. The AASHTO Greenbook (1990) defines the design speed as:

> " *Design speed is the maximum safe speed that can be maintained over a specified section of highway when conditions are so favorable that the design features of the highway govern,* " *(p. 63).*

The Greenbook also makes the following statements regarding the design speed.

> " *Once selected, all of the pertinent features of the highway should be related to the design speed to obtain a balanced design.* ***Above-minimum design values should be used where feasible"*** (emphasis added).

From Standard Index #301					
Design Speed		Entry Speed		Total Deceleration Distance "L"	
35	60 km/h	25	40 km/h	145	45m
45	70 km/h	35	60 km/h	185	60m
50 Urban	80 km/h	40	60 km/h	240	75m
50 Rural	80 km/h	44	70 km/h	320	100m
50 Rural	90 km/h	48	80 km/h	385	120m

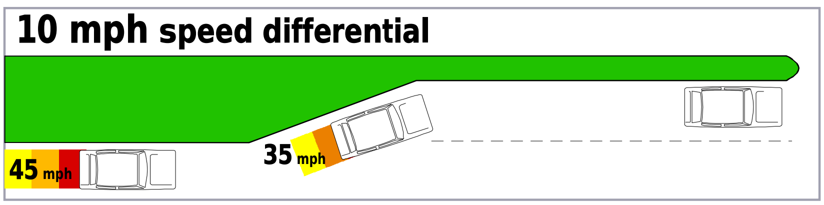
Entry Speed

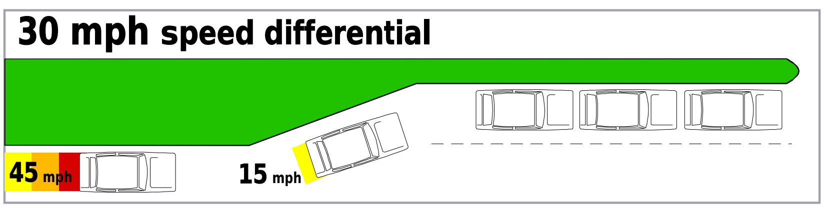
When considering medians and median openings, the greatest use of **design speed** is for determining the length of right and left turn lanes. A reading of the Florida Department of Transportation Standard Index #301 will show that **design speed** or the related **entry speed** are the basis for determining the minimum length of the turn lane for deceleration and stopping behind the turn lane queue.

Total Deceleration Distance —
Why Do We Care About Deceleration Distance?

The turn bay should be designed so that a turning vehicle will develop a speed differential (through vehicle speed - entry speed of turning vehicle) of 15 km/h (10 mph) or less at the point it clears the through traffic lane. The length of the bay should allow the vehicle to come to a comfortable stop prior to reaching the end of the expected queue in the turn bay.

Excessive Deceleration



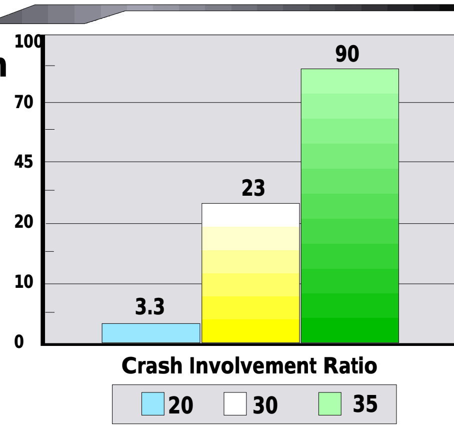


If the turn bay is too short, or queued vehicles take up too much of the deceleration distance, there will be excessive deceleration in the through lane. This creates a high crash hazard as seen in research.

Let's talk speed differential

Relative crash involvement rate ratios

in comparing speed differentials over 10 mph for arterial roads

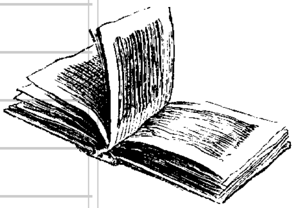


Solomon: 1964
Bureau of Public Roads
Accidents on Main Rural
Highways related to speed

OTHER DESIGN SPEED CONSIDERATIONS

Non-Peak Hour Speeds

Remember: Non-Peak Hours are also important considerations since around 80% of the daily traffic takes place at that time, usually at higher speeds. Turning volumes are lower at those times which will make queuing requirements smaller (see Section 2.2.2/queue storage for a more thorough discussion of this principle).



For More Information on Speed Definitions:

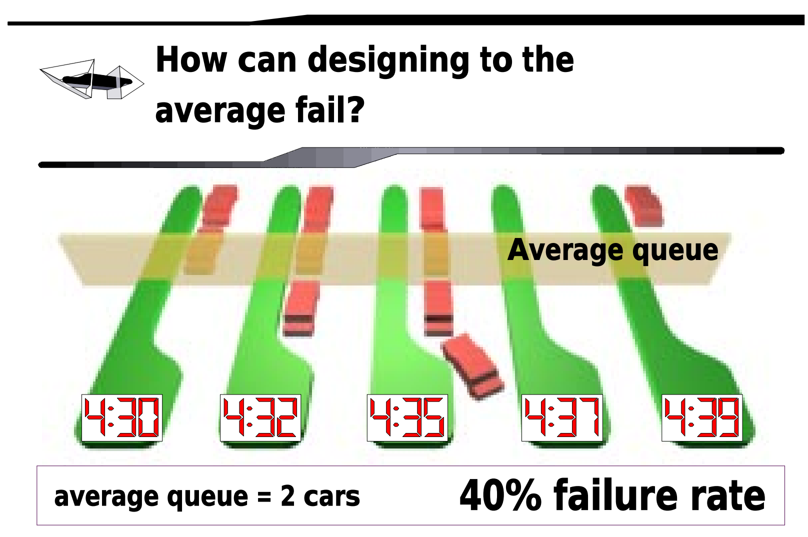
- AASHTO Greenbook 1990 (pgs. 62-71)

For More Information On Speed, Understanding Design, Operating and Posted Speed:

- Report No. 1465-1
- Highway Capacity Manual (1994 Update)
- Texas Transportation Institute/USDOT

Queue Storage

Turn lanes must include adequate length for the storage of traffic waiting to turn. This is also called turn lane queue length. Where a specific queue study does not exist, the Florida Department of Transportation will normally require a minimum of a 100 ft. queue length to satisfy four turning automobiles in an urban/suburban area and a 50 ft. queue length to satisfy two turning automobiles in a rural area. The AASHTO Green Book (1990), pgs. 829-1990 edition, suggests the use of a 2 minute interval for unsignalized locations. The following Figure illustrates that where the average queue is 2 vehicles, the actual queue will probably be over 2 vehicles much of the time.



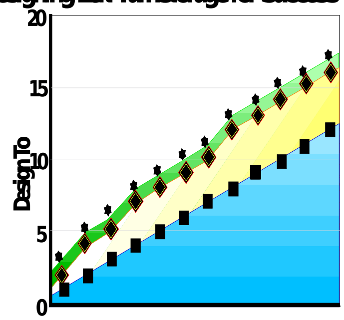
The techniques used to analyze this distribution of queue length is the Poisson Distribution. The Poisson Distribution is used to predict randomly occurring discrete (i.e., 0, 1, 2, 3, etc. occurrences) events such as queues. Using this statistical techniques we see that building queue storage to fit the average means you will “fail” 30% to 40% of the time.

Queue Storage

Remember:

you need almost twice the average queue for storage length

Designing Left Turn Storage for Success



Average Demand Per Cycle		1	2	3	4	5	6	7	8	9	10	11	12
30-40% Failure	■	1	2	3	4	5	6	7	8	9	10	11	12
10% Failure	◆	2	4	5	7	8	9	10	12	13	14	15	16
5% Failure	*	3	5	6	8	9	10	11	13	14	15	16	17

Source: Use of Poission Aproxmation

You should recognize that application of the Poisson Distribution to queue storage length problems assumes that all vehicles arriving on a cycle (or in a specified interval) clear the intersection on that interval. The Poisson Distribution should not be used where one or more vehicles does not clear the intersection and must wait for the next interval. Queue storage where such “carry over” from one cycle to another involves much more complicated analyses. Using Poisson Distribution you can determine the queue length necessary to have "success" 90% of the cycles (usual standard).

There is little difference in storage required to accommodate all left-turns 90% and 95% (10% and 5% failure).

Rule of Thumb:

Design queues are usually 1.5 to 2 times the average.

The following table contains the recommended queue storage length of as variety of left turn volumes. The recommendations were based on a 90% success rate for non-FIHS facilities and 95% for the FIHS. You must consider the historic variability of these numbers, as well as the inherent inaccuracies of traffic projection models when making your recommendation. When possible and desirable get more storage where projections seem to be "light".

Recommended Queue Storage
For Unsignalized Median Openings

Assumptions:
1. 120 second interval
2. Approx. probability of "success" (storing all vehicles)
   90% non-FIHS
   95% FIHS

Lefts/Hour	Average Demand Per Interval	Rec. Queue	Rec. Queue FIHS	
30	1.0	2	3	
40	1.3	3	4	For use in rural areas or small towns
50	1.7	3	4	
60	2.0	4	5	
70	2.3	4	5	
80	2.7	5	6	
90	3.0	5	6	
100	3.3	6	7	
110	3.7	6	7	
120	4.0	7	8	
130	4.3	7	8	
140	4.7	7	8	
150	5.0	8	9	
160	5.3	8	9	
170	5.7	9	10	
180	6.0	9	10	
190	6.3	10	11	
200	6.7	10	11	

Queue Length Adjustments for Trucks

The length of 25 feet (7.6 meters) is an average distance, front bumper-to-bumper of a queue. If the queue is comprised mostly of passengers cars, this distance provides for an average distance between vehicles of about one-half car length. If more than 2% large vehicles are expected, the average length, including gap, per vehicle must be increased as follows:

Adjustment for Large Vehicles

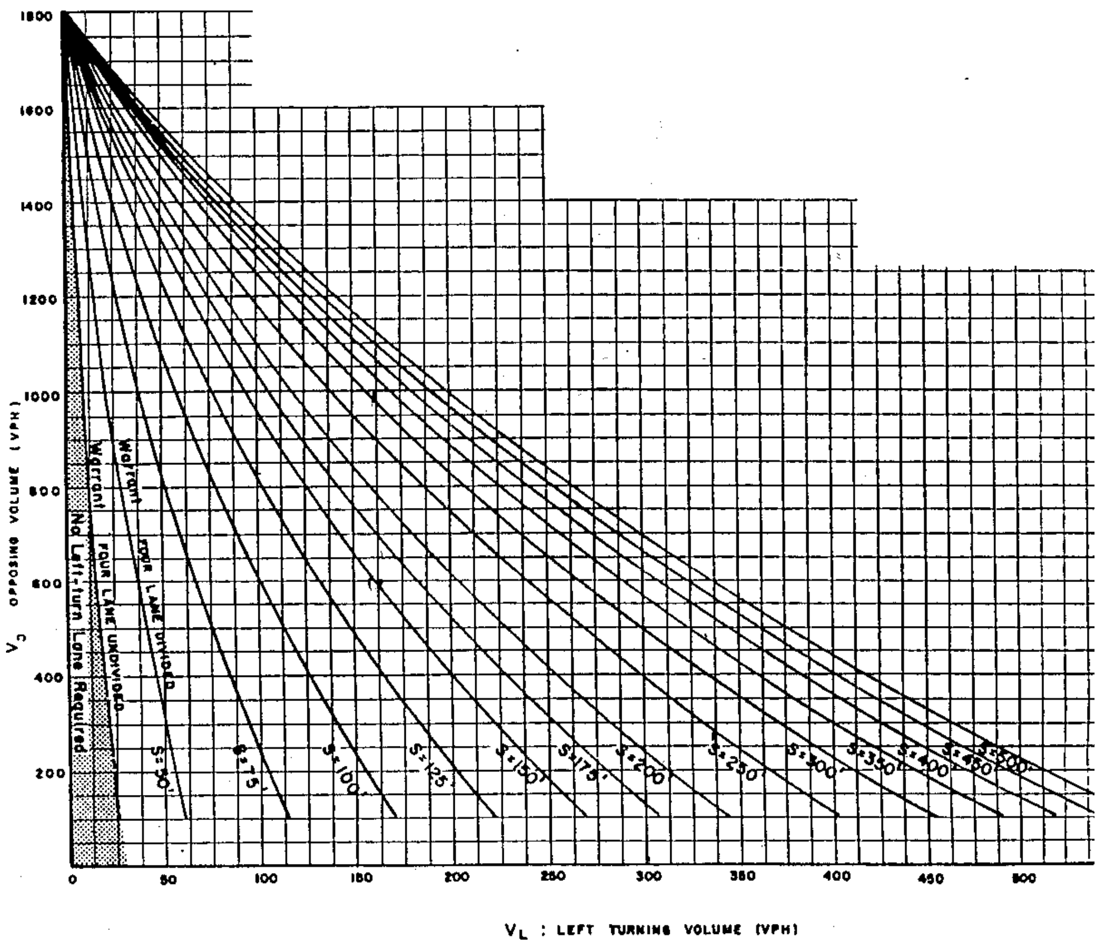
Percent Trucks	Average Storage Length per Vehicle
<2%	7.6m (25ft.)
5%	7.7m (27 ft.)
10%	9.0m (29 ft.)
15%	10.0m (32 ft.)
20%	10.7m (35 ft.)

Harmelink Curves

Another method for determining left turn storage requirements is the use of the curves developed by M. D. Harmelink of Canada specifically for unsignalized locations. This method uses the opposing traffic, as well as the left-turn volume to determine storage needs.

NOTES:

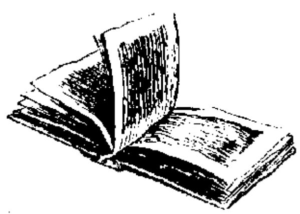
Warrant for left-turn storage lanes on four-lane highways



The nomograph is used by reading horizontally from the opposing traffic volume. $V_{o,}$ on the vertical axis and reading vertically from the left-turn volume, V_L, on the horizontal axis and locating the minimum storage length, S_1, at the point where the horizontal and vertical lines cross. For example, 100 left-turning vehicles per hour, V_L, with an opposing through volume, V_o, of 950 vph, will require a minimum storage length of about 150 feet (45 M).

