Roadway Manual

Lexington-Fayette Urban County Government
Lexington, Kentucky

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CHAPTER 1
INTRODUCTION

1.1 Purpose

The purpose of this manual is for use in the design and maintenance of roadways in Lexington-Fayette County. This manual is to be used in the design of new roadways and in the design of improvements to existing roadways. This manual draws upon nationally accepted standards for roadway planning and design. The manual is intended for use by:

- The Lexington-Fayette Urban County Government
- Engineers designing local roadways
- Developers

1.2 Terms and Definitions

To ensure easier use and interpretation of this manual, certain words, terms, and phrases are interpreted and defined within this section. The terms and definitions used in this manual are drawn from definitions in common use by: the Lexington-Fayette Urban County Government (LFUCG), the Kentucky Department of Highways (KYDOH), and the American Association of State Highway and Transportation Officials (AASHTO). If a word is not specifically defined within this section, but is used within the context of this manual, it is assumed that the word is defined by its common English definition. When standards referenced within this manual change, the most current standards will apply.

It is further assumed in the context of this manual that words used in the present tense include the future tenses; words in the singular number include the plural; and words in the plural include the singular. The word "person" includes a firm, partnership, or corporation, as well as an individual. The word “street” and the word “road” are used interchangeably within the context of this manual; the word "lot" includes the word "plot" or "parcel"; and the word "building" includes the word "structure.” The terms "shall" and "will" are always mandatory and not directory, and the word "may" is permissive.

Average Daily Traffic (ADT). Average number of vehicles that pass a defined point during a 24-hour period.

Bicycle Lane. A portion of roadway designated for preferential or exclusive use by bicycles. It is distinguished from the portion of the roadway for motor vehicle traffic by a paint stripe, pavement marking, curb, or other similar device.

Shared-Use Path. A path or trail that is physically separated from the motorized vehicular traffic of a roadway. It is designed for the exclusive use of non-motorized uses, including bicycle riders, pedestrians, and other non-motorized recreational uses. This shared-use path may be either within the roadway right-of-way or within an independent right-of-way.

Bicycle Route Roadways. A road that is officially designated, signed, and marked as a bicycle route but which is open to motor vehicle travel and upon which no bicycle lane is designated.

Building Set Back Line. A line beyond which buildings must be set back from the right-of-way line.

Clearance (Horizontal). Lateral distance from edge of traveled way to a roadside object or feature.

Clearance (Vertical). The vertical distance between the roadway surface and an overhead object or feature.

Desirable. A condition that should be met when attainable. Desirable values will normally be used where the social, economic, or environmental impacts are not critical.

Developer. An individual, partnership, corporation, or other legal entity or agent thereof that undertakes the activities covered by regulations.

Driveway Approach. A driveway approach designed and intended to serve as access from a roadway to a lot or parcel of land that is adjacent to the roadway.

Easement. The right to use another person's property, but only for a limited and specifically named purpose; the owner generally continues to make use of such land since he has given up only certain, and not all, ownership rights.

Easement Area. A strip of land over, under, or through which an easement has been granted.

Encroachment. Any structure or device positioned within, over, or upon the right-of-way, that is not the property of the Lexington-Fayette Urban County Government.

Engineer. A qualified Professional Engineer registered and currently licensed to practice engineering in the Commonwealth of Kentucky and competent in the area of roadway engineering.

Engineering. The preparation of plans, specifications and estimates for the contract administration of construction of streets, drainage facilities, utilities and other similar public works installed within a subdivision for public use.

Flat Terrain. Topography with grades in the range of 0% to 8%. This terrain is conducive to generally long sight distance potential with little or no construction difficulty or major expense.

Frontage. All property on one side of a street between two intersecting streets (crossing to terminating) measured along the line of the street; or if the street is dead-ended, than all of the property abutting one side between an intersecting street and the dead-end of the street.

Grade. The change in elevation between two points along the vertical alignment of a roadway. Usually expressed as the change per 100 feet or percent.

Gutter. A generally shallow waterway adjacent to a curb used, or suitable for, drainage of water.

Intersection. A point at which two (or more) streets join another street at an angle, whether or not the streets cross the other.

Movement. Is the capacity to move quantities of vehicles or people between various origins and destinations at a reasonable speed.

