



**National Handbook of Traffic Control Practices for
Low Volume Rural Roads and Small Cities
VOLUME II: Small Cities**

MBTC 9206-2

Dr. Eugene R. Russell, P.E.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY <i>(Leave Blank)</i>	2. REPORT DATE 11/22/03	3. REPORT TYPE AND DATES COVERED	
4. TITLE AND SUBTITLE National Handbook of Traffic Control Practices for Low Volume Rural Roads and Small Cities VOLUME II: Small Cities		5. FUNDING NUMBERS <i>(leave blank)</i>	
6. AUTHOR(S) Dr. Eugene R. Russell, P.E.		8. PERFORMING ORGANIZATION REPORT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Mack-Blackwell Transportation Center 4190 Bell Engineering Center University of Arkansas Fayetteville, AR 72701			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) US Department of Transportation Research and Special Programs Administration 400 7 th Street, S.W. Washington, DC 20590-0001		10. SPONSORING/MONITORING AGENCY REPORT NUMBER <i>(office use - leave blank)</i>	
11. SUPPLEMENTARY NOTES Supported by a grant from the U.S. Department of Transportation University Transportation Centers program			
12a. DISTRIBUTION/AVAILABILITY STATEMENT <i>(to be completed by reporting agency - leave blank)</i>		12b. DISTRIBUTION CODE N/A	
13. ABSTRACT (MAXIMUM 200 WORDS) The purpose of this handbook is to assist local officials in the application of Traffic Engineering practices within their community. The traffic problems encountered by local officials are not unique within their jurisdiction. Common problems will generally have common solutions. The solutions to these problems can, therefore, be identified from examples generated from the experience of others. It is recognized that local officials receive questions relative to traffic concerns on a daily basis. It is also recognized that most communities will not have constant access to professional traffic engineering expertise. This handbook is written in a question and answer format, answering key questions considered relevant to small city personnel. This handbook will provide answers to those questions. It will provide methods for developing the answers to other questions. It will also provide direction to other sources of information.			
14. SUBJECT TERMS Low Volume, Township, Road		15. NUMBER OF PAGES	
17. SECURITY CLASSIFICATION OF REPORT none		16. PRICE CODE N/A	
		20. LIMITATION OF ABSTRACT N/A	
18. SECURITY CLASSIFICATION OF THIS PAGE none	19. SECURITY CLASSIFICATION OF ABSTRACT none		



1. Report Number MBTC 9206	2. Government Access No. <i>(leave blank)</i>	3. Recipient's Catalog No. <i>(leave blank)</i>	
4. Title and Subtitle National Handbook of Traffic Control Practices for Low Volume Rural Roads and Small Cities VOLUME II: Small Cities		5. Report Date	6. Performance Organization Code
7. Author(s) Dr. Eugene R. Russell, P.E.		8. Performing Organization Report No.	
9. Performing Organization Name and Address Mack-Blackwell Transportation Center 4190 Bell Engineering Center University of Arkansas Fayetteville, AR 72701		10. Work Unit No. (TRAIS) <i>(leave blank)</i>	11. Contract or Grant No. <i>(leave blank)</i>
12. Sponsoring Agency Name and Address US Department of Transportation Research and Special Programs Administration 400 7 th Street, S.W. Washington, DC 20590-0001		13. Type of Report and Period Covered	
15. Supplementary Notes Supported by a grant from the U.S. Department of Transportation University Transportation Centers program		14. Sponsoring Agency Code <i>(leave blank)</i>	
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17. Key Words Low Volume, Township, Road		18. Distribution Statement No restrictions. This document is available from the National Technical Information Service, Springfield, VA 22161	
19. Security Classif. (of this report) unclassified	20. Security Cassif. (of this page) unclassified	21. No. of Pages	22. Price N/A

**National Handbook of
Traffic Control Practices for
Low Volume Rural Roads and
Small Cities
VOLUME II: Small Cities**

Based On:

**Manual on Uniform
Traffic Control Devices**

Millennium Edition



...serving rural America
MACK-BLACKWELL
Transportation Center



Mack Blackwell Transportation Center
Kansas State University
First National Edition 2003

National Handbook of Traffic Control Practice for Low Volume Rural Roads and Small Cities

This National handbook was made possible by funding from Mack Blackwell Transportation Center.

Project Director/Author:
Dr. Eugene R. Russell, P.E.
Department of Civil Engineering
Kansas State University.

Assistant:
Vijay Kumar Komala, E.I.T,
Graduate Student,
Department of Civil Engineering,
Kansas State University.

...serving rural America
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2003

Disclaimer

The contents of this handbook, National Handbook of Traffic Control Practices for Low Volume Rural Roads (NLVR) and the National Handbook of Traffic engineering Practices for Small Cities (NSCH) reflect the views of the Kansas State University Project Director, who is responsible for the contents and facts and accuracy of the data presented in them. The National LVR Handbook has its basis in a state-specific handbook the Director/Author developed for the Kansas DOT; however, all additions, deletions, modifications and /or deviations to better reflect a national Handbook are solely the responsibility of the Project Director. The contents do not necessarily reflect the views or approval of Mack Blackwell Transportation Center, Kansas State University, the Kansas Department of Transportation, nor any local agency in Kansas or their representatives. The handbooks are meant primarily to supplement the Millennium edition of Manual of Traffic Control Devices (MUTCD 2000) and assist in the proper application of MUTCD 2000. Should there be any discrepancy, actual or implied, MUTCD 2000 should be followed.

These Handbooks do not constitute a standard, specification of regulation.

Acknowledgements

The director acknowledges three individuals who contributed material, made suggestions and authored some sections.

Andy Haney, City of Ottawa, KS.

Larry Mangan, City of Wellington, KS.

Bruce Remsberg, Professional Engineering Consultants.

Table of Contents

Ch.	Title	Page
	Introduction	vii
1	Traffic Ordinances	1
2	Traffic Signs	5
3	Stop Signs.....	13
4	Speed Limits	19
5	Pavement Markings.....	27
6	School Crossings.....	35
7	Traffic Signals.....	43
8	Flashing Beacons	56
9	Traffic Sign Inventory	59
10	Traffic Crashes.....	64
11	Roadway Lighting.....	71
12	Railroad Crossings	77
13	Parking	84
14	Driveways.....	95
15	Private Property Development	100
16	Temporary Traffic Control	104
	APPENDIX – A Traffic Calming Measures.....	115
	APPENDIX – B	122
	APPENDIX – C.....	132

List of Tables

	Page
Table 1. Guideline for Advance Placement of Warning Signs.....	10
Table 2. Visibility Requirements for Stop Signs.....	15
Table 3. Frequency Distribution Table.....	25
Table 4. General Countermeasures for Accident Patterns and Their Probable Causes.....	68
Table 5. Minimum Sight Distances for Combinations of Highway and Train Vehicle speeds.....	83
Table 6. Parking Requirements by Land Use.....	85
Table 7. Parking Layout Dimensions for Varying Degrees of Angle Parking.....	90
Table 8. Number of Spaces Required to Satisfy ADA Regulations.....	93
Table 9. Summary of Trip Generation Rates.....	101

List of Figures

		Page
Figure 1.	Height and Lateral Location of Sign Typical Installation.....	8
Figure 2.	Cumulative Speed Distribution Curve.....	24
Figure 3.	Typical Two-Lane, Two-Way Marking Applications.....	30
Figure 4.	Typical Types of Crosswalk Markings.....	33
Figure 5.	Typical Crosswalk Markings for Exclusive Pedestrian Phase that Permits Diagonal Crossing.....	33
Figure 6.	Standard School Signs.....	40
Figure 7.	Maximum Mounting Height of Signal Faces Located Between 12 Meters and 16 Meters From Stop Line.....	47
Figure 8.	Horizontal Location of Signal Phases.....	48
Figure 9.	Example Intersection.....	52
Figure 10.	Typical Collision Diagram.....	67
Figure 11.	Typical Luminaire Mounting Arrangements.....	74
Figure 12.	Typical Lightning Plan for Intersections.....	76
Figure 13.	Typical Pavement Markings at Railroad-Highway Grade Crossing.....	80
Figure 14.	Typical Highway-Railgrade Crossing Pavement Markings.....	81
Figure 15.	Sight Distance Triangle for Railroad Crossings.....	82
Figure 16.	Curb Parking Configuration.....	89
Figure 17.	Construction Signs.....	107
Figure 18.	Typical Work Zone Signing.....	108
Figure 19.	Use of Hand Signaling Devices by Flaggers.....	113
Figure 20.	Top-Street Closure; Bottom-Traffic Divertor.....	116
Figure 21.	Speed Humps.....	117
Figure 22.	Bulb-out Intersection.....	118
Figure 23.	Choker.....	118
Figure 24.	Mid-block bulb-out with speed hump.....	119
Figure 25.	Chicane.....	119
Figure 26.	Mini Traffic Circle.....	120
Figure 27.	Modern Roundabout.....	121
Figure 28.	Corridor Overlay.....	123
Figure 29.	Inadequate Corner Clearance.....	124
Figure 30.	Joint and Cross Access.....	124
Figure 31.	Cross Access.....	125
Figure 32.	Shared Access.....	126
Figure 33.	Reverse Frontage.....	126
Figure 34.	Avoid Flag Lots.....	127
Figure 35.	Lots of Frontage Requirements.....	127

	Page
Figure 36.	Driveway spacing standards.....129
Figure 37.	Key Features of a Roundabout.....133
Figure 38.	Roundabout Dimension Locations.....135

INTRODUCTION

The purpose of this handbook is to assist local officials in the application of Traffic Engineering practices within their community. The traffic problems encountered by local officials are not unique within their jurisdiction. Common problems will generally have common solutions. The solutions to these problems can, therefore, be identified from examples generated from the experience of others. It is recognized that local officials receive questions relative to traffic concerns on a daily basis. It is also recognized that most communities will not have constant access to professional traffic engineering expertise. This handbook is written in a question and answer format, answering key questions considered relevant to small city personnel. This handbook will provide answers to those questions. It will provide methods for developing the answers to other questions. It will also provide direction to other sources of information.

The local official must also recognize that, regardless of the size of the organization, there will be traffic-engineering issues beyond local abilities. The local authorities must use judgment to determine when the use of outside help is necessary. This handbook should be helpful in making that determination.

The primary resource for this handbook is the Manual on Uniform Traffic Control Devices Millennium Edition. It will often be referred to within the handbook as the MUTCD 2000. The MUTCD 2000 is an essential tool for any agency concerned with the placement and maintenance of traffic control devices. This manual can be obtained from several commercial sources. It can also be accessed on the Internet site at the following address:

<http://mutcd.fhwa.dot.gov/kno-millennium.htm>

The documents can be viewed there and are provided in a printable format.

The 28th Edition of the Standard Traffic Ordinance for Kansas Cities (commonly referred to as the STO) was also used as a reference. These ordinances may not apply in all states. It is recommended that all Cities check their respective state DOT or state league of municipalities if such a document is available, and adopt it by reference. In Kansas the League of Kansas Municipalities produces this document annually and will provide assistance with its adoption.

Other references used are noted within the handbook.

The user of this handbook should recognize that the source documents referenced might, and probably will, be revised. If any conflicts arise between this handbook and the MUTCD 2000 or the STO, those documents shall govern.

Traffic control guidelines contained in this handbook do not necessarily represent those used by the Department of Transportation (DOT) on the State Highway System in your state. All traffic control devices used on the State Highway System within cities usually must comply with the state policies. For example, in Kansas, additions or alterations cannot be made to traffic control devices on the State Highway System without prior approval of the Secretary of Transportation.

CHAPTER 1
TRAFFIC ORDINANCES

INTRODUCTION

Municipalities have the authority to adopt ordinances for control of traffic on their street systems. Ordinances may not, of course, conflict with State Statutes, and they must be within the scope of those matters specifically authorized by the State legislature. All municipalities have an obligation as well to periodically review their ordinances and to update them as conditions change and new needs arise.

The latest edition of the National Model Traffic Ordinance, developed and published by the National Committee on Uniform Traffic Laws and Ordinances (NCUTLO), 1977 Massachusetts Avenue, N.W., Washington, D.C. 20036, may serve as a useful reference in drafting local traffic ordinances.

ARE THERE LIMITS TO THE LOCAL CONTROL AND REGULATION OF TRAFFIC?

Local governments may exercise control only over those portions of the local streets or highway systems over which they have jurisdiction. If the traveled portion of a street is under state jurisdiction, for instance, the municipality may not regulate the speed. On the other hand, if the municipality is responsible for maintaining the parking lanes on the same street, it may regulate such parking. Most state Vehicle Codes permits local regulation of the following traffic elements:

1. Standing or parking.
2. Traffic regulation by police officers or traffic signals.
3. Processions or assemblages on highways.
4. Designation of one-way streets.
5. Speed regulation in public parks.

6. Designation of "through" streets and Stop signs at intersections.
7. Permits for excess size and weight.
8. Regulation of bicycles, including licensing.
9. Turn movements at intersections.
10. Speed regulations on city streets (see Chapter 4 for information on setting speed limits).
11. U-turns
12. Jaywalking (establishment of pedestrian crossings).
13. Parking restrictions during snow removal.
14. Handicapped parking.

Other sections of the law permit local authorities to establish temporary or permanent weight restrictions and to limit the use of highways by vehicle type (establishment of truck routes). Any local regulation is effective and enforceable only when the appropriate signs or other regulatory devices are in place.

**IS AN ORDINANCE NECESSARY FOR EACH LOCATION IN THE CITY
HAVING SOME TRAFFIC CONTROL DEVICE?**

An ordinance must be passed which restricts or prohibits a specific traffic operation. This ordinance must specify each location, street, or section within the municipality to which it applies. In other words, if a city passes an ordinance that prohibits parking at all times, the language of the ordinance must include the names of all streets in the city and the specific locations where parking will be prohibited. This underscores the need not only for making an initial assessment of the location in the city that must be covered by ordinance, but also the need for a periodic review of these locations to determine if changes are necessary.

**WHAT TYPES OF TRAFFIC CONTROL SIGNS, SIGNALS, AND
DEVICES REQUIRE AN ORDINANCE?**

The MUTCD 2000 illustrates most of the standard devices now available and details their appropriate uses. However, not all devices require an ordinance. The following is a list of those, which should have ordinance authority:

1. Stop Signs
2. Weight Limit Signs
3. Yield Signs
4. Truck Route or Truck Regulations
5. Speed Limit Signs
6. Prohibition Signs
7. Parking Signs
8. Loading Zone Signs
9. One-Way Street Signs

DO WARNING AND ADVISORY SIGNS, NEED TO BE COVERED BY ORDINANCE?

Warning and advisory signs do not require ordinances, but all such signs do need to conform to the shape, size and color indicated in the MUTCD 2000.

CAN A MUNICIPALITY REGULATE ON PRIVATE PROPERTY?

Normally, "no". However, local government agencies may enter into agreements with school boards, hospitals, shopping centers and apartment complexes to establish and enforce traffic regulations in parking areas associated with those facilities.

WHAT STEPS SHOULD A MUNICIPALITY TAKE TO MAKE SURE ORDINANCES ARE PROPER AND ENFORCEABLE?

A municipality should take steps to ensure that:

1. The ordinance deals with an activity over which the municipality has jurisdiction and that it does not conflict with state statutes.
2. The ordinance is clear and specific in defining the activity being regulated and the nature of the restriction or limitation.
3. The public is adequately notified through appropriate regulatory devices.
4. All regulatory signs and other devices comply with the requirements of the MUTCD 2000 and that any MUTCD 2000 specified warrants are, in fact, met.

CHAPTER 2

TRAFFIC SIGNS

INTRODUCTION

Traffic signs are the most commonly used traffic control devices. They provide regulatory, warning and directional information to motorists. The use of traffic signs should be limited to those locations where they are needed. Traffic signs are not needed to confirm rules of the road. To be effective, a traffic control device should meet five basic requirements:

1. Fulfill a need.
2. Command Attention.
3. Convey a clear, simple meaning.
4. Command respect of road users.
5. Give adequate time for proper response.

Unfortunately, traffic signs are too often misused. In many instances the wrong sign is used for an application. In many more, signs are used where none should be. The need for standards in signs and their use was recognized many years ago. The first such standard was published in 1927. These standards have been perfected and expanded over the ensuing years to meet evolving traffic conditions. The current standards are set out in the Manual on Uniform Traffic Control Devices, Millennium Edition, referred to hereafter as MUTCD 2000. Local authorities need to recognize their responsibilities in meeting these standards in the traffic signs and other control devices they install. The following paragraph is quoted from the MUTCD 2000 and is provided to emphasize the importance of complying with these accepted standards.

“The Manual on Uniform Traffic Control Devices (MUTCD) is incorporated by reference in 23 Code of Federal Regulations (CFR), Part 655, Subpart F and shall be recognized as the national standard for traffic control devices on all public roads open to public travel in accordance with 23 U.S.C. 109(d) and 402(a).”

WHAT DO "STANDARD, GUIDANCE, OPTION AND SUPPORT" MEAN?

MUTCD 2000 has a new format. The old "shall," "should" and "may" statements have been replaced by sections labeled "standard," "guidance" and "option," respectively, and sections labeled "support" have been added for background material.

As defined in the MUTCD 2000, these are:

1. **Standard:** a statement of required, mandatory, or specifically prohibitive practice regarding a traffic control device. All standards are labeled, and the text appears in bold type. The verb shall is typically used. Standards are sometimes modified by Options.

2. **Guidance:** a statement of recommended, but not mandatory, practice in typical situations, with deviations allowed if engineering judgment or engineering study indicates the deviation to be appropriate. All Guidance statements are labeled. The verb should is typically used. Guidance statements are sometimes modified by Options.

3. **Option:** a statement of practice that is a permissive condition and carries no requirement or recommendation. Options may contain allowable modifications to a Standard or Guidance. All Option statements are labeled. The verb may is typically used.

4. **Support:** an informational statement that does not convey any degree of mandate, recommendation, authorization, prohibition, or enforceable condition. Support statements are labeled. The verbs shall, should, and may are not used in Support statements.

WHAT TYPES OF SIGNS ARE AVAILABLE FOR TRAFFIC CONTROL AND MANAGEMENT?

There are three (3) types of signs. These are classified according to their use.

1. Regulatory Signs give the driver notice of traffic laws and regulations that apply at a given place or on a given roadway. To disregard these signs is punishable by law. Examples: Stop Signs, Yield Signs, and Speed Limits.
2. Warning Signs call attention to conditions in or around a roadway, which are potentially hazardous to traffic operation. Examples are: Curve, Signal Ahead, Stop Ahead, Slippery When Wet.
3. Guide Signs show route destinations, directions, distances, points of interest and other geographical or cultural information including street names and parking areas.

DO ALL SIGNS HAVE TO MEET CERTAIN SPECIFICATIONS IN SIZE, SHAPE AND COLORING?

All regulatory and warning signs are required to conform to the MUTCD 2000. These guidelines are published by the Federal Highway Administration, and are the law in the State of Kansas. There is more flexibility with the design of guide signs and object markers, but where indicated in the MUTCD 2000, some guide signs must meet certain specifications.

1. Table 2B-1 of the MUTCD 2000 provides information on the various sizes of regulatory signs.
2. Table 2C-2 of the MUTCD 2000 provides information on the various sizes of warning signs.
3. Table 2C-3 of the MUTCD 2000 provides information on the various sizes of warning plaques.

WHAT IS RETROREFLECTIVITY?

Retroreflectivity is defined in the MUTCD 2000 as a property of a surface that allows a large portion of the light coming from a point source to be returned directly back to a point near its origin. Unless, specifically stated otherwise, all signs shall be either retroreflective or illuminated to show the same size and shape at night as in the daylight. The Federal Highway Administration (FHWA) is expected to publish guidelines on minimum sign retroreflectivity in 2003. Illumination of a sign must be specific to that sign. The requirements for illumination can not be satisfied by general street lighting.

ARE THERE A SPECIFIC MOUNTING HEIGHT AND LOCATION REQUIREMENTS FOR SIGNS?

1. **Location** - Signs should be located on the right hand side of the roadway where drivers are in the habit of looking for them. Signs are normally erected individually on separate posts or mountings, except where one sign supplements another or they must be grouped. In urban areas, two signs should not be located closer together than 100 feet along the street, except at intersections. All signs should be located so motorists can see them without obstruction for a distance of at least 200 feet.

Supplemental signs may be erected in a raised median

2. **Height** - Signs on roadsides in rural suburban areas should be mounted at least five (5) feet above the level of the pavement or roadway edge measured to the bottom of the sign. In an area where parking might occur or where obstructions may block the motorist's view, the clearance to the bottom of the sign should be a minimum of seven (7) feet. If a secondary sign is mounted below a sign, the bottom of the major sign shall be a minimum of eight feet and the bottom of the secondary sign shall be a minimum of five feet above the level of the pavement edge. See Figure 1.

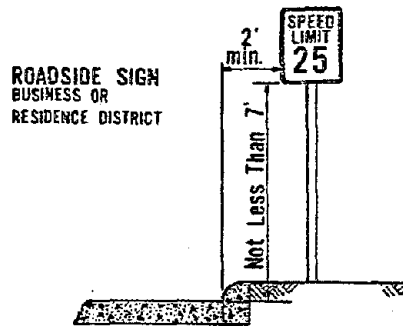


FIGURE 1. HEIGHT AND LATERAL LOCATION OF SIGN TYPICAL URBAN INSTALLATION

3. **Lateral Clearance** - Signs need to be readily visible to motorists but should not be so close to the roadway that they are a hazard to drivers who leave the road. The minimum lateral offset from the edge of the shoulder (or if no shoulder exists, from the edge of the pavement) to the near edge of a roadside-mounted sign shall be six (6) feet. However, in

urban areas where lateral offsets are limited, a minimum lateral offset of two (2) feet may be used. In addition, a minimum offset of one (1) foot from the face of the curb may be used where sidewalk width is limited or where existing poles are close to the curb. Stop and Yield signs should not be placed more than ten (10) feet from the edge of the pavement. The presence of underground utilities must be considered when installing signs, however the minimum clearances may not be violated due to location of such utilities.

4. Erection Details - Signs are normally mounted at right angles to the direction of, and facing, the traffic they are intended to serve. The installation of Parking signs, which may be installed at an angle of between 30 degrees and 45 degrees to the line of traffic, is the only exception to this standard. Should the mirror reflection of the sign reduce its legibility, the sign may be turned slightly away from the road (2 to 5 degrees). On curves, the sign should face approaching traffic rather than be aligned with the road. Sign faces are normally vertical but they can be tilted forward or backward on grades to improve the viewing angle.

WHERE SHOULD WARNING SIGNS BE LOCATED?

Warning signs should be placed at locations on the basis of expected vehicle speed and the action required on the part of the driver. Table 1 lists the recommended distances at which these signs should be located in advance of the condition of which they are warning (stop, curve, etc.). The two basic criteria to determine the advance sign's placement are the approach speed and the reduction in speed (or stop) required to comply with the sign message.

ARE THERE REQUIREMENTS FOR STREET NAME SIGNS?

Street name signs should be erected to identify every street intersection. The lettering on street name signs should be white on a green background with the letters at least six (6) inches high. The sign shall be retroreflectorized for nighttime visibility.

Street name signs should be mounted a minimum of seven (7) feet above the pavement and normally not in conjunction with any other sign on the same post. In residential districts at least one cross street sign is recommended at each intersection. In business districts or on major arteries, street name signs should be placed on diagonal corners so that they are located on the near left-hand and far right-hand side of the intersection for traffic on the major street.

DO NEW SIGN INSTALLATIONS HAVE TO BE APPROVED BY ANOTHER AUTHORITY BEFORE A LOCAL JURISDICTION CAN INSTALL SIGNS?

According to K.S.A. 8-2005, placement of traffic control devices on local roads is the responsibility of the local authorities having jurisdiction over said system. Others wishing to place devices along roadways should receive approval, preferably written, from the appropriate authority. State authorities must approve signs on a State highway in a city or local jurisdiction. Parking control signs can be erected without state approval.

TABLE 1. Guidelines for Advance Placement of Warning Signs
(Source MUTCD 2000, Table 2C-4)

Poste d or 85 th Perce ntile Spee d	Advance Placement Distance ¹						
	Condit ion A: High judgm ent requir ed ²	Condit ion B: Stop conditi on ³	Condition C: Deceleration to the listed advisory speed (mph) for the condition ⁴				
			1 0	2 0	3 0	4 0	5 0
20 mph	175 ft	N/A ⁵	N / A ⁵	—	—	—	—
25 mph	250 ft	N/A ⁵	1 0 0 ft	N / A ⁵	—	—	—
30 mph	325 ft	100 ft	1 5 0 ft	1 0 0 ft	—	—	—
35 mph	400 ft	150 ft	2 0 0 ft	1 7 5 ft	N / A ⁵	—	—
40 mph	475 ft	225 ft	2 7 5 ft	2 5 0 ft	1 7 5 ft	—	—
45 mph	550 ft	300 ft	3 5 0 ft	3 0 0 ft	2 5 0 ft	N / A ⁵	—
50 mph	625 ft	375 ft	4 2 5 ft	4 0 0 ft	3 2 5 ft	2 2 5 ft	—
55 mph	700 ft	450 ft	5 0 0 ft	4 7 5 ft	4 0 0 ft	3 0 0 ft	N / A ⁵

60 mph	775 ft	550 ft	5 7 5 ft	5 5 0 ft	5 0 0 ft	4 0 0 ft	3 0 0 ft
65 mph	850 ft	650 ft	6 5 0 ft	6 2 5 ft	5 7 5 ft	5 0 0 ft	3 7 5 ft

Notes:

- ¹ The distances are adjusted for a sign legibility distance of 50 m (175 ft), which is the appropriate legibility distance for a 125 mm (5 in) Series D word legend. The distances may be adjusted by deducting another 30 m (100 ft) if symbol signs are used. Adjustments may be made for grades if appropriate.
- ² Typical conditions are locations where the road user must use extra time to adjust speed and change lanes in heavy traffic because of a complex driving situation. Typical signs are merge, Right Lane Ends, etc. The distances are determined by providing the driver a PIEV time of 6.7 to 10.0 seconds plus 4.5 seconds for vehicle maneuvers minus the legibility distance of 50 m (175 ft) for the appropriate sign.
- ³ Typical condition is the warning of a potential stop situation. Typical signs are Stop Ahead, Yield Ahead, or Signal Ahead. The distances are based on the 1990 AASHTO Policy for stopping sight distance (page 120) providing a PIEV time of 2.5 seconds, friction factor of 0.30 to 0.40, minus the sign legibility distance of 50 m (175 ft).
- ⁴ Typical conditions are locations where the road user must decrease speed to maneuver through the warned condition. Typical signs are Turn, Curve, or Cross Road. The distance is determined by providing a 1.6 second PIEV time (1990 AASHTO, page 119), a vehicle deceleration rate of 3 m/second² (10 ft/second²), minus the sign legibility distance of 50 m (175 ft).
- ⁵ No suggested minimum distances are provided for these speeds, as placement location is dependent on site conditions and other signing to provide an adequate advance warning for the driver.

WHAT ARE SUPPLEMENTAL SIGN PROCEDURE POLICIES?

The general guidance given in the MUTCD 2000 for many signs, particularly warning signs may be difficult to apply in urban situations. A

literal interpretation of the MUTCD 2000 may result in the placement of unnecessary and excessive signs. A local authority should consider the adoption of Supplemental Sign Procedure Policies. Such a policy will provide a basis for reasonable signing actions taken by the local authority and demonstrates that prior thought was given to these actions. The local authority should keep in mind that these policies can not be used to violate standards set out in the MUTCD 2000 and that the best protection from liability in signing actions is to follow the latest version of the MUTCD.

EXAMPLE:
SUPPLEMENTAL SIGN PROCEDURES
CITY OF _____

The following standard signing procedures are not intended to circumvent specific requirements of the Uniform Manual on Traffic Control Devices (MUTCD). They are intended to provide guidance for installation of certain signs, which may require some type of interpretation of the MUTCD.

These procedures will be followed uniformly throughout the community and, when there is no supplemental procedure outlined for a particular sign, the City's policy will be to follow procedures outlined in the MUTCD.

GENERAL NOTE:

In most instances it will not be necessary to install more than one warning sign to warn of the same condition. It will also not be necessary to install warning signs for a condition a vehicle will encounter after proceeding from a location controlled by a stop sign, (R1-1).

Review and Approved:

(Signed by City Manager/Administrator, City Engineer, Director of Public Works, Chief of Police or other applicable City Officials.)

TYPICAL SUPPLEMENTAL PROCEDURE:

SIGN SUPPLEMENTAL PROCEDURE 1

DATE: _____

Curve (W1-2); Reverse Turn (W1-3); Reverse Curve (W1-4) Curve, Reverse Turn and Reverse Curve signs will be installed, as per the MUTCD, on all arterial streets. (Note: A list of these streets should be attached to the Policy Statement) On all other streets, where the speed limit

is 30 M.P.H. or lower, these sign will not be installed unless one or more of the alignments contain a curve of 90 degrees or more.

It should be kept in mind that MUTCD 2002 states that the decision to use a particular device at a particular location should be made on the basis of an engineering study or the application of engineering judgment, and that jurisdictions with responsibility for traffic control devices that do not have engineers on their staffs should seek engineering assistance from others, such as the State transportation agency, their county, a nearby large city or a traffic engineering consultant. (MUTCD 2000 Section 1A.09)

CHAPTER 3

STOP SIGNS

INTRODUCTION

Stop signs have generally been used by authorities as a catch-all remedy for a host of vehicle management problems. It is not difficult to figure out why they are used so frequently. A stop sign is a low-cost device, easy to install and its message is clear and universally understood. This chapter will help you determine if stop sign control should be used.

The authorization and erection of stop signs shall be in accordance with the applicable State Statute and the latest edition of the Manual on Uniform Traffic Control Devices.

WHEN SHOULD A STOP SIGN BE USED AT AN INTERSECTION?

Stopping frequently at intersections can create problems for traffic flow. It is irritating to motorists, particularly when they are stopped at locations with little or no conflicting traffic. It also causes vehicles to use more fuel. It is important therefore, that stop signs only be used where they are needed. The question becomes, what situations and problems at an intersection are best solved by installing a stop sign?