STORAGE LENGTH TO BE ADDED TO CHART VALUES OF LEFT-TURN LANE STORAGE LENGTHS (Length in Feet)						
	% TL = % TRUCKS IN VL					
	0%	10%	20%	30%	40%	50%
75'	0	25'	25'	25'	50'	50'
100'	0	25'	25'	50'	50'	50'
125'	0	25'	25'	50'	50'	75'
150'	0	25'	50'	50'	75'	75'
175'	0	25'	50'	75'	75'	100'
200'	0	25'	50'	75'	100'	100'
250'	0	25'	50'	75'	100'	125'
300'	0	50'	75'	100'	125'	150'
350'	0	50'	75'	125'	150'	175'
400'	0	50'	100'	125'	175'	200'
450'	0	50'	100'	150'	200'	225'
500'	0	50'	100'	150'	200'	250'

This figure shows the truck adjustment factors. If, in the last example, the truck percentage of turning volume is 20%, then you would add 50ft to the 150ft to equal 200ft total queue storage.



For More Information On Queues, Storage, and Projecting Left Turns:

- Storage Requirements for Signalized Intersection Approaches, ITE Journal, February 1996.
- AASHTO Greenbook (1990), (pg. 829).
- FDOT Design Traffic Handbook, Statistics Office, 1996, Chapter 7.
- Volume Warrants for Left-Turn Storage Lanes at Unsignalized Grade Intersections, M.D. Harmelink.
- For Signalized Intersections: Storage Requirements for Signalized Intersections Approaches, Joseph and Jane Oppenlander, ITE Journal. Feb. 1996.

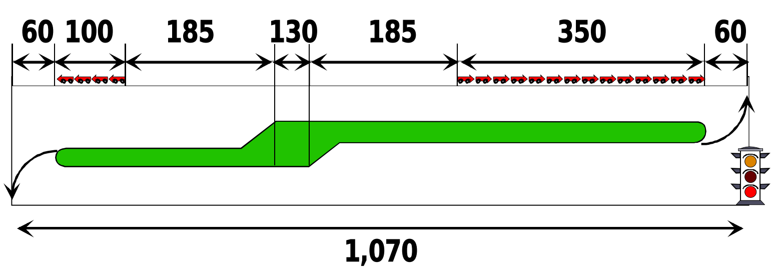
Median Opening Spacing —
How All These Factors Impact the Spacing of Openings

The spacing of median openings will be the sum of the following factors for both directions of the roadway.

- **Deceleration**
- **Queue Storage**
- **Turn Radius (usually 60 feet)**
- **Perception/Reaction distance or Full Width of Median -** The length of the median which is not a part of the turn lanes or the taper. These sections provide for visibility, buffer and landscaping opportunity.

A realistic minimum urban scenario

Urban conditions @ 45 mph design

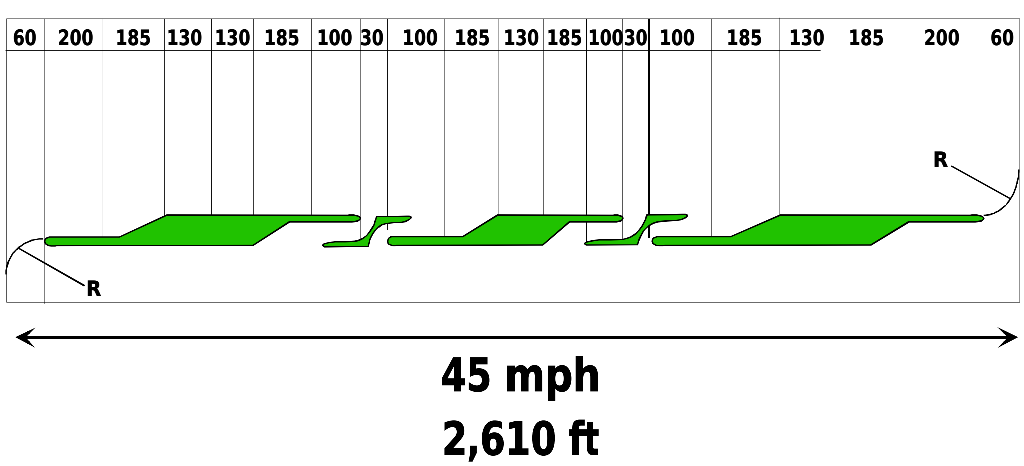


Example
Design Speed -
45 MPH Suburban Location

Left Turn Queue Storage (Signalized) = 350 ft.
Deceleration = 185 ft.

Left Turn Queue Storage (Unsignalized) = 100 ft.
Full width Median = 130 ft.
Turn Radii = 60 ft.

Why is 1/2 mile spacing so good?



Space for:
- *Safety*
- *Operations*
- *Flexibility*
- *Signal Progression*
- *Aesthetics*

Problem

A left-turn median opening on an existing 4-lane roadway in a suburban environment. Posted speed is 45 mph, the 85th percentile speed is observed to be 50 mph. The median opening will serve a public street, a fast food restaurant and a gasoline station. Peak left turn traffic volume is expected to be 100 vph.

Questions using the Poisson method.

1. How many vehicles need to be stored?
2. How much deceleration distance is need?
3. How long does the turn lane need to be?
4. If the opposing volume was 800 vehicles/hour, what would the Harmelink curves tell us?
5. What if the volume were 10% trucks?

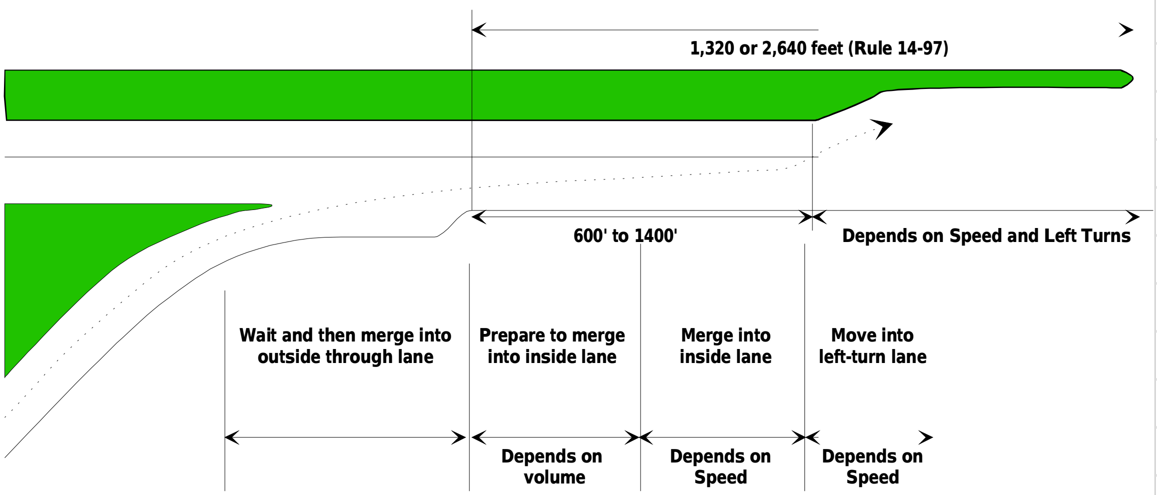
Solution

2.3 WHAT DISTANCE IS NEEDED FROM A FREEWAY RAMP TERMINAL TO THE FIRST MEDIAN OPENING?

Observations indicate that drivers tend to make erratic maneuvers when there is a limited separation between the gore area of the off-ramp and the median opening, drivers will make erratic maneuvers as illustrated.

Desirable conditions would permit a driver to accelerate, merge into the outside traffic lane, select an acceptable gap in order to merge into the inside lane and then move laterally into the left-turn lane and then come to a stop as illustrated.

Space Needed Between Freeway Off-Ramp and Median

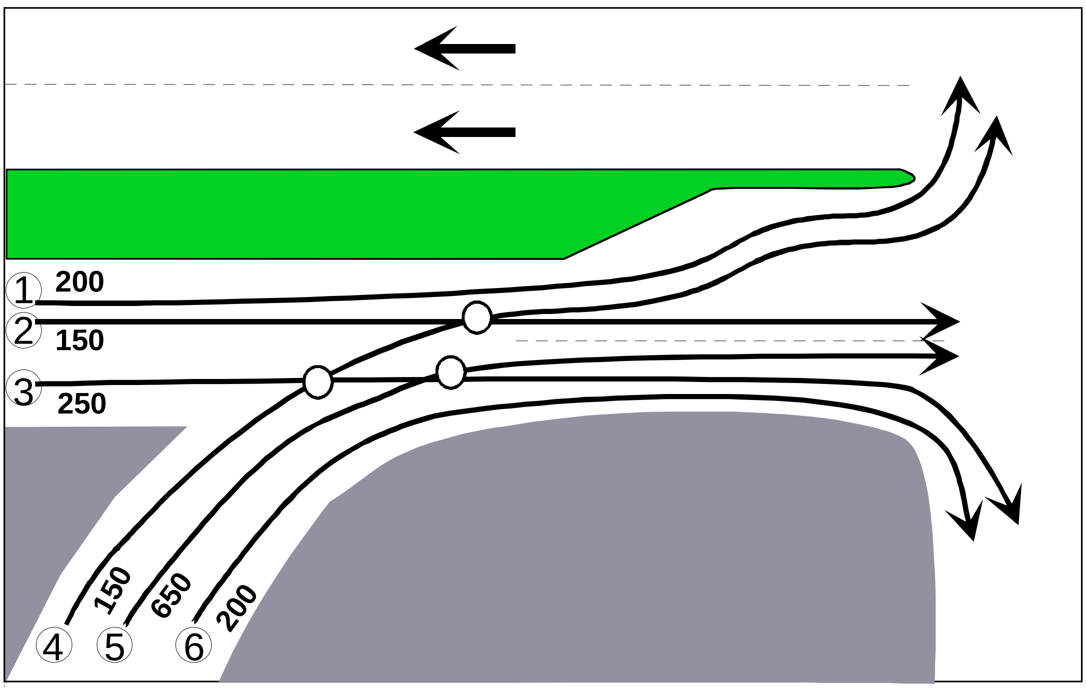


We already have sufficient guidance on the distance needed for queues and deceleration. Determining the appropriate distance for the weaving portion of this maneuver may be accomplished through a technique developed by Jack Leisch in ***Procedure for Analysis and Design of Weaving Sections*** (FHWA Project - 1982). The procedure was developed to determine weaving distances from freeway ramps to intersections on frontage roads. This technique as adapted by Joel Leisch, is transferable to the analysis of weaving on to an arterial road.

This weaving distance may be determined by.

- conflicting weaving vehicle flows
- desired running speed of the weaving vehicles

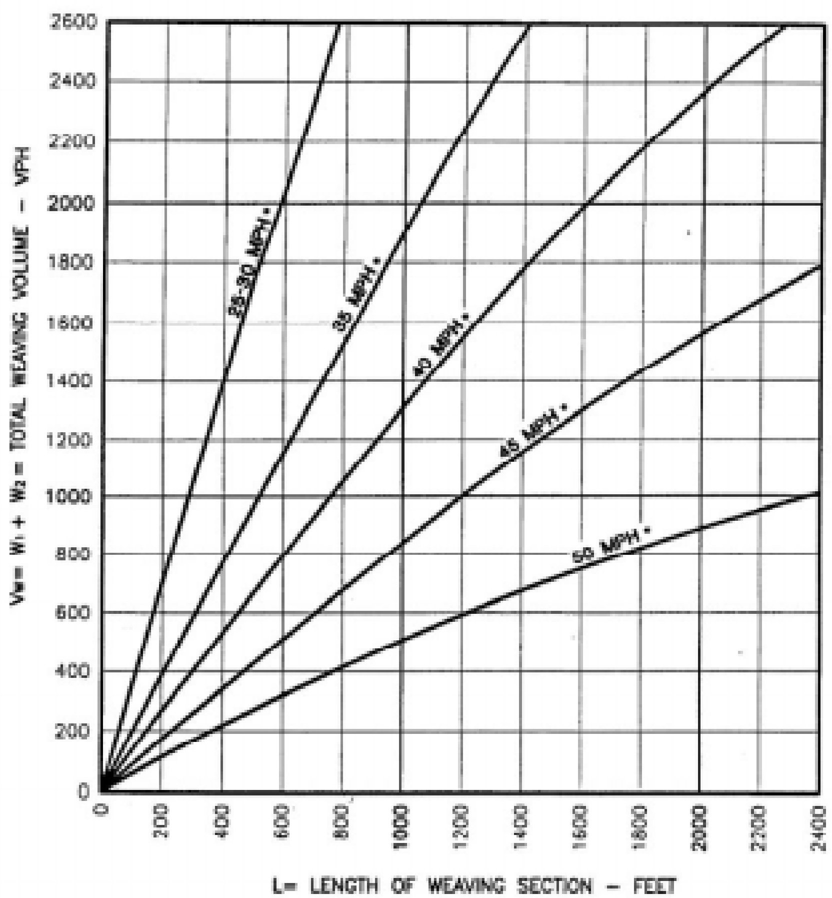
The next figure shows how conflicting movements are determined.



The total volumes for conflicting weave streams are as follows:

Movement	**Volume**
2	150
3	250
4	150
5	650
Total	**1,200**

If you wanted to design for a weaving speed of 35 mph you would use the following graph going up the left side to 1,200 and then going to the right until you get to the 35 mph line. Then you would follow the line down to the bottom of the graph to read approximately 600 feet. Experience shows that most urban situations fall within 800 to 1,600 conflicting weaving movements in the peak hour. If we design for a weaving running speed between 35 and 45 mph, we see that the weave section should be between 400 to 1,600 feet.



Experience shows that most urban situations fall within 800 to 1,600 conflicting weaving movements in the peak hour. If we design for a weaving running speed between 35 and 45 mph, we see that the weave section should be between 400 to 1,600 feet.