Owner. The governing body of Lexington-Fayette Urban County, the Lexington-Fayette Urban County Government, is referred to as “owner” throughout this manual. When referenced in the context of this manual, the terms “owner” and “LFUCG” are defined to include all applicable decision making bodies in relations to roadway and/or subdivision design approvals.

Pavement (Asphalt). A flexible pavement structure consisting of mineral aggregates bound together with asphalt material. The structure maintains intimate contact with and distributes loads to the subgrade and depends on aggregate interlock, particle friction, and cohesion for stability.

Pavement (Concrete Slab). A rigid pavement structure that distributes loads to the subgrade. The pavement consists of one course of portland cement in a concrete slab. This slab has relatively high bending resistance.

Pavement. Pavement refers to the materials used to cover the ground surface along roadways. It is a combination of granular base, base course, and surface course placed on a subgrade to support the traffic load and distribute the load to the roadbed. Pavement has several distinct layers:

SUBGRADE. The natural soil material upon which the upper roadway layers are constructed.

MODIFIED SUBGRADE. Layer designed to augment the subgrade strength. This layer is only used when subgrade strength is below a particular level. It consists of chemically altered or compacted subgrade materials, often in combination to achieve certain strength characteristics required in specific conditions. Additionally, modified subgrade acts to reduce frost and water intrusion actions.

GRANULAR BASE. Constructed on top of the subgrade. It consists of granular material such as crushed stone or gravel. The specifications for the granular base are more rigorous than that for the subgrade in terms of strength, hardness, gradation, and aggregate types. The granular base layer is placed on the subgrade to support an asphalt base course or a portland cement slab.

BASE COURSE. The base course is the layer, or layers, of a specified material of designed thickness placed on the granular base. In the case of an asphalt pavement, the base course further serves as a foundation course to support the surface course. In the case of a portland cement pavement, there is only one course of pavement material and the base course and surface course are one and the same.

SURFACE COURSE. The purpose of the surface course is to accommodate the traffic load, provide a smooth riding surface, resist the wear and tear from traffic, provide skid resistance to vehicles, and prevent excessive water from penetrating into the base course. In the case of asphalt pavement, the surface course of the pavement section consists of a mixture of mineral aggregates and asphalt materials. In the case of a portland cement pavement, there is only one course of pavement material and the base course and surface course are one and the same.

Pedestrian Way. A travel route designed primarily for pedestrian travel.

Recommendation. The formal opinion of the LFUCG staff concerning approval, conditional approval, disapproval, or postponement of consideration of a plan or plat or the opinion of a responsible agency concerning an aspect of a plan or plat.

Right-of-way (ROW). The strip of land dedicated for public streets and/or related facilities, including utilities and other transportation uses.

Right-of-way Width. The shortest horizontal distance between the lines which delineate the right-of-way of a street.

Road. For the purpose of this manual "road" shall be defined the same as "street."

Rocking. The preparation of a roadway base.

Rolling Terrain. Topography with grades over 8%. This terrain offers condition where the natural slopes consistently rise above and fall below the road or street grade and where occasional steep slopes offer some restriction to normal horizontal and vertical alignment.

Rural Roadway. A term used to describe a right-of-way within the rural service. This right-of-way provides a channel for vehicular movement between certain points in the community, may provide for vehicular access to properties adjacent to it, and may also provide space for the location of underground and above ground utilities. A rural roadway shall include a right-of-way, the street pavement, and shoulders.

Shall. Also defined as "must." A mandatory condition. Where certain requirements in the design or application of this manual are described with the "shall" or the "must" stipulation, it is mandatory that the requirements be met.

Shared Parking. Parking that can be used to serve two or more individual land uses without conflict or encroachment.

Should. A desirable advisory condition. Where the word "should" is used in this manual, it is considered to be advisable and usually recommended, but not mandatory.

Sidewalk. A paved area within the street right-of-way or sidewalk easement specifically designed for pedestrians.

Sight distance. The distance visible to the driver of a passenger automobile, measured along the normal path of roadway. The minimum sight distance available on a road should be sufficiently long to enable a vehicle traveling at or near the design speed to stop before reaching a stationary object in its path.

Street. A general term used to describe a right-of-way within the urban service. This right-of-way provides a channel for vehicular and pedestrian movement between certain points in the community and which may provide for vehicular and pedestrian access to properties adjacent to it, and which may also provide space for the location of underground and above ground utilities. A street shall include a right-of-way, the street pavement, curb, and gutter. A street is primarily used as a channel for vehicular movement and secondarily as a drainage channel for stormwater. For the purposes of this manual, the terms “street” and “road” are all used interchangeably.