1. A stop sign is appropriate when a less frequently traveled road intersects with a highly traveled road where application of the normal right-of-way rule would not be reasonably safe.
2. A stop sign should be used on the minor street when it intersects a through street, highway or road.
3. A stop sign can be used at "T" intersections, where the minor street forms the base of the "T".
4. Stop signs should be used facing a minor street at an unsignalized intersection where several of the intersections along the intersecting roadway are signalized.
5. Stop signs should be used at other intersections where high speed traffic, a restricted view or frequent crashes indicate the need for stop sign control.

Illogical installations should be avoided, such as stopping only one leg of a four-legged intersection, or three legs at a four-legged intersection, or one of the through legs of a "T" intersection. These illogical installations violate driver expectations.

WHEN IS IT PERMISSABLE TO INSTALL A MULTI-WAY STOP?

Multi-way stops should only be used where justified and where traffic on the intersecting roads is approximately equal. Multi-way stops can be used at a location where a traffic signal is justified as a temporary measure until the signal is in place.

An Engineering Study should be performed to determine if one of the following conditions exist:

1. A crash record shows five (5) or more right-turn, left-turn, right-angle and similar types of collisions, subject to correction by a multi-way stop, have occurred within a 12-month period.
2. The total number of vehicles entering the intersection from both approaches of the major street must average at least 300 vehicles per hour for any eight (8) hours of an average day, and the combined count of vehicles, pedestrians and bicycles entering from the minor street equals at least 200 units per hour for the same eight (8) hours. The average delay to the traffic entering from the minor road must be at least 30 seconds during the highest hour.

If the 85th percentile approach speed of the major road is 40 miles per hour or more, the minimum vehicular volume criteria is 70 percent of the above.

3. If both of the above are met at 80 % of the full criteria, a multi-way stop is justified. However, the reduction of 70% for the higher speed approach cannot be included in this calculation.

Other criteria that may be considered are:

1. The need to control left-turn conflicts.
2. The need to control vehicle/pedestrian conflicts near locations that generate high pedestrian volumes.
3. Locations where a road user, after stopping, cannot see conflicting traffic and is not able to safely negotiate the intersection unless conflicting traffic is also required to stop.

4. An intersection of two residential neighborhoods through streets of similar design and operating characteristics, where multi-way stop control would improve the traffic operation of the intersection.

THERE IS A STOP SIGN IN TOWN THAT DRIVERS SEEM TO MISS. WHAT SHOULD BE DONE ABOUT IT?

Possibly the stop sign has been mounted in the wrong location, has very poor reflectivity or is of insufficient size to be properly visible. The following are some guidelines for selecting the proper size and location for these signs.

1. The normal stop sign is 30" x 30" in size. On low-volume local streets and secondary roads with low approach speeds, a 24" x 24" size may be used. For expressways or roads having a speed limit of 40 miles per hour (mph) or greater, the sign size should be increased to 36" x 36", or even 48" X 48" in special cases.
2. The proper location for a stop sign is illustrated elsewhere in following sections of this handbook and MUTCD 2000 2b.06.

The STOP sign shall be located as close as practical to the intersection it regulates, while optimizing its visibility to the road user it is intended to regulate.

3. If your signs are of correct size and in the proper location, it is possible that motorists are not being adequately warned of the need to stop. On certain occasions, objects along the approach may be obscuring the sign's visibility, like trees or shrubs. Table 2 gives the minimum distance back from the intersection that the sign should be visible for various approach speeds. (Also refer to MUTCD 2000 Table 2C-4)

TABLE 2. Visibility Requirements for Stop Signs.

<u>Approach Speed</u>	<u>Minimum Distance (Feet)^(a)</u>
20 MPH	175
30 MPH	200
40 MPH	275
50 MPH	350
55 MPH	425

^(a)For concrete or asphalt pavement having a maximum grade of three percent.

4. If the stop sign is not visible for the minimum distance shown in Table 2, and if the obstructing items cannot be removed, a "Stop Ahead" sign should be used. The proper location for a "Stop Ahead" sign is illustrated elsewhere in this handbook.

CAN A STOP SIGN BE USED TO CONTROL EXCESSIVE SPEED?

If the only reason for placing a stop sign at an intersection is to control vehicle speed, it should not be used. Where stop signs have been used in an attempt to control speeds, it has been observed that speeds downstream are higher than if the stop signs were not there. Better options are available including speed control signs, expanded enforcement and warning signs as appropriate. Also, MUTCD 2000 states that stop signs should not be used for speed control. (MUTCD 2000, Section 2B.05)

SHOULD A STOP SIGN BE PLACED NEXT TO A TRAFFIC SIGNAL IN CASE THE POWER FAILS?

Stop signs should never be used in conjunction with a traffic signal. When the traffic signal is operational, motorists will become confused about which control device to obey. It is important that no more than one type of traffic control sign or signal be used at any given location.

In case of power failure, stop signs may be installed as a temporary means of controlling traffic. When power is restored, the stop signs are to be removed.

IF TRAFFIC VOLUME IS LOW AT AN INTERSECTION BUT THE STREETS ARE CROSSED FREQUENTLY BY PEDESTRIANS, SHOULD A STOP SIGN BE USED?

If traffic volumes are low, adequate traffic gaps should be available for pedestrians to safely cross the roadway without the aid of stop signs. Stop signs should not be used under such circumstances. More information concerning traffic controls for pedestrians can be found elsewhere in this handbook.

SHOULD A STOP SIGN BE USED AT A RAILROAD CROSSING?

Stop signs are permissible at railroad crossings if visibility is insufficient to see trains approaching the crossing and the crossing is not signal controlled. Elsewhere in this handbook, there is information suggesting minimum sight distance required. Under Kansas Statute 8-1552, the Secretary of Transportation, and local authorities with approval of the Secretary, may erect

stop signs at grade crossings. Note that local authorities in Kansas cannot erect stop signs at grade crossings without approval of the Secretary.

ARE TURNABLE OR ROLL OUT STOP SIGNS PERMISSIBLE?

The use of turnable or roll-out Stop signs are not recommended except in an emergency. These types of signs are subject to vandalism (being turned at the wrong time or in the wrong direction or of being removed). Consequently, driver expectations can be easily violated, creating dangerous situations.

WHAT SHOULD BE DONE IF A STOP SIGN IS TO BE ADDED OR REMOVED?

1. Prearrange a target date for the removal or addition of the sign.
2. Publicize the impending removal or addition through whatever media is available (newspaper, radio, television, etc.). Make sure that the publicity is widespread and is at least a week or two in advance.
3. If adding a sign, several days immediately preceding the target date, erect the sign but keep it covered. Mount flags on the sign to begin attracting the public's attention to it.
4. If going from a multi-way stop to a two-way stop, it will be necessary to place informational signs at the approaches which retain stop signs to indicate that cross traffic does not stop. If going from multi-way stop to uncontrolled, it will be necessary to place informational signs on all the approaches that cross traffic does not stop. If going from a two-way stop to uncontrolled, it will be necessary to place informational signs on all the approaches that cross traffic does not stop. These warning signs should be kept covered until the stop signs are removed on the target date.
5. In the early morning hours of the target date, the signs can be removed or added and informational signs uncovered, if applicable. It is advisable to have law enforcement personnel present during the removal or addition to direct traffic if necessary.
6. Leave the informational signs in place for 90 days so that local drivers may fully adjust to the new conditions.
7. Conduct follow-up studies on the effects of the stop sign removal or addition to include citizens' response and possible increase/decrease in traffic accidents.

DO STOP SIGNS REALLY PROVIDE MORE EFFECTIVE INTERSECTION CONTROL THAN YIELD SIGNS?

No! If there is adequate sight distance at an intersection and stop signs are not warranted by volume, the use of yield signs is more effective as well as more economical and energy efficient.

The use of stop signs where they are not needed causes disrespect for the sign message among drivers, who will not stop unless they feel that there is a reason to do so.

IS THERE A TRUE ENERGY SAVINGS REALIZED WHEN UNNEEDED STOP SIGNS ARE REMOVED FROM AN INTERSECTION?

Yes! Each time a vehicle slows, stops and accelerates, it consumes more fuel (at a cost to the driver) than if it had been permitted to maintain its original speed. Therefore, if it is possible for fewer vehicles to slow or to stop, the result will be a true savings in energy and its cost.

CHAPTER 4

SPEED LIMITS

NOTE: Speed limits are often determined by state statutes. This chapter relates to Kansas, as it would be almost impossible to include material specific to all 50 states. Although the general information should be helpful, non-Kansas readers should check with their own DOT for state-specific guidance.

INTRODUCTION

Speed limits are among the most important tools one can use to create and maintain a safe traffic environment. But, as in all regulatory procedures, the limits imposed must be reasonable and appropriate to the situation. Most drivers tend to regulate their own speed according to traffic, road and weather conditions. It is the normal driver's speed which is used by traffic engineers as a guide in setting speed limits.

Other factors must also be taken into account in setting appropriate speed limits. School zones, for example, create special conditions and require special consideration. The important point to remember is that speed regulations inform the driver of the limits in which one can safely operate a vehicle under normal circumstances and within which the driver can be expected to react safely to driving problems. Setting speed limits at appropriate levels will create a reasonably uniform flow of traffic, discourage violation of the law and help keep streets and highways safe.

IS THERE A MAXIMUM SPEED LIMIT ESTABLISHED BY THE STATE OF KANSAS?

The latest edition of the Standard Traffic Ordinance for Kansas Cities states the following maximum speed limits, except in special cases as defined in the State Statutes:

1. Twenty, (20) miles per hour in any business district.
2. Thirty, (30) miles per hour in any urban district.
3. Seventy, (70) miles per hour on any separated multilane highway, as designated and posted by the secretary of transportation.
4. Fifty-five, (55) miles per hour on any county or township highway.
5. Sixty-five, (65) miles per hour on all other highways.

These maximum speed limits may be altered as authorized by K.S.A. Supp. 8-1559 and K.S.A. Supp. 8-1560 and amendments thereto.

HOW CAN A LOCAL AUTHORITY CHANGE THE SPEED LIMIT FOR ITS JURISDICTION?

There are limitations in changes to which a local authority is restricted.

Authorization from KDOT is needed to change the speed limit on a city street, which is a state highway.

For local authorities to change the speed limit on a highway or street within their jurisdiction, they must first conduct an engineering study in accordance with established traffic engineering practices. From this study, the speed limit may be established by the authorized agency.

When a speed limit is to be posted, it should be the 85th percentile speed of free-flowing traffic, rounded up to the nearest five (5) mph increment. Other factors that may be considered when establishing speed limits are the following:

1. Road characteristics, shoulder condition, grade, alignment and sight distance;
2. The pace speed;
3. Roadside development and environment;
4. Parking practices and pedestrian activity; and
5. Reported crash experience for at least a 12-month period.

WHERE SHOULD SPEED LIMIT SIGNS BE LOCATED?

Speed limit signs, indicating speed limits for which posting is required by law, shall be located at the points of change from one speed limit to another.

At the end of the section to which a speed limit applies, a Speed Limit sign showing the next speed limit shall be installed. Additional Speed Limit signs shall be installed beyond major intersections and at other locations where it is necessary to remind road users of the speed limit that is applicable.

Speed Limit signs indicating the statutory speed limits shall be installed at entrances to State and jurisdictional boundaries of metropolitan areas.

Speed Limit signs indicating the maximum speed in a business district shall be installed at the entrance into any business district.

HOW FAR APART SHOULD SPEED LIMIT SIGNS BE INSTALLED ALONG THE ROADWAY?

The following general guidelines are recommended for roads and streets under local jurisdictions:

Speed limit (MPH)	Minimum Distance	Maximum Distance
30 or Less	660 Ft. or 2 Blocks	1320 Ft. or 4 Blocks
35 or 40	990 Ft. or 3 Blocks	1900 Ft. or 6 Blocks
45 or 50	1320 Ft. or 4 Blocks	2640 Ft. or 8 Blocks

IF RESIDENTS OF A NEIGHBORHOOD ARE REPORTING THAT CARS ARE SPEEDING ON THEIR STREETS, SHOULD THE SPEED LIMITS BE LOWERED TO SLOW THE DRIVERS DOWN?

For a speed limit regulation to be effective, at least 85 percent of the drivers should voluntarily comply with the law. The first action one should take if speed violations are being reported is to undertake a study of vehicle speeds.

The basis for the proper speed on any stretch of highway or street is the nationally recognized "85th percentile speed." This is the speed at or below which 85 percent of the observed free flowing traffic is moving. The experience of traffic engineers has been that posting higher or lower speed limits does not significantly change the 85th percentile speed. Moreover, raising the speed limit to the 85th percentile should not result in an increase in the frequency or severity of accidents and should reduce maximum speeds observed. It is good practice to monitor streets where the speed limit has been changed to determine if the incidence of accidents has actually increased or decreased.

Adoption of the 85th percentile speed recognizes that a small minority of highway users drive at speeds in excess of that considered safe by the majority of drivers. Obviously, enforcement action should be directed toward that minority.

HOW IS AN ENGINEERING STUDY IN ACCORDANCE WITH ESTABLISHED TRAFFIC ENGINEERING PRACTICES CONDUCTED?

The prevailing speed of free-flowing traffic should be used in establishing the speed limit. Three methods for conducting the engineering study may be used:

1. Eighty-fifth percentile speed (the preferred method). This is the speed at or below which 85 percent of the free-flowing vehicles observed on the roadway under study are traveling.
2. Upper limit of the 10 miles per hour pace. Observation of vehicles on the roadway will determine the 10-mile per hour range at which most of the vehicles are traveling.
3. Average Test Run Speed. This method is optional on low-volume roadways and is only applicable for determining the prevailing speed of passenger cars.

To determine either the 85th percentile or the 10-mile pace, a spot speed study must be conducted. A spot speed study is made by measuring the individual speeds of a sample of the vehicles passing a given point (spot) on a street or highway. These individual speeds are used to estimate the speed distribution of the entire traffic stream at that location. Location of the study at the mid-point of the area usually will provide viable data.

Study Location

1. General Location depends upon the purpose of the study. For determining speed trends, stations are usually established at a central location on open stretches of straight, rural highways or at mid-block locations on urban streets away from the influence of Stop signs and signals.
2. The specific site is selected within the general location to reduce or eliminate the influence of the observer and measuring equipment on vehicle speed. Equipment should be concealed, the observer and his vehicle should be as inconspicuous as possible and on-lookers must be kept from the area.
3. Variables which might influence the study should be minimized. Do not locate the site on curves, grades, rough stretches of road, or near construction unless the study requires these conditions. Other factors such as environment (weather, visibility) and traffic volumes should be taken into consideration if these conditions are not normal.

Time of Study

Off-peak hours are normally used in conducting a spot speed study although the purpose of the study should determine the time. It is important that trend studies and "before and after" studies be made during the same hours under comparable conditions. Bad weather and unusual traffic conditions should be avoided.

Size and Selection of Sample

The speeds of 100 free flowing vehicles in each direction should be obtained for any one location. On low volume roads where it would be difficult to obtain a sample of 100 vehicles in each direction, the study may be terminated after a study period of three (3) hours in each direction. Vehicles should be selected at random from the free flow of a traffic stream to avoid bias in the results. The following provides some guidelines for selecting vehicles:

1. Always select the first vehicle in a platoon, because that is an indication of the speed that the first driver wants to travel. Others in the platoon may want to travel faster, but how much faster cannot be determined; therefore, should not be part of the study sample.
2. Do not select too large a portion of trucks - their speeds may not be representative of the rest of the sample. Attempt to obtain about the same proportion of trucks in the sample as exists in the traffic stream.
3. The selection must be made at random of only free flowing vehicles, for example, every fourth free flowing vehicle's speed. Do not select too large a proportion of higher speed vehicles or the results will be biased toward the upper range of speeds.

To Determine the 85th Percentile

To make use of the data collected, the next step is the analysis. The best way to summarize the data is to chart the speeds collected on a frequency distribution table. Table 3, used as an example of a frequency distribution table, includes the speeds of 100 vehicles. The speeds are grouped into 3-mph increments (groups of 1, 2, 4, or 5 mph may be used) with the second column indicating upper-limits for each 3-mph increment. The upper limits are needed later for plotting a curve. All of the speeds collected in the example range from a low of 13.6 miles per hour to a high of 49.5 miles per hour. The third column lists the number of vehicles observed operating within each of the 3-mph groups.

The cumulative frequency (column 4) is the total of each of the numbers (frequencies) in column 3 added together row by row from the top down. The last column is a running percentage of the cumulative frequency from the top down.

Once the frequency distribution table has been constructed, the best way to determine the 85th percentile is to plot the speed distribution on a graph. Take the upper-limit of each grouping (column 2) and plot that speed on the graph where it corresponds with the cumulative percent of vehicles observed (column

5). Where the curve intersects the 85th percent line, is the 85th percentile speed. In the example given, the curve intersects at 37 miles per hour (Figure 2).

The actual speed limit posted should be this 85th percentile speed rounded off to the nearest five mile per hour increment; in this case 35 mph.

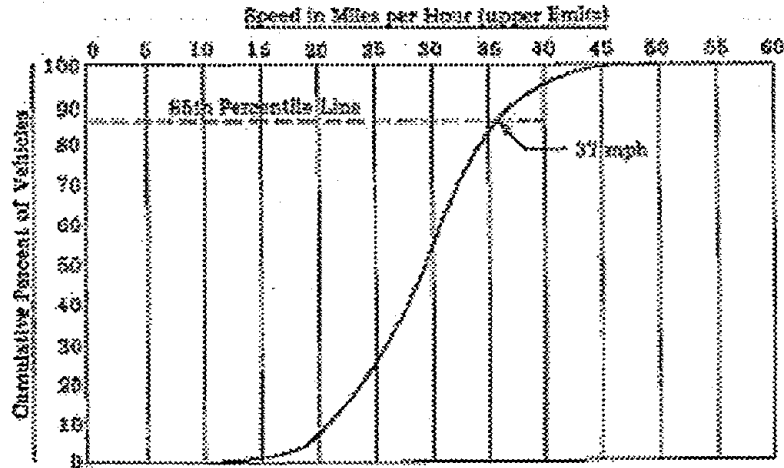


FIGURE 2. CUMULATIVE SPEED DISTRIBUTION CURVE.

To Determine the 10 Mile Pace

The same distribution of vehicle speeds in Table 3 can be used to determine the 10 mile pace or the 10 miles per hour range containing the most vehicles. By dividing the vehicle speeds into 10 mile ranges (15 to 25 mph, 26 to 35 mph, etc.), it becomes evident that the largest number of vehicles (approximately 51 vehicles) were traveling at speeds between 25 and 35 miles per hour. The upper limit of this range is 35 mph and this study would, therefore, result in the same speed limit being established as the 85th percentile method: 35 mph.

To Determine the Average Test Run Speed

Average test run speeds are determined on the basis of five runs in each direction over the length of the proposed zone. The most important part of the test run is to determine the maximum permissible speed. Time periods are disregarded and while making the test run, the driver should try to "float" in the traffic stream (drive as an average or typical vehicle in the traffic stream).

TABLE 3. FREQUENCY DISTRIBUTION TABLE.

<u>Row</u>	<u>1</u> <u>Groupings</u> <u>of Speeds</u> <u>Observed</u>	<u>2</u> <u>Upper-</u> <u>Limits</u>	<u>3</u> <u>Frequency</u> <u>of</u> <u>Vehicles</u>	<u>4</u> <u>Cumulative</u> <u>Frequency</u>	<u>5</u> <u>Cumulative</u> <u>Percent*</u>
1	13.6 to 16.5	16.5	1	1	1%
2	16.6 to 19.5	19.5	2	3	3%
3	19.6 to 22.5	22.5	6	9	9%
4	22.6 to 25.5	25.5	12	21	21%
5	25.6 to 28.5	28.5	13	34	34%
6	28.6 to 31.5	31.5	20	54	54%
7	31.6 to 34.5	34.5	18	72	72%
8	34.6 to 37.5	37.5	14	86	86%
9	37.6 to 40.5	40.5	6	92	92%
10	40.6 to 43.5	43.5	6	98	98%
11	43.6 to 46.5	46.5	1	99	99%
12	46.6 to 49.5	49.5	<u>1</u>	100	100%
			100 Vehicles		

*Cumulative Percent = $\frac{\text{Cumulative Frequency}}{\text{Total Number of Vehicles}} \times 100$

ARE THERE OTHER WAYS TO CONTROL VEHICLE SPEED?

The following are other methods of controlling vehicle speed:

1. Signals can be timed in progression to have motorists on a given street move at or near a predetermined speed.
2. Advisory speed limit plates (in multiples of 5 miles per hour) can be used on curves and at hazardous locations to indicate the advisory maximum speed. These speeds should be determined through accepted traffic engineering procedures and periodically checked and corrected if necessary. They are always posted in conjunction with another warning sign and are not required if the critical speed is less than 5 miles per hour below the posted speed limit.
3. Side friction in the form of on-street parking or reduced width roadway sections tend to slow the traffic speed. Speed "humps" are another alternative in certain situations. These physical forms of speed control will not be popular with everyone.

4. Consistent enforcement of the speed limits is critical. Signals, signs and other warning devices will not be truly effective unless motorists are aware that violation of these rules will result in penalties. Municipalities should draw on local, county and state law enforcement agencies for assistance in regulating traffic. Motorists usually tend to act more lawfully if a law enforcement vehicle is observed on a roadway. Consistent monitoring of a roadway by law enforcement agencies will lead to a reduction in speeding violations and other unsafe driving practices.
5. Traffic calming measures – covered in a later chapter in this handbook.

WHAT IS TRAFFIC CALMING?

Many communities are using traffic calming to reduce speeds in residential areas. Some common traffic calming measures are discussed and illustrated in Appendix A.

CHAPTER 5

PAVEMENT MARKINGS

INTRODUCTION

Pavement markings can provide a very useful function in overall traffic control either as a supplement to other devices or used alone. They serve very effectively in conveying certain regulations and warnings that could not otherwise be made as understandable to the motorist. Moreover, they can be used to advise the motorist without diverting his attention from the roadway. But markings do have significant limitations. Visibility of the markings can be limited by snow, debris and water on or adjacent to the markings. Marking durability is affected by material characteristics, traffic volumes, weather and location. Pavement markings can enhance roadway delineation with the addition of audible features such as bars, differential surface profiles, raised pavement markers and other devices intended to alert the motorist that a delineation on the roadway is being traversed.

WHAT TYPES OF PAVEMENT MARKINGS ARE USED?

Pavement markings are normally used as follows:

1. Centerlines
2. Edge Lines
3. No Passing Zones
4. Lane Lines
5. Stop Lines
6. Crosswalk Lines
7. Railroad Crossing Markings, Arrows, and Other Lane Messages

WHAT COLORS CAN BE USED FOR PAVEMENT MARKINGS?

The colors for pavement markings are yellow, white, red or blue. Black in conjunction with one of the above colors shall be a usable color for object markers and may be used in combination with the above colors where a light-colored pavement does not provide sufficient contrast with the markings.

Yellow lines delineate the separation of traffic traveling in opposite directions (center lines) or mark the left edge of the roadway on divided highways and one-way highways and ramps. Yellow lines also delineate the separation of two-way left turn lanes and reversible lanes from other lanes.

White lines delineate the separation of traffic flows in the same direction (lane lines) or mark the right edge of the roadway.

Red lines delineate roadways that shall not be entered or used.

Blue lines delineate parking spaces for persons with disabilities.

WHAT WIDTH AND SPACING REQUIREMENTS ARE USED FOR LONGITUDINAL PAVEMENT MARKINGS?

1. A solid line prohibits or discourages crossing.
2. A normal line is four to six inches wide.
3. A wide line is at least twice the width of the normal line.
4. A double line consists of two normal width lines separated by a discernible space.
5. A broken line consists of normal line segments separated by gaps, usually in the ratio of one to three.
6. A dotted line consists of noticeably shorter line segments, separated by shorter gaps than used for a broken line.

WHEN SHOULD A BROKEN LINE BE USED?

Broken lines are permissive in character and constitute a guide for the motorist. For example, a broken white line is used as the lane line on a multi-lane roadway. The motorist is allowed to change lanes and cross the broken line if traffic conditions permit. Other uses for broken lines are:

1. A normal broken yellow line is used as a centerline of a two-lane, two-way road where passing is permitted.
2. A double line indicates maximum or special conditions. It can consist of a normal broken yellow line and a normal solid yellow line, is used as a separation between travel paths in opposite directions to regulate passing. (Note: If both lines are solid, passing is prohibited in both directions.)
3. A dotted line provides guidance. It can be used to delineate the extension of a line through an intersection or interchange area.

4. Reversible lane markings (double broken lines) are used for lanes specified to have traffic traveling in the opposite direction at different periods of the day. (Will be supplemented with appropriate directional signing.)

WHAT TYPES OF LONGITUDINAL PAVEMENT MARKINGS (LINES) SHOULD BE USED ON TWO-LANE ROADS?

1. Where passing is permitted, a normal broken yellow line is used.
2. Where passing is permitted in one direction only, a double line, consisting of a normal broken yellow center line and a normal solid yellow line in the lane from which passing is prohibited, is used.
3. Where passing is prohibited in both directions, a double line, consisting of two normal solid yellow lines, is used.
4. A normal solid white line is used to delineate the edges of the pavement.

Figure 3 on page 30 depicts the typical centerline and edge line markings on a two-lane road.

SHOULD ALL ROADS HAVE A CENTERLINE?

1. Centerline markings shall be placed on all paved urban arterials and collectors that have a traveled width of 20 feet or more and an ADT of 6,000 vehicles per day or greater.
2. Centerline markings shall also be placed on all paved two-way streets or highways that have three or more traffic lanes.
3. Centerline markings can be placed on all paved urban arterials and collectors that have a traveled width of 20 feet or more and an ADT of 4,000 vehicles per day or greater.
4. Centerline markings can be placed on all rural arterials and collectors that have a traveled width of 18 feet or more and an ADT of 3,000 vehicles per day or greater.
5. Centerline markings can be placed on other traveled ways where an engineering study indicates a need for them.

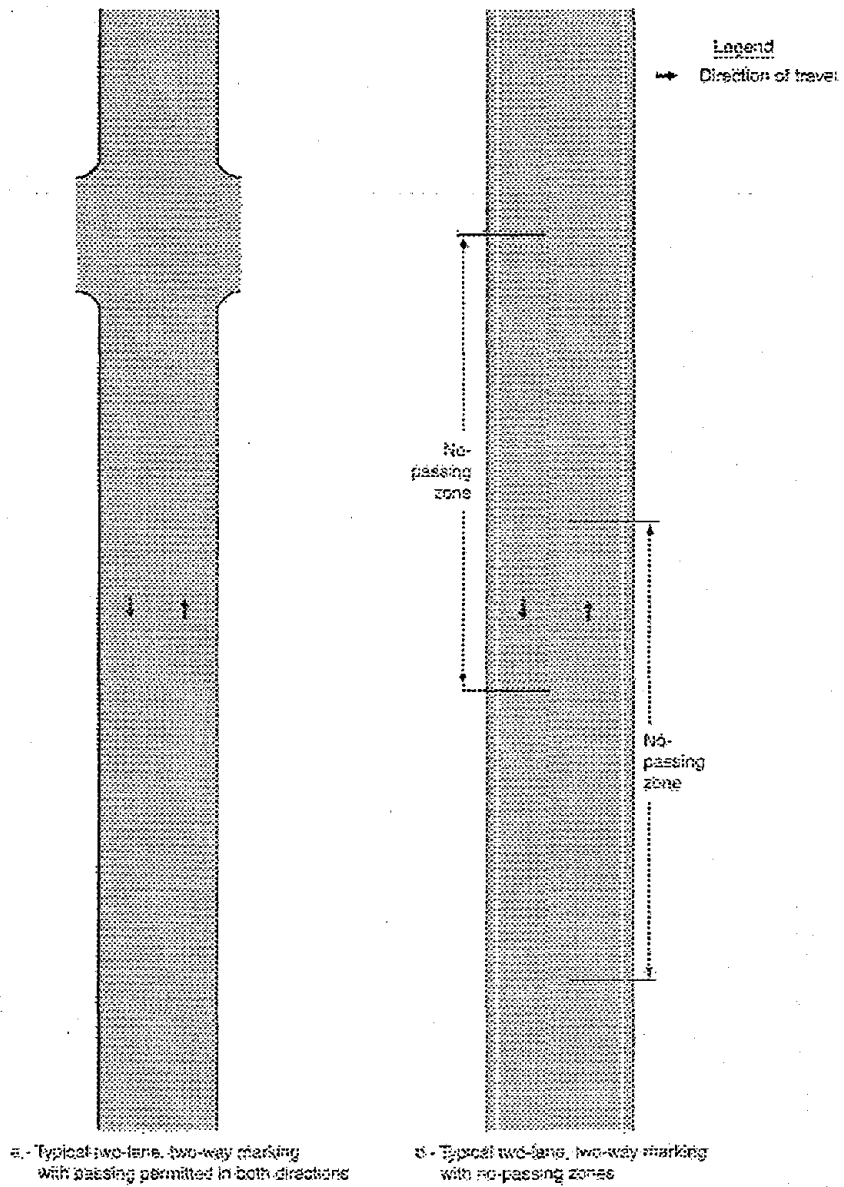


FIGURE 3. TYPICAL TWO-LANE, TWO-WAY MARKING APPLICATIONS.

UNDER WHAT SITUATIONS ARE PAVEMENT EDGE LINES USED?

1. Edge line markings shall be placed on paved streets or highways that are freeways, expressways and rural arterials with a traveled way 20 feet or more in width and an ADT of 6,000 vehicles per day or greater.
2. Edge line markings can be placed on rural arterials and collectors with a traveled way 20 feet or more in width and an ADT of 3,000 vehicles per day or greater.
3. Edge line markings can be used when it is desirable to delineate the right or left edges of a roadway as a guide for drivers, particularly during adverse weather and visibility conditions.
4. Edge line markings can be used where it is desirable to reduce driving on paved shoulders or refuge areas of lesser structural strength than adjacent pavements.
5. Edge line markings can be used where an engineering study indicates a need for them.