Remember, this is strictly the minimum weaving distance from the end of the ramp to the beginning of the deceleration area of the interchange. **You may also add a portion of perception/reaction distance between the end of the weave and the beginning of the left turn taper (start of the deceleration maneuver distance) to the total distance if justified.**

IMPORTANT POINT

This technique is only useful in unsignalized off ramp situations. If the ramp is signalized, this weaving distance will need to be determined by a signal spacing analysis.

2.4 MEDIAN END TREATMENTS

The median end design for an urban arterial should be designed for a passenger vehicle while assuring it can accommodate a larger design vehicle.

Different median ends can be used. Alternative designs are semicircular, symmetrical bullet nose, asymmetrical bullet nose, half-bullet nose, **but remember: always use turn lanes.**

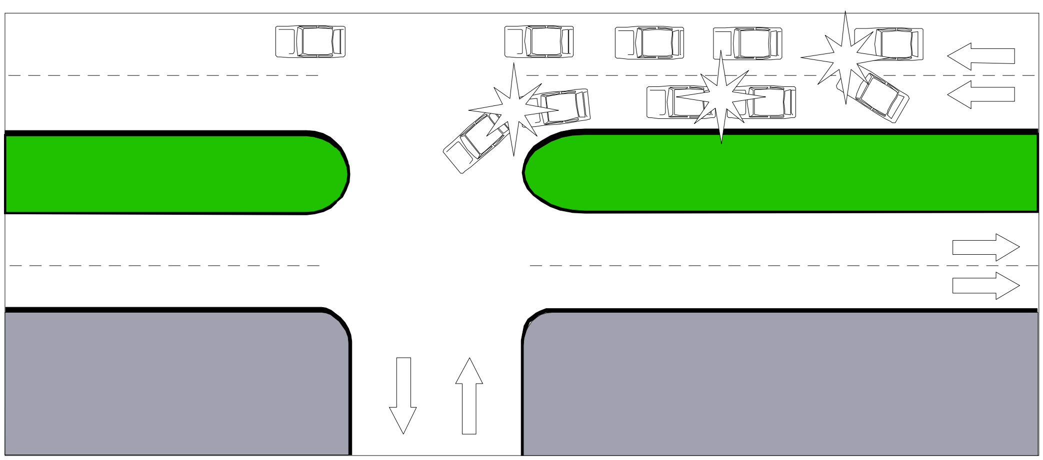
"The only openings that should be provided without turns lanes would be for official or emergency use only."

Problem

A Strictly Bullet Nose Opening

The "bullet nose" median opening requires a vehicle to make a left turn from a through traffic lane (see next figure) interfering with the through traffic. This results in a high potential for rear-end crashes between following vehicles and the potential for crashes between following vehicles changing lanes and vehicles in the adjacent lane.

Potential crash problems when left-turn is made from the through traffic lane

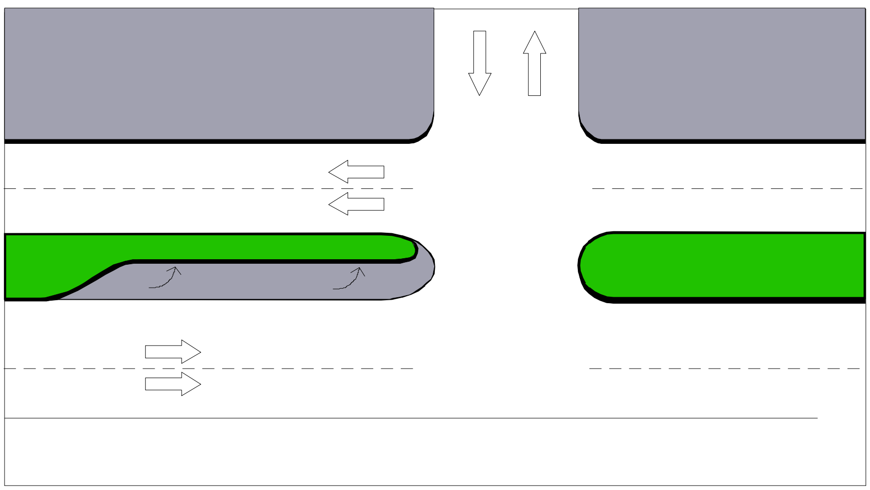


Solution

The only way in which left-turn vehicles can be removed from a through traffic lane is to install a left-turn bay (see next Figure). The lane should be of sufficient length to allow for adequate maneuver distance plus queue storage as discussed in Chapter 2. The total length of the left-turn deceleration lane, including the taper, should be sufficient to allow the turning vehicle to decelerate from the speed of through traffic to a stop plus queue storage.

Existing bullet nose, median openings should be replaced with a left-turn bay.

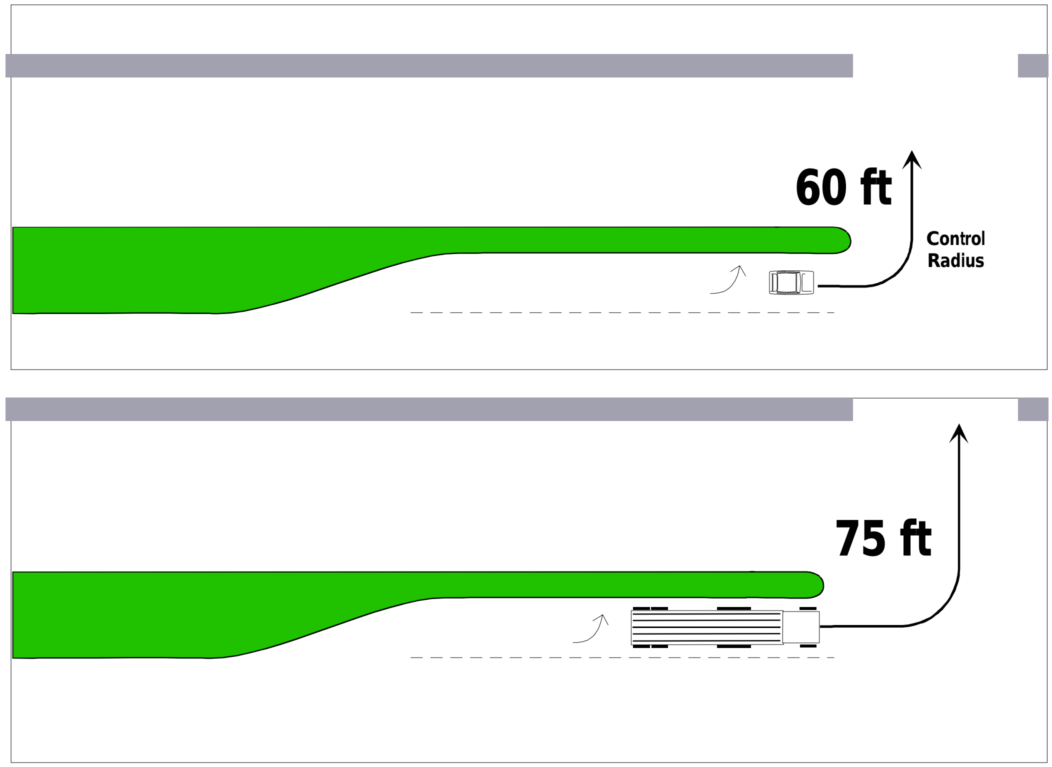
Provision of left-turn bay to remove left-turn vehicles from the through traffic lanes



Always use turn lanes!

2.5 MEDIAN OPENING LEFT TURN RADIUS

The Department has historically used 60ft (18m) for most situations and 75ft (23m) when heavy truck use is expected.



NOTES:

2.6 MEDIAN OPENING LENGTH

Median opening length is governed by the

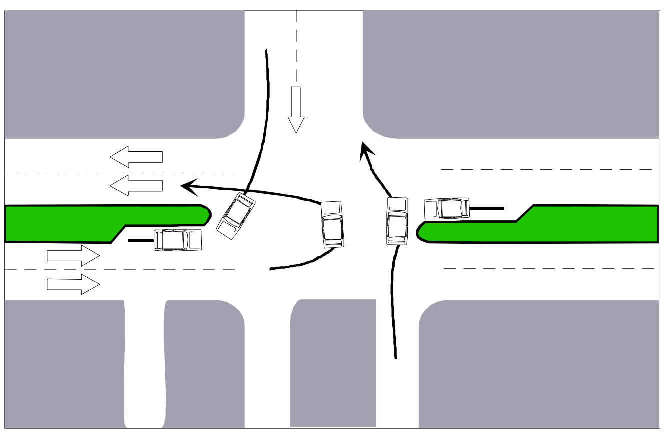
- Turn radii
- Side street geometrics
- Median (traffic separator) width
- Intersection skews
- Intersection legs

Problem:

Excessively Wide Median Opening

An excessively wide median opening will store two or more vehicles in an unsignalized full median opening while they are waiting to complete a maneuver results in multiple conflicts for both the turning vehicles and through traffic. The situation shown results at full median openings on high volume roads during peak periods. This often occurs in areas where development has occurred and traffic volumes substantially increased since the median opening was originally constructed.

Vehicles stopped in excessively wide median opening



Solutions:

Alternative solutions to the problem are:

1) Reconstruct the unsignalized full opening as a more restrictive median opening.

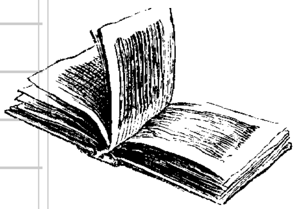
2) Close the median opening.

Which solution is selected, as well as the design of the restrictive movement if used, will depend upon such things as proximity to other median openings, alternative routes, traffic volumes and crash experience.

The presence of several vehicles in the median opening results in impaired sight distance, especially when one or more of the vehicles is a pickup, van, or RV.

Signalization should be considered only if the median opening conforms to signalized intersection standards.

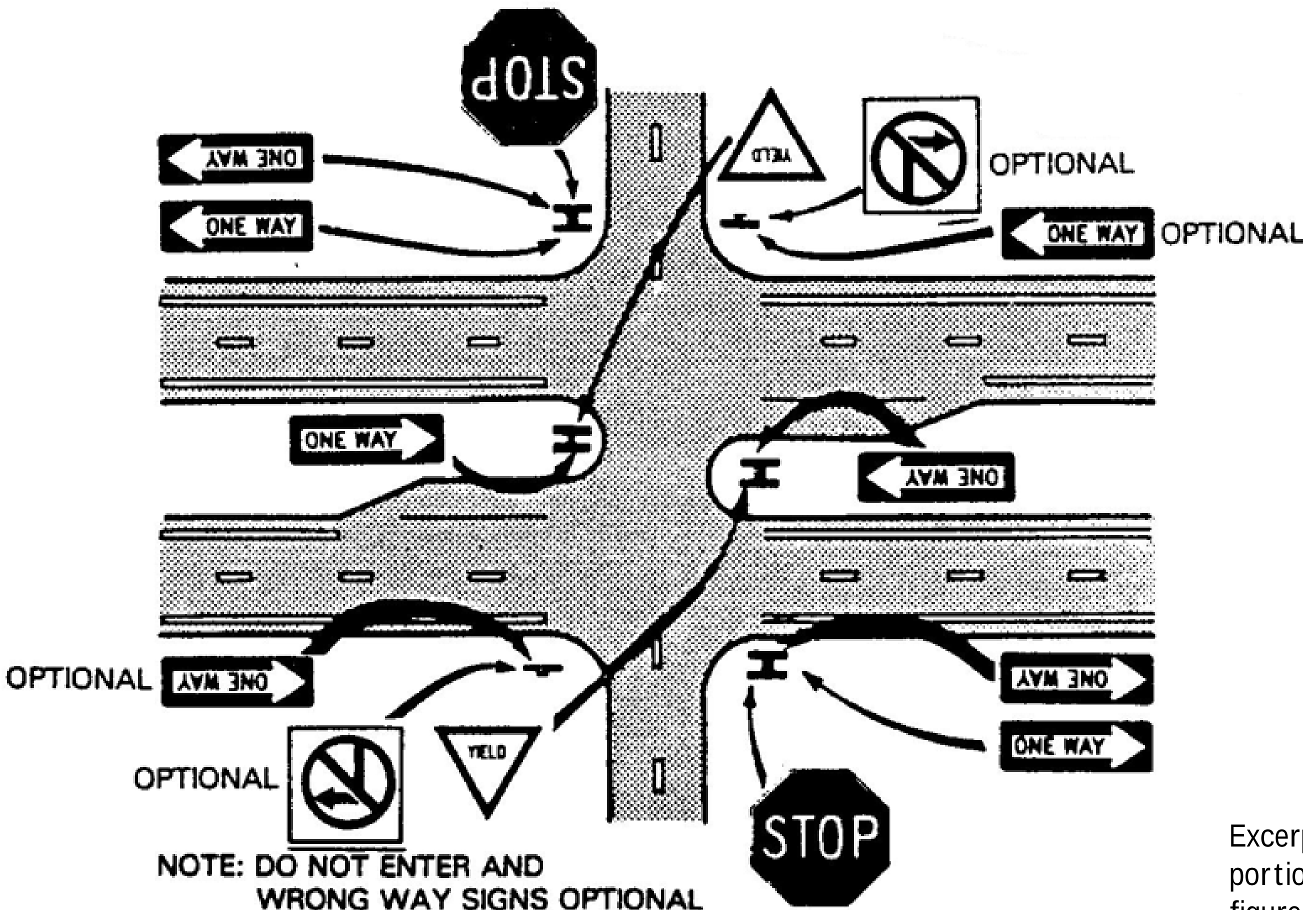
For More information on Median Opening Length:



- AASHTO Greenbook Median Openings Section of the "At-Grade Intersections" Chapter IX.

2.7 PAVEMENT MARKINGS AND SIGNING

The Manual on Uniform Traffic Devices contains guidance on the type and placement of signs and traffic control devices at median opening areas.



Excerpt from the lower portion of M.U.T.C.D. figure 2-3a

This is an example for signing on extra wide medians in rural areas.