Street, Approved. Any vehicular way approved by the Lexington-Fayette Urban County Government as providing vehicular and pedestrian travel, and--as appropriate--access to a lot. Included in this definition are:

> PUBLIC STREETS. Are streets dedicated to the public use and which are maintained by the LFUCG.
>
> PRIVATE STREETS. Are streets owned, constructed, used, and maintained by a particular subdivision under the appropriate LFUCG subdivision regulations and the covenants of the particular subdivision.
>
> ACCESS EASEMENTS. When permitted, by the Lexington-Fayette Urban County Government as the sole means of vehicular access to a lot, are a type of restricted street that may be used by the public, or privately, as designated by the LFUCG and subject to the provisions of the Lexington-Fayette County subdivision regulations.

Street, Classified. A street, either existing or proposed, which is assigned a functional street Classification by the Lexington-Fayette Urban County Government.

Street, Classification. Types of streets as set forth in this manual. The following street classifications are established in this manual:

> EXPRESSWAYS. Hold the first rank in the classification of streets, and are used only for movement of vehicles, providing for no vehicular or pedestrian access to adjoining properties. Expressways generally carry higher volumes, require greater right-of-way width, and permit higher speed limits than any other class of street.
>
> ARTERIALS. Hold the second rank in the classification, and should be used only for the movement of vehicles, and should not provide for vehicular access to adjacent properties.
>
> COLLECTORS/CONNECTORS. Hold the third rank in the classification of streets, and are used both for the movement of vehicles and for providing access to adjacent properties
>
> LOCALS. Hold the fourth rank in the classification of streets, and are used primarily for providing access to adjacent properties.

SERVICE ROADS. – Are local streets that run parallel to a street with a higher classification on one side and run parallel to properties requiring access on the other side. In this way, a service road provides an access route to properties adjacent to higher classification streets while at the same time reducing the number of access points from these properties onto the higher classification streets.

ALLEYS - Alleys generally have two open ends, each end connects with different streets, and property generally backs onto both sides of the alley. Designed primarily to provide access to or from the rear or side of a property.

NOTE: These street classifications are discussed in greater detail in Chapter 2 of this manual.

Street Grade. The officially established grade of the street upon which a lot fronts. If there is no officially established grade, the existing grade of the street at the midpoint of the lot shall be taken as the street grade.

Street Name Sign. The street name sign is the sign that designates the official name of the street.

Traveled Way. The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

1.3 Federal, State, and Local Permits/Laws

This roadway manual is to be used in conjunction with federal, state, and local permit requirements and laws. The manual in no way supersedes federal, state, and local permitting or design requirements dealt with in other laws and ordinances. When referenced standards change, the most up-to-date standards and requirements will apply.

1.4 Standard Drawings and Specifications

References to “standard drawings and specifications” within this manual are in reference to the standardized drawings utilized by the Lexington-Fayette Urban County Government, which are generally modeled from drawings and specifications utilized by the Kentucky Department of Highways.

1.5 Referenced Documents and Manuals

A great deal of research went into the development of this Roadway Manual. The following technical documents were used as references materials in the development of this document, which is designed specifically for use in Lexington-Fayette County:

AASHTO, A Policy on Geometric Design of Highways and Streets. "The Green Book." American Association of State Highway and Transportation Officials (AASHTO), Washington, DC, 1994 (metric) and 1990 (English units).

AASHTO, Guide for Design of Pavement Structures. American Association of State Highway and Transportation Officials (AASHTO), Washington, DC, 1993.

AASHTO, Guide for the Development of Bicycle Facilities. American Association of State Highway and Transportation Officials (AASHTO), Washington, DC, 1991.

AASHTO, Roadside Design Guide. American Association of State Highway and Transportation Officials (AASHTO), Washington, DC, 1996.

"AASHTO, Stopping Sight Distance Model and Stopping Sight Distance Design Requirements." American Association of State Highway and Transportation Officials (AASHTO), Washington, DC, 1990.

Asphalt Institute. The Asphalt Handbook. Manual Series Number 4, The Asphalt Institute, College Park, Maryland. 1989 Edition.

Asphalt Institute. "Asphalt Pavement Thickness Design." The Asphalt Institute, Information Series Number 181, Second Addition. College Park, Maryland, January 1983.