Edge lines shall not be continued through intersections but should not be broken for driveways.

WHEN SHOULD STOP LINES BE USED?

Stop lines shall consist of solid white lines extending across approach lanes to indicate the point behind which vehicles are required to stop, in compliance with a Stop sign or traffic control signal.

Stop lines are solid white and are normally 12 to 24 inches wide.

Stop lines should normally be placed at least four (4) feet in advance of and parallel to the nearest crosswalk line. In the absence of a marked crosswalk, the stop line should be placed at the desired stopping point but no more than 30 feet nor less than four feet from the nearest edge of the intersecting roadway. Stop lines should be placed to allow sufficient sight distance for all approaches to an intersection. Stop lines should always be placed perpendicular to the flow of traffic being stopped.

WHERE ARE CROSSWALK MARKINGS NECESSARY?

Marked crosswalks are necessary at all signalized intersections where pedestrian indications are used. Crosswalks should also be marked at all stop sign

controlled intersections where there are substantial conflicts between vehicle and pedestrian movements. Crosswalks should be used with caution at other locations. Unless a signal or Stop sign is present, drivers tend to ignore a marked crosswalk. Pedestrians will be given a false sense of security at these locations. Marked crosswalks away from traffic signals or stop signs, whether mid-block or at uncontrolled intersections, are particularly dangerous for older pedestrians. Studies have shown that fatal accidents involving older pedestrians are 3.5 times more likely to occur at a marked crosswalks than at an unmarked ones.

Adequate visibility on the approach to any marked crosswalk must be provided by parking prohibitions. The STO prohibits parking within 20 feet of a crosswalk at an intersection. This distance should be used as guidance at all marked crosswalks.

WHAT COLOR AND WIDTH OF LINES ARE USED FOR CROSSWALKS?

Crosswalk lines shall be solid white lines that mark the crosswalk. The lines shall not be less than six (6) inches nor greater than twenty-four (24) inches in width and should not be less than six (6) feet apart.

Crosswalk lines, if used on both sides of the crosswalk, should extend across the full width of the pavement to discourage diagonal walking between crosswalks.

For added visibility, the area of the crosswalk may be marked with white diagonal lines at a 45-degree angle to the line of the crosswalk or with white longitudinal lines parallel to the traffic flow. These lines should be approximately 12" to 24" wide and spaced 12" to 24" apart. When diagonal or longitudinal lines are used to mark a crosswalk, the transverse crosswalk lines may be omitted. This type of marking is intended for use at locations where substantial numbers of pedestrians cross without any other traffic control device, at locations where physical conditions are such that added visibility of the crosswalk is desired or at places where a pedestrian crosswalk might not be expected.

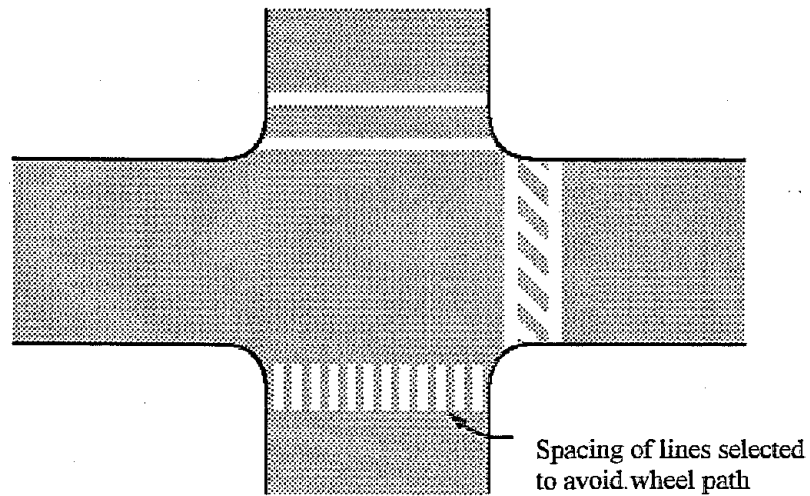


FIGURE 4. TYPICAL TYPES OF CROSSWALK MARKINGS.

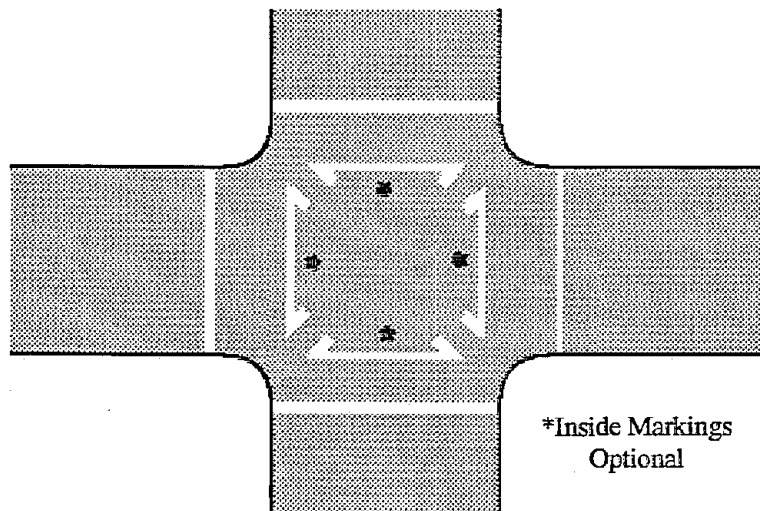


FIGURE 5. TYPICAL CROSSWALK MARKINGS FOR EXCLUSIVE PEDESTRIAN PHASE THAT PERMITS DIAGONAL CROSSING.

IF THE MOTORIST FAILS TO YIELD TO PEDESTRIANS AT A CROSSWALK, CAN THE CROSSWALK'S VISIBILITY BE IMPROVED?

Motorists may be failing to yield to pedestrians at certain crosswalks because the crosswalk is not readily visible or it is unexpected. This usually

occurs when a crosswalk is located in the middle of a block or on a narrow street with parked cars and other physical obstructions blocking the motorist's view.

The following are possible solutions to this problem:

1. The width of the lines could be increased up to 24 inches.
2. The area of the crosswalk could be marked with diagonal or longitudinal lines to make the walkway more visible.
3. Parking should be prohibited on both sides of the crosswalk for some distance in both directions.
4. Warning signs should be installed to alert motorists to the upcoming crosswalk.

The main reasons for pedestrian-vehicular conflicts at crosswalks are that most drivers, as well as pedestrians, are ignorant of the laws governing the situation and police enforcement of these laws is rare.

CHAPTER 6

SCHOOL CROSSINGS

INTRODUCTION

School areas often require special traffic control treatment because of the danger to children, who are generally less likely to be able to judge traffic situations. The question facing traffic managers is how to best handle the school safety problem in light of the many issues and factors involved. Parents and school officials will often make demands based on emotions rather than a factual set of circumstances. City officials will be equally concerned with the safety of the children but will be required to work within budget constraints and the demands of the total driver population. What is needed is a program that is acceptable and utilized by educators, enforcement officials, parent-teacher groups, the children and others involved.

WHERE SHOULD SCHOOL CROSSINGS BE LOCATED?

The best approach to locating school crossings is to establish a coordinated school traffic safety program. The first step in the coordinated approach is to set up a school traffic safety committee of governmental and school board officials with the authority to implement the program. The committee's first task is to develop a suggested school route plan for each school serving elementary and kindergarten students. The plan should consist of a simple map showing streets, sidewalks, the school, existing controls and, by arrow markings, the school routes for the children. The school route plan should be designed to provide maximum protection for children at a reasonable cost. This can be accomplished by selecting routes that take advantage of the protection afforded by existing traffic controls. Some children may also need to walk longer distances to avoid hazardous crossings.

When developing the plan, officials may find the route crosses a major highway or goes through an intersection with particularly heavy traffic. These locations could be particularly hazardous. Each of these locations should be studied to determine if adequate gaps in the traffic stream exist to allow the children to cross safely. If the delay time between adequate gaps is too long, the children may get impatient and attempt to cross under unsafe conditions. There are publications available from the Kansas Department of Transportation the Institute of Transportation Engineers on developing a school traffic safety program and crossing plan.

WHO SHOULD BE INVOLVED IN DEVELOPING A SAFE SCHOOL CROSSING PLAN?

For the crossing plan to be effective and acceptable, school administrators, teachers, parents, the local police department and governmental agencies such as the city engineering traffic department (or the Kansas Department of Transportation for crossings on State routes) should be involved in developing and implementing the plan. The pupils themselves should become involved, some on school safety patrols in directing other children at crossings, and all of them in being the recipients of thorough instruction on the purpose and use of the school route plan.

HOW CAN ONE TELL IF A SCHOOL CROSSING IS UNSAFE?

The number of safe crossing gaps in the traffic stream needs to be calculated.

The gap time is the time it would take a student to cross a road using an average walking speed of 3.5 feet/second and a perception and reaction time of three seconds. The formula is $W/3.5 + 3$ where W is the width of the road in feet. For example, a 24 feet wide road has a gap time of about 10 seconds. (Note – Add two seconds of pedestrian clearance time for each additional row of students).

The number of safe gaps, then, for a 24 feet wide road, is the number of 10-second spaces between vehicles. When the delay between the occurrence of adequate gaps becomes excessive, students might become impatient and endanger themselves by attempting to cross the street during an inadequate gap. Generally, if the safe gaps are less frequent than one per minute, it is an indication that some form of traffic control is needed to create gaps.

For further information on gap studies refer to publications by the Kansas Department of Transportation and The Institute of Transportation Engineers.

WHAT ARE THE ALTERNATIVES FOR PROTECTING SCHOOL CROSSINGS ?

There are basically four types of measures available for reducing traffic hazards to children at school crossings:

1. Adult crossing guards and student patrols
2. Traffic control devices including signs, pavement markings and signals

3. Overpasses and underpasses
4. One-way streets.

WHEN IS AN OVERPASS (OR UNDERPASS) JUSTIFIED AT A SCHOOL CROSSING?

An overpass or underpass is a major investment. The following conditions should be met before considering this measure:

1. The obstacle the school children must cross is permanent, such as a freeway.
2. The cost of an overpass or underpass is less costly over time than other measures.
3. The location is appropriate for this kind of structure.
4. The funds spent on the structure won't limit money available for other school crossing protection.
5. The structure will serve other pedestrians besides school children.
6. There is no likelihood that re-planning the school route will eliminate the need for the overpass or underpass.
7. Traffic conditions are such that children feel the need to use it.

WILL A REDUCED SPEED LIMIT BE HELPFUL IN SAFEGUARDING PEDESTRIANS AT SCHOOL CROSSINGS?

The speed of vehicles can be a contributing factor to the incidence of accidents involving vehicles and pedestrians. Local authorities may want to set a speed limit appropriate for school zones.

ARE THERE SITUATIONS WHERE SCHOOL SPEED LIMITS SHOULD NOT BE POSTED?

It should be recognized that school speed limit signs are not a "cure-all" because of the difficulty in enforcement, particularly in rural areas. School speed limit signs would be unnecessary under any of the following conditions:

1. School children are protected by other traffic control devices such as Stop signs and signals, where motorists are required to come to a complete stop. An exception may be made when the speed zone serves to protect children walking on or adjacent to the roadway in the school area.
2. The school or school grounds are completely isolated from the roadway by means of a fence or other barrier, and no access to the roadway is provided.
3. An underpass or overpass has been provided.
4. Entrance to and exit from the school grounds are by school bus or other vehicle only.

WHEN SHOULD ADULT GUARDS OR STUDENT PATROLS BE USED AT A SCHOOL CROSSING?

There are two types of school crossing supervision. There is adult control of pedestrians and vehicles by adult guards or police officers and there is student control of only pedestrians by student patrols.

Adult crossing guards should be considered if:

1. Traffic volumes are near the level required to warrant traffic signals and gaps in traffic are so short and infrequent that an adult is required to select adequate gaps and to control waiting children.
2. The costs of a guard are more economical than a pedestrian grade separation structure or a traffic control signal.
3. There are special hazards such as fog, complicated intersections, or high vehicle speeds that can be properly handled only by adult supervision.
4. A change in school routes or districts is imminent and protection is needed only for a limited time.

A student patrol is most useful at locations where some supervision of children using the crossing is desirable but the conditions do not require the actual direction of motor vehicles. They should be assigned to locations adjacent to school grounds only where adequate gaps in traffic occur frequently enough for safe crossings without stopping traffic. Student patrols should not be permitted to halt or direct vehicular traffic. Refer to the MUTCD 2000 Section 7E.07 for further information on this topic.

WHAT STANDARD TRAFFIC CONTROL SIGNS SHOULD BE USED FOR SCHOOLS?

The following traffic control signs are used for schools. Refer also to the MUTCD 2000, part 7B.

1. The School Advance Warning sign (S1-1) shall be used in advance of any installation of the School Crossing sign, in advance of the school grounds or in advance of the first installation of the School Speed Limit sign assembly. It shall be supplemented with the legend "AHEAD" or the distance ahead.
2. The School Crossing Warning assembly (S1-1 with diagonal downward pointing arrow) shall be installed as close as possible to the marked School Crosswalk. The School Crossing Warning assembly shall not be installed on approaches controlled by a Stop sign. Only crossings adjacent to schools and those on established school pedestrian routes shall be signed in this manner.
3. The School Bus Stop Ahead sign (S3-1) should be installed in advance of locations where a school bus, when stopped to pick up or discharge passengers, is not visible for a distance of 500 feet in advance and where there is no opportunity to relocate the bus stop to provide 500 feet of visibility.
4. School Speed Limit signs (S4-1, S4-2, S4-3, S4-4, S5-1) shall be used to indicate the speed limit where a reduced speed zone for a school area has been established (in accordance with law based on an engineering study) or where a speed limit is specified for such areas by statute.

The School Speed Limit assembly shall be either a fixed-message sign assembly or a Speed Limit Sign Beacon may be used, with a "WHEN FLASHING" legend to identify the time periods that the school speed limit is in effect.

5. No Parking and Stopping signs may be used to prevent parked or waiting vehicles from blocking pedestrian's views and driver's views of pedestrians, and to control vehicles as a part of the school traffic plan.

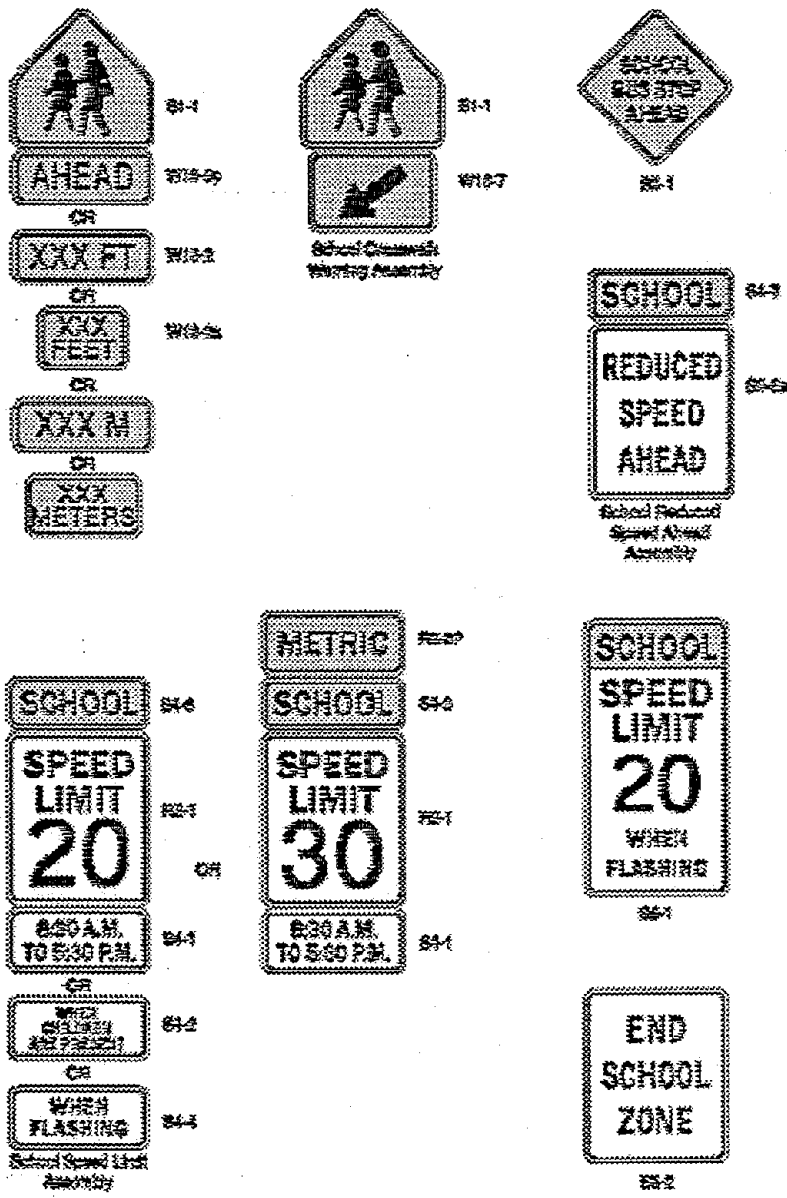


FIGURE 6. STANDARD SCHOOL SIGNS.

SHOULD PAVEMENT MARKINGS BE USED FOR CROSSINGS?

Pavement markings can be used in conjunction with traffic signals and signs or used solely as a crossing safeguard. One should be aware, however, that pavement markings have limitations because they can be hidden by snow and may be worn off by heavy traffic. The following are typical applications of pavement markings at school crossings.

1. Crosswalk Markings are solid white parallel lines marking both edges of the crosswalk. They shall not be less than six (6) inches nor greater than twenty-four (24) inches in width, spaced not less than six (6) feet apart and extend from curb to curb. As an option, the area of the crosswalk may be marked with white diagonal lines at a 45 degree angle to the line of the crosswalk or with white longitudinal lines parallel to traffic flow.

Crosswalks should be marked at all intersections on established routes to school where there is substantial conflict between drivers, bicyclists and pedestrian movements, where students are encouraged to cross between intersections, or where students would not otherwise recognize the proper place to cross.

2. Stop Line Markings are solid white lines, 12 to 24 inches wide, extending across approach lanes to indicate the point at which the stop is intended or required to be made, in compliance with a Stop sign or traffic signal. Stop lines, if used, should be placed four (4) feet in advance of the nearest crosswalk line.
3. Curb Markings for Parking Regulations are used to restrict parking near school crossings in order to allow both drivers and pedestrians adequate sight distance. Curb markings are normally yellow and may be supplemented with signs.
4. Pavement Word and Symbol Markings are used to supplement standard signs. They shall be white in color and six feet or more in height, not exceeding three lines of information.

SHOULD A TRAFFIC SIGNAL BE INSTALLED AT A BUSY INTERSECTION IF SCHOOL CHILDREN WILL CROSS THERE FREQUENTLY?

School signals can be erected at established school crossings in order to create gaps in traffic to allow children to safely cross a roadway. Depending upon conditions, they may be installed either at intersections or at mid-block crossings.

The School Crossing signal warrant is intended for application where the fact that school children cross the major street is the principal reason to consider installing a traffic control signal.

The need for a traffic control signal shall be considered when an engineering study of the frequency and adequacy of gaps in the vehicular traffic stream indicates there are inadequate gaps in the traffic stream to allow children to safely cross the street. In order to warrant traffic signals at school crossings, each of the following conditions must be met:

1. During daily school crossing periods, the number of adequate gaps in traffic is insufficient to permit children to safely cross the street.
2. There must be a minimum of 20 students crossing during the highest crossing hour.
3. Consideration must be given to the implementation of other remedial measures, such as warning signs and flashers, school speed zones, school crossing guards, or a grade-separated crossing.
4. The warrant shall not be applied at locations where the distance to the nearest traffic control signal along the street is less than 300 feet.

CHAPTER 7

TRAFFIC SIGNALS

INTRODUCTION

Traffic signals are used to alternately direct traffic to stop and to proceed. This Chapter will provide information on determining when the use of a traffic signal is appropriate and on the various types of traffic signals available for use.

WHAT IS A TRAFFIC SIGNAL WARRANT?

The term Traffic Signal Warrant is used to cover a set of conditions which, if they exist, indicate that a traffic signal may be an appropriate control device at a location.

On page 1A-22 of the MUTCD 2000 the following definition is given. "A warrant describes threshold conditions to the engineer in evaluating the potential safety and operational benefits of traffic control devices and is based upon average or normal conditions. Warrants are not a substitute for engineering judgment. The fact that a warrant for a particular traffic control device is met is not conclusive justification for the installation of the device."

WHAT WARRANTS MUST BE SATISFIED FOR A TRAFFIC SIGNAL INSTALLATION?

Sections 4C.01 through 4C.09 of the MUTCD 2000 provide information on eight traffic signal warrants. That information is lengthy and is therefore not repeated here. The following information is provided for emphasis.

The MUTCD 2000 sets the following Standard:

1. An engineering study of traffic conditions, pedestrian characteristics, and physical characteristics shall be performed to determine whether installation of a traffic control signal is justified at a particular location.
2. The satisfaction of a traffic signal warrant or warrants shall not in itself require the installation of a traffic control signal.
3. Minimum traffic and pedestrian volume requirements may be reduced in the built-up areas of isolated communities having a population of less than 10,000.

WHAT DATA SHOULD BE COLLECTED FOR AN ENGINEERING STUDY?

The Engineering study data should include the following:

1. The number of vehicles entering the intersection in each hour from each approach during 12 hours of an average day. It is desirable that the hours selected contain the greatest percentage of the 24-hour traffic volume.
2. Vehicular volumes for each traffic movement from each approach, classified by vehicle type (heavy trucks, passenger cars and light trucks, public-transit vehicles, and, in some locations, bicycles), during each 15-minute period of the 2 hours in the morning and 2 hours in the afternoon during which total traffic entering the intersection is greatest.
3. Pedestrian volume counts on each crosswalk during the same periods as the vehicular counts in Paragraph B above and during hours of highest pedestrian volume. Where young, elderly, and/or persons with physical or visual disabilities need special consideration the pedestrians and their crossing times may be classified by general observation.
4. Information about nearby facilities and activity centers that serve the young, elderly, and/or persons with disabilities, including requests from persons with disabilities for accessible crossing improvements at the location under study. These persons may not be adequately reflected in the pedestrian volume count if the absence of a signal restrains their mobility.
5. The posted or statutory speed limit or the 85th-percentile speed on the uncontrolled approaches to the location.
6. A condition diagram showing details of the physical layout, including such features as intersection geometrics, channelization, grades, sight-distance restrictions, transit stops and routes, parking conditions, pavement markings, roadway lighting, driveways, nearby railroad crossings, distance to nearest traffic control signals, utility poles and fixtures, and adjacent land use (existing and proposed).
7. A collision diagram showing crash experience by type, location, direction of movement, severity, weather, time of day, date, and day of week for at least one (1) year.

The following data, which are desirable for a more precise understanding of the operation of the intersection, may be obtained during the periods specified in Paragraph B above.

1. Vehicle-hours of stopped time delay determined separately for each approach to be consistent with the Peak Hour Warrant.

2. The number and distribution of acceptable gaps in vehicular traffic on the major street for entrance from the minor street.

3. The posted or statutory speed limit or the 85th-percentile speed on controlled approaches at a point near to the intersection but unaffected by the control.

4. Pedestrian delay time for at least two 30-minute peak pedestrian delay periods of an average weekday or like periods of a Saturday or Sunday.

5. Queue length on stop-controlled approaches.

HOW IS THE DATA FOR AN ENGINEERING STUDY COLLECTED?

Automatic counters should measure the number of vehicles entering the intersection over long periods of time. Traffic volumes are an essential piece of information for any decision regarding traffic control. Automatic counters are relatively inexpensive and can be used in many situations by local governments. The cost and use can be shared among a number of local agencies if necessary.

Turning movements and pedestrian counts can only be obtained through visual counts. A minimum of two individuals is required for the collection of this data.

The method for the determination of the 85th-percentile speed is discussed in Chapter 4.

Condition and Collision Diagrams are discussed in Chapter 10.

**IN WHAT CASES WOULD A TRAFFIC SIGNAL NOT BE INSTALLED IF
A WARRANT IS MET?**

Many public officials and certainly the general public believe that a traffic signal will solve all problems at an intersection. This is not the case. In some instances the installation of a traffic signal will trade one problem for another. Right angle crashes may be replaced by rear end collisions. Drivers may select alternate routes to avoid the signal, thus creating problems elsewhere on the street system. In addition, signalization may also increase traffic levels on the side street by making access to the major street easier. Therefore, as part of the required engineering study the following should be determined:

1. Will the overall safety and/or operation of the intersection be improved?
2. Will the signal seriously disrupt progressive traffic flow?

A much more serious issue is the commitment of the local authority to the installation of properly designed and maintained traffic signals. If the responsible agency is not willing to spend the funds necessary for an installation that meets the need of a particular location, and for the proper maintenance of the signal, they should not proceed. A traffic signal that does not meet the needs of a location will result in a decrease in the overall safety and operation. Modern traffic signals are specialized equipment. Maintenance personnel must receive specific training. The local agency must be committed to providing these trained employees for as long as the signals are in place.

**HOW ARE THE NUMBER AND LOCATION OF SIGNAL FACES
DETERMINED?**

The first step is to consider the number and type of signal phases. An example would be the need for, and type of, left turn control. The information gathered during the engineering study will provide guidance on this.

An accurate topographic survey of the intersection is essential. The location of the signal faces is governed by rules; however, these locations are also governed by the physical characteristics of the intersection. Geometric changes to the intersection may be required for a proper traffic signal installation. The survey will provide the installing agency a better understanding of the total scope of the project.

There are some basic rules governing the layout of a traffic signal installation. These are:

1. A minimum of two signal faces shall be provided for the major movement on each approach, even if the major movement is a turning movement.
2. One and preferably both of the required signal faces shall be located not less than 40 feet and not more than 150 feet beyond the stop line; and shall be as near as practical to the line of the driver's normal view (if mounted over the roadway). Refer to Figure 4D-2 on Page 4D-26 of the MUTCD 2000.

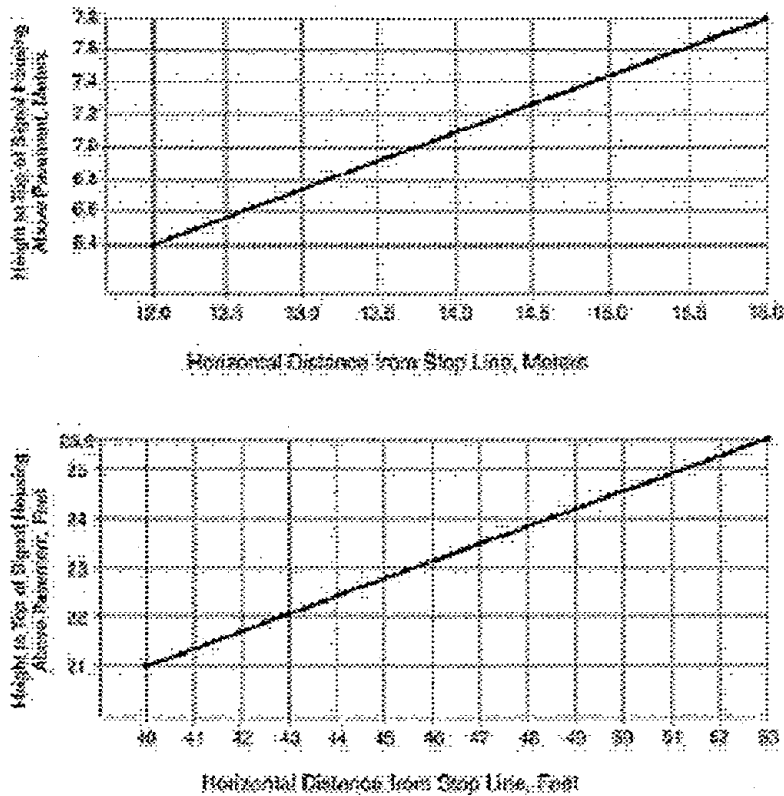


FIGURE 7. MAXIMUM MOUNTING HEIGHT OF SIGNAL FACES LOCATED BETWEEN 12 METERS (40 FEET) AND 16 METERS (53 FEET) FROM STOP LINE.

3. At least one and preferably both of the required signal faces shall be located within a 40 degree cone with the sides of the cone extending 20 degrees left and right of the center of the approach extended. Refer to Figure 4D-2 on Page 4D-26 of the MUTCD 2000.
4. The signal heads must also fall within a range of heights. These heights vary based on the horizontal distance from the stop line. Refer to Figure 7.
5. Pedestrian signal heads may be required as discussed below. Refer to Section 4E.03 of the MUTCD 2000. Pedestrians can be guided by vehicular signal indications. However, the pedestrian indications, whether vehicular signals or pedestrian heads, must be placed so that they are visible to pedestrians. Separate pedestals may be required to ensure that proper visibility is attained. Engineering judgment must be applied to every installation to determine if conditions merit the use of pedestrian signal heads.