CHAPTER 3

Sight Distance as it Relates to Medians and Median Opening Design

This chapter addresses sight distance issues related to unsignalized median openings and roadway connections. The bulk of the chapter text contains discussion of the assumptions relating to stopping, intersection and decision sight distances with an evaluation of AASHTO's minimum stopping and decision sight distances. This discussion is included to provide background for the suggested/recommended sight distances which are included in the chapters relating to locations and design of median openings and roadway connections. Passing sight distance is not addressed because it is not normally an element in median opening location and design.

3.1 INTRODUCTION TO SIGHT DISTANCE CONCEPTS

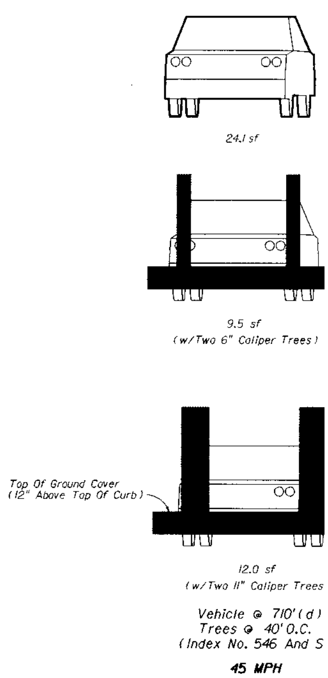
Highways must be designed to provide sufficient sight distance so that drivers can control and safely operate their vehicles. The following sight distances are of concern on median and median opening decisions, both urban and rural.

- **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.

- **Height of Eye -** In determining sight distance, the height of the eye of the person who must stop or pass through the intersection is assumed to be 1.07m (3.5 ft.) Above the highway surface. This assumption has significant bearing on such issues as the placement of landscaping which might obstruct the view of the vehicle at the assumed height.

- **Height of Object** - AASHTO assumes the height of object for intersection sight distance to be 1.3m (4.25 ft.). A height of 0.60m (2.0 ft.) above the pavement surface should be used as the height of object for intersection sight distance. This will allow the driver to view the headlights of an oncoming passenger car, not just one headlight alone at night.



AREA SIZE OF VEHICLE

Florida DOT has developed criteria for sight distance that allows a 50% “Shadow” control for sight DISTANCE. This means that if a driver can see at least 50% of the visual area of a vehicle it is considered “visible”.

TIME OF VISIBILITY

Where visibility is blocked by over 50%, the Department will allow for two seconds unobstructed visibility.

WHAT IS STOPPING SIGHT DISTANCE?

Sight distance is the length of roadway ahead visible to the driver. The minimum sight distance available on a roadway should be sufficiently long to enable a vehicle traveling at or near the design speed to stop before reaching a stationary object in its path. The sight distance at every point along the highway should be at least that required for a below-average operator or vehicle to stop in this distance.

AASHTO's wet pavement stopping sight distance has been used as a good indication of stopping sight distance.

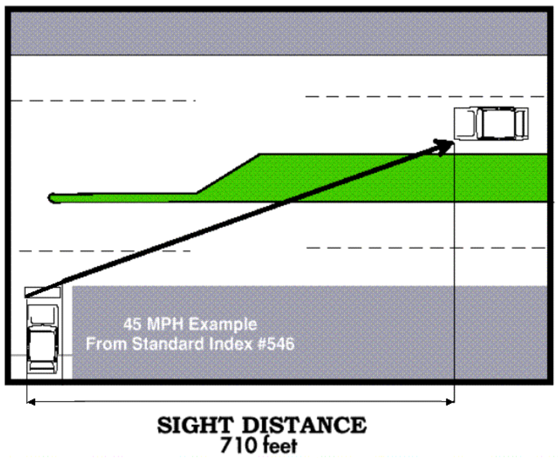
AASHTO STOPPING SIGHT DISTANCE(Wet Pavements)	
Design Speed (mph)	Feet
35	250
40	325
45	400
50	475
55	550
60	650

Source: AASHTO Green Book (1990 & 1984)
TABLE III - 1

3.2 SIGHT DISTANCE FOR SPECIFIC MEDIAN OPENING MANEUVERS

3.2.1 Right Turns and Left Turns on Divided Roadway

The Standard Index #546 specifies the following sight distances for right and left turns at intersections on multi-lane roads with medians. These should be considered minimums. The following figure shows an example at 45 mph.

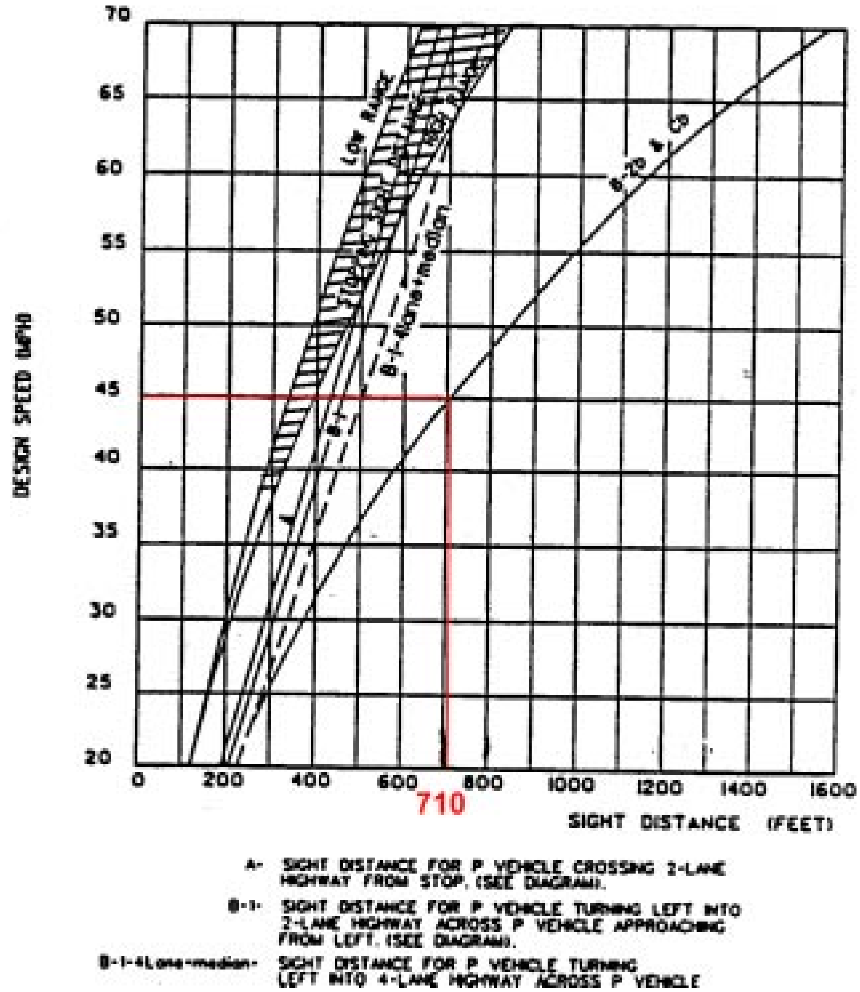


Design Speed	
Speed (mph)	Sight Distance at Intersection
35	470
40	580
45	710
50	840
55	990
60	1150
Metric Speed (km/h)	Sight Distance (m)
60km/h	160
70km/h	205
80km/h	255
90km/h	310
100km/h	375

These figures were derived from the Intersection Sight Distance of the AASHTO Green Book 1994 (Figure IX-41) from the B-2b Curve.

The curves B-2b and Cb are not exactly reproduced when utilizing the following assumptions and acceleration data presented in the 1990 "Greenbook".

- 2.0 second perception reaction
- turning vehicle accelerates to 85% of design speed; and thus approaching vehicles reduce speed by 15%.
- the acceleration of passenger cars (AASHTO Figure IX-33)
- no indication of clearance between the accelerating vehicle and the approaching through vehicle.



As a Two-Step Maneuver

For divided highways with medians (the median is wider than the length of the design vehicle plus front and rear clearance), the maneuvers can be performed as two operations. The stopped vehicle must first have adequate sight distance to depart from a stopped position and cross traffic approaching from the left. The crossing vehicle may then stop in the median prior to performing the second operation. The second move requires the necessary sight distance for vehicles to depart from the median, to turn left into the cross road, and to accelerate without being overtaken by vehicles approaching from the right.

3.2.2 Should the Through Movement Speed be Reduced?

The sight distances given in the AASHTO Green Book assume a 15% reduction in speed for the through movement. It also assumes a 2.0 second perception reaction time for left and right turns. In order to find more desirable sight distances for state highways, new figures were calculated using "no speed reduction" for through vehicles and 2.5 seconds reaction time for right turns and 3.5 seconds for left turns. These may be most appropriate for the FIHS or wherever the designer may want a greater margin of safety.

Intersection Sight Distance (in feet)

Design Speed	FDOT Standard Index #546	1990 AASHTO	Calculated Sight Distance			
			Zero Speed Difference		10 MPH Reduction	
			Left	Right	Left	Right
30 MPH	380	375	475	425	375	350
35 MPH	470	475	600	524	475	425
40 MPH	580	580	725	650	600	525
45 MPH	710	710	850	775	725	650
50 MPH	840	830	1000	925	850	775

Source: Vergil Stover, Medians, A Short Course, 1995

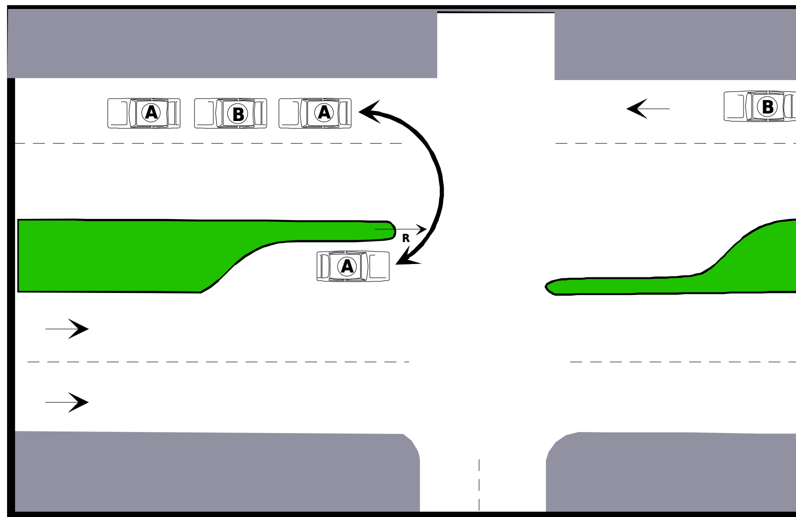
3.2.3 Sight Distance for U-Turns

U-Turns are more complicated than simple turning or crossing maneuvers. Knowing this, sight distances for U-Turns were calculated for automobiles with the following assumptions:

- ✔ "P" vehicle (Passenger vehicle)
- ✔ 2.0 seconds reaction time
- ✔ Extra time spent in 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 1990, Figures IX - 34 - pg. 749
- ✔ 50 feet clearance factor

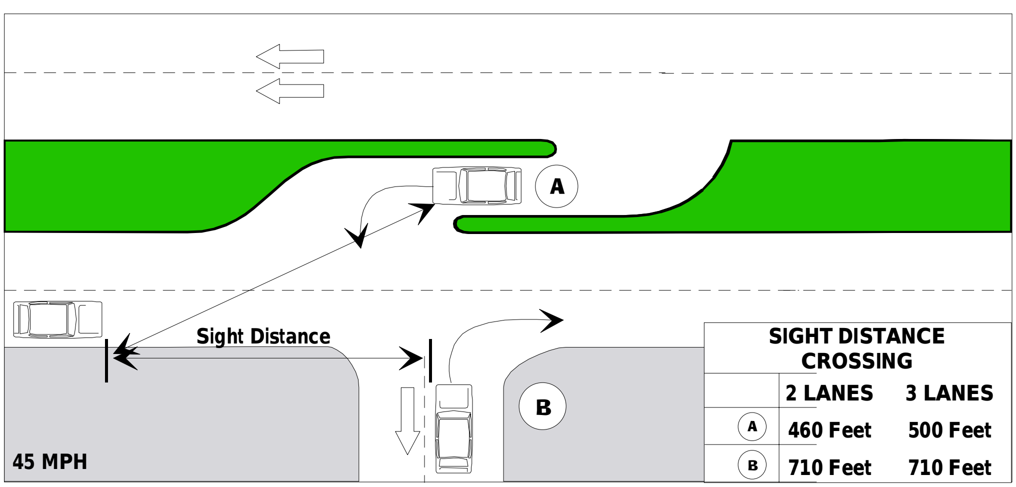
Sight Distance for U-Turn at Unsignalized Median Opening	
Speed MPH	**Sight Distance (ft.)**
35	520
40	640
45	830
50	1,040
55	1,250
60	1,540
SI/METRIC	
Speed	Sight Distance(M)
60km/h	160 M
70km/h	200 M
80km/h	260 M
90km/h	380 M
100km/h	470 M

HOW A U-TURN SIGHT DISTANCE WAS CALCULATED



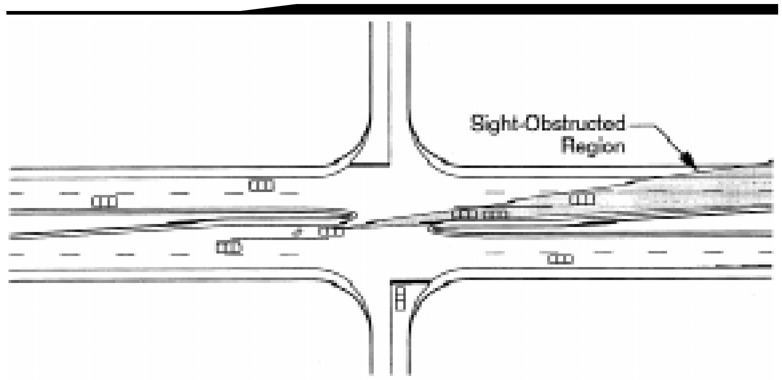
3.2.4 Sight Distance for Left Turn into Side Street

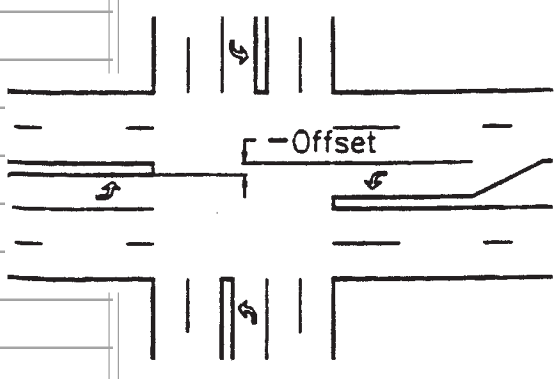
After calculating the sight distances for this left turn in maneuver it becomes clear that in most cases the right turn sight distance from the side street would control the sight distance of this area. If the area has enough sight distance to allow a right turn vehicle from the side street, the sight distance should have sufficient sight distance for the left turn egress vehicle.