Asphalt Institute. Thickness Design - Asphalt Pavements for Highways and Streets. Manual Series Number 1, The Asphalt Institute, College Park, Maryland. Originally printed September 1981, revised and reprinted October 1984.

Baltimore County Design Manual for Water Mains, Sanitary Sewers, Storm Drains, Roads and Streets, Bridges and Culverts, Structural, and Land Acquisition. Baltimore County Department of Public Works, Towson, Maryland. Adopted and published November 18, 1985.

Baltimore County Development Procedures and Policy Manual. Baltimore County Department of Public Works, Towson, Maryland. Adopted and published November 1985.

Boone County Subdivision Regulations. Boone County, Kentucky, Planning Commission.

"Checklist for: Subdivisions." Jefferson County, Kentucky, Public Works and Community Development Department, Public Works and Transportation Division, July 1994.

"Checklist for: Traffic Review." Jefferson County, Kentucky, Public Works and Community Development Department, Public Works and Transportation Division, July 1994.

"Concrete Streets: Typical Pavement Sections and Jointing Details." Published by Concrete Information, Portland Cement Association, 1980.

Florida Department of Transportation. Bicycle Facilities Planning and Design Handbook. Florida Department of Transportation State Safety Office. Revised February 1998, originally November 1997.

Hettinger, Dale R. "Minimum Pavement Design Chart Memorandum." Jefferson County, Kentucky Public Works and Transportation. October 22, 1993.

Homburger, Wolfgang S., et al. Residential Street Design and Traffic Control. Institute of Transportation Engineers, Prentice-Hall, Englewood Cliffs, NJ, 1989.

Hoyle, Cynthia L. Traffic Calming. Report Number 456, American Planning Association Planning Advisory Service (APA PAS).

Highway Capacity Manual Special Report 209. The Transportation Research Board National Research Council.

ITE Technical Council Committee 5A-5. "Design and Safety of Pedestrian Facilities: A Proposed Recommended Practice." Institute of Transportation Engineers, Washington DC, 1994.

ITE Technical Council Committee 5A-25A. "Guidelines for Residential Subdivision Street Design: A Recommended Practice." Institute of Transportation Engineers, Washington DC, 1993.

ITE. "Guidelines for Urban Major Street Design." Institute of Transportation Engineers, Washington DC, 1983.

ITE Technical Council Committee 5P-8. "Traffic Engineering for Neo-Traditional Neighborhood Design." Institute of Transportation Engineers, Washington DC, February 1994.

ITE Technical Council Committee 5P-8. "Traditional Neighborhood Development Street Design Guidelines." Institute of Transportation Engineers, Washington DC, June 1997.

ITE. ITE Traffic Engineering Handbook, Fourth Edition. Institute of Transportation Engineers, Washington DC, 1992.

"Jefferson County Subdivision, Land Development, and Construction Regulations." Jefferson County, Kentucky, adopted January 6, 1981, amended and reprinted May 5, 1992.

KYDOH. Division of Design Guidance Manual. Kentucky Transportation Cabinet Department of Highways, Frankfort, Kentucky.

KYDOH. Division of Traffic Guidance Manual. Kentucky Transportation Cabinet Department of Highways, Frankfort, Kentucky.

KYDOH. Standard Drawings. Kentucky Transportation Cabinet Department of Highways, Frankfort, Kentucky.

KYDOH.. Standard Specifications for Road and Bridge Construction, 1994 Edition., Kentucky Transportation Cabinet Department of Highways, Frankfort, Kentucky.

Kulash, Walter M., P.E. "The Street Grid: Why the Traffic Works." Prepared by Glatting, Jackson, Kercher, Anglin, Lopez, Rinehart, Inc., Orlando, Florida. October 1993.

Kulash, Walter M., P.E. "Traffic Calming: A New Approach for Tennessee's Cities." Roadtalk, Volume 11, Number 3. Tennessee Transportation Assistance Program, The University of Tennessee, Fall 1997.

Land Subdivision Regulations. Lexington-Fayette Urban County Government. Adopted December 15, 1983 , amended and reprinted most recently June 5, 1995.

Minimum Subdivision Regulations. Knoxville-Knox County, Tennessee. Adopted July 8, 1971. Most recently amended and reprinted August 13, 1996,

"Neighborhood Traffic Management Program." City of Portland, Oregon, Technical Evaluation Committee, January 1992.