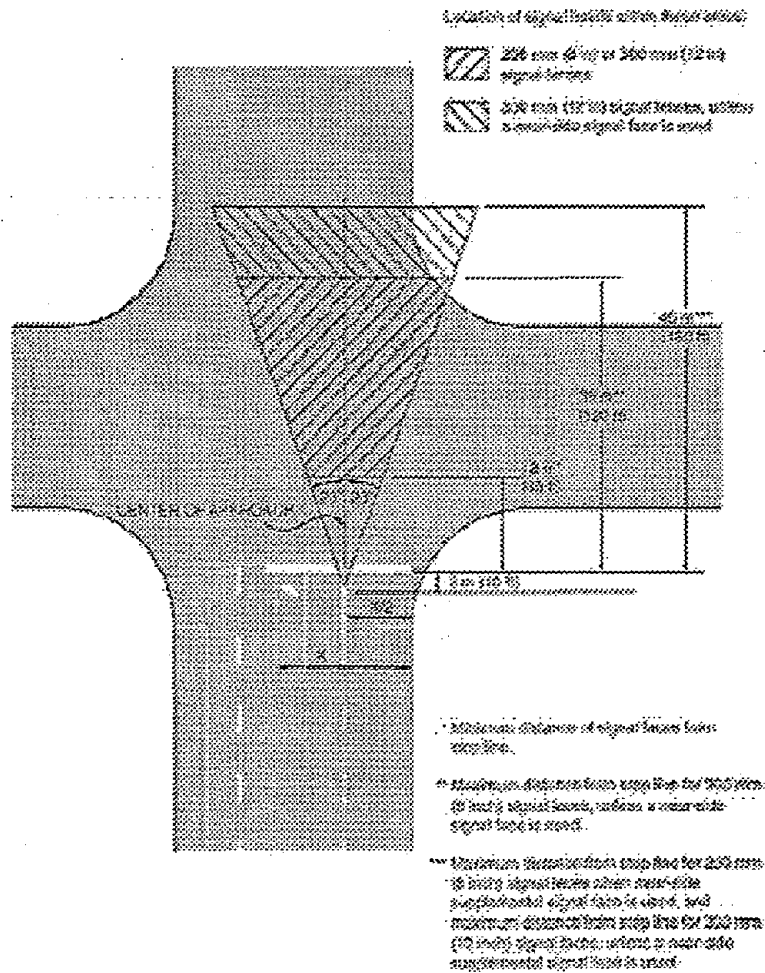


FIGURE 8. HORIZONTAL LOCATION OF SIGNAL PHASES.

Pedestrian signal heads shall be used if:

1. If the signal installation is justified by meeting Warrant 4, Pedestrian Volume or Warrant 5, School Crossing
2. If an exclusive signal phase is provided or made available for pedestrian movements in one or more directions, with all conflicting vehicular movements being stopped.

3. At an established school crossing.
4. When multi-phase signal indication would tend to confuse pedestrians guided only by vehicular signal indications.

Pedestrian signal heads should be used under any of the following conditions:

1. If it is necessary to assist pedestrians in making a safe crossing or if engineering judgment determines that pedestrian signal heads are justified to minimize vehicle-pedestrian conflicts.
2. If pedestrians are permitted to cross a portion of a street, such as to or from a median of sufficient width for pedestrians to wait, during a particular interval but are not permitted to cross the remainder of the street during any part of the same interval; and/or
3. If no vehicular signal indications are visible to pedestrians, or if the vehicular signal indications that are visible to pedestrians starting or continuing a crossing provide insufficient guidance for them to decide when it is safe to cross, such as on one-way streets, at T-intersections, or at multiphase signal operations.

WHAT IS MEANT BY CYCLE LENGTH?

The cycle length is the total time required for one complete sequence of signal indications.

WHAT IS MEANT BY SIGNAL PHASE?

Signal Phase refers to the right-of-way (green time), yellow change and red clearance intervals in a cycle that are assigned to an independent traffic movement or combination of movements.

WHAT ARE THE DIFFERENCES BETWEEN PRETIMED, SEMI-TRAFFIC ACTUATED AND FULLY-TRAFFIC ACTUATED SIGNALS?

The term "Pre-timed Signal" refers to one in which the cycle lengths and phase times are preset. These are also referred to as fixed time signals.

A Semi-Traffic Actuated Signal is one in which at least one but not all of the phases function through the use of a detector. The most common example of this is for the initiation and/or extension of a minor street traffic phase.

A Fully-Traffic Actuated Signal is one in which all phases are initiated and/or extended through the use of detectors.

WHEN CAN PRETIMED SIGNALS BE USED?

Advances in technology have made the use of traffic-actuated signals economical for most installations. The controller modules in use today are all capable of receiving input from a traffic detector. A variety of detector types allow for an inexpensive installation of these devices.

A location where a pre-timed signal could be considered is at an intersection with a high volume of traffic on the minor approaches during a majority of the day. Fixed time signals are often appropriate in Central Business Districts. However, a series of pre-timed signals placed along a street should be interconnected to allow for progression timing. Pre-timed signals may be programmed to change to allow for automatic flashing modes at night or other low use periods.

WHAT CYCLE LENGTH SHOULD BE SELECTED FOR A PRE-TIMED SIGNAL?

The shortest practicable cycle lengths are the most desirable. Cycle lengths longer than necessary to accommodate the existing traffic or pedestrian volumes produce unnecessary delays. This results in driver impatience and, therefore, potential reduction of the overall safety and/or operation of the intersection. The following paragraphs provide instructions for the calculation of the various components of the signal cycle.

WHAT IS THE DESIRABLE LENGTH FOR THE YELLOW CHANGE INTERVAL?

The yellow change interval advises the motorist that the right-of way interval is about to end. The motorist is also thereby informed that the red clearance interval is about to commence. This interval should be of sufficient length to permit the motorist to bring his vehicle to a safe stop if he has not entered the intersection. The motorist past the point of a safe stop needs sufficient time to clear the far edge of the intersection within the yellow change interval.

The length of the yellow change interval is a function of the approach speed, acceptable deceleration rates, driver perception/reaction times, vehicle length, intersection width and street grades. The yellow change interval is normally between three (3) and six (6) seconds in length. If times longer than six (6) seconds are necessary, extend the time with the use of an all-red clearance interval of 1 to 3 seconds in length. The all-red clearance interval should not exceed six (6) seconds in length. The following equations should be used for determining the timing for yellow change intervals and all-red clearance intervals.

$$y = t + (v/(2a+64.4g))$$

where y = yellow interval, in seconds

t = reaction time (use 1.0 seconds)

v = 85th percentile approach speed in feet per second

a = deceleration rate (use 10 feet/second/second)

g = grade of approach over the breaking distance in percent/100

Example: For 30 mph and street grade of +1%

$$y = 1.0 + (44/(2 \times 10 + 64.4 \times 1/100)) = 3.13 \text{ seconds}$$

Note that grade of -1% results in 3.28 seconds for yellow interval.

$$r = (w+L)/v$$

where r = all-red interval, in seconds

w = width of intersection, in feet

v = 85th speed of vehicle in feet per second

HOW IS THE TIMING OF A PEDESTRIAN SIGNAL DETERMINED?

The WALK Interval should be at least four (4) but no more than seven (7) seconds in length.

The FLASHING DON'T WALK Interval should be long enough for a pedestrian to leave the curb and travel to the center of the farthest traveled lane. A walking speed of 3.5 seconds is often used. This is a median between 4 seconds for an active adult and 3 seconds for the elderly and very young.

HOW MUCH TIME SHOULD BE ALLOCATED TO EACH RIGHT-OF-WAY (GREEN) INTERVAL?

The right-of-way interval can be calculated using the following formula.

$$\text{Right-of-way interval} = (2.1) n + 3.7''$$

2.1 is the amount of time allocated for each vehicle to clear the intersection in seconds.

n is the number of vehicles per interval

3.7 is the initial delay at the beginning of the interval.

The following is an example of a signal timing calculation.

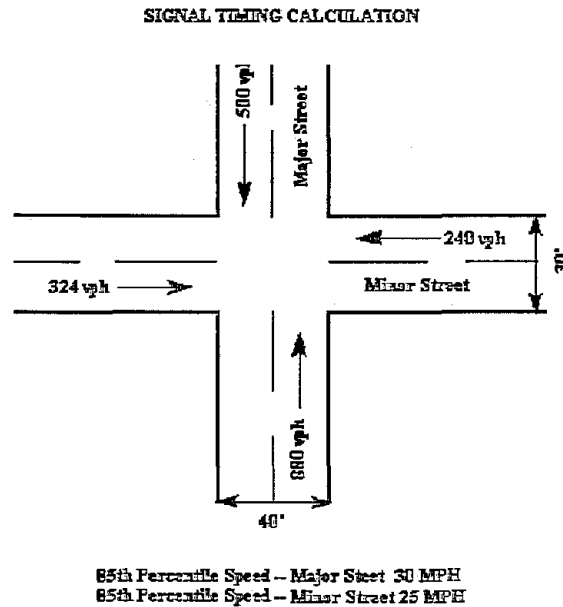


FIGURE 9. EXAMPLE INTERSECTION.

1. Step 1-Determine Yellow Change and All-Red Intervals

From the equations, we determine that the yellow change and all-red intervals for the major street is 5.6 seconds. For the minor street these are determined to be 4.0 seconds.

2. Step 2-Assume A Minimum Cycle Length

Assume a 55-second cycle length

Therefore: Cycles per Hour = $3600 \text{ seconds} / 55 \text{ seconds}$
= 65 cycles

3. Step 3-Calculate Minimum Right-of-Way Intervals Based on Assumed Cycle Length

Major Street

Critical Volume = 880 vehicles/hour
 Vehicles/Interval = $880/65 = 13.5$ vehicles/interval

Minimum Interval = $(2.1)*(13.5)+3.7 = 32.1$ seconds

Critical Volume = 324 vehicles/hour
 Vehicles/Interval = $324/65 = 5.0$ vehicles/interval

Minimum Interval = $(2.1)*(5.0)+3.7 = 14.2$ seconds

4. Step 4-Calculate Pedestrian Crossing Times

Major Street
 Crossing Time = $40 \text{ ft.}/3.5 \text{ ft./second} = 11.4$ seconds
 Start Time = 3 seconds
 Total Time = 14.4 seconds

This is greater than the Minimum Right-of-way Interval for the Minor Street (remember that the pedestrian crossing the Major Street does so during the Minor Street Right-of-way Interval). The larger value must be used for the total cycle time calculation.

Minor Street

Crossing Time = $30 \text{ ft.}/3.5 \text{ ft./second} = 8.6$ seconds
 Start Time = 3 seconds
 Total Time = 11.6 seconds

The Major Street Right-of-way Interval will govern.

5. Step 5-Calculate The Minimum Cycle Length

Minor Street

Major Street Right-of-way Interval = 32.1 seconds

Major Street Yellow Change Interval	= 5.6 seconds
Minor Street Right-of-way Interval	= 14.4 seconds
Minor Street Yellow Change Interval	= <u>4.0 seconds</u>
Total	= 56.1 seconds

6. Step 6-Adjust Cycle Length As Required

The calculated minimum cycle length is reasonably close to the assumed cycle length. Had the calculated cycle length been considerably different, Steps 2-5 should be repeated using a more appropriate cycle length.

7. Step 7-Review Actual Conditions At The Operating Signal

The signal should be closely monitored during the first days of operation. The observer should determine if the calculated cycle lengths are appropriate for the conditions in the field. The signal should be checked thereafter on a regular basis to determine if conditions have changed over time.

HOW IS THE PHASE TIMING DETERMINED FOR TRAFFIC ACTUATED SIGNALS?

The major difference between the pre-timed and the actuated signal is that the cycle length is not fixed for the actuated signal. A phase will not provide a Right-of-way Interval unless traffic is present. The Right-of-way Interval can vary in length depending on the traffic volume present during each use of a phase. As stated earlier, the shortest cycle time is the most desirable. This is the major benefit of using this type of signal.

A minimum of six (6) to eight (8) seconds initial Green Time is usually provided. This interval will be allowed to extend to a maximum number. The calculation of the maximum number is based on anticipated traffic volume and can be performed as shown previously for the pre-timed signal. The maximum Green Time should be established at 1.25 to 1.5 times the value calculated for pre-timed signals. The Yellow Change Interval and All-Red Clearance Interval are determined in the manner described previously.

WHAT IS A "DILEMMA ZONE"?

At intersection where the speeds of approaching traffic are greater than 30 mph, drivers are frequently faced with a dilemma. This dilemma occurs at the beginning of the yellow change interval as to whether to stop or to proceed.

Dilemma zone problems at a pre-timed signal can be controlled through appropriate adjustment of the yellow change interval and the all-red clearance interval. Proper placement of advance detection loops will control dilemma zone concerns at an actuated signal. The correction of a dilemma zone problem requires expertise. Local agencies that believe a dilemma zone problem may exist at an intersection, and who do not have Staff experienced in correcting this problem, should use the resources of a consulting engineer or of the Kansas Department of Transportation.

WHAT IS "STRETCH"?

This term is normally associated with detectors. It refers to the amount of time that a detection call will be presented to the controller after the vehicle has departed the detection zone. In other words, when a vehicle is detected, a detection call will be registered with the controller. Once the vehicle exits the detection zone, the call will continue to be registered with the controller for an additional amount of time as determined by the stretch timer setting.

WHAT IS "PASSAGE"?

This term is normally associated with unit time settings. It refers to the amount of time a green indication will be extended after all detectors associated with that particular phase have ceased to register calls, assuming the maximum green time setting has not been reached. Passage times are calculated to allow a vehicle to pass over the advance detector at the 85th percentile speed to clear the far curb line or crosswalk at or before the completion of the clearance interval.

ARE THERE ALTERNATIVES TO THE USE OF A TRAFFIC SIGNAL?

The cost of operating and maintaining traffic signals can be a major expense. Malfunctions of signals cause serious traffic delays and a high potential for an unsafe situation. Studies are currently underway in the United States on the safety and operational benefits of Roundabouts. While similar in appearance to Traffic Circles, Roundabouts have a number of geometric and operational differences that address problems experienced at Traffic Circles.

The initial cost of Roundabout construction may be as much or more than that of a traffic signal installation. However, the long-term operational costs for both the local agency and the driving public will be less. The use of a Roundabout may not be appropriate at all locations, but local agencies should be

aware of their potential and should consider their use as the need for improved traffic control arises.

CHAPTER 8

FLASHING BEACONS

WHEN SHOULD FLASHING BEACONS BE CONSIDERED?

TYPES OF BEACONS

There are two general types of beacons:

1. Sign beacons - These beacons are mounted on a STOP sign, speed limit sign, or warning sign to supplement the sign message. The beacons call attention to an unusual intersection or condition.
2. Overhead beacons (sometimes called intersection control beacons) - These beacons are intended to be installed over a roadway where a traffic study indicates the intersection has an unusual traffic or physical condition.

An engineering study or engineering judgment should be used.

USE AND MISUSE OF BEACONS

Beacons serve a useful purpose where the flashing light is used to alert drivers of *unusual conditions* that are not readily apparent, such as obstructions in the roadway, uncommon roadway conditions, narrow bridges, or unusual conditions hidden from motorists' view. At intersections, the MUTCD states: "Beacons are intended for use . . . where traffic or physical condition do not justify conventional traffic signals but where high crash rates indicate a special hazard."

For any beacon to be effective, it must command the respect of the motoring public. In other words, immediately after seeing the beacon, the driver must *consistently* see an unusual condition that is being singled out for attention. Furthermore, the motorist should view the condition as serious enough to justify the special treatment provided by the beacon.

When beacons are used improperly or installed at too many locations they soon lose much of their effectiveness. They simply cease to command the respect of the drivers. After continually being alerted to a condition which seldom, if ever, appears unusual, drivers actually stop "seeing" the beacon. When this happens, beacons which are truly needed may well be disregarded by drivers who have become conditioned to believe that beacons are just "window dressing." Because of this normal human reaction, even one improper

installation greatly reduces the effectiveness of beacons at locations where they may be beneficial in increasing driver awareness. When seen with a system-wide perspective, it is apparent that the needless or excessive installation of beacons tends to "water-down" the effectiveness of this important traffic control device.

The Kansas Department of Transportation strives for standardization of traffic control, thus meeting driver expectations. When drivers see beacons at locations that do not have any unusual characteristics, beacons begin to lose their effectiveness in the minds of drivers.

In school zones beacons may also give pedestrians, children and their parents a false sense of security. Quite often communities request beacons in the belief that they will improve crossing safety, rather than attempting to solve the underlying problems. For example, there may be no established route to and from school, no pedestrian safety program, or no adult crossing guards. Some parents and school districts believe the entire responsibility for crossing safety lies in the traffic control devices and not in themselves or the children. Children will not automatically be more visible to drivers merely because a beacon is in place. Choosing an appropriate time to cross is the pedestrian's responsibility.

A common misconception is that a beacon, when used alone or in conjunction with a speed or warning sign, will slow down traffic. Drivers tend to drive at a speed that they perceive to be safe based on their surroundings, such as width of pavement, roadway features, (i.e. curves) and type and number of developments.

ENGINEERING STUDY

Before deciding to install a new beacon or remove an existing beacon, an engineering study should be conducted. The traffic engineering study should include: reviewing the location; its accident history; roadway features, such as type of pavement, number of lanes, lane width; vehicle speeds; vehicle volumes; number of pedestrians and school children; and sight restrictions.

OVERHEAD BEACONS

Overhead beacons may be installed at an intersection with unusual traffic or physical conditions. They should be used sparingly so as to indicate to the driver that "this is an intersection where I need to use extra caution."

IN SUMMARY

When beacons are properly located, they serve a useful function. When they are used improperly and installed at locations where they are not needed, they soon lose much, if not all, of their effectiveness. More seriously, improper usage greatly reduces the effectiveness of other beacons installed in areas where there is a real need.

MUTCD 2000, Chapter 4K also has a section on flashing beacons.

CHAPTER 9

TRAFFIC SIGN INVENTORY

INTRODUCTION

The overall purpose of a traffic sign inventory is to allow local governments to keep a current file on record of all signs in their jurisdiction. Having an inventory will help to maintain the local sign system in the following ways:

1. It will establish a basis for the upgrading of traffic signs through a planned program of modernization.
2. It will establish the location and condition of all signs within the jurisdiction.
3. It will provide written evidence that inspection of signs has been conducted with regularity. This will help to protect against liability claims.

WHAT INFORMATION SHOULD BE INCLUDED IN A SIGN INVENTORY?

Information which should be included in a sign inventory includes a record of:

1. Type of sign and support system.
2. Size of sign.
3. Location of sign.
4. Time, date, and by whom the sign was installed or inventoried.
5. Condition of sign and support:
 - a. What is the sign's retro-reflectivity condition?
 - b. Is sign peeling or faded?
 - c. Has the sign been vandalized?

- d. Is sign reasonably clean (i.e., can it be read)?
6. Date and by whom maintenance was performed may be marked on the sign; however, a separate record should also be kept. Care should be taken to insure that all records are updated whenever maintenance is performed on a sign, since signs are sometimes stolen.

HOW SHOULD THE INVENTORY INFORMATION BE RECORDED AND FILED?

After determining what types of information need to be included in the sign inventory, a convenient way to record and file the information must be provided. There are several different methods currently in use. Remember, having a system that works for you is more important than what system it is.

1. Sign Inventory Card Systems – Although old and possibly outdated, these systems allow the user to group and arrange data into any form that is desired, thus allowing sign information to be located by type. These cards are easily filed in that there is no order necessary for storing the cards. These sign inventory card systems are inexpensive, simple, and adaptable to all levels of roads, and are available from commercial sources. These same commercial sources probably have newer, computerized versions available.
2. Location - Identification Map - This system utilizes color-coded pins to represent different type signs. A large size map of the jurisdiction, or sections of the jurisdiction, can be used. Appropriate pins are then placed on the map at the sign locations, with each pin having a slip of paper attached to it identifying the sign, its exact location, and the last date of maintenance and inspection.
3. Computer Systems – Data collected may be stored within computers for easy access and data comparison with associated accounting tables, maintenance information and locations. Several sign companies and/or suppliers can provide these types of systems.

HOW CAN THE CITY BENEFIT BY USING A SIGN INVENTORY SYSTEM?

With the initiation of a sign inventory system, the city can likely reduce the number of liability claims resulting from traffic accidents. Many times these accidents occur at locations where signs have been stolen, vandalized, or are well past their life and in need of replacement. By using a sign inventory system

most of these problem areas can be spotted and proper action can be taken to upgrade the signing.

A traffic sign inventory also can help the engineer evaluate other areas of concern and interest. For example, as vandalism rates increase all around, these increased rates can be seen in the sign system. By analyzing sign inventories, costs of replacing signs that have been vandalized can be estimated. Also, other signing costs could be estimated in a similar fashion. By making these estimations the engineer will be able to make a more precise budget for the signing needs of the city.

WHAT TYPE OF SYSTEM IS RECOMMENDED?

Whatever system works for a local jurisdiction. Currently there are any number of sophisticated computer systems available. It is suggested that the local jurisdiction contact KDOT, their county, a large city, sign companies, sign distributors, etc. to get advice on the latest, available systems.

As a minimum, each local jurisdiction should have some record of keeping track of their signs, the age of the signs, and when they were last inspected. In the near future (expected in 2003) FHWA will publish minimum retroreflectivity standards and a sign inventory system will be beneficial in meeting whatever standards are published.

WHAT PREPARATION IS NECESSARY PRIOR TO CONDUCTING A SIGN INVENTORY?

No matter what system is used, before a sign inventory can be made, care should be taken to organize and plan all aspects. The following guidelines may be helpful for getting started.

1. Divide the geographical area of interest into, say ten control sections and number them 1-10. (A control section is a small area within which a sign inventory is performed. The number will vary according to the size of the city.)
2. Plot the ten control sections on a reproducible mylar master map.
3. Be sure that road names or numbers are on the reproducible mylar master map. As added options, the following things could be done:
 - a. Produce one map of each control section for field data collection purposes. Sign inventory crews should then color the road

segments, as the sign survey is completed, with a red or yellow marker to avoid duplication and to aid in planning the work effort.

- b. One copy of the complete master map should be reproduced for official purposes and should be mounted on a wall near the card storage area to aid in cataloging and for reference.
4. Develop a sign code list for each of the survey teams. Use state sign codes as a basis for developing the list. Unique numbers should be assigned for each sign type, including special signs and pavement markings.
 5. To aid survey teams in identifying sign age, samples from existing signs should be made. Small samples (i.e. 1" x 3") for each color and material type should be produced. These samples should then be rated as either "good", "average" or "bad", and their age marked on the backside.
 6. Train all applicable employees. This training should include an understanding of the fundamentals of retroreflectivity and acceptable methods of meeting minimum retroreflectivity values (Expected from FHWA in 2003). This includes not only the survey teams, but other employees who may aid in the survey during their regular routine. Some possibilities include:
 - a. City road crews.
 - b. Law enforcement officers.
 - c. Water meter readers.
 - d. Electric meter readers.

WHAT ARE THE FIELD DATA COLLECTION STEPS TO TAKE?

This depends upon what system the local jurisdiction adopts. Whatever system is adopted, a periodic schedule of day and night inspection and data collection should be developed and followed. A permanent record of the data obtained should be kept.

HOW CAN THE INVENTORY BE UPDATED?

After the initial inventory of signs, updating of the inventory will be required. The frequency of updating will depend upon various factors such as employee availability and funding and meeting MUTCD standards. To aid in updating process, certain city employees could be trained to watch for and report problems noted during their normal routine. Possible employees that could be utilized in a system like this include the following:

1. City road crews could perform inventory on slow work days, and also in going to and from job sites.
2. Law enforcement officers.
3. Utility company field personnel.

CHAPTER 10

TRAFFIC CRASHES

INTRODUCTION

Establishment of a record system, which permits the accurate retrieval and analysis of traffic crash records is of utmost importance to all governmental jurisdictions. Good records will facilitate the planning of crash prevention measures through engineering, education and enforcement.

Local agencies needing assistance in setting up a records system are encouraged to contact The Bureau of Local Projects of The Kansas Department of Transportation. An excellent guide to traffic crash report filing is The Manual on Identification, Analysis and Correction of High Accident Locations (HAL Manual) written by Kansas State University (KSU) which is available from the Kansas Department of Transportation or KSU. KSU also developed training courses based on the HAL Manual which are offered periodically to Kansas public officials and employees.

WHY IS THIS CHAPTER TITLED TRAFFIC CRASHES INSTEAD OF TRAFFIC ACCIDENTS?

Webster's Seventh New Collegiate Dictionary defines an accident as "an event occurring by chance or from unknown causes." With this definition in mind, this handbook will refer to traffic collisions and crashes rather than traffic accidents. It is important for both public officials and the traveling public to realize that traffic crashes do not happen by chance or from unknown causes. Although some persons disagree - sometimes adamantly - there is a current national trend to accept the term "crash" in place of "accident."

HOW SHOULD LOCAL CRASH RECORDS BE FILED?

To facilitate analyses, the original reports of crashes should be filed by year and by location of occurrence. As a less desirable alternative, the original reports could be filed chronologically and a location cross-reference index file could be developed to permit retrieval of data for specific locations.

In cities, and in counties that have developed an address system with road names, the location file can be set up according to an easily understood and followed system. Such a system could be based upon the following criteria:

1. **Intersection Crashes:**
Major Street (alphabetized)/Lessor Major Street (alphabetized)
Major Street (alphabetized)/Minor Street (alphabetized)
Minor Street (alphabetized)/Lessor Minor Street (alphabetized)
2. **Block Crashes**
Streets (alphabetized) by Range of Blocks North, East, West and South

It is very important that all crashes at an intersection be recorded in a consistent manner. A common practice is to establish file folders for each intersection or length of street based on the above criteria. Copies of the reports are kept within these file folders over a calendar year period. At the end of each year, the copies are removed and the folders reused. This allows for easy and uniform recording of locations over a period of time. The copies can then be stored in bulk folders in the same order for easy retrieval.

The HAL Manual, mentioned previously, gives details in setting up a filing system that could be very beneficial for a local agency that does not have one.

HOW LONG SHOULD CRASH RECORDS BE RETAINED?

Changes to traffic control devices should only be made after a long-term study. The accepted practice is to base decisions to revise traffic control measures on a three year basis as a minimum.

WHAT IS A SPOT MAP?

A Spot Map is a tool that can be used to pinpoint problem locations. In particular, a spot map furnishes a quick visual index of the location of crash concentrations, thus supplementing the location file system discussed above.

The most common spot map is one showing crashes by color-coded pins, spots or symbols on the map at the location of each occurrence. This map is updated as reports are received and filed. The legend should be as simple as possible, using not over four or five types, sizes or colors of spots. These should represent, at a minimum, property damage only crashes, injury crashes and fatalities.

Traffic crash spot maps are normally maintained for the calendar year. The map should be filed with the copies of that year's reports or a copy, such as a photograph, is taken and it filed for future reference. If the public agency has computer-mapping capabilities, the spot map for each year can be maintained as a computer file as well as printed and filed.

With the aid of a spot map and the crash location file, locations of high accident frequency are readily detectable. Annual or more frequent periodic listing of these locations can then be compiled for purposes of analysis and correction.

WHAT IS A COLLISION DIAGRAM?

A Collision Diagram, along with a Condition Diagram, is one of the most effective tools for analyzing traffic crash patterns to determine probable causes for unusually high rates of crashes at a location.

A Collision Diagram illustrates graphically, by means of directional arrows and symbols, the paths of vehicles and the nature of collisions. These diagrams are schematic and, therefore, are seldom drawn to scale. As is shown in Figure 20-1, a set of arrows is used to represent each accident. The date, time of day, the Accident Report Reference Number and other special information are written next to one of the arrows depicting that particular crash.

WHAT IS A CONDITION DIAGRAM?

A Conditions Diagram is a scaled drawing showing the physical characteristics of the location being studied. The type of information traditionally shown includes; but is not limited to:

- | | |
|-----------------------------------|---------------------------------|
| 1. Curb Lines | 8. Drainage structures |
| 2. Traffic Controls | 9. Street names |
| 3. Property Lines | 10. North arrow |
| 4. Buildings and Other Structures | 11. Above ground utilities |
| 5. Sidewalks and Driveways | 12. Other pertinent information |
| 6. Trees and Shrubbery | |
| 7. View Obstructions | |

This drawing can be used in conjunction with the collision diagram to identify the reason for a particular type of crash. For instance, a high incidence of right angle collisions may be caused by a visibility obstruction at one corner of the intersection.

WHAT OTHER RECORDS SHOULD BE MAINTAINED?

Each Governmental Agency should maintain a record of citizen comments/concerns received regarding traffic issues. These records should be kept separately from the Crash Records but can be indexed in the same manner. As much information regarding the comment as possible should be recorded.

The date, person filing the comment, the nature of the comment and actions taken are example of essential information. The agency should respond to all citizen concerns. A record of the information gathered and reviewed and any response should be kept on file.

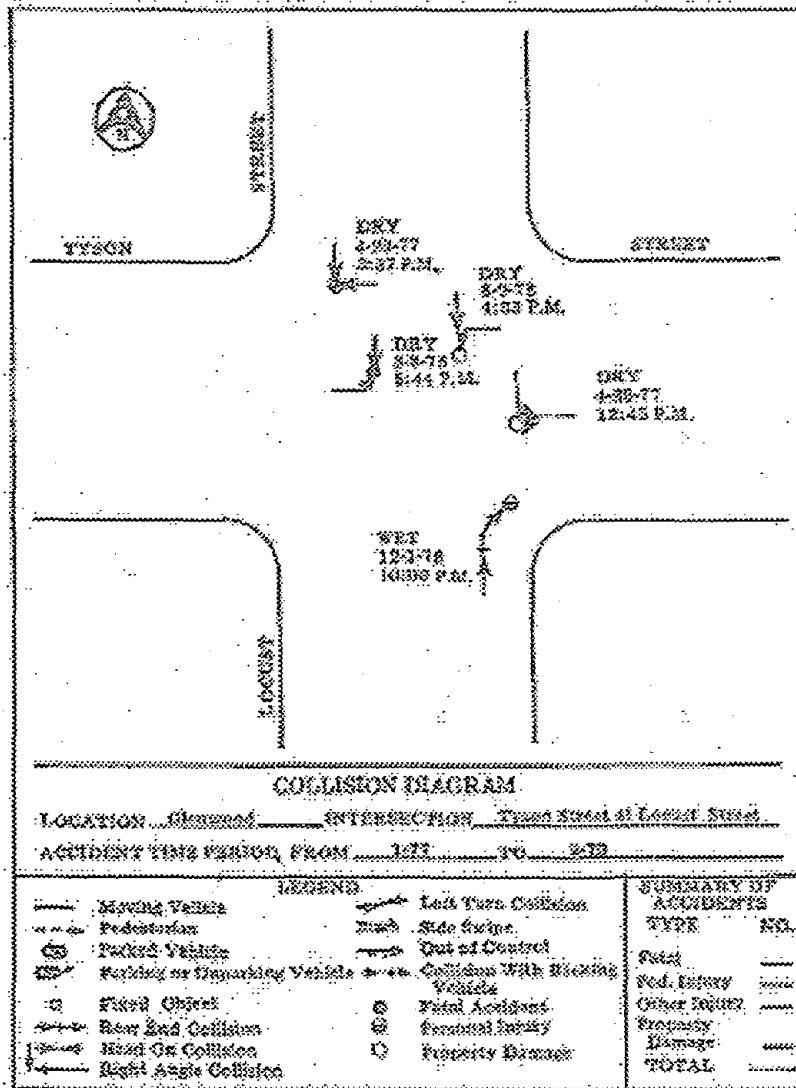


FIGURE 10. TYPICAL COLLISION DIAGRAM.