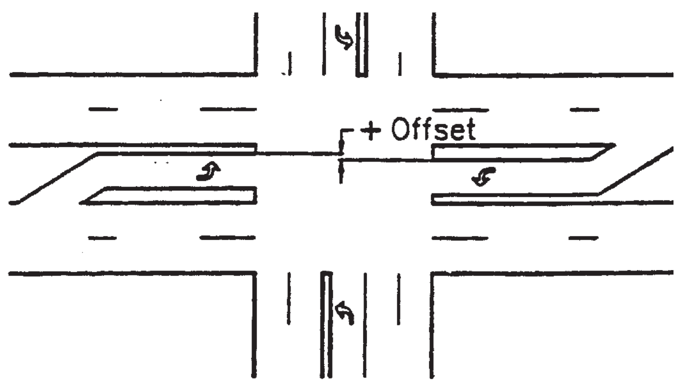
3.2.5 Left Turn Lane Offset

Vehicles turning left from opposing left turn lanes restrict each other's sight distance 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. When the right edge of the opposing left turn is to the left of the left edge of the left turn lane, the offset is negative as shown. If it is to the right, it is a positive offset as indicated below. Desirable offsets should all be positive with a recommended minimum 0.6-meter (2-foot) offset when the opposing left turn vehicle is a passenger car and a recommended minimum 1.2-meter (4-foot) offset when the opposing left turn vehicle is a truck. In both cases the left turn vehicle is assumed to be a passenger car.



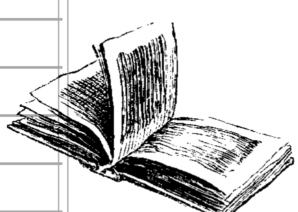


Negative offset between opposing left-turn lanes



Positive offset between opposing left-turn lanes

Source: District 1 Access Management Unsignalized Median Opening Guidelines



For More Information On Offset:

- District 1 Access Management Unsignalized Median Opening Guidelines
- Transportation Research Record #1356

3.3 LANDSCAPING AND SIGHT DISTANCE ISSUES

Two important Florida Department of Transportation documents address landscaping as they relate to medians:

- Standard Index #546 (Sight Distance at Intersections)
- "Florida Highway Landscaping Guide" (FDOT, Environmental Management Office)

The Landscape Guide States the Importance of Access Management in Providing Good Visibility and Landscaping Opportunities:

> "Access management is the management of vehicular access to the highway. This includes ingress to the highway, egress from the highway and median openings on divided highways. A well-designed highway with good access management can be aesthetically pleasing. It provides the landscape architect greater opportunity in the development of practical and efficient landscape plans. When the number of median openings and driveway connections are reduced, a greater area is generally available for landscaping.
>
> The reduction of median openings and driveways also reduces the number of locations that must meet clear-sight requirements. This allows greater flexibility in the landscape plan. Therefore, any plan for landscaping a highway should consider access management."

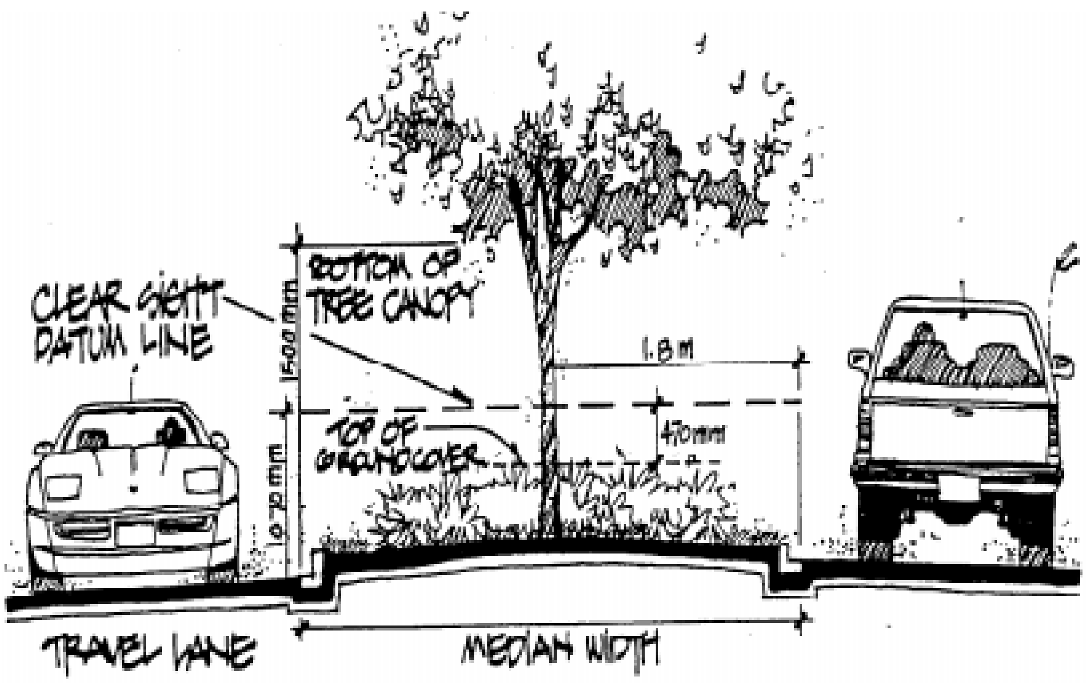
When the number of median openings and driveway connections are reduced, a greater area is generally available for landscaping.

Major Criteria for Decisions on Sight Distance and Planting Area and Spacing in Medians

- **Sight Distance -** for right and left turns as stated in Standard Index #546
- **Stopping Sight Distance** (for absolute clear area)
- **Tree Caliper** - 100 mm or less measured 150 mm above ground
- **Tree Spacing** - as stated in Standard Index #546
- **Area Size of Vehicle Seen** - 50% coverage or 2 seconds of complete visibility
- **"Clear" zones** - as stated in Standard Index #700 or Plans Preparations Manual
- **Clear sight window** criteria - see next Figure.

Why are the same standards used for both signalized and unsignalized intersections?

- ✔ Signal can malfunction
- ✔ Signal can go to flashing mode



LANDSCAPING GUIDE/STANDARD INDEX

ENGLISH UNITS

Description	Speed (mph)													
	30		35		40		45		50		55		60	
Maximum Caliper (Diameter) (Within Limits Of Sight Window) (mm)	>4"≤11"	>11"≤18"	>4"≤11"	>11"≤18"	>4"≤11"	>11"≤18"	>4"≤11"	>11"≤18"	>4"≤11"	>11"≤18"	>4"≤11"	>11"≤18"	>4"≤11"	>11"≤18"
Minimum Spacing (c. to c. Of Trunk) (ft)	22	91	27	108	33	126	40	146	45	165	52	173	60	193

Sizes and spacings are based on the following conditions:

(a) A single line of trees in the median parallel to but not necessarily colinear with the centerline.

(b) A straight approaching mainline, within skew limits as described in No. 2 above.

(c) 1. Trees and palms ≤ 11" in diameter casting a vertical 6' wide shadow band on a vehicle entering at stop bar location when viewed by mainline driver beginning at distance 'd': see SHADOW DIAGRAM, Sheet 2.

2. Sabal palms with diameters > 11" - ≤ 18" spaced at intervals providing a 2 second full view of entering vehicle at stop bar location when viewed by mainline driver beginning at distance 'd': see PERCEPTION DIAGRAM, Sheet 2.

For any other conditions the tree sizes, spacings and locations shall be detailed in the plans: see Design Note No. 4.

METRIC (SI)

Description	Speed (km/h)											
	50		60		70		80		90		100	
Maximum Caliper (Diameter) (Within Limits Of Sight Window) (mm)	>100 - ≤290	>290 - ≤450	>100 - ≤290	>290 - ≤450	>100 - ≤290	>290 - ≤450	>100 - ≤290	>290 - ≤450	>100 - ≤290	>290 - ≤450	>100 - ≤290	>290 - ≤450
Minimum Spacing (c. to c. Of Trunk) (m)	7.0	29.0	9.0	36.0	12.0	42.0	15.0	50.0	17.0	54.0	20.0	62.0

Sizes and spacings are based on the following conditions:

(a) A single line of trees in the median parallel to but not necessarily colinear with the centerline.

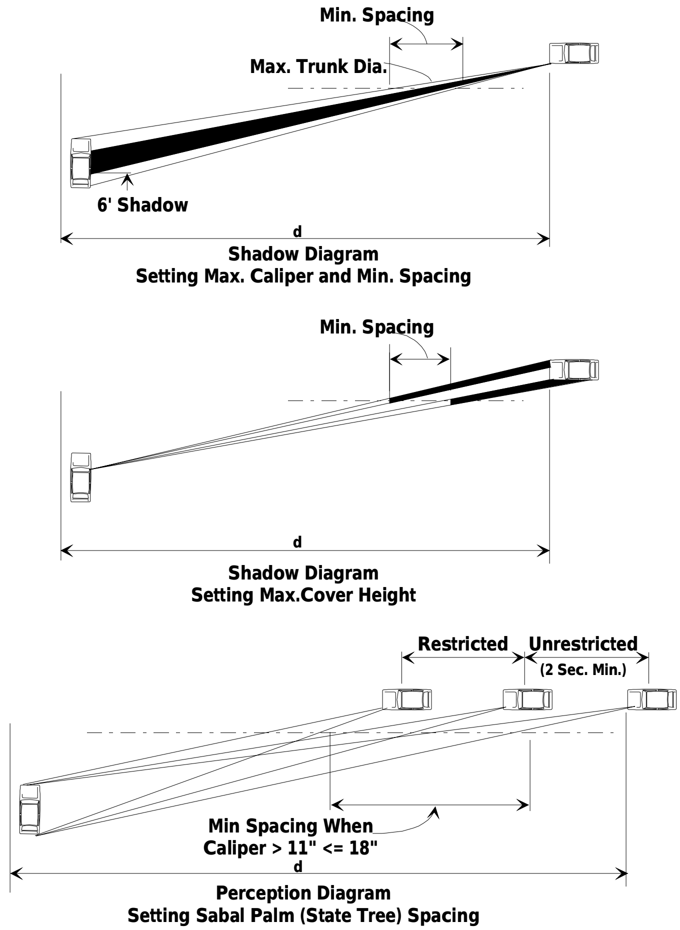
(b) A straight approaching mainline, within skew limits as described in No. 2 above.

(c) 1. Trees and palms ≤ 290 mm in diameter casting a vertical 1.8 m wide shadow band on a vehicle entering at stop bar location when viewed by mainline driver beginning at distance 'd': see SHADOW DIAGRAM, Sheet 2.

2. Sabal palms with diameters > 290 mm - ≤ 450 mm spaced at intervals providing a 2 second full view of entering vehicle at stop bar location when viewed by mainline driver beginning at distance 'd': see PERCEPTION DIAGRAM, Sheet 2.

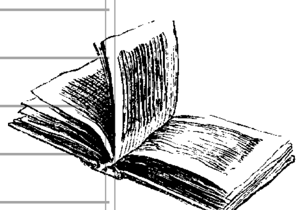
For any other conditions the tree sizes, spacings and locations shall be detailed in the plans: see Design Note No. 4.

The spacing of trees is based on the design speed and the caliper of the tree trunk. Once the caliper of the tree trunk is over 18" or 450mm, the driver can completely loose sight of the other vehicle, therefore, the spacing of the trees increases dramatically to allow a complete 2 second view between trees.



TREES IN MEDIAN INTERSECTION SIGHT CORIDOOR AND OUTSIDE CLEAR ZONE (6' HORIZONTAL CLEARANCE), CURB AND GUTTER

For More Information on Landscaping and Sight Distance



- Florida Highway Landscaping Guide, FDOT - Environmental Management Office (1995)
- AASHTO Green Book (1990), pg. 739
- Standard Index #546 (Sight Distance at Intersections)

CHAPTER 4

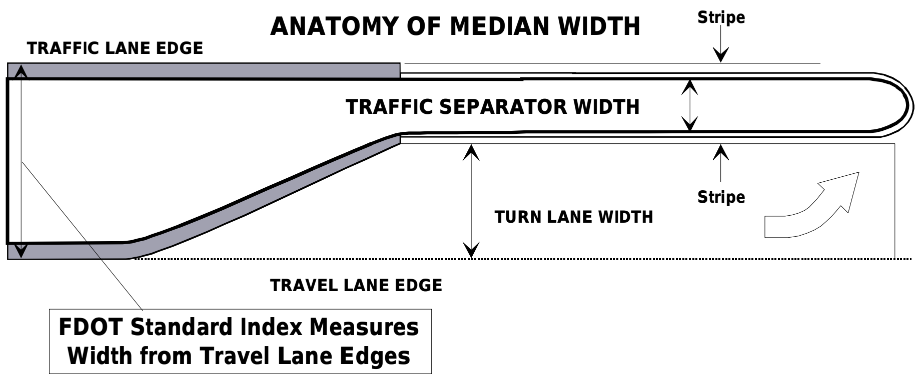
MEDIAN WIDTH

4.1 Function Determines Median Width

The appropriate median width is a function of the purpose which the median is to serve in a particular application. Applications on roadways having at-grade intersections which affect median width include the following:

- Separate opposing traffic streams
- Pedestrian refuge
- Left-turn to side street
- Left-turn out of side street
- Crossing vehicles
- U-turns
- Aesthetics and maintenance

4.2 ANATOMY OF MEDIAN WIDTH



Important Point: Never use the gutter space as part of your turn lane width.