OKI: Ohio Kentucky Indiana Regional Council of Governments. Worldwide Web Site: www.oki.org.

Oregon Department of Transportation. Worldwide Web Site: www.odot.state.or.us.

Residential Streets, Second Edition. American Society of Civil Engineers (ASCE), National Association of Home Builders, and Urban Land Institute. ASCE, Washington, DC, 1990.

Shaw, Gordon, R. "Impact of Residential Street Standards on Neo-Traditional Neighborhood Concepts." ITE Journal, July 1994.

"Standard Drawings." Lexington-Fayette Urban County Government. 1997 revisions.

"Subdivision Regulations." City of Greenville, South Carolina.

Supplement to the State of Ohio Department of Transportation Construction and Material Specifications. City of Cincinnati, Ohio. April 1991.

"Traffic Review Checklist: Preliminary and Construction." Jefferson County, Kentucky, Public Works and Community Development Department, Public Works and Transportation Division, July 1994.

Transportation Development Criteria Manual. City of Austin, Texas, March 1996.

UDA Architects. The Bluegrass Handbook "A Guide for Community Design." Funded by Bluegrass Tomorrow and prepared for the Bluegrass Tomorrow Community Design Committee. November 1994.

USDOT: United States Department of Transportation. Flexibility in Highway Design. United States Department of Transportation Federal Highway Administration.

USDOT. Manual of Uniform Traffic Devices. United States Department of Transportation Federal Highway Administration.

Wallwork, Michael J. "Traffic Calming." Chapter 23 in The Traffic Safety Toolbox: A Primer on Traffic Safety. Institute of Transportation Engineers, Washington, DC, 1993.

Zoning Ordinance. Knoxville, Tennessee. As amended through January 28, 1997.

Zoning Ordinance. Lexington-Fayette County, Kentucky. Adopted December 15, 1983. As amended through January 6, 1997 (including Expansion Area Zoning Categories and Restrictions).

Zoning Ordinance. Louisville/Jefferson County, Kentucky. Adopted October 1994.

CHAPTER 2
STREET STANDARDS AND DESIGN CRITERIA

2.1 Overview of Standards by Street Classifications

Proposed streets must conform to adopted Lexington-Fayette Urban County Government's standards and policies for design and construction. The only exception to these requirements is when the LFUCG deems it necessary to apply different standards in an effort to:

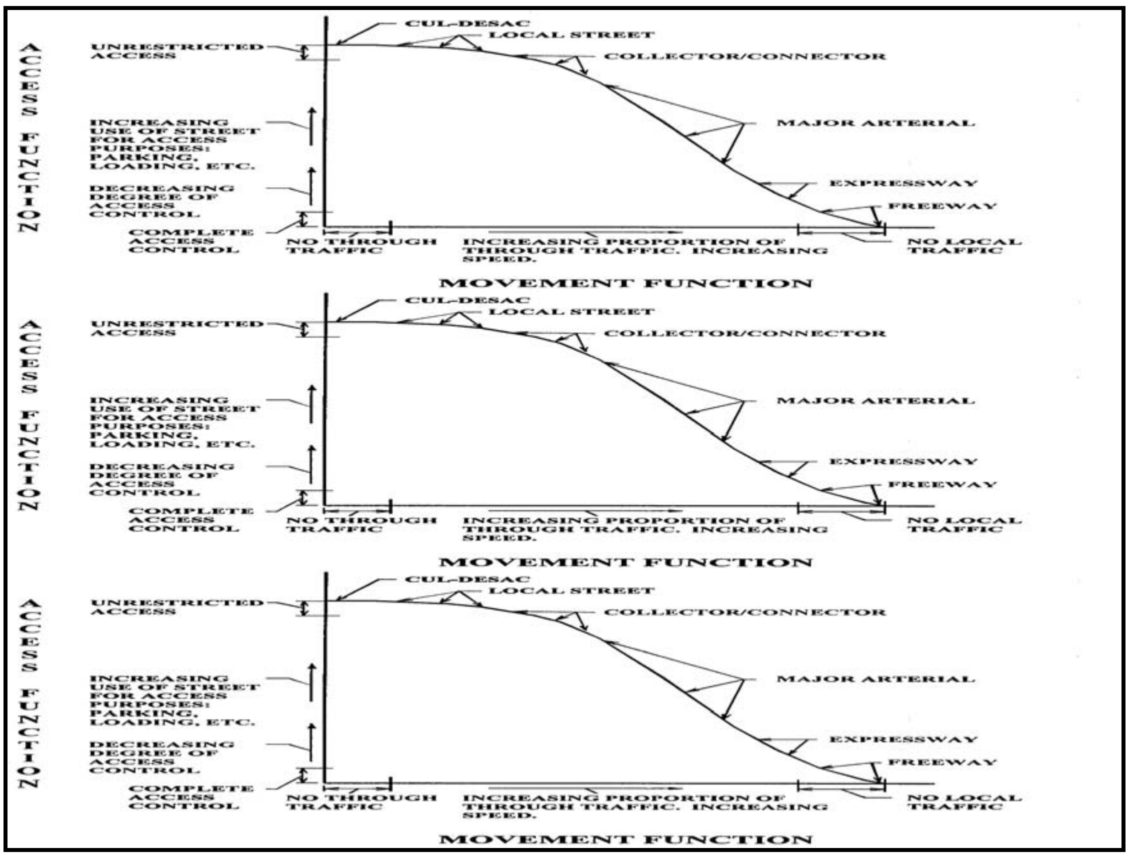
- Preserve trees or other natural features
- Minimize grading or impervious surfacing
- Accommodate utilities, landscaping, or other street side facilities
- Increase the suitability of the design or construction to the terrain, soil, surface drainage, groundwater, or anticipated traffic load or speed
- Achieve specific community goals deemed beneficial to Lexington-Fayette County by the Lexington-Fayette Urban County Government