WHAT MEASURES CAN BE EMPLOYED TO LOWER THE CRASH RATE AT A LOCATION?

The Spot Map, Collision Diagram and Condition Diagram will be helpful in identifying the crash pattern and possible causes for these at a particular location. Selection of the appropriate countermeasure to alleviate the crash problem is the next step. Table 4 is a summary of some of the countermeasures that can be employed to deal with the more typical crash causes. If these measures do not prove effective for a particular location, the local agency is encouraged to seek the help of a professional traffic engineer.

**TABLE 4
GENERAL COUNTERMEASURES FOR ACCIDENT PATTERNS AND THEIR PROBABLE CAUSES**

<u>Accident Pattern</u>	<u>Probable Cause</u>	<u>General Countermeasure</u>
Right Angle Collisions (Signalized Intersection)	Poor Signal Visibility	Install 12" signal lenses Install mast arm mounted signals Install backplates, visors Install advance warning signs Improve signal head locations Add signal heads
	Inadequate Signal Timing	Adjust yellow phase Provide all-red clearance Retime signals
Right Angle Collisions (Unsignalized Intersection)	Restricted Sight Distance	Remove sight obstructions Restrict parking Install Stop signs Install warning signs Reduce speed limit Install signals
	Heavy Traffic Volume	Install signals
	High Approach Speed	Reduce speed limit Install rumble strips for stop condition

TABLE 4 (Cont.)

Rear End Collisions (Signalized Intersections)	Poor Signal Visibility	Install advance warning signs Install overhead signals Install 12" signal lenses Install backplates, visors Relocate signals Add signal heads Improve signal head location
	Inadequate Signal Timing	Adjust yellow phase
	Slippery Surface	Overlay pavement Groove Pavement Reduce speed limit
	Large Turning Volumes	Create turning lanes Prohibit turns Increase curb radii
Rear End Collisions (Unsignalized Intersection)	Driver Not Aware of Intersection	Install/improve warning signs
	Slippery Surface	Overlay pavement Groove pavement Reduce speed limit
Fixed Object Collisions	Objects Near Traveled Way	Remove obstacles Install barrier curbing Protect objects with guardrail
	Slippery Surface	Overlay pavement Groove pavement Reduce speed limit
Night Accidents	Poor Visibility	Install/improve street lighting Install/improve warning signs Install/improve delineation markings
Left-Turn Collisions	Large Volume of Left Turns	Provide left turn signal phase Prohibit left turns Channelize intersection Create one-way streets

WHERE CAN I GET MORE INFORMATION OF THIS TYPE?

Contact KDOT or KSU, Department of Civil Engineering for the latest edition of the High Accident Location (HAL) Manual or request a course covering HAL manual techniques.

CHAPTER 11

ROADWAY LIGHTING

INTRODUCTION

Roadway lighting helps provide for the safe movement of traffic during darkness, reduces night crashes, and reduces night crime in urban areas. Proper lighting will provide the visibility necessary for drivers to make decisions concerning the safe operation of their vehicles.

The principal objectives of roadway lighting are:

1. To supplement vehicle headlights by extending the visibility range beyond their limits both laterally and longitudinally.
2. To improve the visibility of objects and features on or near the roadway.
3. To delineate the roadway.
4. To provide visibility of the environment.
5. To reduce the apprehension of those using the roadway.

In most municipalities, street lighting is installed either by the public or private utility company or by a private electrical contractor. When lighting is desired on a roadway under the jurisdiction of the Kansas Department of Transportation (KDOT), the District Engineer should be contacted before proceeding with any work. The District Engineer will advise the local governmental agency as to the specific requirements for lighting installations on rights-of-way under KDOT jurisdiction.

WHAT ILLUMINATION LEVELS SHOULD BE USED IN STREET LIGHTING?

The function of the roadway should always be considered when determining lighting needs. The recommended values for roadway illumination levels have been developed by the Illuminating Engineering Society (IES).

The publication, American National Standard Practice for Roadway Lighting RP-8, published by IES, is an excellent reference for the design of lighting installations.

The IES recommends average-to-minimum uniformity ratios of 3:1 for all roadways except local residential streets, which should have a ratio not exceeding 6:1. The uniformity ratio on the pavement area is the ratio of the average lumens of illumination to the foot candles at the point of least illumination. The average foot candles of illumination depends upon the type of luminaire and lamp used, the age of the lamp, lamp maintenance (cleaning), luminaire location and spacing and width of road lighted. Details of the design procedure and other pertinent information are found in the IES publication previously mentioned.

WHAT IS THE DIFFERENCE BETWEEN PARTIAL VS CONTINUOUS LIGHTING?

Partial lighting refers to illumination at designated sections of the roadway such as at intersections, isolated curves, or rail-highway crossings where increased visibility is needed. Continuous lighting refers to uninterrupted illumination along the roadway. Continuous lighting is more expensive to install, operate, and maintain. By gradually increasing the light intensity to its maximum level and gradually phasing it back to darkness, the eye adaption problem can be reduced.

WHAT IS THE MOST EFFECTIVE LIGHT SOURCE?

The selection of the most effective light source should increase safety. Existing light sources have unique advantages and disadvantages that should be considered in the selection of lighting equipment. Uniformity of lighting is more important than intensity.

High Pressure Sodium: excellent luminous effect, low power costs, good lumen maintenance, long life, and acceptable color, but has a higher lamp cost and more expensive ballast.

Metal Halide: excellent color, higher effect than mercury lamps and good for high-mast lighting; but has a short life and is sensitive to lamp orientation.

Low Pressure Sodium: exceptionally high luminous effect; but has monochromatic color and a large fixture.

Mercury: good luminous effect, fair to good color, small in size, and long dependable life; but has a relatively low luminous effect, and poor lumen maintenance. Generally not used.

Tungsten-Halogen: good color, no need for ballast, and "instant-on" characteristics; but has a high lamp cost; poor optical control, low luminous effect, and short life.

Incandescent: low initial cost, good color, "instant-on" characteristics, and no need for ballast; but has a low luminous effect, high power costs, and a short life. Generally not used.

Fluorescent: good color, good luminous effect, and long life; but has a large size, poor optical control, and susceptibility to cold temperatures.

WHERE SHOULD STREET LIGHTING BE INSTALLED?

Crash experience is a primary factor in determining street lighting location:

Major arterials in urban areas or sections of streets or highways in residential areas may need lighting where four or more night crashes have occurred in one year or six night crashes in two years (provided the cause of the crashes was attributed to improper lighting) or where the ratio of nighttime to daytime crash rates is higher than the statewide average for similar locations. However, these numbers are very general and each jurisdiction should use engineering judgment in applying them or in developing their own, which may be more applicable.

Crosswalks should be illuminated if a study indicates a need.

WHAT TYPE OF LUMINAIRE SPACING SHOULD BE USED?

The safest luminaire support location is one that is protected from traffic such as upon or behind an existing barrier or retaining wall. If the support is not protected, the probability of a vehicle-object collision is greater as the number of supports increases or the distance from the roadway edge decreases. If a support must be installed less than 30 feet from the roadway edge in rural areas, breakaway devices should be considered. In urban areas an engineering study or engineering judgment should be used to determine the best type and location of luminaires. Breakaway supports should not be used when the hazard of a falling support is greater than a vehicle-object collision (such as in pedestrian areas).

Luminaire spacing is based upon the average intensity of illumination required.

Figure 11 shows typical luminaire mounting arrangements. Staggered spacing is the preferred arrangement as there are less supports adjacent to the edge of roadway which could result in a vehicle-object collision. Opposite

spacing would be appropriate where the width of street exceeds twice the mounting height than. Median spacing is more commonly used on freeways or divided highways in urban areas. One-side spacing should only be used on narrow roadways.

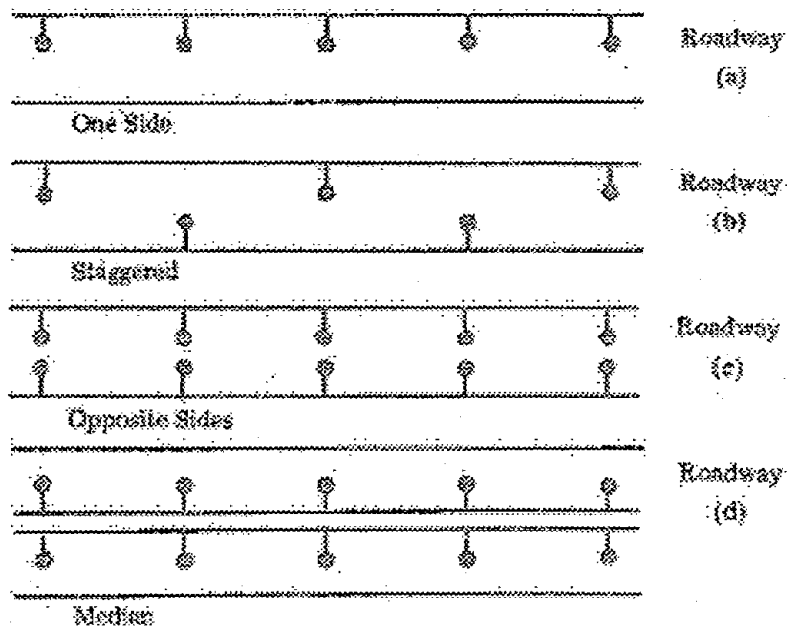


FIGURE 11. TYPICAL LUMINAIRE MOUNTING ARRANGEMENTS.

WHAT MOUNTING HEIGHT SHOULD BE USED?

The mounting height is determined by lamp output, desired average illumination, and uniformity of distribution. Light sources should be mounted at a minimum height of 30 feet. The higher the luminaire is mounted the better the uniformity.

WHAT ADVANTAGE/DISADVANTAGES EXIST WITH VARIOUS LUMINAIRE SUPPORTS?

There are five types of poles used for luminaire supports:

Steel: should be galvanized in new construction. Galvanized steel poles are expensive and have a long life; painted steel poles require extensive maintenance. Many breakaway devices have been developed for steel poles.

Aluminum: Aluminum poles are relatively maintenance-free, lighter than steel poles, but higher in cost. Breakaway devices are available for aluminum poles.

Stainless steel: Stainless steel poles are relatively maintenance free, lightweight, but more expensive than the previous two types. Breakaway devices have been developed for stainless steel poles.

Wood: Wood is the most economical lighting pole, can be treated to prevent rotting, and may be painted to improve its appearance. One wood pole can be used for several utility functions such as supporting telephone and power lines. However, wood poles have no breakaway characteristics.

Concrete: Concrete poles are economical in certain geographic locations. They can be set on a breakaway base, or can be direct buried similar to wooden poles. Direct buried concrete poles will not break away.

It is suggested that KDOT be contacted regarding their experience with the above luminaire supports.

WHAT IS A TYPICAL LAYOUT FOR INTERSECTION LIGHTING?

Figure 10 shows a typical layout.

WHAT PROBLEMS ARE CAUSED BY GLARE?

Glare reduces visibility and causes eye discomfort. Glare can be diminished by reducing luminaire brightness, by increasing mounting height and by increasing the effective luminaire area.

WHAT TYPE OF ROUTINE MAINTENANCE IS REQUIRED FOR LIGHTING INSTALLATIONS?

Proper maintenance of the system insures continued levels of illumination at the original design value. It also minimizes repair cost and protects the capital investment.

The responsible department or agency should establish a luminaire cleaning and washing schedule. Based upon the surrounding conditions, glassware should be washed at least once a year. It is also necessary to set up an inspection system to insure replacement of burnt out lamps.

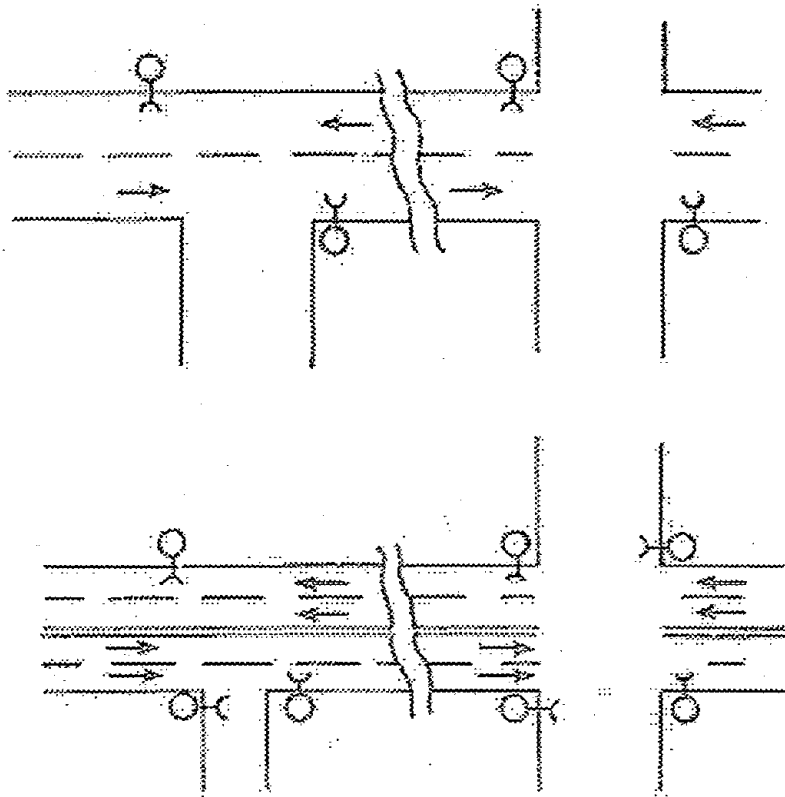


FIGURE 12. TYPICAL LIGHTING PLAN FOR INTERSECTIONS.

WHAT TYPES OF CRASHES MAY BE CORRECTABLE BY STREET LIGHTING?

Street lighting may assist in preventing nighttime accidents involving:

- Obstacles located within the roadway (islands, medians, bridge piers).
- Single vehicle crashes at locations where the geometrics of the road (or intersection) may contribute to the cause of the accident ("T" intersection, curve, with poor horizontal alignment).
- Right angle collisions.
- Turning movement crashes due to limited visibility (of pedestrians, vehicles and obstacles) around corners in the absence of lighting.

CHAPTER 12

RAIL-HIGHWAY CROSSINGS AT GRADE (GRADE CROSSINGS)

INTRODUCTION

Each year, a number of rail-highway crossings at grade (grade crossings) are improved with signals, gates and other more sophisticated warning devices. A large number of crossings, however, primarily located in rural areas, remain marked only by crossbuck and advance warning signs and on paved roads, pavement markings.

Unsignalized crossings in rural areas are among those crossings which can be particularly dangerous, although it is a fact that most rail-highway crashes accidents occur at busier urban locations with active warning devices where vehicular traffic is much higher. Train-car collisions may not be the most frequent type of crash, but when these crashes do occur, they often result in fatalities. In Kansas, the responsibility for grade crossing safety and safety improvements at grade crossings rests with the coordinating Section in the KDOT Bureau of Design. However, the local jurisdiction that has control of the approach road or street is responsible for various warning signs and markings on the approaches, and have a responsibility for maintaining adequate sight distances insofar as removable obstructions (e.g., brush) are concerned.

WHAT FACTORS DETERMINE WHETHER A RAILROAD CROSSING IS SAFE?

Various formulas have been developed for use by traffic engineers in evaluating railroad crossings. Most formulas look at three variables if a crossings is suspected to be hazardous.

1. Are the warning devices now on the crossing approach appropriate and sufficient to warn motorists of approaching trains?
2. What is the probability of a conflict between vehicles and trains at a crossing. This is usually measured by exposure which is the number of trains per day multiplied times the number of vehicles crossing the tracks per day. An engineering study may also consider how often do trains frequent a crossing; how long do they occupy the right-of-way; and is the traffic volume at the crossing particularly heavy?
3. Do motorists have sufficient sight distance in approaching the crossing to avoid collisions?

A study of typical railroad-highway grade crossings identified the following 10 conditions as major contributors to unsafe crossings:

1. Pavement markings were missing, improperly located, or in need of maintenance.
2. Vehicles required by law to stop at all crossings presented a hazard to other vehicles by blocking traffic lanes and obstructing the protective signs and signals.
3. The driver's visibility of a railroad approach was obstructed by vegetation growth.
4. There was a lack of illumination at night.
5. The driver's attention was distracted by traffic conditions and other traffic controls on adjacent roads.
6. Advance warning signs were missing, improperly located or in need of maintenance.
7. No appropriate areas were available for the driver to take evasive action.
8. The driver's view of the crossing signs or signals was obstructed by highway signs and fixed objects.
9. Legally parked vehicles blocked the motorist's view of the warning devices.
10. Fixed-mount warning devices (e.g. crossing gate arms) were themselves a hazard to vehicles.

The local jurisdiction could greatly improve grade crossing safety, thereby reducing risk of death or injury to their own citizens by observing and improving conditions indicated by the first nine (9) conditions above. Local jurisdictions should pay particular attention to numbers 1, 3, 5, 6, 8 and 9 above. KDOT should be consulted if there is any questions of the local jurisdiction's responsibility or any doubt regarding the safety of any grade crossing within the local jurisdiction.

WHAT SIGNS AND MARKINGS SHOULD BE USED TO WARN MOTORISTS OF A RAILROAD CROSSING?

Signs and markings are passive traffic control devices and serve to alert the motorist of the existence of a railroad crossing and to take appropriate action.

Railroad Crossing Markings are placed in advance of a railroad crossing and they consist of an "X", the letters "RR", a "No Passing" marking and certain transverse lines. They should be placed on all paved approaches to grade crossings where signals or gates are located, at crossings where the prevailing speed of traffic is 40 miles per hour or greater and at crossings where engineering studies indicate a significant potential for train-vehicle accidents (see Figure 13).

The signs to be used at a railroad crossing consist of the Railroad Advance Warning sign (W10-1), the Railroad Crossing sign (R15-1,2), more commonly known as the "crossbuck", and if there are two (2) or more tracks, the number of tracks is to be indicated on an auxiliary sign mounted below the crossbuck.

Where a road or street parallels the track such that there is less than 100 feet on an approach to the track from the parallel road or street, warning signs W10-2, W10-3 or W10-4 should be used. (See MUTCD 2000, Section 8B.03 and pictures on page 8B-4 and/or consult KDOT.)

WHAT CONTROL DEVICES AND SIGNALS ARE AVAILABLE FOR USE AT A RAILROAD CROSSING?

Because there are so many variables involved in evaluating a grade crossing, there is no single standard system of traffic control devices universally applicable for grade crossings. An engineering and traffic investigation must be made to determine which signals and devices are appropriate for each site.

The appropriate device(s) is normally determined jointly by KDOT and the Railroad Company involved. Key persons from the local jurisdiction are often involved. The KDOT, Railroad and local persons constitute what is called a diagnostic team.

When a grade crossing has automatic warning devices present and is located within 200 feet of the near side of a signalized highway intersection, the control of the intersection traffic signal should be preempted by the railroad crossing signal controller upon the approach of a train to avoid entrapping vehicles in the crossing. This is not something any local jurisdiction should attempt to do on their own. KDOT should be contacted.

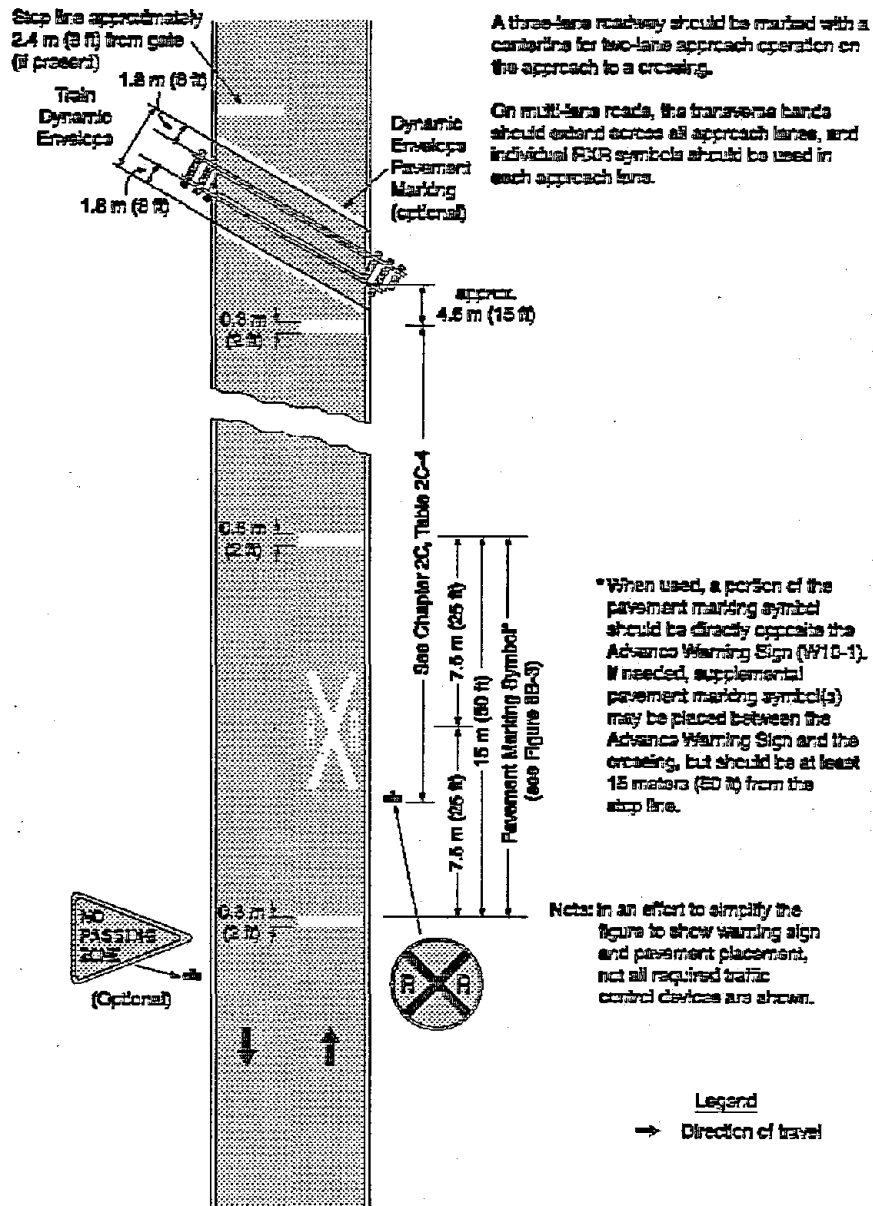


FIGURE 13. TYPICAL PAVEMENT MARKINGS AT RAILROAD-HIGHWAY GRADE CROSSING.

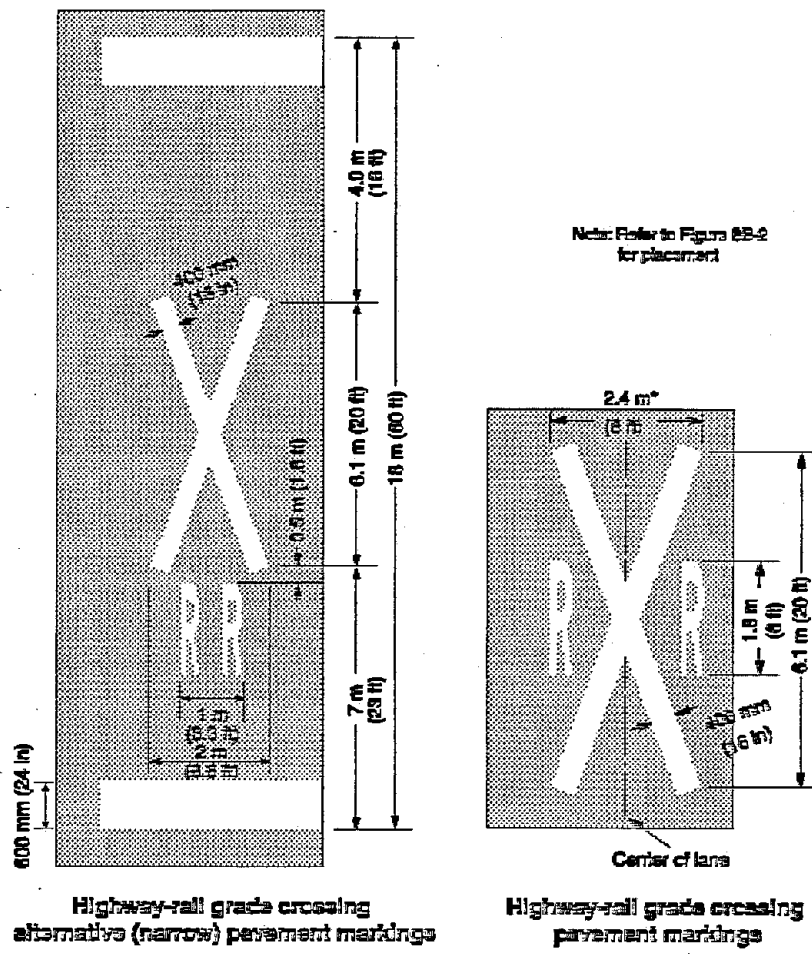


FIGURE 14. TYPICAL HIGHWAY-RAILGRADE CROSSING PAVEMENT MARKINGS.

HOW MUCH DISTANCE DOES A MOTORIST NEED TO SIGHT AN APPROACHING TRAIN IN ORDER TO EITHER CLEAR THE TRACKS OR TO STOP SAFELY?

As a driver approaches a railroad crossing, he has to decide whether or nor it is safe to cross. In the absence of signals or gates, he must be able to observe any approaching train and make a judgment involving his own speed, that of the approaching train, and their respective distances from the crossing. At a minimum, he must be able to observe the approaching train while he is still far

enough from the crossing to bring his vehicle to a safe stop, if necessary. This is a complex task for the average driver and he/she needs adequate clear sight distance.

Figure 15 illustrates the distance (Y) required to react to the situation, apply the brakes, and decelerate to a stop at a safe distance in advance of the crossing. This distance, of course, varies with the speed of the vehicle, the driver's reaction time, and the braking characteristics of the vehicle, which may in turn be affected by the roadway surface. The accompanying table (see Table 5) is based on some reasonably conservative assumptions with regard to the vehicle, driver and roadway, and establishes distance (Y) for various driving speeds. Distance (X) in the table is the distance the train will travel at various speeds during the same time that the driver is reacting and stopping. By comparing distances (X) and (Y) for any given combination of vehicle and train speeds, one can define the "line of sight" that must be clear of obstacles for safe operations at the crossing. It is particularly important that advance warning signs, markings and crossbucks be well placed and maintained in cases where sight distances are limited. (Note: Although crossbucks are the railroad's responsibility, deficiencies should be brought to the attention of KDOT or the railroad.)

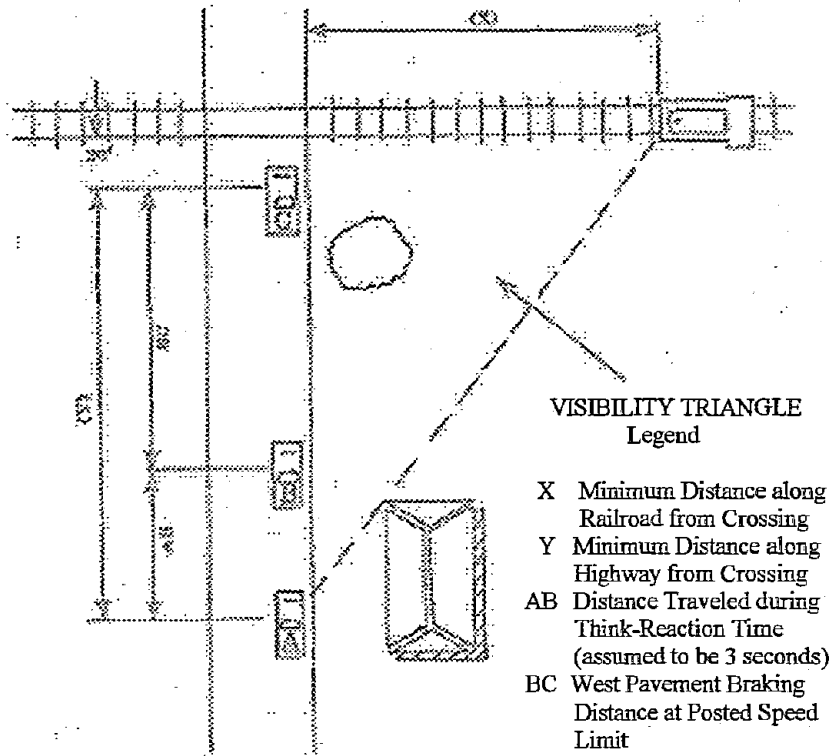


TABLE 5
MINIMUM SIGHT DISTANCES
FOR COMBINATIONS OF HIGHWAY AND TRAIN VEHICLE SPEEDS
(In Feet)

Train Speed	HIGHWAY SPEED IN MPH						
	0	10	20	30	40	50	55
	MINIMUM DISTANCE ALONG RAILROAD FROM CROSSING (X)						
10	162	126	94	94	99	107	113
20	323	252	188	188	197	214	225
30	484	378	281	281	295	321	337
40	645	504	376	376	394	428	450
50	807	630	570	470	492	534	566
60	967	756	562	610	590	642	675
70	1,129	882	656	704	684	750	786
80	1,290	1,008	752	752	788	856	900
90	1,450	1,134	844	844	884	964	1,010

MINIMUM DISTANCE ALONG HIGHWAY FROM CROSSING (Y)
20 65 125 215 330 470 560

(Source: Federal Highway Administration, Railroad-Highway Grade Crossing Handbook, FHWA-TS-86-215, Washington, D.C., 1986)

FIGURE 15. SIGHT DISTANCE TRIANGLE
FOR RAILROAD CROSSINGS.