Median width in most urban situations is made to accommodate turning lanes and a separator. The width of both the lane and separator are critical to the operations of the median opening.

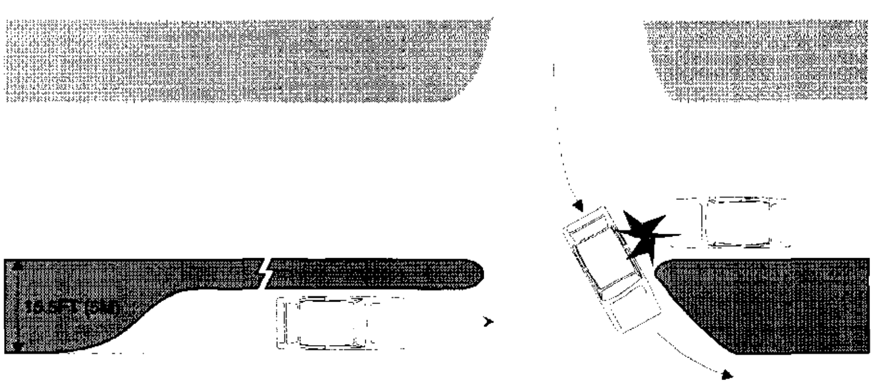
4.3 MINIMUM AND RECOMMENDED WIDTHS

Summary of Standards and Recommendations

		Feet	Meters
Minimum	Plans Preparation Manual (Reconstruction Projects) = 40 mph and less	15.5	5
Minimum	Plans Preparation Manual (Reconstruction Projects) 45 mph	19.5	6
Minimum	Plans Preparation Manual less than 55 mph	22	7
Guidance from Plans Preparation Manual	When greater than 80 km/h (55 mph)	40	12
Recommended	4 lane highways with medians expecting significant u-turns and directional median openings with excellent positive guidance	30 feet for single left turns and 42 feet for dual lefts	9 meters for single left turns and 12.6 meters for dual lefts
Recommended	6 lane highways with medians expecting significant u-turn and direcitonal median openings with excellent positive guidance	22 feet for single left turns and 34 feet for dual lefts	7 meters for single left turns and 10.6 meters for dual lefts

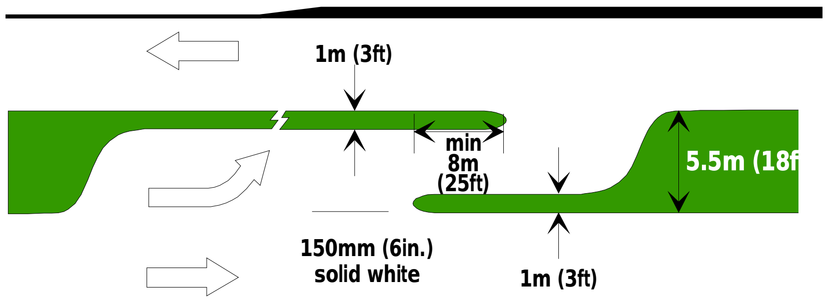
Also remember, where left turns are not expected due to terrain or land use, a median as narrow as 6 feet can help channelize traffic and provide more positive guidance and prevent unwanted left turns.

A critical function of many medians is to protect vehicles turning left. The following figure shows how some narrow medians cannot do this task.

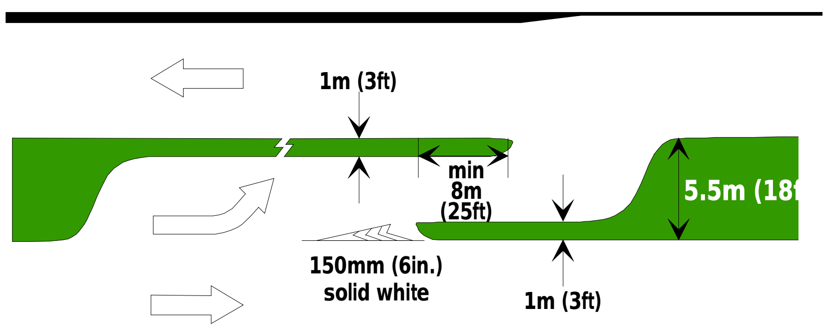


Movements in a 15.5 ft wide (5m) median

4.4 SOME EXAMPLES



Minimum Design for Restrictive Left-Turn Ingress



Desirable Design for Restrictive Left-Turn Ingress

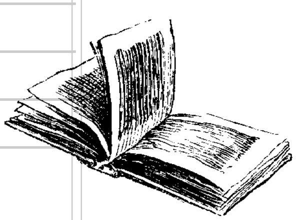
Median Width: 9m (30 ft) - What it does

Desirable Aspects

✔ Greater flexibility in the choice of lane widths and separation width at double left-turn, full median openings.

✔ Additional width for landscaping the overlapping "traffic separators" at directional median openings.

✔ Permits separate vertical and/or horizontal alignment of the two roadways.



For More Information On Turn Lane Width:

- Plans Preparation Manual Table 2.1.1

4.5 MINIMUM TRAFFIC SEPARATOR WIDTH AT INTERSECTIONS

The minimum width of a median traffic separator "nose" has commonly been 1.2m (4 ft). Where the right-of-way is limited, 0.6m (2 ft) and even as little as 460mm (18in.) has been used. AASHTO indicates that "*... the minimum narrow median width of 4 ft is recommended and is preferably 6 to 8 ft wide." (AASHTO Greenbook, p. 835).* The 1994 edition includes the same statement with 1.2m minimum and preferable widths of 1.8 to 2.4m (p. 786).

4.6 PEDESTRIAN CONSIDERATIONS AT TRAFFIC SEPARATORS

Pedestrian refuge minimum for common practice is to use a minimum of a 1.2m (4ft) separator between the left-turn lane and the opposing traffic lane. The minimum width for pedestrian refuge is 1.8m (6 ft). Where more than occasional pedestrians may be present, the median width should be at least 2.5m (8.5 ft) and preferable at least 3 m (10 ft).

4.7 SEEING TRAFFIC SEPARATORS AT INTERSECTIONS

Very narrow median noses are very difficult to see, especially at night and in inclement weather. Reflectorized paint is of little help as it rapidly becomes dirty and loses its limited reflectivity. Reflectorized traffic buttons and/or reflectorized pylons help but lack the "bulk" to provide good "target value".

Carefully selected landscaping is the only effective way to provide excellent visibility of the median and median openings. A minimum traffic separator width of 1.8m (6 ft) and preferable 2.5m (8.5 ft) is needed for the median nose to be of sufficient width back-to-back of curbs to provide adequate area for vegetation to make it highly visible.

Landscaping of the median nose to provide visibility is especially important where long left-turn lanes are used. Obviously the choice of vegetation and the landscaping design must ensure that sight distance is not obstructed.

4.8 MINIMUM MEDIAN WIDTH FOR U-TURNS

SEE CHAPTER 5 FOR COMPLETE ANALYSIS

U-turns should not be permitted from through traffic lane because of the potential for high speed, rear-end crashes and serious detrimental impact on traffic operations. Rather all left-turns, and u-turns should be made from a left-turn/u-turn lane.

Extremely wide medians are needed for a u-turn by all design vehicles other than the P-vehicle, the P-vehicle can not make a u-turn on a 4-lane divided roadway with curb and gutter and commonly used median nose widths. A very high percentage of the automobile fleet is intermediate and smaller than the "P" design vehicle. Small or intermediate vehicles can complete a u-turn on a 4-lane divided roadway having curbs and gutters and a 2m (6 ft) median traffic separator nose.

The design P-vehicle can make a u-turn on a 4-lane divided roadway with a 2m (6 ft) median nose by “flaring” the receiving roadway.

4.9 DESIGN FOR TRUCKS - SEE CHAPTER 5 FOR COMPLETE ANALYSIS

The extremely wide median that is required for buses and trucks to make a u-turn makes it impractical to design for these vehicles except in exceptional cases. The need for u-turns by large vehicles can generally be avoided in the following ways: (1) Bus routes can be laid out so as to eliminate the need for u-turns on a major roadway. (2) Driveway connections can be located and on-site circulation designed to eliminate the need for u-turns by trucks.

CHAPTER 5

SPECIAL U-TURN CONSIDERATIONS

5.1 AASHTO GUIDANCE ON WIDTH AND U-TURNS

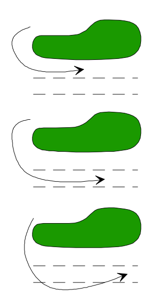
The AASHTO GREEN BOOK contains some guidance on the relation between median width and u-turn movements. Unfortunately, the figure in the Green Book shows the u-turn movements made from the inside (left) lane (AASHTO Figure IX-67, pg. 825). This is contrary to the basic principle of having left turns made in auxiliary lanes rather than through lanes. Therefore, you need to add at least 12 feet (3.6 m) to the width for this purpose. The next figure shows the AASHTO Green Book figures with 12 feet added for a better guide to median width and u-turns.

As you can see, in order to make the width sufficient for a Passenger Car (P) to make a u-turn from the turn lane to the outer lane, it would require 30 feet. If you cannot provide 30 feet, then the car will encroach on to the shoulder. This is okay as long as this encroachment has been built into the design.

When designing for 6 lane highways, 20 feet of median width will usually provide sufficient space for the u-turn for the passenger car (P) vehicle.

IMPORTANT: The "P" vehicle is approximately the size of a luxury car or a Chevy Suburban. Therefore, many vehicles in the passenger car "fleet" can make tighter u-turns.

Minimum Width of Median for U-Turns for 4 Lane Roads



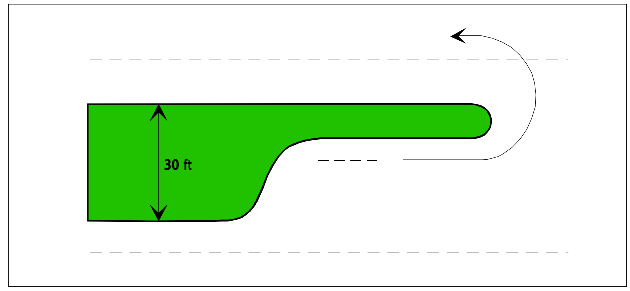
Measures in Feet	Passenger P	Single Unit SU	Semi-Trail WB-50
Turn Lane to Inner Lane	42	75	83
Turn Lane to Outer Lane	30	63	71
Turn Lane to Shoulder	20	53	61

Source: AASHTO Figure IX-67 (with added 12 ft for turn lane width)

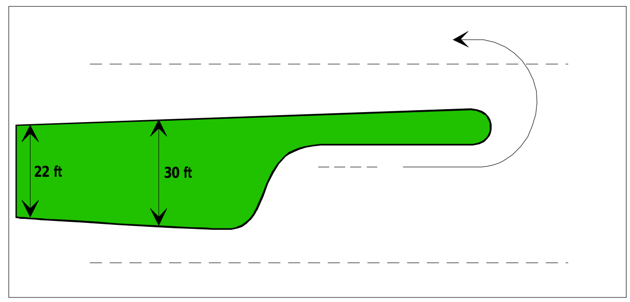
5.2 OPTIONS FOR U-TURNS

In order to handle u-turns there are essentially three options available:

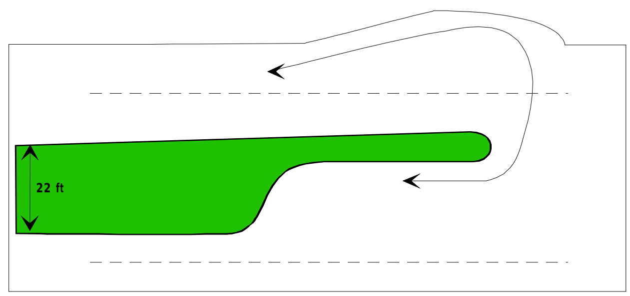
1. Wide medians



2. Median "Bulb-Out"



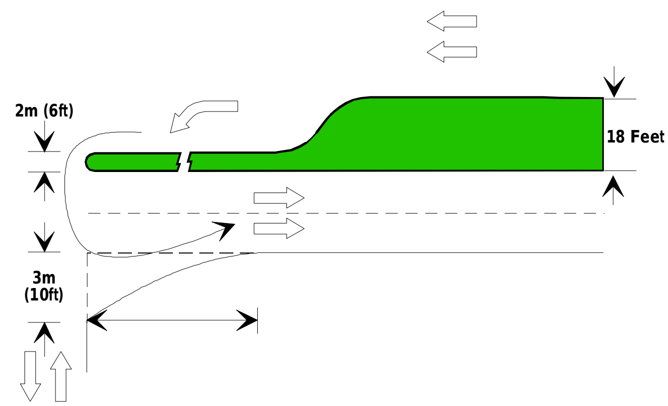
3. Flare-Out (Jug Handles)



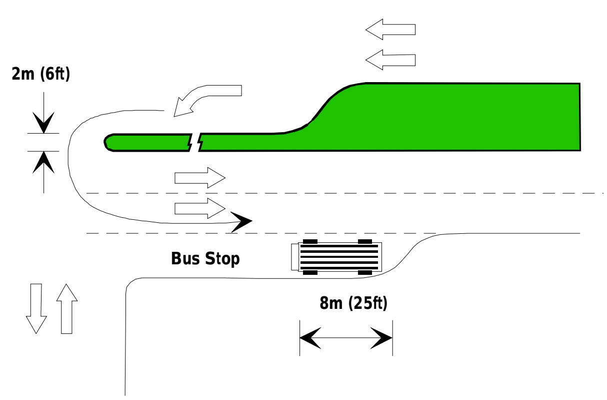
Each of these options have their strengths and weaknesses. Traffic, land use and terrains will play important roles in the decision on their options.