Streets shall be related to topography and shall generally provide for the continuation of existing or dedicated streets in adjoining or nearby tracts, and provide for connection to adjoining unsubdivided tracts, especially those which would otherwise be land-locked. Expressways and arterials shall not penetrate or bisect existing or proposed neighborhoods, but rather, shall be located as appropriate boundaries for such. Collectors/Connectors shall carry traffic from arterials into neighborhoods. Locals shall carry traffic from collectors/connectors into the neighborhood for the primary purpose of access to individual properties.

2.2 Street Classifications

Streets are defined as a vehicular way, a general term used to describe a right-of-way that provides a channel for vehicular and pedestrian movement between certain points in the community, which may provide for vehicular and pedestrian access to properties adjacent to it, and which may also provide space for the location of underground or aboveground utilities.

FIGURE 2. 1 - SCHEMATIC RELATIONSHIP BETWEEN ACCESS AND MOVEMENT FUNCTION OF STREETS

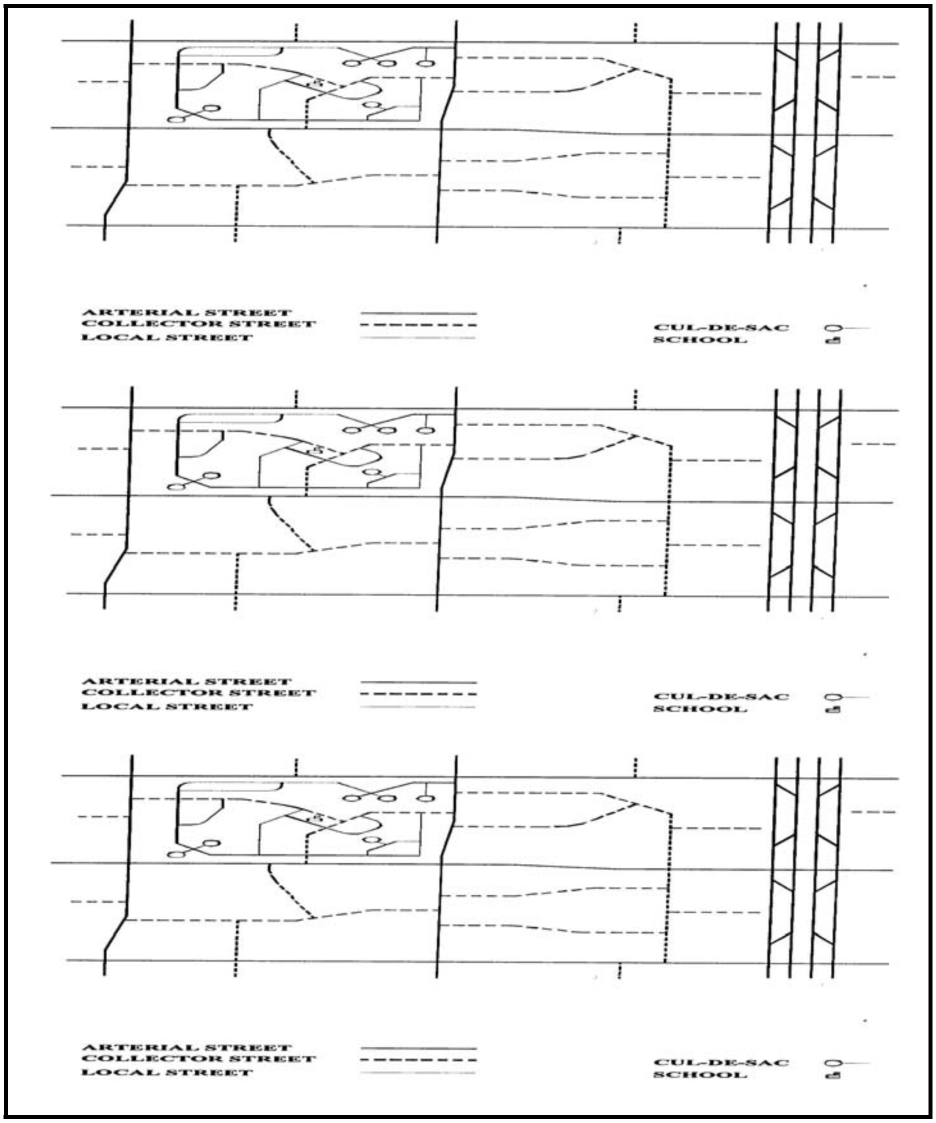


Reference: Adapted from AASHTO-Geometric Design of Highways and Streets, 1984.

For transportation purposes, streets provide two primary functions: *movement* between various origins and destinations at reasonable volumes and speeds, and access to individual parcels of land (specifically driveways connecting streets and private property.)

These two functions are often in conflict with each other; thus street classifications must be used to balance these needs. Figure 2-1, below, illustrates how the access verses movement conflict is resolved for various street classifications.

FIGURE 2. 2 - STREET NETWORK SYSTEM



Reference: Adapted from City of Austin, TX drawing.

In planning a street network for Lexington-Fayette County, the following street classifications, by function, are utilized:

2.2.1 Expressways