CHAPTER 13

PARKING

INTRODUCTION

Parking is one of the essential elements of any workable transportation system. Poorly planned and sized parking facilities can result in safety concerns for the general public and economic hardship for those they are meant to serve. Parking characteristics are influenced by the size of the city, whether it is a regional center, the other modes of transportation available to commuters and the size of traffic generators and their location within the community relative to other larger scale uses.

Every city should consider controlling parking issues through Zoning Regulations by requiring off-street parking be provided. Even parking within a single-family residential area can become a problem if some off-street parking is not provided at each residence.

This chapter provides basic information on how to determine parking needs, the dimensions of parking spaces and appropriate signs. As with all traffic management questions, one should take advantage of reference materials for assistance in developing the best possible system for a municipality.

Every City Official must also be aware that the Americans with Disabilities Act (ADA) requires that certain actions must be taken in regards to provision of parking. These requirements are discussed within this chapter.

A reference for parking issues in Central Business Districts is "The Parking Handbook for Small Cities" produced by the National Main Street Center of the National Trust for Historic Preservation and The Institute of Traffic Engineers. This document should be used as a guide for any City contemplating revisions to their downtown parking system.

HOW CAN THE NUMBER OF PARKING SPACES NEEDED IN VARIOUS PARTS OF THE CITY BE DETERMINED?

Parking space requirements vary by city and land use. This variability means that no magic numbers exist to precisely define the exact amount of parking required for a certain land use in a certain city. Table 6 defines ranges in the amount of parking that have been found adequate in sample locations. These ranges coupled with local judgment can be used to develop off-street parking requirements for Zoning Regulations.

**TABLE 6
PARKING REQUIREMENTS BY LAND USE**

Building Type	Range	Mode
<u>Commercial and Industrial</u> (spaces per 100 sq. ft.)		
Office Buildings, Banks	0.08 – 1.33	0.25
Business and Professional Services	0.08 – 1.33	0.33
Commercial Recreational Facilities	0.16 – 2.00	1.00
Shopping Goods (Retail)	0.06 – 3.00	0.50
Convenience Goods (Retail)	0.10 – 1.33	0.50
Restaurants	0.06 – 2.00	1.00
Personal Services and Repairs	0.08 – 1.00	0.50
Manufacturing	0.08 – 1.00	0.20
Warehouses	0.02 – 0.67	0.10
Wholesale	0.03 – 1.33	0.15
<u>Residential</u> (spaces per unit)		
Single Family Dwelling	0.50 – 3.00	1.00
Duplexes	0.50 – 2.00	1.00
Multiple Family Dwellings	0.50 – 2.00	1.00
Apartment Hotels, Rooming Houses	0.25 – 1.50	1.00
Hotels (spaces per bedroom)	0.16 – 2.00	1.00
Motels (spaces per bedroom)	0.25 – 1.25	1.00
<u>Public Buildings</u> (spaces per 100 sq. ft.)		
Museums and Libraries	0.10 – 3.33	0.33
Public Utilities	0.10 – 1.00	0.33
Welfare Institutions	0.10 – 0.67	0.25
<u>Medical Buildings</u> (spaces per 100 sq. ft.)		
Medical and Dental Offices	0.08 – 1.33	0.50
Hospitals	0.10 – 2.00	1.00
Convalescent Homes	0.08 – 1.00	0.50
<u>Auditoriums</u> (spaces per seat)		
General Auditoriums and Theaters	0.06 – 0.33	0.25
Stadiums and Arenas	0.05 – 0.33	0.25
School Auditoriums	0.05 – 0.25	0.10
University Auditoriums	0.06 – 0.25	0.10

While parking issues tend to occur more often in new developments, these can be addressed with the requirement that sufficient off-street parking is provided by the developer. Problems within existing built-up areas can be persistent and more difficult to solve. As an example, it is common for Cities not to require individual owners to provide off-street parking in a Central Business District (CBD). Conflicts often arise in the CBD between businesses that require parking for shoppers and those that require long-term parking for employees. Solving these problems requires an efficient and effective use of existing facilities.

An accurate understanding of the parking needs in a city requires some basic demand and supply evaluations. Parking demand results from the necessity to "store" vehicles while the vehicle's occupants complete their trips. This "demand" can vary with the type of trip and the time of day, week and month. The key demand factors to be evaluated are: the amount of demand, the distributions of demand with time and the rate of turnover.

The supply, or "storage", is the amount of on-street and off-street parking that is available to meet demand. In areas where parking needs are an issue, supply can be increased by providing more area for parking use or by reducing the length of time a vehicle may be in a given space, thereby increasing the turnover rate within parking stalls. This action will allow more individuals to utilize a given area. Either of these decisions can have significant impact and must be well thought out before implementation.

Among the techniques to examine parking supply and demand characteristics are:

Supply:

Parking Inventories- This involves a comprehensive cataloging of all public and private parking spaces within a given area and the manner in which these spaces are managed. The basic information should include the location, the ownership, if it is available for public use and any time restrictions.

Demand:

Parking Usage Studies- This is an analysis of the number of times a parking space is used in a given time period as well as the average length of stay of a parked vehicle.

Parking Accumulation Studies- This is a determination of which days of the week and hours of the day parking areas are most used.

Methods:

License Plate Checks: This is a technique for determining parking duration and turnover. It is a labor-intensive operation requiring the recording of the license plate of each car in each stall and a follow-up over the course of a day at regular intervals to record changes. The data obtained will assist in determining if the balance between long-term and short-term parking is appropriate in an area. The data developed can also be useful in determining if enforcement of parking regulations will help alleviate complaints.

Bulk Counts: This involves the counting of vehicles within a defined area on a daily basis over a longer period. This data is used for parking accumulation studies and can be useful in determining whether problems are perceived or real.

Parking Interviews: This is a method of determining trip origin, destination, purpose and walking distance through interviews of motorists by mailed questionnaire or personal interview.

WHAT CAN BE DONE IF PARKING IS INADEQUATE?

If the studies discussed above indicate that parking is inadequate, then a municipality must turn to public or privately financed parking facilities. Financing of private parking areas is usually through merchant efforts in the immediate vicinity. Public facilities can be financed by General Obligation Bonds, Revenue Bonds or by Improvement Districts. Public-private efforts can include tax incentives, technical advice or the use of City-owned land by the private operator.

HOW MUCH SPACE IS NEEDED FOR EACH PARKING STALL?

A parking car requires approximately an 8.5-foot by 19-foot area. There are, however, variables resulting from the type of parking stall that will require actual space size to differ. These are discussed below.

Parallel Parking

Three kinds of stalls are used when allocating space for parallel parking: *end stalls*, *interior stalls* and *paired parking stalls*. Since a vehicle can be driven directly into and out of an end stall, only the length of the vehicle needs to be accommodated. Interior stalls require room for a car to maneuver and, therefore, should be no less than 23 feet and need not be more than 26 feet in length. The stalls should be delineated by painted markings.

Paired parking stalls are laid out such that two vehicles are parked bumper to bumper with each pair of stalls separated by a maneuver area of between 8 and 10 feet. This method is best when a double parking meter is installed between each pair of vehicles so they do not encroach upon the maneuver area. (See Figure 16)

Angle Parking

Parking at an angle of 45 degrees or less is more commonly used for on-street parking or in lots with narrow traveled ways. Angles equal to or greater than 45 degrees are more often used in off-street parking lots. Ninety (90) degree parking gives the greatest number of parking spaces per lineal foot of lot (nearly 2-1/2 times more spaces than parallel parking) but as the angle increases, the width of road or access way necessary for maneuvering into and out of the stall also increases. Within off-street parking lots the use of 90-degree parking also allows the motorist to travel either direction away from the stall.

Stall Marking

Marking of parking stalls creates additional maintenance costs. It also requires that the parking area be paved with a material capable of receiving and holding paint. However, marking is justified where high usage and turnover rates are experienced. The absence of markings will cause an inefficient use of available space.

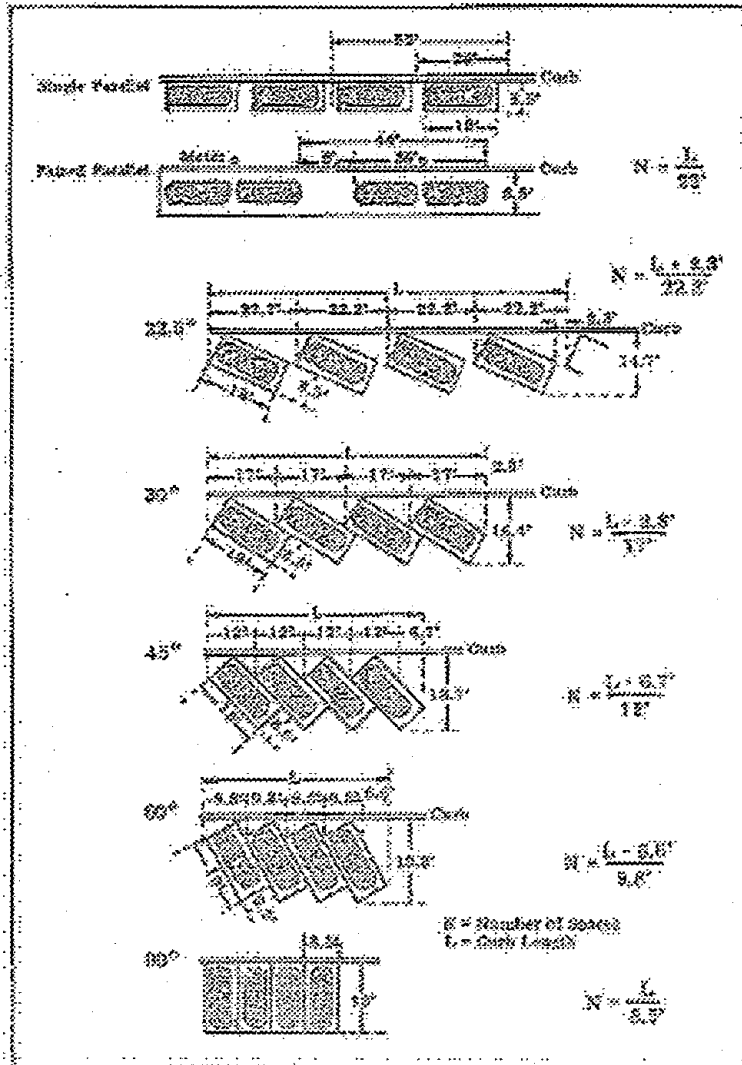
WHAT ARE THE DIFFERENCES BETWEEN ON-STREET AND OFF-STREET PARKING?

On-street parking is that which falls on the sides of public streets. Off-street parking is on property owned by either a public entity or a private concern. The parking stalls within this property should not be accessed directly from the street.

WHAT ARE THE ADVANTAGES AND DISADVANTAGES OF ON-STREET PARKING?

The advantage of on-street parking is that it allows for full use of the street system. Where traffic volumes are low or where additional street width is

available for the purpose, on-street parking gives convenient access to homes and businesses.

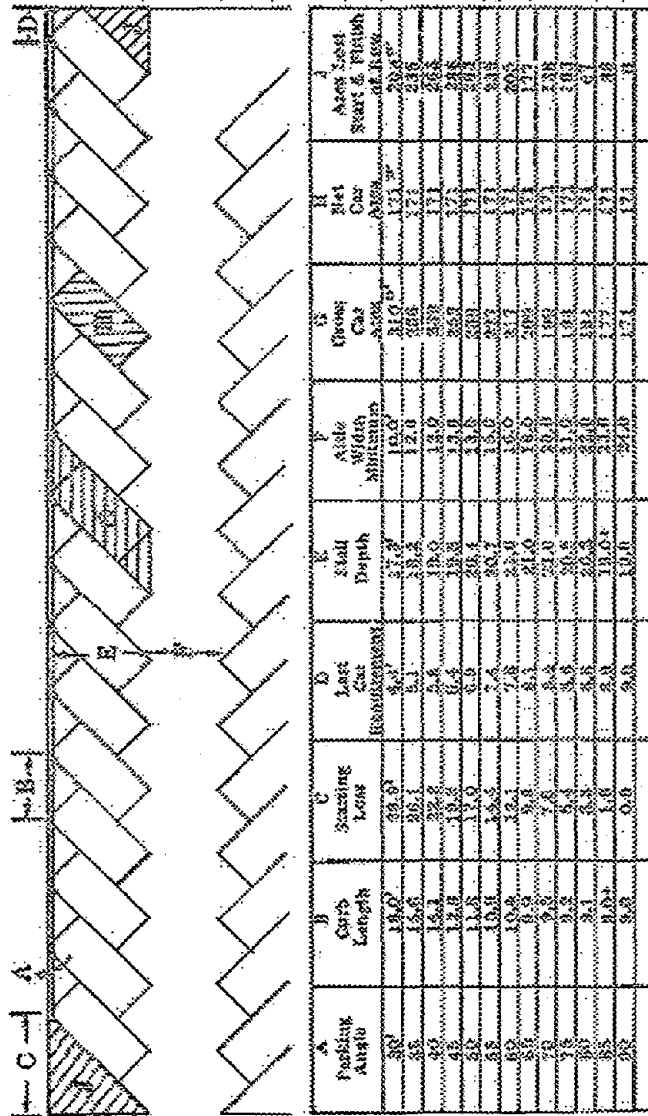


Source: Adapted from Gaswood, F., "Fatal and Serious Accidents Involving Parked Vehicles," Road Research Laboratory, Crowthorne, England September 1938, p. 8.

FIGURE 16. CURB PARKING CONFIGURATIONS.

TABLE 7

PARKING LAYOUT - DIMENSIONS FOR VARYING DEGREES OF ANGLE PARKING.



PARKING AREAS

1. All Dimensions are based on parking stall area of 110°.
 2. All Dimensions based on 110° and 110° change as stall areas are changed.
 3. Chevrolet has width and type of parking that best suits your particular needs.
 4. Do not stress on stalls.

Conversely, where traffic volumes are higher, on-street parking can result in traffic congestion, delays and increased crashes. On-street parking may increase the number of traffic crashes for the following reasons:

1. Parking, parked, stopped and backing vehicles are obstacles for moving traffic.
2. Parking maneuvers often occur with inadequate warning to other traffic.
3. Parked vehicles reduce the sight distance at locations where pedestrians cross or cross traffic must enter the roadway.
4. Former occupants of parked vehicles create unexpected mid-block conflicts while near their vehicles.

The use of parallel parking results in fewer crashes than angle parking. It is preferred when streets are narrow and the volume of traffic is high. However, it takes almost three times as long to parallel park as it does to angle park. While angle parking is easier for the motorist to maneuver in to and out of, it has the disadvantage that the driver's vision is often impaired as he exits the space. Drivers traveling in a through lane will tend to keep about two (2) feet further away from angle spaces than parallel spaces.

WHERE SHOULD ON-STREET PARKING ALWAYS BE PROHIBITED?

The Standard Traffic Ordinance defines three terms for use in parking prohibitions, park, stand, and stop, as follows:

Park: the standing of a vehicle, whether occupied or not, otherwise than temporarily for the purposed of and which actually engaged in loading or unloading property or passengers.

Stand: the halting of a vehicle whether occupied or not, otherwise than temporarily for the purpose of/and while actually engaged in receiving or discharging passengers.

Stop: when prohibited means any halting even momentarily of a vehicle, whether occupied or not, except when necessary to avoid conflict with other traffic or in compliance with the directions of a police officer or traffic-control sign or signal.

The following provisions of the Standard Traffic Ordinance pertain to the layout of on-street parking.

“Except when necessary to avoid conflict with other traffic or in compliance with the directions of a police officer or official traffic-control device, no person shall stand or park a vehicle:

In front of a public or private driveway;

Within 15 feet of a fire hydrant;

Within 20 feet of a crosswalk at an intersection;

Within 30 feet upon the approach to any flashing signal, stop sign or traffic-control signal located at the side of a roadway;

Within 20 feet of the driveway entrance to any fire station and on the side of a street opposite the entrance to any fire station within 75 feet of said entrance, when properly sign-posted.

No person shall park a vehicle, except temporarily for the purpose of and while actually engaged in, loading or unloading property or passengers within 50 feet of the nearest rail of a railroad crossing.”

WHAT TYPES OF NO PARKING SIGNS CAN BE USED?

There are a wide variety of no parking situations and each must be analyzed separately as to how it should be treated. All no parking signs must conform to the MUTCD 2000 in shape, color, location and use. The regulations that will be

displayed on each sign should be listed from top to bottom in the following order:

1. Restriction or prohibition.
2. Time of day applicable, if not at all hours.
3. Days of week applicable, if not every day.

Parking prohibition signs are used where parking is prohibited at all times or at specified times. These signs shall have red letters and border printed on a white background.

Parking restriction signs are used where limited time parking or parking in a particular manner is permitted. These signs shall have green letters and border printed on a white background. Various styles of signs are permitted. (See MUTCD 2000, Section 2B.34)

In rural districts special parking prohibition signs may be used to emphasize that no person shall stop, park or leave standing any vehicle on the paved or traveled part of the highway.

Refer to Table 2B-1 of the MUTCD 2000 for the required size of each type of No Parking Sign in various applications.

Parking signs with arrows are used to indicate the limits of a restricted zone. The signs should be set at an angle of not less than 30 degrees and no more than 45 degrees to the line of traffic flow so that they are visible to approaching drivers. If the zone is unusually long (a block or longer), signs with a double arrow should be set at intermediate points within the zone. To minimize the number of parking signs, blanket prohibitions and/or restrictions which apply to an entire district can be posted at municipal boundary lines.

WHAT ARE THE REQUIREMENTS RELATIVE TO HANDICAP ACCESSIBLE PARKING?

There are many variables that must be considered in the layout of accessible facilities. The basic requirements for accessible parking are set out below. The information was derived from the "Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)". This is published by the Architectural and Transportation Barriers Compliance Board; 1331 F Street, NW; Suite 1000; Washington, DC 20004-1111. Their Website is <http://www.access-board.gov>.

The following table gives the minimum number of spaces required when parking is provided.

**TABLE 8
NUMBER OF SPACES REQUIRED TO SATISFY ADA REGULATIONS.**

TOTAL PARKING IN LOT	REQUIRED MINIMUM NUMBER OF ACCESSIBLE SPACES
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 to 300	7
301 to 400	8
401 to 500	9
501 to 1000	2 percent of total
1001 and over	20, plus 1 for each 100 over 1000

One in every eight, but not less than one, of these spaces must be Van Accessible.

Note that all accessible spaces must be signed as such. If the space is Van Accessible, a supplementary sign giving that information must be used.

Size Of Spaces

Accessible parking spaces shall be at least 96 inches (2440 mm) wide. An additional area must be provided adjacent to the space. This area must be a minimum of 60 inches (1525 mm) wide. For an space to be considered as Van Accessible the access aisle must be a minimum of 96 inches (2440 mm) wide.

Two spaces may share the same access aisle.

The parking space and access aisle must be level with surface slopes not exceeding 1:50 (2%) in all directions.

Location Of Spaces

Spaces must be located on the shortest accessible route of travel to an accessible entrance. It is easier to know where to locate space in a lot constructed for a specific use. Public parking lots are meant to serve a number of uses, therefore, best judgment should be used in the layout of spaces in a public lot. Many communities have found it useful to receive input from local handicapped citizens in the layout of spaces in public lots.

A factor for consideration in the location of spaces is that accessible routes must be provided for all accessible spaces. In general, this route must be at least 60 inches (1525 mm) and have no more than a 1:12 slope. If the 1:12 slope extends for more than 30 feet, a level landing of at least 60 inches (1525 mm) shall be provided.

CHAPTER 14

DRIVEWAYS

INTRODUCTION

Driveways are privately-owned roads which connect buildings, parking lots and other areas with public roads and highways. Although driveways are essential to provide access to these facilities, they can produce hazardous highway conditions. Engineering studies have shown that as commercial establishments become more frequent along a public road, crash rates increase. The objective, therefore, is to regulate the design and frequency of driveways and other private access roads so as to minimize the incidence of crashes and thereby maintain a reasonable traffic flow along the highway. Appendix B provides some practical guidelines for managing access. Access to the State Highway System is governed by KDOT's, Corridor Management Policy. KDOT should be contacted regarding any access to a state highway.

A permit is required for the construction of any new access driveway or the revision of any existing driveway within the right-of-way along a State highway. The permit is issued by the appropriate district office of the Kansas Department of Transportation and all construction work performed is subject to the condition of the permit with accompanying plans, drawings, sketches or other attachments.

WHAT FACTORS SHOULD A LOCAL AUTHORITY TAKE INTO

ACCOUNT IN PROVIDING GUIDELINES FOR DRIVEWAY

CONSTRUCTION?

Any policies established at the local level related to driveways should be consistent with policies governing zoning, subdivision regulations, or other appropriate policy documents.

Driveways accessing major streets and highways require more stringent requirements than those accessing secondary roads or streets. Standards for all driveways, however, should minimize potential conflicts between through vehicles and those entering and leaving the driveway. Some of the objectives to be achieved through the use of proper driveway design standards are:

1. Minimize the speed differential between through vehicles and those using the driveway.

2. Eliminate encroachment of turning vehicles on adjacent lanes.
3. Prohibit motorists from using the road or highway as a means of circulating between parking rows.
4. Provide sufficient space between driveways to reduce interference from traffic using adjacent driveways.
5. Discourage motorists from parking on streets or backing out onto the highway or road.
6. Preserve the original intent of the roadway, pedestrian walkway and drainage facilities.
7. Provide adequate sight distance for motorists exiting the driveway so that they can see on-coming traffic.
8. Where possible, driveways should access private property from the lowest classified adjacent street/highway in order to provide for entry/exit into slower, less dense traffic.
9. Consider corridor management policies that can minimize the effect of driveways. (KDOT can provide guidance on corridor management.)

WHAT CRITERIA SHOULD BE USED IN DETERMINING WHERE DRIVEWAYS CAN BE SAFELY LOCATED?

When considering a proposed driveway, the following four criteria should be used in determining that its construction will not endanger lives and property.

1. The driveway should be located where motorists using the proposed drive and abutting road will have adequate sight distance, and where grade and alignment conditions are favorable.
2. There should be no unnecessary interference with the free and safe movement of highway/arterial street traffic.
3. The safety and convenience of pedestrians and other users of the roadway should not be compromised.
4. Driveways serving commercial, industrial and high-density residential developments can affect the efficiency and safety of the street or highway onto which they enter and exit. Perhaps the single most important factor in developing a safe access plan for these

developments is a determination of the potential traffic volumes generated (see Chapter 15).

WHAT ARE THE DESIGN STANDARDS FOR A RESIDENTIAL DRIVEWAY?

The following standards are recommended for single-family residences:

Width of Drive: Single-family residential driveways should have a width between 12 and 24 feet with appropriate flares at the curb or pavement edge.

Flare Radii: The recommended radii for flares at residential drives is three feet (3'), minimum and five feet (5'), maximum.

Angle of Driveway: The driveway center line should generally be at a right angle (90 degrees) to the pavement edge and follow this angle from the roadway to the right-of-way line.

The following standards are recommended for multi-family residences:

Width of Drive: Multi-family residential driveways should have a width between 24 and 44 feet with appropriate flares at the curb or pavement edge.

Flare Radii: The recommended radii for flares at residential drives is three feet (3'), minimum and five feet (5'), maximum.

Angle of Driveway: The driveway center line should generally be at a right angle (90 degrees) to the pavement edge and follow this angle from the roadway to the right-of-way line.

WHAT ARE THE DESIGN STANDARDS FOR A COMMERCIAL DRIVEWAY?

The following standards are recommended:

Width of Drive: Commercial two-way driveways should be no less than twenty-four feet (24') wide, and should be limited to a maximum width of 40 feet measured at right angles to the center line of the drive and exclusive of flares.

Flare Radii: In urban areas the radii should no less than fifteen feet (15'), and no more than twenty-five feet (25').

Angle of Driveway: Generally, the driveway should be at a right angle to the roadway or parallel to the side property line.

WHAT ARE THE DESIGN STANDARDS FOR INDUSTRIAL DRIVEWAYS?

Please refer to the Commercial Driveway standards previous section for geometric guidelines. In addition, there should be separate entrances for employee parking and for industrial (truck) access.

WHAT IS THE RECOMMENDED GRADE FOR A DRIVEWAY?

To prevent difficulty with vehicular ground clearance, changes in driveway grade over the length of a vehicle (20 feet +/-) should not exceed a twelve percent (12%) increase or an eight percent (8%) decrease.

In urban areas, the slope should be compatible with the drainage of the area but should not exceed six (6) and eight (8) percent, respectively, for commercial and non-commercial driveways. Driveways in urban areas should rise to a point at least as high as any adjacent curb in order to contain storm water runoff within the curb and gutter.

HOW CLOSELY CAN DRIVEWAYS BE SPACED?

Residential Driveways

Normally, only one driveway should be permitted for each residential property. For residential drives near intersections the minimum distance between the drive and the nearest public road should be no less than 50 feet, measured from the back of curb or edge of pavement.

Commercial and Industrial Driveways

These entrances should be from collector/local streets, as far removed from arterial traffic as possible. Commercial developments should be required to plan such traffic patterns where possible.

A minimum distance of 440 feet, and preferably 660 feet, should be required between the centerlines of entrances into shopping centers and similar developments that generate high traffic volumes. If these requirements cannot be accommodated, designs with deceleration lanes may be effective. However, service drives into these centers which are not used by the general public may be closer than 440 feet as long as they do not encroach on turning lanes. The

minimum separation distance of 440 feet is also desirable between major commercial/industrial entrances and the nearest public road.

CAN A DRIVEWAY BE SHARED JOINTLY BY TWO ADJACENT PROPERTY OWNERS?

If two or more property owners have a legal agreement describing their joint right to property access, the only barrier to allowing such a driveway would be the safety and traffic flow issues already addressed in this chapter. Many jurisdictions, however, discourage this practice in residential areas in order to avoid possible problems.

ARE THERE GUIDELINES FOR DRIVEWAYS FOR SPECIAL USES?

Along with traffic volumes, other critical factors to be examined include the number of entrances, the size of the parking area, the length of storage lanes for traffic entering and leaving these establishments, and the internal traffic circulation pattern. Different kinds of developments also demand special conditions.

- Office Space. The exits should be designed to accommodate heavy traffic during peak hours.
- Drive-in Service Establishments. The layout of the site must provide that all waiting vehicles are off the right-of-way and not concentrated on the entrance driveway.
- Fueling Stations. The site should be laid out so that the minimum distance from the right-of-way line to the near edge of the pump island is 13 feet. A greater distance is recommended to permit easier movement of larger vehicles and to ensure they are entirely off the street.

CHAPTER 15

PRIVATE PROPERTY DEVELOPMENT

INTRODUCTION

Changes in land use can greatly modify the traffic patterns of an area. These changes are particularly significant if the property undergoes change from a relatively undeveloped parcel to one having commercial usage.

The traffic impact of such development proposals should be carefully reviewed. Of particular importance are the following two issues:

1. Will this project cause congestion or create an unsafe traffic condition?
2. Is sufficient off-street parking being provided?

This chapter examines issues relative to congestion as well as other questions, which may arise concerning this type of project. Chapter 13 examined parking issues.

HOW MUCH TRAFFIC WILL BE GENERATED BY A NEW COMERCIAL DEVELOPMENT?

Because of the many variables affecting traffic generation, it is difficult to predict the precise amount of traffic, which will be generated by a given project. However, transportation studies have quantified, in general terms, the volume of traffic generated for different types of projects.

Table 9 presents a tabulation of generation values, which may be expected for both residential and commercial developments. Daily and PM peak hour forecasts are given for each type of project.

In addition, for large commercial developments, many communities require the developer to have a traffic engineering study prepared, submitted and approved. The developer may also be required to pay all or at least a share of roadway improvement costs necessitated by the development.

**TABLE 9
SUMMARY OF TRIP GENERATION RATES**

<u>Land Use</u>	<u>Average weekday Vehicle Trip Ends (1)</u>	
	<u>Daily</u>	<u>P.M. Peak Hour</u>
<i>Residential</i>		
Single Family Unit	10 per unit	1 per unit
Apartment	6 per unit	0.7 per unit
<i>Retail</i>		
0 to 50,000 GSF	5 per 1000 GSF (2)	15 per 1000 GSF
50,000 to 100,000 GSF	0 per 1000 GSF	per 1000 GSF
100,000 to 200,000 GSF	60 per 1000 GSF	6 per 1000 CSF
<i>Office</i>		
General Office	12 per 1000 GSF	2.5 per 1000 GSF
Medical Office	75 per 1000 GSF	6.5 per 1000 GSF
<i>Restaurant</i>		
Fast Food	550 per 1000 GSF	30 per 1000 GSF
High Turnover, Sit Down	165 per 1000 GSF	10.5 per 1000 GSF
<i>Industrial</i>		
Per Employee	3	0.6
Per 1000 GSF	5.5	1
Per Acre	60	12

1. A trip end is one trip either entering or exiting the development.
2. GSF = Gross Square Feet of floor area in the building.

* REFERENCE - TRANSPORTATION & TRAFFIC ENGINEERING HANDBOOK, 2nd Edition, ITE 1982

HOW MANY ACCESS DRIVES ARE NEEDED TO ACCOMMODATE A DEVELOPMENT?

Access requirements will depend upon the volume traffic on the main road, the number of trips generated by the development, existing roadway conditions, property dimensions, etc. One rule of thumb, which can be used as a guideline, is that the volume of traffic in the predominant direction of travel along the adjacent highway (measured in vehicles per lane per hour) plus that exiting from the development (measured in vehicles per lane per hour) should not exceed 1,200. When this volume is exceeded, additional lanes (or additional access

points) must be provided. As a practical point, it is generally a good policy to provide two access driveways (at least 440 to 660 feet apart) if the size of the commercial development exceeds 25,000 square feet.

The following are other guidelines, which should be considered:

- Access driveways should generally be designed with two exiting lanes when the left turn volume exceeds 100 vehicles per hour.
- A left-turn storage lane should be provided along the adjacent highway when left-turning movements into the site exceed 100 vehicles per hour at any given location.
- Where at all possible, align the proposed access drives directly opposite existing driveways or streets so that offset intersections can be avoided.