Two Examples of a Flare

The design P-vehicle can make a u-turn on a 4-lane divided roadway with a 2m (6 ft.) Traffic separator by "flaring" the receiving roadway or where a far-side bus stop is used, the u-turn can be accommodated as illustrated in the following Exhibits.



Flare to Allow Design P-Vehicle to Make U-Turn on 4-Lane Divided Roadway Having Curb and Gutter



Design for P-Vehicle U-Turn on 4-Lane Divided Roadway Having Curb and Bus Stop

5.3 TRUCK U-TURNS

Special consideration for truck u-turns is usually not a major consideration.

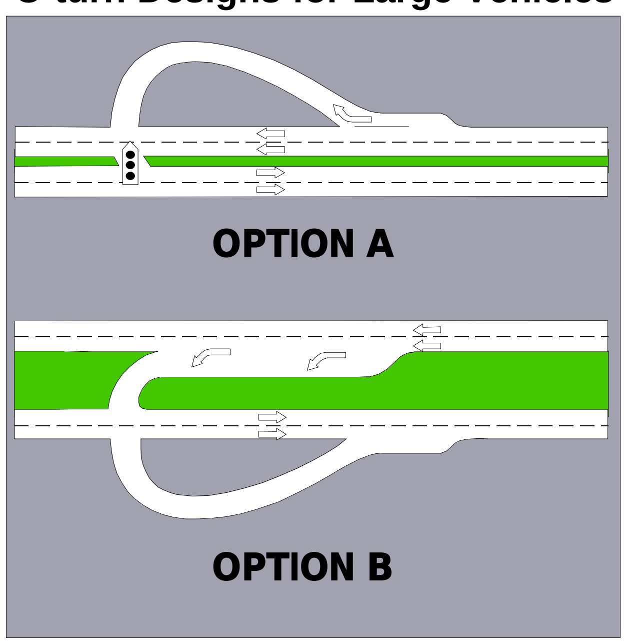
These special designs will probably only be necessary at, or near, truck facilities, major industrial areas, or truck staging areas.

The extremely wide median that is required for buses and trucks to make a u-turn makes it impractical to design for these vehicles except in exceptional cases. The need for u-turns by large vehicles can generally be avoided in the following ways:

- Bus routes can be laid out so as to eliminate the need for u-turns on a major roadway.
- Driveways can be located and on-site circulation designed to eliminate the need for u-turns by trucks.
- Local governments can avoid the need for u-turns by large vehicles through their subdivision, and site development ordinances.

Alternatives for accommodating u-turns by large vehicles (such as delivery, trucks and semis)

U-turn Designs for Large Vehicles



In most cases Option "A" would need a signal. Option "B" has the following desirable operational features.

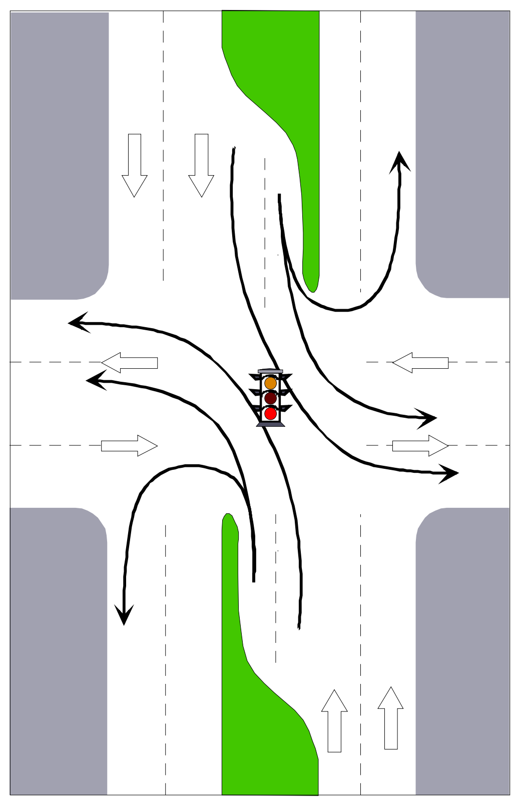
- The u-turning vehicle is stored in the median parallel to the through traffic lanes.
- A suitable gap is needed in the opposing traffic stream only.
- After completion of the u-turn the driver can accelerate prior to merging into the through traffic lane.

These options require more right-of-way than most standard highway designs, but it may be designed into our highway corridors where public land is available such as parks, government maintenance facilities, etc. These truck u-turns might be most helpful on our Florida Intrastate Highway corridors.

5.4 U-TURN LOCATIONS

5.4.1 U-Turn at Signalized Intersections

Where medians are of sufficient width to accommodate dual left-turn lanes, an excellent option is to allow u-turns from the inside (left-most) left-turn bays as illustrated.



U - turns at signal when:

- ✔ Median is of sufficient width
- ✔ Low combined left-turn plus u-turn volume at signalized single left-turn

You should note:

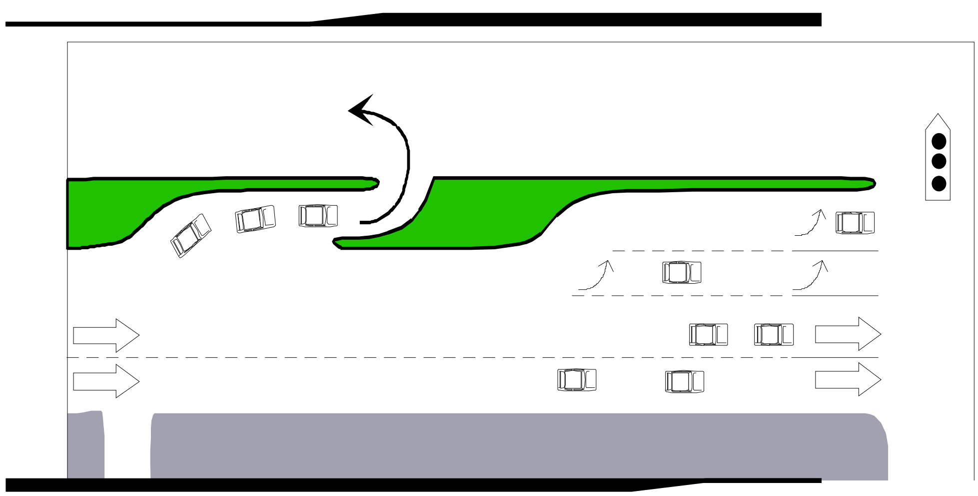
- ✔ Consider "right-on-red" restrictions for side streets
- ✔ Remember to look at signal operation
- ✔ Don't let the signalization work against U-turns.

5.4.2 U-Turns in Advance of a Signal

A u-turn in advance of a signalized intersection will result in two successive left-turn lanes as illustrated in the figure. Unless there is a substantial length of full median width, drivers may mistakenly enter the u-turn lane. And realizing their mistake, make an abrupt re-entry into the through traffic lane. Over one hundred feet of full median width is needed to avoid this problem unless the engineers can see that signage or other markings can be used to guide the driver.

Indications that you should consider a U-Turn opening before a signal are:

- ✔ Level of Service problems at intersection
- ✔ Heavy left turns currently at signal
- ✔ High conflicting right turn
- ✔ Lanes at signalized side street (where restrictions would hurt)
- ✔ Where gap of oncoming vehicles would be beneficial at separate U-turn opening
- ✔ Where there is sufficient space to separate signalized intersection and opening



5.4.3 U-Turn After Signal

Locating the u-turn after a traffic signal has the same separation issues as the U-Turn located before a signal. There should be sufficient space to assure left and U-turns don't become confused on the location of their turn lanes.

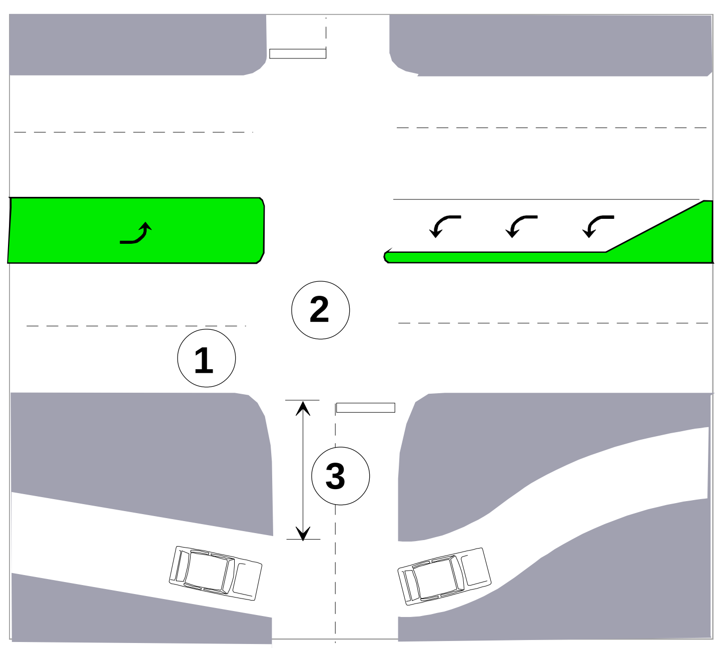
CHAPTER 6

WHERE THE TURNING VEHICLE GOES

INTRODUCTION

As a vehicle turns left from a median opening and crosses the highway, it enters the driveway and side street. The design of this entrance is critical to the safety and operations of the median opening. The three major areas of concern for access management issues here are:

1. Design of driveway (geometrics)
2. Placement of driveway in relation to the median opening and neighboring streets or connections.
3. How far the driveway should extend before the first conflict. (Throat Length)



6.1 WHAT TO LOOK FOR

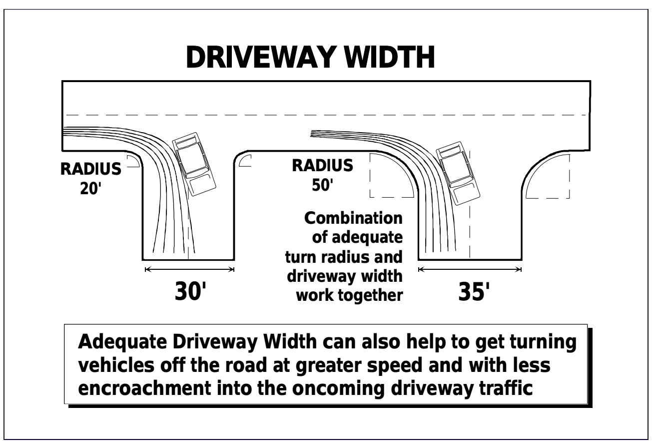
The geometric design of all access connections should allow drivers to complete the ingress maneuver (enter the abutting sidestreet or property) with minimum effect on vehicles in the through traffic lane.

Things to Look For:

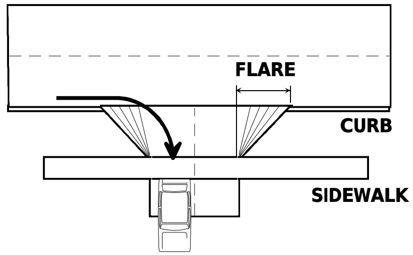
- ✔ Proximity to Other Access Connections and Median Openings
- ✔ Driveway Profile and Grade
- ✔ Curb Return Radius and Throat Width
- ✔ Throat Length (distance before first conflict)
- ✔ Queue Storage
- ✔ Traffic Control

6.2 CURB RETURN RADIUS AND THROAT WIDTH

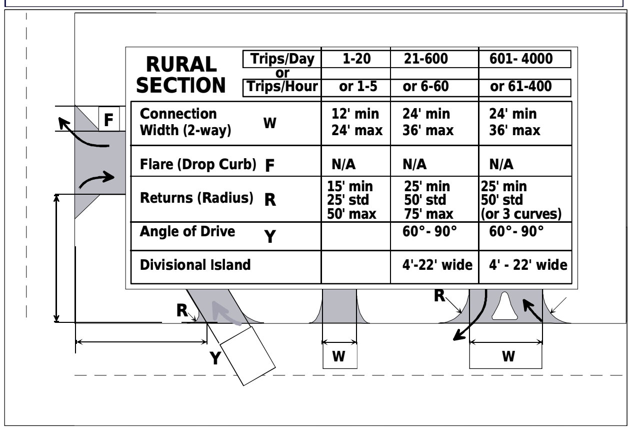
The combination of curb return radius and throat width should allow drivers to enter and exit an access connection quickly and with minimal interference with through traffic. These figures show that the trajectories of right-turning vehicles entering an access connection are less dispersed when a long entry curb radius is used. Thus, narrower entry widths can be used on connections which have larger radii.