Expressways hold the first rank in the classification of streets, and are used only for movement of vehicles, providing for no vehicular or pedestrian access to adjoining properties; interchange of traffic between an expressway and other streets is accomplished by grade separated interchanges with merging deceleration and acceleration lanes, and no at-grade intersections are permitted. Expressways generally carry higher volumes, require greater right-of-way width, and permit higher speed limits than any other class of street, and should be depressed in urban or urbanizing areas. Arterials are the only class of street that generally should be connected with expressways at interchange points. Expressways will not be addressed in this guidance manual, the Engineer is referred to AASHTO's *A Policy on Geometric Design of Highways and Streets*, and/or KDOH's *Design Manual* for background and information with regards to expressways.

2.2.2 Arterials

Arterials hold the second rank in the classification, and should be used only for the movement of vehicles, and should not provide for direct vehicular access to adjacent properties. Bicycle usage of arterials should be limited to designated bicycle/multi-use paths or bicycle lanes. Pedestrian use of arterials should be limited to designated bicycle/multi-use paths or sidewalks. Interruption of traffic flow should be permitted only at street intersections that should contain medians, deceleration lanes, and left turn storage lanes. Arterials are the link between expressways and collectors, and rank next to expressways in traffic volumes, speed limit, and right-of-way width.

Arterials may be further divided into two classes, "principal" and "minor". Principal arterials carry the major portion of trips entering and leaving the urban area, as well as the majority of through movements desiring to bypass the central city. In addition, significant inter-area travel such as between the downtown and outlying residential areas, between major inner city communities or between major suburban centers is to be served by this class of facilities. Minor arterials interconnect with and augment the principal arterial and provide service for trips of moderate length at a somewhat lower level of travel mobility.