WHAT ARE THE GUIDELINES TO DETERMINE IF A DEVELOPMENT WILL NEED ADDITIONAL TRAFFIC LANES ALONG AN ADJACENT STREET?

The critical lane analysis is useful in determining if additional traffic lanes will be needed. Count peak hour volumes on the adjacent street. If the volume of traffic in the heaviest direction of travel (expressed in vehicles per lane per hour) plus that exiting from the access road to the development (vehicles per lane per hour) exceeds 1,200 vehicles, additional lanes will be required.

Example

- Main Street
Has two traffic lanes (one in each direction)
Peak hour traffic volume:
Northbound – 800 Southbound - 400

- Driveway to the Proposed Development
Has two traffic lanes (one in each direction)
Peak hour exiting traffic volume - 500
- Critical Lane Analysis

Main Street	800 Vehicles per lane per hour
Driveway	<u>500</u> Vehicles per lane per hour
 Total Volume	 1,300 Vehicles per lane per hour

The total volume exceeds 1,200 vehicles per lane per hour; therefore, additional lanes will be required on Main Street or additional exiting lanes (or driveways) should be built to the proposed development.

ARE THERE GUIDELINES FOR STREET AND AREA LIGHTING IN COMMERCIAL DEVELOPMENT?

Lighting on commercial properties is normally the responsibility of the property owner(s) and must be located on private property unless special permits allow location on the right-of-way. Lights on commercial properties should not be a nuisance to passing motorists and cannot be similar to traffic control devices. No flashing, oscillating or rotating lights visible from any public highway should be permitted to be placed on any building or structure within 200 feet of and visible from the highway, and no illuminated signs should be allowed to have unshielded lights which might impair the vision of passing motorists on the adjacent street. Local codes generally control the type of lighting and signs.

WHAT PROCESS MUST A DEVELOPER FOLLOW TO OBTAIN NECESSARY PERMITS?

The developer of a commercial property which accesses State and/or municipal roads must comply with local building codes, setback requirements, minimum lot sizes, density of building, provision for adequate parking and other regulations. Access to the State Highway System is governed by the Kansas Department of Transportation "*Corridor Management Policy*", effective July 1, 1997. Subdivision development of properties abutting the State Highway System must have KDOT review and approval with regard to access to the highway prior to final plat approval, otherwise the subdivision properties will not be considered for access to the State highway System.

WHAT TYPES OF COMMERCIAL DEVELOPMENTS HAVE SPECIAL ACCESS REQUIREMENTS?

Some extensive developments, such as major truck stops, industrial parks/complex, regional malls, neighborhood shopping centers, convenience stores, discount stores, specialty department stores, office and medical centers, fast food strip developments, and other high traffic generators that generate 50 or more vehicles in the peak hour will require special access and geometric consideration such as added lanes, compound curves, channelizing median islands, etc.

CHAPTER 16

TEMPORARY TRAFFIC CONTROL

INTRODUCTION

Because of varying construction conditions, the safe and expeditious movement of traffic through work zones is a difficult problem. Studies of crash patterns in work zones show there is almost always an above-average crash rate during those periods when a construction or maintenance activity is taking place.

This chapter answers some of the basic questions concerning the design, application, installation and maintenance of various types of traffic control devices required for road or street construction, maintenance and utility operations. More detailed information on this subject is contained in Part 6 of the Manual on Uniform Traffic Control Devices (MUTCD 2000).

WHAT ARE THE LOCAL RESPONSIBILITIES FOR WORK ZONE TRAFFIC CONTROL?

The MUTCD 2000 includes the following Standard "Temporary traffic control plans and devices shall be the responsibility of the authority of a public body or official having jurisdiction for guiding road users. There shall be adequate statutory authority for the implementation and enforcement of needed road user regulations, parking controls, speed zoning, and incident management. Such statutes shall provide sufficient flexibility in the application of temporary traffic control to meet the needs of changing conditions in the temporary traffic control zone."

It is clear from this that local agencies must take actions to ensure the safety of the public and workmen in work zones on public streets within their jurisdiction. This is true whether the project is being performed by agency employees, companies under contract to the agency or by those under the employ of others.

WHAT TYPES OF SIGNS ARE AVAILABLE FOR WORK ZONE TRAFFIC CONTROL?

Regulatory Signs: Regulatory signs (Stop, Yield, Speed Limit, etc.) will be of the same size, shape and color as for normal use. Because of the legal

obligations imposed by these signs, it is essential that their use be authorized by the public body or official having jurisdiction.

Warning Signs: Warning signs (Road Work Ahead, Detour 1000 Feet, Flagger Ahead, etc.) are also of the same size and shape as regular warning signs. However, they have one distinguishing difference; the background for warning signs for work zones is orange, not yellow as for normal application. Where any part of the roadway is obstructed or closed, the approach warning signs should have a standard size of 48" x 48". Where speeds are low (30 mph or less), 36" x 36" signs may be used.

Guide Signs: Guide signs have a number of purposes and, consequently, may have messages and shapes other than the standard orange diamond. "End Road Work" and "Pilot Car Follow Me" are two examples, where these signs are used, they shall have a black symbol or message on an orange background and shall be rectangular in shape. Figure 17 illustrates many of the signs used in construction and maintenance activities.

IS THERE A SPECIFIC MOUNTING HEIGHT AND LOCATION FOR THESE SIGNS?

The standards for positioning these signs are the same as for normal signs. Chapter 2 discusses typical applications of warning signs in urban areas. (See also, MUTCD 2000, Part 2, Signs.)

WHICH WARNING SIGNS SHOULD BE USED FOR A TYPICAL WORK ZONE SITUATION?

No one standard sequence of signs or other control devices can be set up as an inflexible arrangement for all situations due to the variety of conditions encountered. In general, however, warning signs are used to achieve three objectives:

1. To warn the motorist of unusual activity;
2. To inform the motorist of conditions that will be encountered; and
3. To guide the motorist through the area.

Warning signs are generally used in this sequence.

Approach warning signs such as "Road Work Ahead" (W20-1) warn motorists of an upcoming work zone. These signs would be the first in the sequence of traffic control devices employed.

Signs such as "Right Lane Closed Ahead" (W20-5) are specific warning signs and follow next in the sequence. These signs tell the motorist in greater detail what to expect.

Finally, signs such as "Lane Ends Merge Left" (W9-2) or (W4-2) (See Figure 17) and other devices such as cones or barricades help guide the motorist through the area. (Note: A Lane Ends Merge Left (W9-2) must never be used on a two-lane, two-way road or street.)

Figure 18, illustrates a typical application of these signs on a 2-lane, two-way highway, for further illustrations, refer to the MUTCD 2000.

WHAT IS THE BEST PROCEDURE FOR INFORMING A CONTRACTOR AS TO WHICH DEVICE TO USE FOR TRAFFIC CONTROL AT A WORK ZONE?

The use of a traffic control plan (TCP) is the best technique for informing the contractor (or the project engineer) specifically which devices to use. This TCP should provide for the safe and efficient movement of traffic through the work zone in a manner conducive to the safety of both motorists and workers. The TCP should include, but not be limited to, such items as signing; application and removal of pavement markings; construction scheduling; methods and devices for delineation and channelization; placement and maintenance of devices; roadway lighting; traffic regulations; and surveillance and inspection.

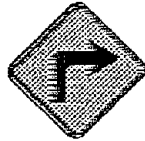
Public agencies should always include a TCP in project plans issued under their authority. They should also require reference to the MUTCD 2000, if not a TCP, on utility company plans and private development plans affecting public streets within their jurisdiction.

Whether a formal TCP is provided or not, the MUTCD 2000 should be followed to the maximum practicable extent.

HOW FAR IN ADVANCE OF THE WORK ZONE SHOULD THE WARNING SIGNS BE PLACED?

Where open highway conditions prevail on the approach to the work site, advance warning signs should be placed approximately 1,500 feet in advance of the condition to which they are calling attention. Where a series of advance warning signs are used, the warning sign nearest the work site should be placed

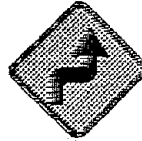
approximately 500 feet from the point of restriction with additional signs at 500-1,000 foot intervals. On expressway and limited access facilities, the advance warning distance should be increased to one-half mile or more.



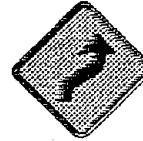
W1-1
760 x 760 mm
(30 x 30 in)



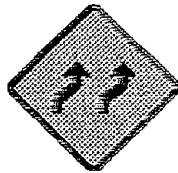
W1-2
760 x 760 mm
(30 x 30 in)



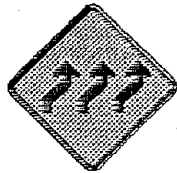
W1-3
760 x 760 mm
(30 x 30 in)



W1-4
760 x 760 mm
(30 x 30 in)



W1-4b
900 x 900 mm
(36 x 36 in)



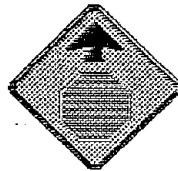
W1-4c
900 x 900 mm
(36 x 36 in)



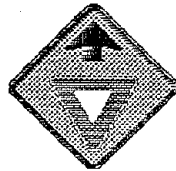
W1-5
1200 x 600 mm
(48 x 24 in)



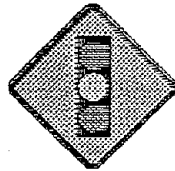
W1-6
460 x 600 mm
(18 x 24 in)



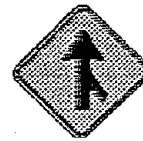
W3-1a
600 x 900 mm
(24 x 36 in)



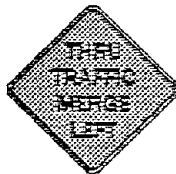
W3-2a
600 x 900 mm
(24 x 36 in)



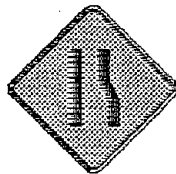
W3-3
900 x 900 mm
(36 x 36 in)



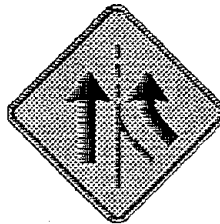
W4-1
760 x 760 mm
(30 x 30 in)



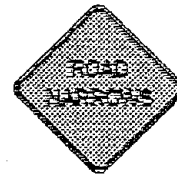
W4-1a
600 x 900 mm
(24 x 36 in)



W4-2
600 x 900 mm
(24 x 36 in)



W4-3
1200 x 1200 mm
(48 x 48 in)



W5-1
600 x 900 mm
(24 x 36 in)

FIGURE 17. CONSTRUCTION SIGNS.

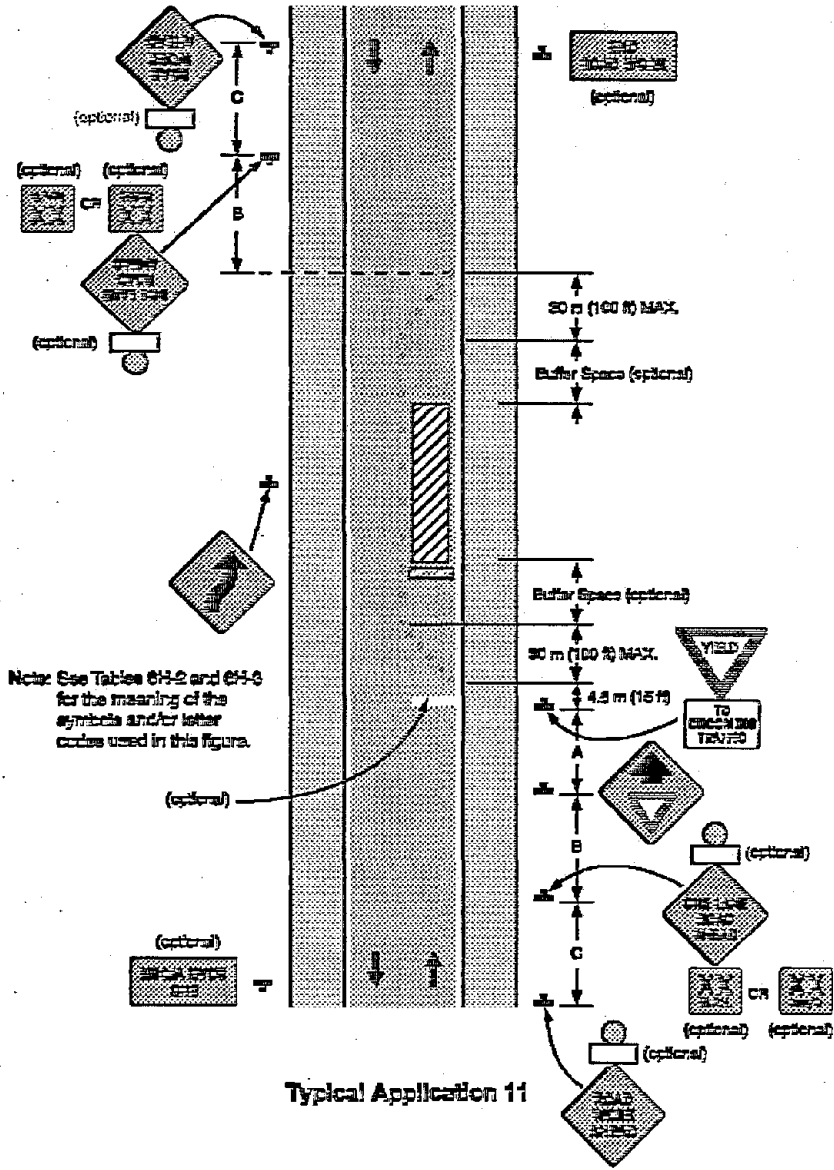


FIGURE 18. TYPICAL WORK ZONE SIGNING.

On city streets, where more restrictive conditions generally prevail on the approach to the work area, signs in the immediate vicinity of the work may be placed at closer spacings of 150 to 300 feet. Warning signs will also be required on side streets in urban areas.

WHAT TYPE OF DEVICES ARE MOST USEFUL FOR CHANNELIZING TRAFFIC?

Cones, vertical panels, drums, barricades, pavement markings, and temporary concrete barriers may all be used to channelize traffic flows through work zones. The device to use depends upon the type of project, the length of time during which the work activity will take place, and the volume and speed of traffic.

For example, cones are easiest to install and remove and, therefore, best suited for short term projects during daytime. Conversely, if the project will be of some duration, will require nighttime channelization, or is on a high volume (or high speed) road, barricades or drums would provide more permanent protection and would be more appropriate. Barriers are generally used to channelize or separate traffic on high speed roads such as freeways.

As would be expected, channelizing devices for night time use shall be retroreflectorized and may be supplemented with warning lights.

More information concerning the design and application of these devices is contained in Part 6 of the MUTCD 2000.

WHAT TYPES OF WARNING LIGHTS ARE AVAILABLE AND HOW SHOULD THEY BE USED?

Warning lights are normally used to supplement and draw attention to other warning or channelizing devices during the hours of darkness.

Most of the warning lights in common use are portable, battery-powered, lens directed, enclosed units and may be used on channelizing devices and signs. The color of the light emitted shall be yellow.

The principal types and uses of warning lights are:

Type A: Low intensity flashing lights, Type A, are appropriate for use on a channelizing device to warn of an isolated hazard at night.

Type B: High intensity flashing lights, Type B, are appropriate to use on advance warning signs day and night.

Type C: Steady-burn lights, Type C, are appropriate for use on a series of channelizing devices which either form the taper to close a lane or shoulder or keep a section of lane or shoulder closed, and are also appropriate on the channelizing device alongside of the work area at night. Flashing lights shall not be used in such applications.

Type A and Type C lights may have either one or two directional faces.

WHAT LENGTH OF TAPER SHOULD BE SELECTED TO CHANNELIZE TRAFFIC FLOWS AROUND A REDUCTION IN PAVEMENT WIDTH?

The single most important element of a traffic control plan in a work zone is the taper used for channelization. The minimum desirable taper length for construction and maintenance purposes should be computed by the formula $L = S \times W$, for all roadways having a posted speed of 45 MPH or greater. The formula $L = WS^2/60$ should be used for streets having a posted speed of 40 MPH or less. In these formulas, L is the taper length in feet, W the width of offset in feet, and S the posted speed or off-peak 85th percentile speed. Where the terrain is hilly or sight distance is limited, some adjustments may be required to provide sufficient visibility.

The following calculations illustrate the application of these formulas.

Example 1

Posted Speed = 50 MPH

W = 12 feet

Taper = $50 \times 12 = 600$ Feet

Example 2

Posted Speed = 30 MPH

W = 11 Feet

Taper = $11 \times 30 \times 30/60 = 165$ Feet

IS THERE A PROPER SEQUENCE FOR INSTALLING OR REMOVING TRAFFIC CHANNELIZING DEVICES AND WARNING SIGNS?

All traffic signs and channelizing devices should be installed so that they will be seen by an approaching motorist, i.e., the sign farthest from the work zone would be installed first. Where one lane of a two-lane, two-way roadway is to be closed and all motorists must use the other lane the sign farthest from the work zone but on the opposite side of the road (the lane open to traffic) would be placed first. The remaining signs and devices along that side of the roadway would then be placed in the order seen as one approaches the work zone. The same procedure would then be repeated for the opposing traffic lane.

When work is completed, the devices should be removed but in the opposite order of installation by starting with the devices closest to the work area and continuing away from the area. Use flashing arrow panels, high-level warning devices, flaggers, or flashing vehicle lights to protect the workers removing the devices.

IF FLAGGERS ARE NEEDED, WHAT SIGNALING TECHNIQUES SHOULD THEY USE IN DIRECTING TRAFFIC?

Flaggers use Stop/Slow paddles to control traffic in work areas, as is described in the Kansas Traffic Control Handbook for Flaggers. Figure 19 shows how both the flag and the paddle are used, but the following technique using the paddle is much more positive and easily understood by the motorist.

To Stop Traffic. The flagger shall face traffic and extend the paddle in a vertical position so the full STOP face is visible. For greater emphasis, the free arm may be raised with the palm toward approaching traffic to indicate that the vehicle is required to stop.

When it is Safe for Traffic to Proceed. The flagger shall move to a safe position on the shoulder. He shall face traffic and extend the paddle in a vertical position so the full SLOW face is visible. He then waves traffic forward by moving his free arm across his body.

Where It Is Desired to Alert or Slow Traffic. Where it is desired to alert or slow traffic the flagger shall stand in a safe position on the shoulder. He shall face traffic and extend the paddle in a vertical position so the full SLOW face is visible. For added emphasis the free arm may be extended horizontally away from the body and raised and lowered.

To flag traffic at night, the flagger's station should be adequately illuminated.

ARE THERE CERTAIN RULES OF SAFETY WHICH A FLAGGER SHOULD FOLLOW IN HIS /HER JOB?

Flaggers are responsible for the safety of motorists and workers. Because of the importance of this job, there are certain safety rules, which they should observe:

- Be alert.
- Always look towards traffic.
- Stand clear of other workers so that the flagger is always clearly visible to motorists.
- Don't block or be blocked by signs.
- Avoid standing in the pavement. An exception to this rule is when the flagger must stand on the pavement to be seen around vehicles already stopped by the flagger.
- Don't stand inside of obstacles which could restrict the flagger's ability to avoid an oncoming vehicle.
- Wear appropriate clothing (which includes such items as an orange hard hat or cap and orange jacket, shirt or vest for visibility).

WHAT TYPE OF RECORDS SHOULD BE KEPT OF THE SIGNS AND OTHER DEVICES USED AT A WORK ZONE?

Good records are a key to minimizing an organization's legal liability in the event a traffic accident occurs at the work zone site. A careful record of job-related activities will document the efforts made to provide good traffic control at the work site. The record system should reflect priorities and a planned safety program and may include any of the following types of records:

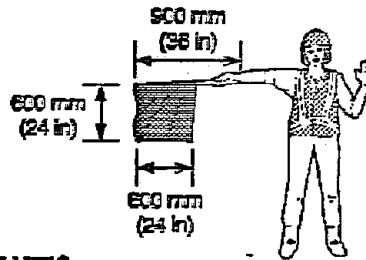
- Traffic control plan.
- Notes on the construction plans showing the placement of devices.

- Photographs at key project stages and for unusual situations.
- A daily diary.
- Inspection sheet or checklist showing the status of the devices in place.
- Copies of reports of all crashes occurring within the work zone.

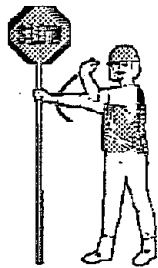
PREFERRED METHOD
STOP/SLOW Paddle

EMERGENCY SITUATIONS ONLY
Red Flag

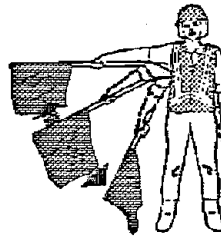
450 mm (18 in)



TO STOP TRAFFIC



TO LET TRAFFIC PROCEED



TO ALERT AND SLOW TRAFFIC

FIGURE 19. USE OF HAND-SIGNALING DEVICES BY FLAGGERS
(Source: MUTCD 2000, page 6E-4, figure 6E-1.)

HOW OFTEN SHOULD AN INSPECTION BE MADE OF TRAFFIC CONTROLS IN WORK ZONES?

There are no set standards for frequency of inspection. At a minimum however, these inspections should be of such frequency as to assure the continuity and quality of the traffic control system. An inspection each morning as work is commencing for the day may suffice. However, nighttime inspection of work zone traffic controls in place is appropriate. Other guidelines to use in establishing inspection intervals include:

- Traffic volumes.
- Frequency of observed deficiencies.
- Frequency of crash experience.
- Severity of hazards.
- Size of project.

WHAT ARE THE MOST COMMON DEFICIENCIES ENCOUNTERED DURING INSPECTIONS?

The type of deficiencies may vary depending upon whether it is a daytime or nighttime inspection.

Typical daytime deficiencies include:

- Lack of a taper or insufficient taper length.
- Channelizing devices out of place.
- Inappropriate sign messages.
- Inadequate flagging protection.
- Inadequate sign placement.

The most commonly experienced nighttime deficiencies include:

- Warning lights not working.
- Warning lights misaimed.
- Retroreflectivity not sufficient.
- Unmarked hazard

APPENDIX – A

TRAFFIC CALMING MEASURES¹

INTRODUCTION

Too much speed and too many vehicles are common complaints in many urban communities. To address these public concerns, many jurisdictions are tempted to adopt apparently easy solutions, such as lowering speed limits and/or installing Stop signs. However, without consistent and increased enforcement, speed limits lower than the 85th percentile are ineffective and not recommended. Installation of Stop signs without proper warrants is never recommended. Traffic calming offers an alternative solution.

Traffic calming is defined by the Institute of Traffic Engineers as “the combination of mainly physical measures to reduce the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users.”

The concept of traffic calming involves physical alterations to a road or street, which cause or invite motorists to decrease driving speed and pay increased attention to the driving task. Some results include reduced speeds and volumes, reduced collision severity, reduced need for extraordinary law enforcement, improved safety for pedestrians and bicyclists, and improved access for all modes of traffic.

The cost of traffic calming measures can vary from a few thousand dollars for closures, speed humps, and bulb-outs to \$50,000 or more for extensive roundabout designs.

Parts 2 and 3 of the *MUTCD* include recommendations for the signing and marking of certain traffic calming measures. This resource should be consulted for appropriate traffic control. Chapter 2C contains description of new signs for traffic calming use, such as Speed Hump (W17-1) and Circular Intersection (W2-6).

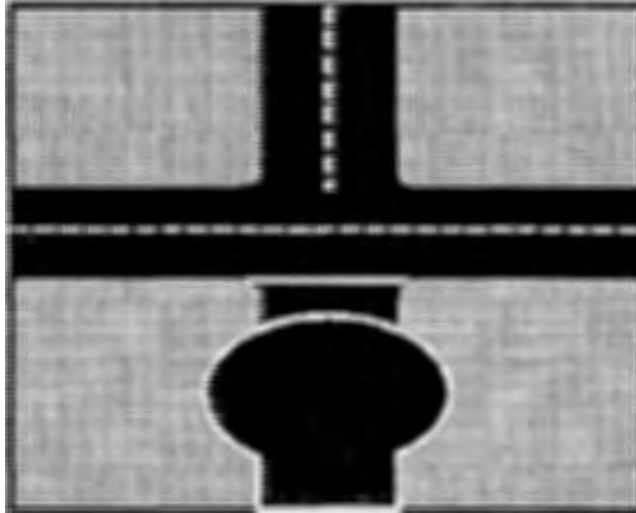
When considering implementation of any traffic calming initiatives, it is recommended to seek appropriate public input and support. Temporary measures such as removable curbs and islands can be used to gauge public reaction and support for any permanent implementation under consideration.

¹ Reproduced with permission from "Iowa Traffic Control Devices and Pavement Markings: A Manual for Cities and Counties", Iowa DOT, Ames, IA 2001

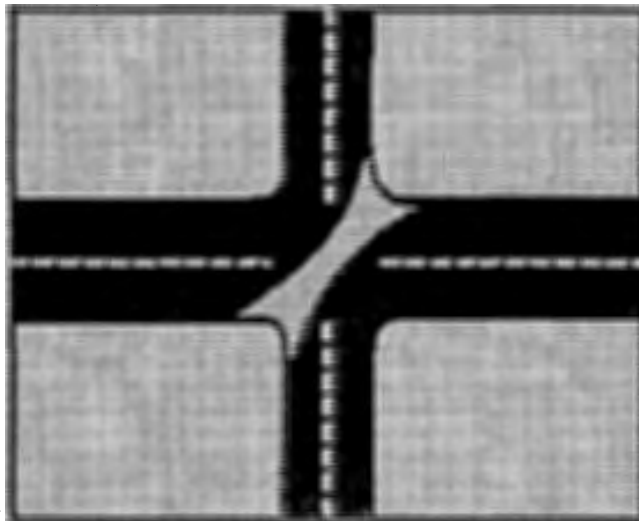
Common traffic calming measures include the following practices.

Closures, Diversions, and Semi-Diversions

These steps would have an obvious effect on reducing traffic volume on a given road or street, but effects to adjacent routes must also be considered.



Street closure (cul-de-sac)



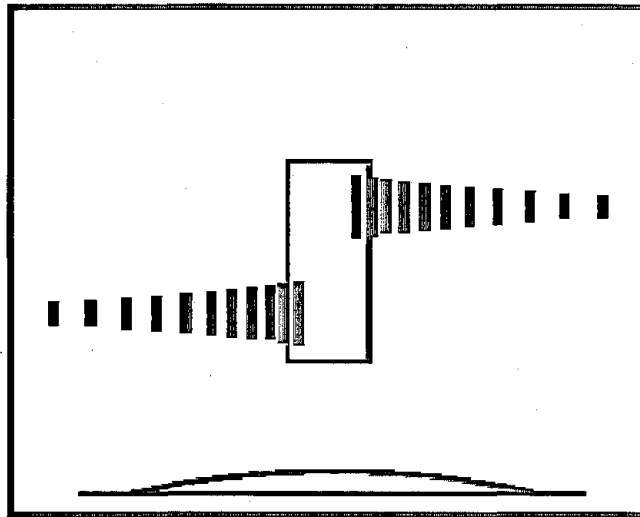
Traffic diverter

**FIGURE 20. Top-Street Closure (cul-de-sac); Bottom-Traffic Diverter
Medians and Islands**

These installations can separate opposing traffic, prevent undesirable turns, and reduce road or street width.

Speed Bumps, Humps, Tables, and Rumble Strips

These devices usually vary from 12 to 20 feet in length and consist of a vertical displacement in pavement surface or, with rumble strips, an audible and physical sensation to gain motorist attention.

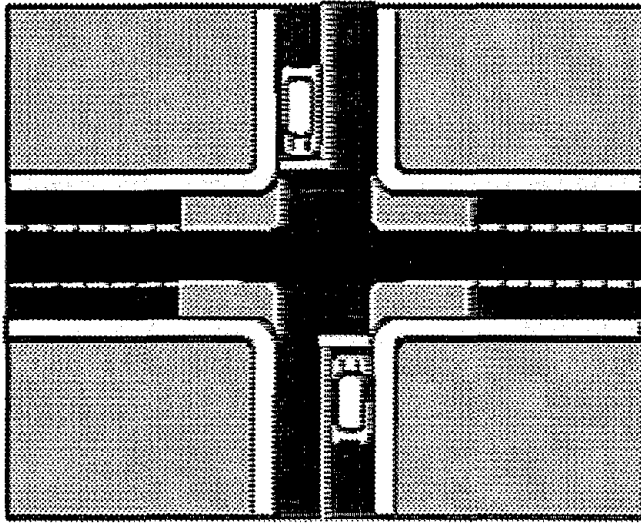


Speed humps

FIGURE 21. Speed Humps

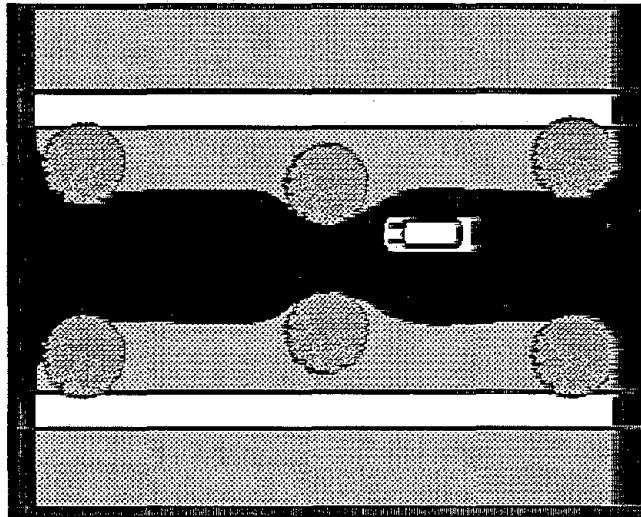
Chokers and Bulb-Outs

These measures involve semicircular or longer extensions of curb or roadside landscaping to invite drivers to slow down. Narrowing of the street to permit easier pedestrian usage is also a potential benefit.