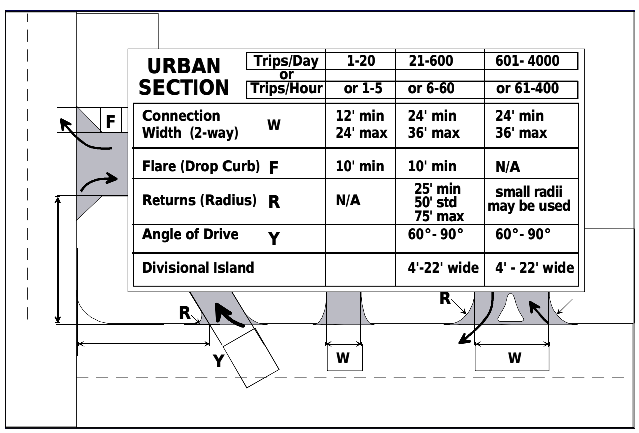
DRIVEWAY FLARE



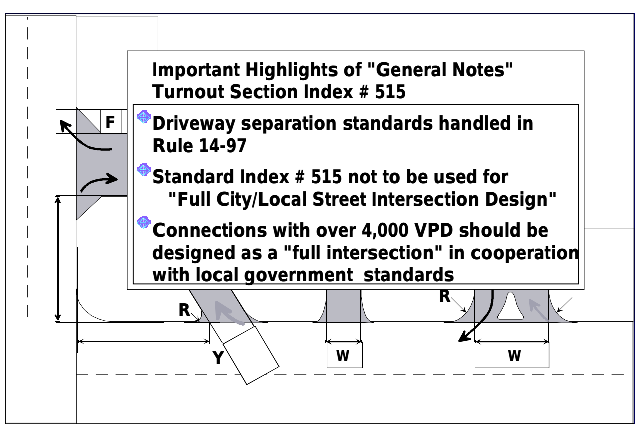
Driveway flare is used to replicate turn radius in areas with curb and gutter construction



RURAL SECTION		Trips/Day or Trips/Hour	1-20 or 1-5	21-600 or 6-60	601- 4000 or 61-400
Connection Width (2-way)	W		12' min 24' max	24' min 36' max	24' min 36' max
Flare (Drop Curb)	F		N/A	N/A	N/A
Returns (Radius)	R		15' min 25' std 50' max	25' min 50' std 75' max	25' min 50' std (or 3 curves)
Angle of Drive	Y			60°- 90°	60°- 90°
Divisional Island				4'-22' wide	4' - 22' wide



URBAN SECTION		Trips/Day or Trips/Hour	1-20 or 1-5	21-600 or 6-60	601- 4000 or 61-400
Connection Width (2-way)	W		12' min 24' max	24' min 36' max	24' min 36' max
Flare (Drop Curb)	F		10' min	10' min	N/A
Returns (Radius)	R		N/A	25' min 50' std 75' max	small radii may be used
Angle of Drive	Y			60°- 90°	60°- 90°
Divisional Island				4'-22' wide	4' - 22' wide



Important Highlights of "General Notes" Turnout Section Index # 515

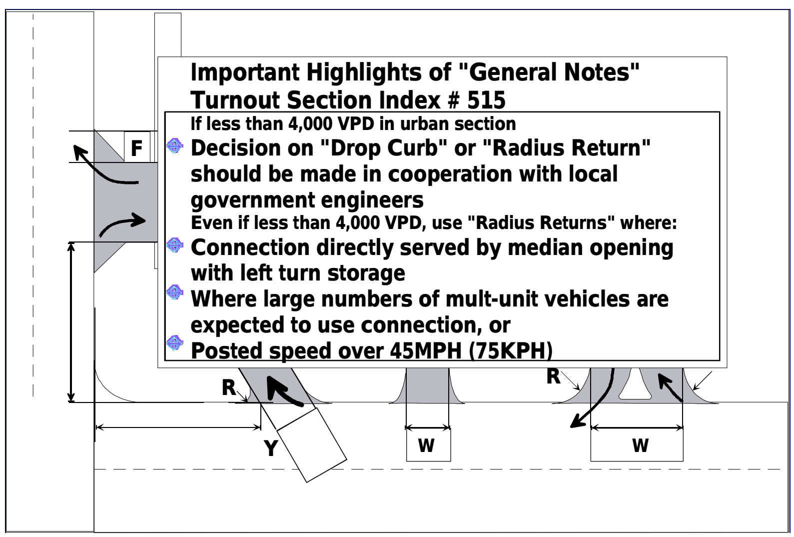
- **Driveway separation standards handled in Rule 14-97**
- **Standard Index # 515 not to be used for "Full City/Local Street Intersection Design"**
- **Connections with over 4,000 VPD should be designed as a "full intersection" in cooperation with local government standards**

Florida Department of Transportation Standard Index #515 (Turnouts)

TRIP GENERATION EXAMPLES

1-20 trips/day or 1-5 trips/hour	1 or 2 single family homes
21-600 trips/day or 6-60 trips/hour	Quadraplex Apartment building < 60 units Small office in converted home Mom & Pop business
601-4,000 trips/day or 61-400 trips/hour	Small "STRIP" shopping center (20 - 75K ft) Gas station/Convenience market
over 4,000 trips/day or over 400 trips/hour	150K ft shopping center- grocery/drug store + 10-15 smaller stores (9,000 trips split w/ 2 driveways)

if they have more than one driveway, there wil be less traffic on each driveway

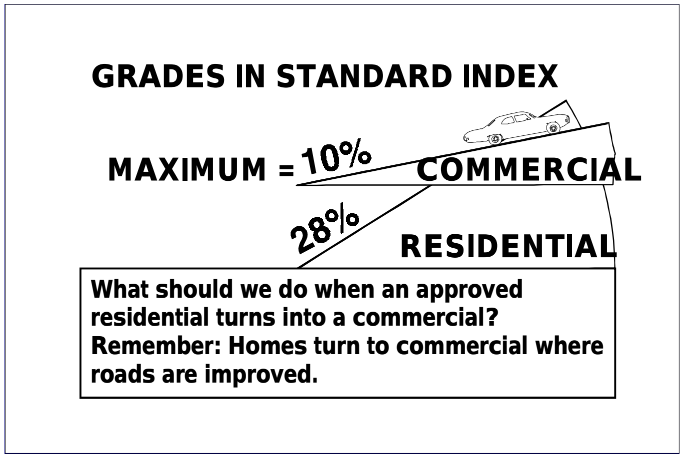


Important point: Radius returns are needed anytime a driveway or side street is served by a median opening. Source: Standard Index #515

Florida Department of Transportation has guidance to help in the design of these driveways. Most of this guidance is found in the Standard Index #515.

6.3 DRIVEWAY PROFILE

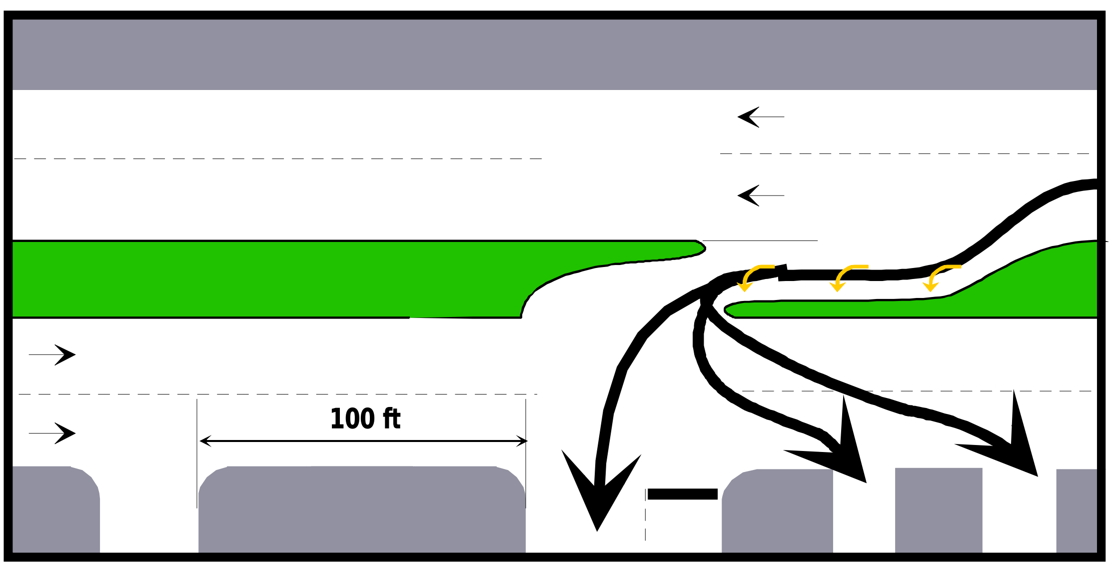
The vertical profile of all access connections should permit drivers to make a smooth, comfortable transition from the highway onto the abutting site.



6.4 PLACEMENT OF DRIVEWAYS

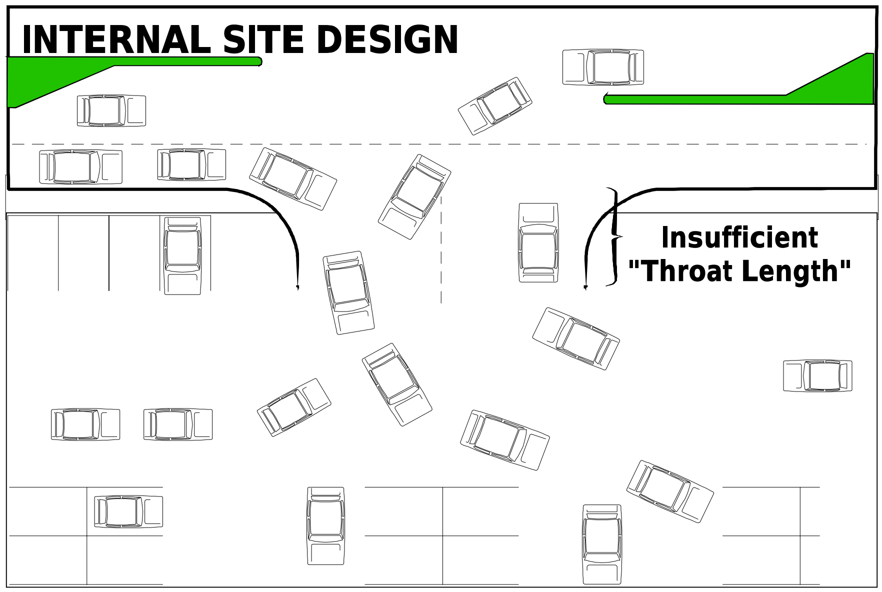
Access connections should be located directly opposite or downstream from a median opening as illustrated. Driveway access should be located more than 30 m (100 ft) upstream from the median opening to prevent wrong way maneuvers as seen in the figure.

ENTRY MANEUVERS

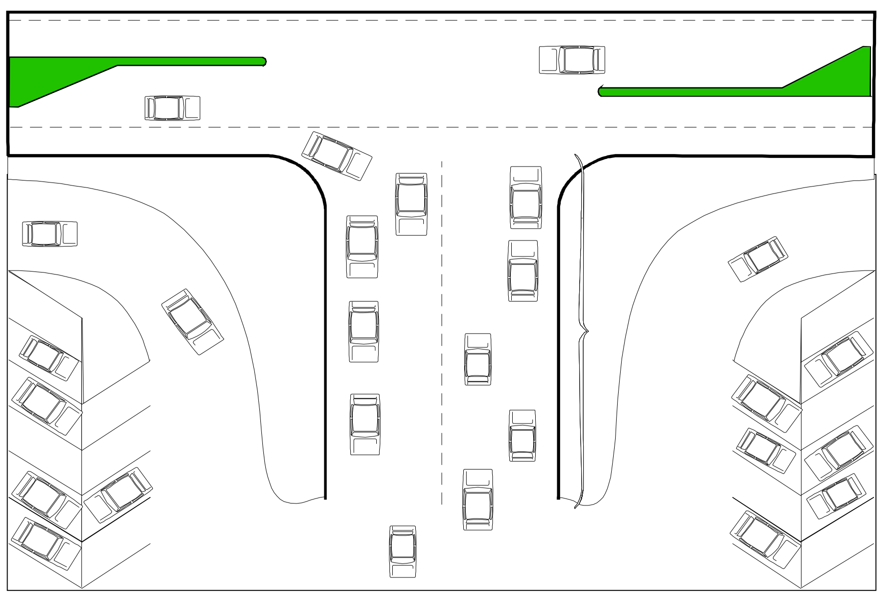


6.5 THROAT LENGTH

The throat length must be of sufficient length to enable the intersection at the access connection and abutting highway and the on-site circulation to function without interference with each other. Drivers entering the site should first clear the intersection of the highway and access connection before encountering the intersection of the access connection and on-site circulation. The figure illustrates the problem for entering traffic when the throat is too short.

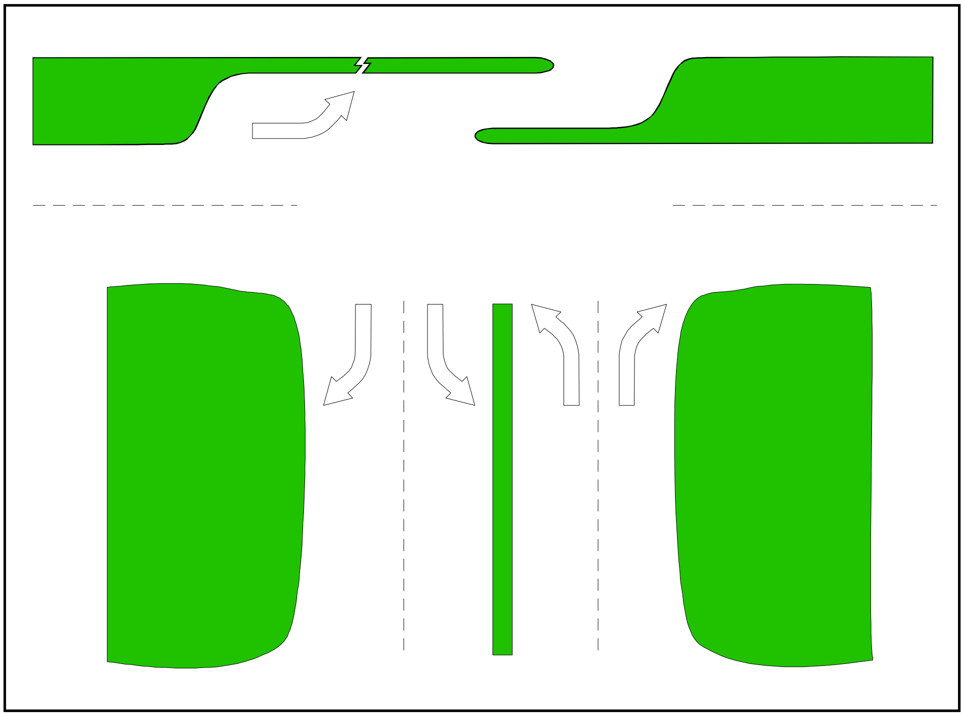


Important Point: If the site is so small, you cannot get good throat length, does it need a median opening?



6.6 CHANNELIZATION AT MEDIAN OPENING ENTRANCES

As mentioned in Standard Index #515, connections served by median openings should be treated like street intersections. With this in mind, separation of traffic movements and channelization becomes an important issue. At a minimum a separate left turn out becomes necessary.



INDEX

R

S

T

U

V

W