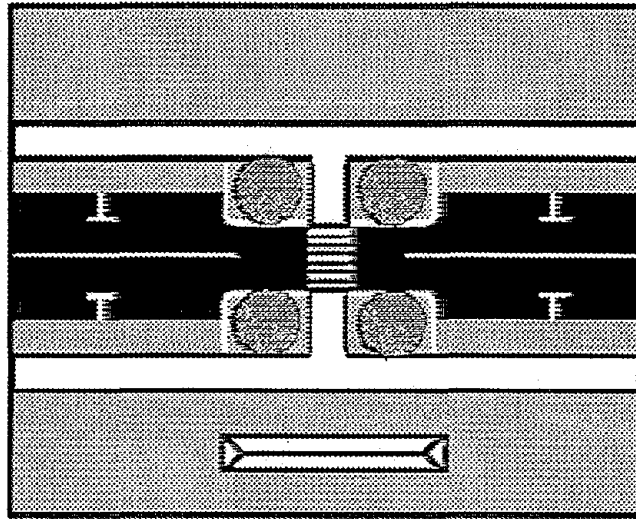
Bulb-out Intersection

FIGURE 22. Bulb-out Intersection



Choker

FIGURE 23. Choker

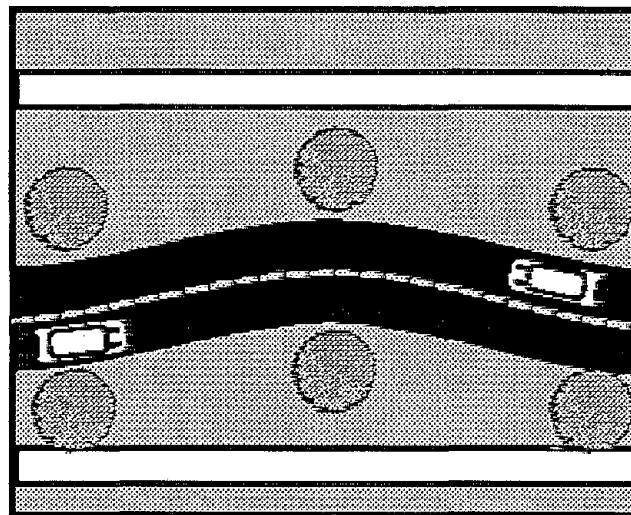


Midblock bulb-out with speed hump

FIGURE 24. Midblock bulb-out with speed hump

Chicanes

Chicanes are short, horizontal displacements in alignment that encourage slower speeds



Chicane

FIGURE 25. Chicane

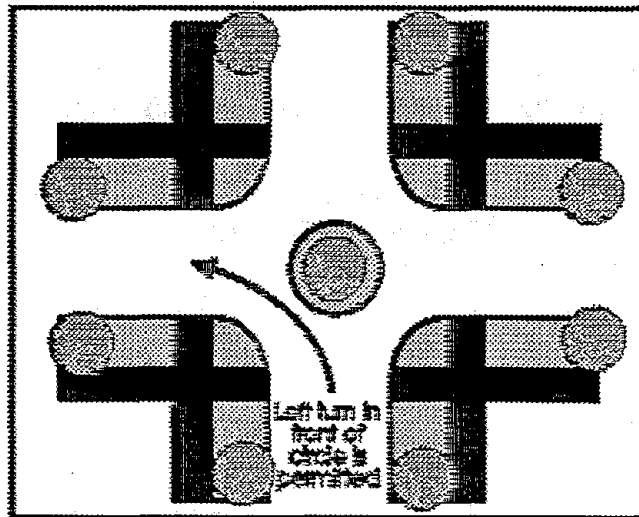
Roundabouts and Traffic Circles

While generally not considered a traffic calming measure, roundabouts involve an intersection design that can often improve operation, reduce crashes, and eliminate signal need. Extensive design recommendations are available for roundabouts in particular. Traffic circles are small islands placed in intersections. They are meant to reduce traffic speeds by requiring through vehicles to navigate around the circle.

Still other measures such as landscaping, fencing, pedestrian crossings, and lighting can have beneficial effects in slowing traffic and providing a safer environment for all roadway users.

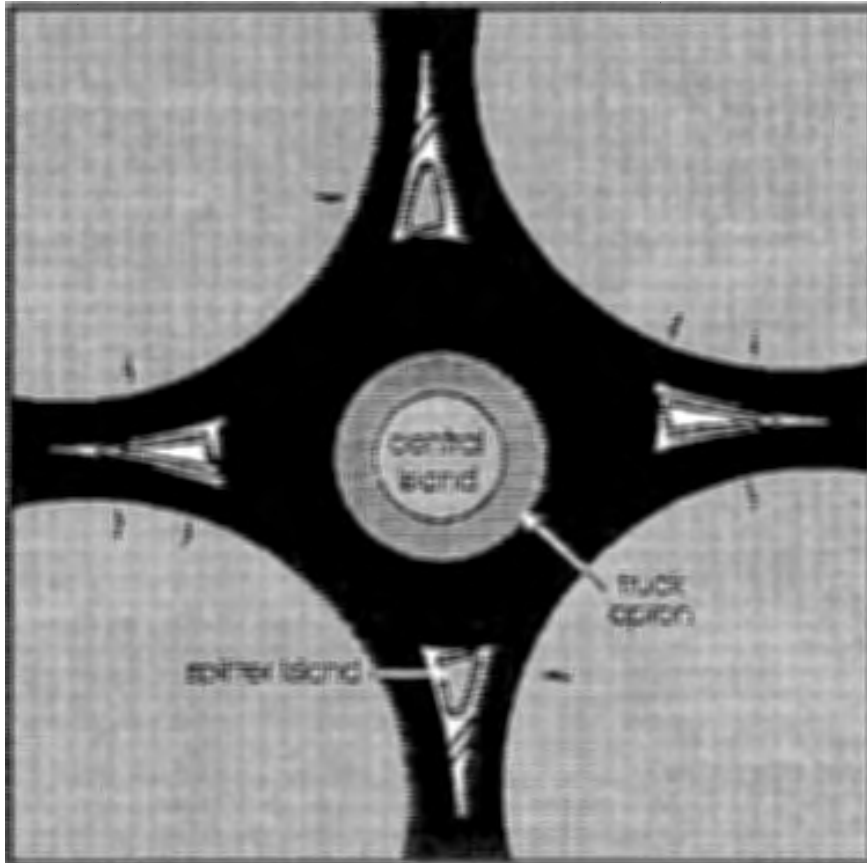
Traffic calming measures may also have negative impacts on snow removal, bus and commercial traffic, and emergency response, etc., which should be considered. Effects on surrounding routes should also be considered by viewing potential traffic calming projects as part of the entire roadway network. Advice from the Iowa Department of Transportation, ITE publications, and other jurisdictions with traffic calming experience is also advisable.

Refer to Parts 2 and 3 of the *MUTCD* and "Pavement Markings" (D1) in this manual for advice on signing and marking for certain traffic calming measures.



Mini traffic circle

FIGURE 26. Mini Traffic Circle



Roundabout

FIGURE 27. Modern Roundabout

APPENDIX B



Ten Ways to Manage Roadway Access In Your Community²

Costly improvements are not always the solution to safety and congestion problems. Roads, like other resources, also need to be carefully managed. Corridor access management strategies extend the useful life of roads at little or no cost to taxpayers. Following are ten ways that you can make the most out of your transportation system.



Lay the foundation for access management in your local comprehensive plan.

To assure that your roadways are managed properly, your comprehensive plan needs to address certain key issues. *First*, include goals, objectives, and policies related to access management in the plan. Tailor policy statements to advance the access management principles in this brochure. For example, a policy could be adopted promoting interconnection of adjacent developments along major roadways.

Second, make sure that your local transportation plan classifies roadways according to function and desired level of access control. This hierarchy of roadways is reinforced through roadway design and access standards in your land development code. For example, arterials require a much higher level of access control and different design standards than collectors or local streets. Some roadways require special attention because of their importance, the need for additional right-of-way, or due to significant access problems. These areas may be designated for special treatment in the comprehensive plan.

Third, provide for a greater variety of street types with varying design standards. Options could include access lanes, alleys, variations in on-street parking, and so on. This reduces development costs, promotes compact development, increases opportunities to interconnect streets, and helps save your major thoroughfare system. Many communities have only a few residential

² Reproduced with permission from Center for Urban Transportation Research, University of Southern Florida, Tampa, Florida.

street design options that apply whether a subdivision has 8 homes or 80. Lack of design flexibility impedes infill development and results in a monotonous street layout. It can also cause a proliferation of substandard and inadequately maintained private streets.

2

Restrict the number of driveways per lot.

Establish a basic requirement that driveways are limited to one per parcel, with special conditions for additional driveways. Lots with larger frontages, or those with needs for separate right and left-turn entrances, could be permitted more than one driveway, in accordance with driveway spacing standards. Limitations on new driveways may be established using a "corridor overlay" approach, which adds new requirements onto the underlying zoning (see Figure 1). It is necessary to first identify and map the boundaries of all existing lots and parcels along the corridor. Then you could assign one driveway to each mapped parcel by right. This land may be further subdivided, but all new lots would need to obtain access from the existing access point.

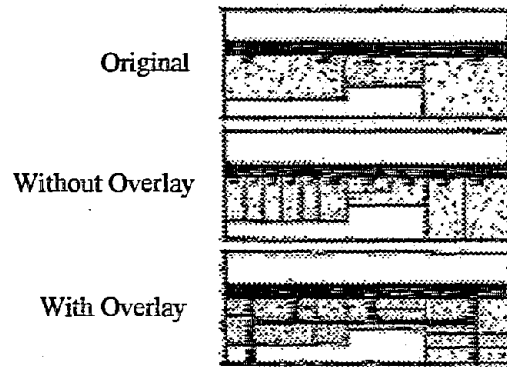


FIGURE 28. Corridor overlay

3

Locate driveways away from intersections.

Setting driveways and connections back from intersections reduces the number of conflicts and provides more time and space for vehicles to turn or merge safely across lanes. This spacing between intersections and driveways is known as corner clearance. Adequate corner clearance can also be assured by establishing a larger minimum lot size for corner lots. You could impose

conditional use limitations where adequate corner clearance cannot be obtained. This helps assure that corner properties do not experience access problems as traffic volumes grow.

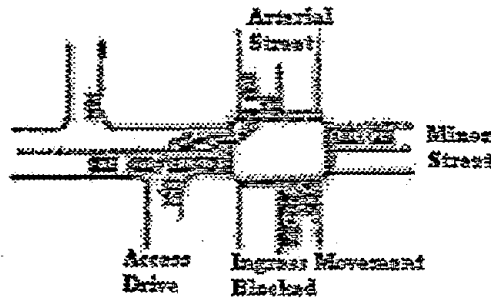


FIGURE 29. Inadequate corner clearance.



Connect parking lots and consolidate driveways.

Internal connections between neighboring properties allow vehicles to circulate between businesses without having to re-enter the major roadway (see Figure 30 and 31). Joint and cross access requirements in your land development code can help to assure connections between major developments, as well as between smaller businesses along a corridor.

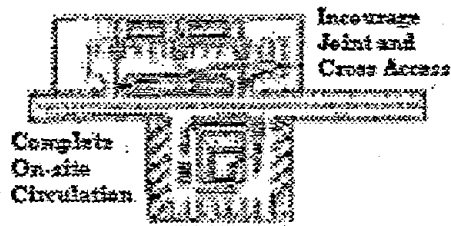


FIGURE 30. Joint and cross access.

Cross access also needs to be provided for pedestrians. Sidewalks are typically placed far away from buildings on the right-of-way of major roadways, or are not provided at all. Pedestrians prefer the shortest distance between two points and will walk if walkways are provided near buildings. Joint and cross access strategies help to relieve demand on major roadways for short trips, thereby helping preserve roadway capacity. They also help to improve customer convenience, emergency access, and access for delivery vehicles.

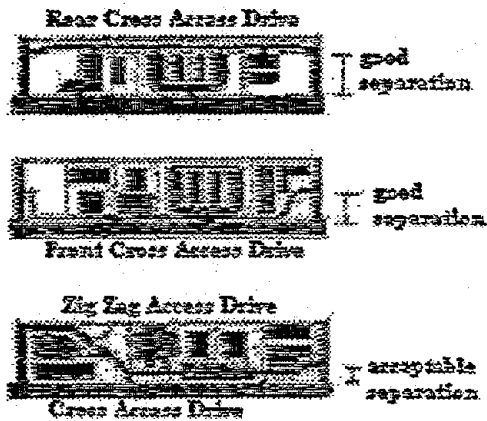


FIGURE 31. Cross access.

5

Provide residential access through neighborhood streets.

Residential driveways on major roadways result in dangerous conflicts between high-speed traffic and residents entering and exiting their driveway. As the number of driveways increase, the roadway is gradually transformed into a high speed version of a local residential street. Subdivisions should always be designed so that lots fronting on major roadways have internal access from a residential street or lane (also known as "reverse frontage" – see Figures 32 and 33). Minor land division activity can be managed by establishing a restriction on new access points and allowing land to be further subdivided, provided all new lots obtain access via the permitted access point. A variation of this approach is to allow lot splits on major roadways only where access is consolidated. Another steps to prohibit "flag lots" along major thoroughfares. Some property owners subdivide their land into lots shaped like flags to avoid the cost of platting and providing a road. Instead, the flag lots are stacked on top of each other, with the



Without Access Management



With Access Management

FIGURE 32. Shared access.

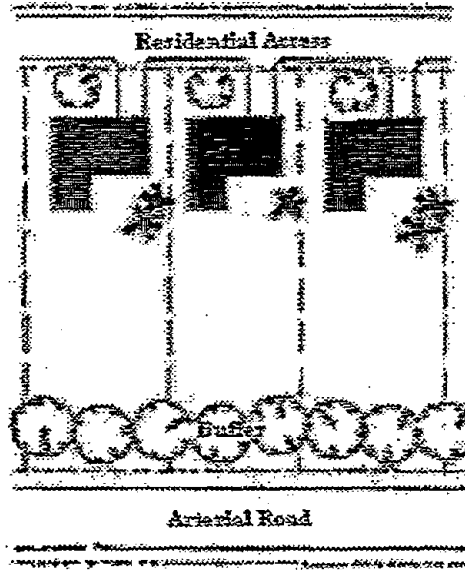


FIGURE 33. Reverse Frontage.

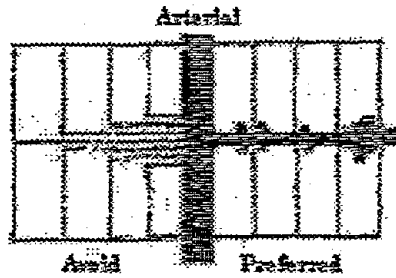


FIGURE 34. Avoid flag lots.

“flag poles” serving as driveways to major roads (see Figure 34). This results in closely spaced driveways that undermine the safety and efficiency of the highway. Eventually, residents may petition for construction of a local public road passing the cost of providing a subdivision road onto the community.

6

Increase minimum lot frontage on major roads.

Minimum lot frontages need to be larger for lots that front on major roadways, than those fronting on local roads. Narrow lots are a problem on major roads because they result in closely spaced driveways. Lots need to be deeper and wider along arterials to allow adequate flexibility in site design and to increase separation of access points (see Figure 35). Assuring an adequate lot size also protects the development potential and market value of corridor properties.

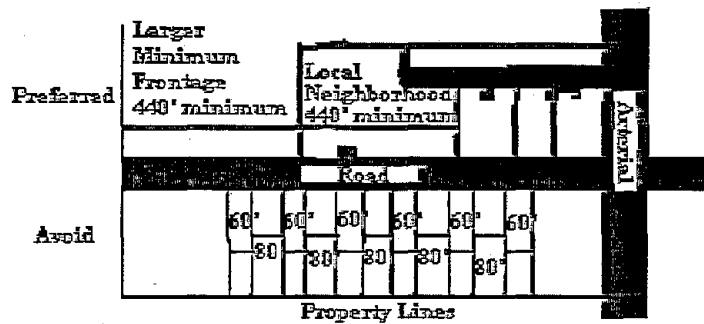


FIGURE 35. Lot frontage requirements.



Promote a connected street system.

As communities grow and land is subdivided for development, it is essential to assure continuation and extension of the existing local street system. Dead end streets, cul-de-sacs, and gated communities force more traffic onto collectors and arterials. Fragmented street systems also impede emergency access and increase the number and length of automobile trips. A connected road network advances the following growth management objectives:

- fewer vehicle miles traveled
- decreased congestion
- alternative routes for short, local trips
- improved accessibility of developed areas
- facilitation of walking, bicycling, and use of transit
- reduced demand on major thoroughfares
- more environmentally sensitive layout of streets and lots
- interconnected neighborhoods foster a sense of community
- safer school bus routes

Connectivity can be enhanced by a) allowing shorter blocks (600 ft.) and excluding cul-de-sacs from the definition of intersection; b) requiring stub streets to serve adjacent undeveloped properties; c) requiring street connections to nearby activity centers; d) requiring connections to or continuation of existing or approved public streets; and e) requiring bicycle/pedestrian access-ways at the end of cul-de-sacs or between residential areas and parks, schools, shopping areas or other activity centers. It is also important to allow a greater variety of street types.

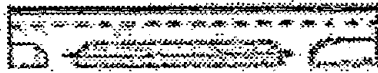


Encourage internal access to outparcels.

Shopping center developments often include separate lots or "outparcels" fronting on the major roadway. The outparcels are leased or sold to businesses looking for highly valued corridor locations. Access to these outparcels should be incorporated into the access and circulation system of the principal retail center. This reduces the need for separate driveways on the major road, while maintaining overall accessibility to the site. To accomplish this, establish that development sites under the same ownership or those consolidated for development will be treated as one site for the purposes of access management. Then require a unified traffic circulation and access plan for the overall development site.

Regulate the location, spacing, and design of driveways.

Driveway *spacing* standards establish the minimum distance between driveways along major thoroughfares (see Figure 36). These standards help to reduce the potential for collisions, as travelers enter or exit the roadway. They also encourage the sharing of access for smaller parcels, and can improve community character by reducing the number of driveways and providing more area for pedestrians and landscaping. The *location* of driveways affects the ability of drivers to safely enter and exit a site. If driveways do not provide adequate sight distance, exiting vehicles may be unable to see oncoming traffic. In turn, motorists on the roadway may not have adequate time to avoid a crash. Driveway *design* standards assure that driveways have an adequate design so vehicles can easily turn onto the site. Standards also need to address the depth of the driveway area. Where driveways are too shallow, vehicles are sometimes obstructed from entering the site causing others behind them to wait in through lanes. This blocks traffic and increases the potential for rear-end collisions.



Adopt minimum spacing standards for Driveways

Reinforce with minimum lot frontage and joint access requirements

FIGURE 36. Driveway spacing standards.

Coordinate with the Department of Transportation.

The Florida Department of Transportation is responsible for access permits along state roadways. Local governments oversee land use, subdivision, and site design decisions that affect access needs. Therefore, State and local coordination is essential to effective access management. Lack of coordination can undermine the effectiveness of regulatory programs and cause unnecessary frustration for permit applicants.

Timely communication is key to an effective review procedure. Begin by establishing a coordinated process for review of access permits along state highways. The state permitting official could have applicants send a copy of the complete permit application to the designated local reviewing official. Prior to

any decision or recommendation, the state permitting official could then discuss the application with the local reviewing official.

Property owners also may be required to submit the necessary certificates of approval from other affected regulatory agencies, before a building permit is issued. In Florida, this should include a "notice of intent to permit" from the Florida Department of Transportation where access to the state highway system is requested.

An effective method of coordinating review and approval between developers and various government agencies is through a tiered process. The first stage is an informal meeting and "concept review" period, which allows officials to advise the developer about information needed to process a development application. This includes information on required state and local permits, and any special considerations for the development sites.

The concept review provides the developer with early feedback on a proposal, before the preliminary plat or site plan has been drafted. Once the preliminary plan is drafted, it can be checked to determine if additional conditions are required for approval. The final plan that is formally submitted should then require only an administrative review.

Local governments could also request a response from the FDOT prior to approval of plats on the state highway system. Applicants could be required to send a copy of the subdivision application to the state access permitting official. This should occur early in the plat review process, preferably during conceptual review. Early monitoring of platting activity would allow the Department of Transportation an opportunity to identify problems and work on acceptable alternatives.

Intergovernmental agreements or resolutions can facilitate coordination between the state and local governments on access management. These tools can be used to clarify the purpose and intent of managing access along major thoroughfares, roadways that will receive special attention, and state and local responsibilities for advancing access management objectives.

Additional References

- "Model Land Development Regulations that Support Access Management," Center for Urban Transportation Research, 1994.
- Williams, K., Marshall, M. "Managing Corridor Development," Center for Urban Transportation Research, 1996.
- Williams, K., Forrester, R., "NCHRP Synthesis 233: Land Development Regulations that Promote Access Management." Transportation Research Board, Washington, D.C.: National Academy Press, 1996.

Training Opportunities

“Access Management: Site Planning,” FDOT 1997 (A Training Unit), available through Gary Sokolow.

“Land Development Regulations that Support Access Management,” FDOT 1997 (A Training Unit), available through Gary Sokolow.

Visit our Web Page at:

<http://www.cutr.eng.usf.edu>

For More Information, Contact:

Kristine M. Williams, AICP, Senior Research Associate

Center for Urban Transportation Research

(813) 974-9807

e-mail krwillia@cutr.eng.usf.edu

Gary Sokolow, Systems Planning Office

Florida Department of Transportation

(850) 488-9747

e-mail gary.sokolow@dot.state.fl.us

APPENDIX - C

MODERN ROUNDABOUTS

The modern roundabout is the safest, most efficient form of intersection traffic control available today. In this section, the term modern roundabout is used to stress that these modern traffic control devices (TCDs) are distinctly different from the big, high speed, generally confusing, circular intersections built in the early 1900's. Some of these circular intersections, sometimes called rotaries, still exist in the eastern USA. But they are not modern roundabouts. The first modern roundabout was built in the USA in 1990. Keep in mind anything built prior to that is probably not a modern roundabout and most likely won't have the characteristics that make them safe and efficient.

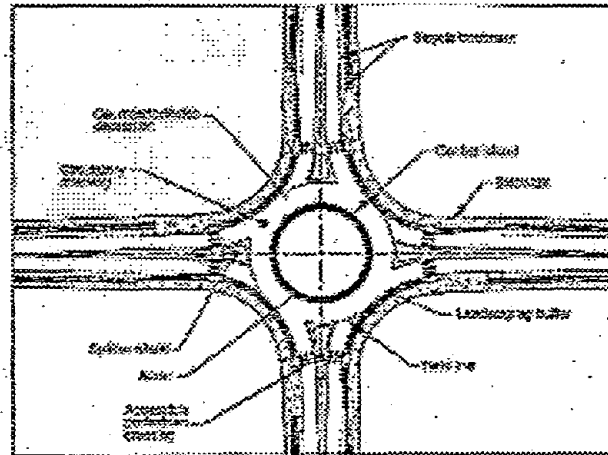
There is no doubt that modern roundabouts are much safer than all other forms of intersection traffic control. This is a proven fact based on both USA studies and worldwide studies. A USA study of intersections where modern roundabouts replaced stop signs and traffic signals showed the roundabouts reduced all crashes by about 40% and injury crashes by about 80%. Also, fatal crashes can be expected to be reduced by 90%.

In regard to efficiency, modern roundabouts require less stopping and they reduce delay to motorists. Studies of several roundabouts in Kansas by KSU have shown that in regard to total stopping and delay they are comparable to two-way stop controlled intersection, and have significantly less stopping and delay (up to 80%) than four-way stop control and traffic signals.

In spite of the proven safety record and operational efficiency, there is often unwarranted opposition by some persons. Usually the opposition is due to lack of understanding of exactly what a modern roundabout is and/or confusing them with the big, old traffic circles from years past or small traffic circles that may be used for speed control at residential intersections. Thus, it is important that people understand what a modern roundabout is and what it isn't. The following definitions from the Federal Highway Administration (FHWA) Roundabout Guide are a good start (FHWA, 1999).

A roundabout is a type of circular intersection, but not all circular intersections can be classified as roundabouts. In fact, there are at least three distinct types of circular intersections:

- **Rotaries** are old-style circular intersections common to the United States prior to the 1960's. Rotaries are characterized by a large diameter, often in excess of 100 m (300 ft). This large diameter typically results in travel speeds within the circulatory roadway that exceed 50 km/h (30 mph). They typically provide little or no horizontal deflection of the paths of through traffic and may even operate according to the traditional "yield-to-the-right" rule, i.e., circulating traffic yields to entering traffic.
- [Small] **Neighborhood traffic circles** are typically built at the intersections of local streets for reasons of traffic calming and/or aesthetics. The intersection approaches may be uncontrolled or stop-controlled. They do not typically include raised channelization to guide the approaching driver onto the circulatory roadway. At some traffic circles, left-turning movements are allowed to occur to the left of (clockwise around) the central island, potentially conflicting with other circulating traffic.
- **Roundabouts** are circular intersections with specific design and traffic control features. These features include yield control of all entering traffic, channelized approaches, (i.e., raised splitter islands) and appropriate geometric curvature to ensure that travel speeds on the circulatory roadway are typically less than 50 km/h (30 mph). Thus, roundabouts are a subset of a wide range of



circular intersection forms.

FIGURE 37. Key features of a roundabout

Key features in the figure above are described below (Source FHWA, 1999).

Central island	The <i>central island</i> is the raised area in the center of a roundabout around which traffic circulate.
Splitter island	A <i>splitter island</i> is a raised or painted area on an approach used to separate entering from exiting traffic, deflect and slow entering traffic, and provide storage space for pedestrians crossing the road in two stages.
Circulatory roadway	The <i>circulatory roadway</i> is the curved path used by vehicles to travel in a counter-clockwise fashion around the central island.
Apron	If required on smaller roundabouts to accommodate the wheel tracking of large vehicles, an <i>apron</i> is the mountable portion of the central island adjacent to the circulatory roadway.
Yield line	A <i>yield line</i> is a pavement marking used to mark the point of entry for an approach into the circulatory roadway and is generally marked along the inscribed circle. Entering vehicles must yield to any circulating traffic coming from the left before crossing this line into the circulatory roadway.
Accessible pedestrian crossings	<i>Accessible pedestrian crossings</i> should be provided at all roundabouts. The crossing location is set back from the yield line, and the splitter island is cut to allow pedestrians, wheelchairs, strollers, and bicycles to pass through.
Bicycle treatments	<i>Bicycle treatments</i> at roundabouts provide bicyclists the option of traveling through the roundabout either as a vehicle or as a pedestrian, depending on the bicyclist's level of comfort.
Landscaping buffer	<i>Landscaping buffers</i> are provided at most roundabouts to separate vehicular and pedestrian traffic and to encourage pedestrians to cross only at the designated crossing locations. Landscaping buffers can also significantly improve the aesthetics of the intersection.
Inscribed circle diameter	The <i>inscribed circle diameter</i> is the basic parameter used to define the size of a roundabout. It is measured between the outer edges of the circulatory roadway.

The Following roundabout dimensions are illustrated in the Figure 38

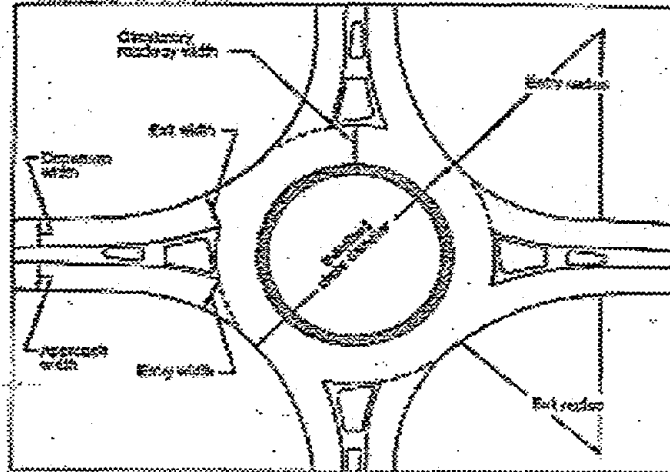


FIGURE 38. Roundabout Dimension Locations

Circulatory roadway width

The *circulatory roadway width* defines the roadway width for vehicle circulation around the central island. It is measured as the width between the outer edge of this roadway and the central island. It does not include the width of any mountable apron, which is defined to be part of the central island.

Approach width

The *approach width* is the width of the roadway used by approaching traffic upstream of any changes in width associated with the roundabout. The approach width is typically no more than half of the total width of the roadway.

Departure width

The *departure width* is the width of the roadway used by departing traffic downstream of any changes in width associated with the roundabout. The departure width is typically less than or equal to half of the total width of the roadway.

Entry width

The *entry width* defines the width of the entry where it meets the inscribed circle. It is measured perpendicularly from the right edge of the entry to the intersection point of the left edge line and the inscribed circle.

Exit width	The <i>exit width</i> defines the width of the exit where it meets the inscribed circle. It is measured perpendicularly from the right edge of the exit to the intersection point of the left edge line and the inscribed circle.
Entry radius	The <i>entry radius</i> is the minimum radius of curvature of the outside curb at the entry.
Exit radius	The <i>exit radius</i> is the minimum radius of curvature of the outside curb at the exit.

A modern roundabout has yield control on all entries. Vehicles in the circle - on the one-way circulating roadway - have the right of way. It is no different than a driver entering a through one-way roadway with traffic traveling left to right from a street with a yield sign at the intersection. The driver looks to the left and enters the roadway immediately if there is a sufficient gap; or if there is not a sufficient gap yields until there is one. The only difference in entering a modern roundabout compared to a one-way roadway is that the one-way roadway being entered is curved.

Summary

In summary, compared to other forms of intersection traffic control, modern roundabouts - different than older traffic circles or rotaries built prior to 1990 - are safer, require less delay or stopping and have lower life cycle costs. The costs associated with constructing and operating a modern roundabout are considerably less than the costs of a traffic signal. In short, use of modern roundabouts for intersection traffic control can save lives and money while cutting air pollution, and motorists' frustration by reducing stopping, de.