2.2.3 Collectors/Connectors

Collectors/Connectors hold the third rank in the classification of streets, and are used both for vehicles and for providing access to adjacent properties. Access to adjoining properties should be planned and controlled so that minimum disturbance is made to the traffic moving efficiency of the Collector/Connector. Bicycle usage of Collector/Connectors should be limited to designated bicycle/multi-use paths, bicycle lanes, or streets designated as bicycle routes that provide a widened outside land or a paved shoulder that can be utilized by bicyclists. Pedestrian use of Collector/Connectors should be limited to designated bicycle/multi-use paths or sidewalks.

It should be noted that this classification of street, on a national level, is commonly referred to simply as a "collector." The special term "collector/connector" has been intentionally chosen by the LFUCG to reflect the owner's goal of emphasizing the continuing and connecting nature of this street classification. The term "collector" quite simply translates to a street that collects traffic from local streets and feeds this traffic into the larger, higher traffic volume, and arterial road system. The term "connector" has been added to this definition to reflect the LFUCG's further goal that these streets are themselves a connection route to the rest of the area. That is to say, a collector/connector street can be used as a travel route in-and-of itself, if a driver so desires.

Collectors/connectors are streets that are designed to interconnect the city as a whole, as well as to provide a link between arterials and local streets. Collector/connectors generally rank next to arterials in traffic volumes, speed limits, and right-of-way width.

2.2.4 Locals

Locals hold the fourth rank in the classification of streets, and are used primarily for providing access to adjacent properties. Vehicles moving on these streets should have an origin or destination in the immediate vicinity, and all types of through traffic should be eliminated through initial design of its connections with other streets. Local streets are the primary link between trip generation points (homes, offices, stores, work) and collector streets. Locals have the least right-of-way, the lowest speed limit, and the least amount of vehicular traffic. Local streets can be subdivided further into six sub-classes, listed below.

A. **Continuing**: Are local streets having two open ends; each end generally connects with different streets; one or more other streets may intersect it between its two open ends; and property fronts on both sides of the streets.

B. **Service Roads**: Are local streets that run parallel to a street with a higher classification on one side and run parallel to properties requiring access on the other side. A service road generally has two or more open ends, connecting at street intersections that run perpendicular to the service road and its adjacent street of higher classification. In this way, a service road provides an access route to properties adjacent to higher classification streets while at the same time reducing the number of access points from these properties onto the higher classification streets. Generally, in a given block, one or no access points are provided directly to the higher classification streets, but multiple access points are provided onto the adjacent properties.

C. **Loop**: Are local streets forming a “U” shape and having two open ends; each end generally connects with the same street; no other streets generally intersect between its two ends, and property fronts on both sides of the street.

D. **Close**: (Pronounced with a long “o”.) Are one-way local streets forming a “U” shape and having two open ends; each end generally connects with the same street. Property fronts on the outside of the “U” but the interior of the “U” should be natural or landscaped open space. This interior area should generally be between fifty and one hundred fifth feet wide. The close is a neo-traditional street design used as an alternative to cul-de-sacs in areas where it is difficult to provide a through street.

E. **Cul-de-sac**: Are local streets having only one open end providing access to another street; the closed end provides a turn-around circle for vehicles, no other street generally intersects between the two ends, and property fronts on both sides of the street.

F. **Stubs**: Are local, closed end streets that are only acceptable as a temporary street conditions. Stubs are similar to cul-de-sacs except that they provide no turnaround circle at their closed end. Stub streets shall only be used when a future continuation is planned.

2.2.5 Alleys

Alleys generally have two open ends, each end connects with different streets, and property generally backs onto both sides of the alley. The use of alleys is very restricted in Lexington-Fayette County. Alleys may only be used if LFUCG neo-traditional design standards are followed or special permission is obtained from LFUCG for their use.

2.3 Neo-Traditional Design Elements

2.3.1 Overview

The Lexington-Fayette Urban County Government views the use of neo-traditional neighborhood design as an innovative approach to residential developments. As such, the Urban County Government will consider certain street design flexibility in neighborhoods attempting to meet a neo-traditional design standard. Engineers and contractors should realize, however, that this design flexibility shall only be considered when the neo-traditional design concepts are presented as a package. A street design that utilizes only one, or a few, of the flexible design criteria discussed below shall not be considered a neo-traditional design and will not receive special consideration.

2.3.2 Key Features of a Neo-traditional Neighborhood

Neo-traditional neighborhoods, and their streets' design, use specific design features in an attempt to create a living environment in which:

1. A sense of neighborhood community is fostered.

2. A community center-piece creates a "sense-of-place (i.e. open space, parks, and/or civic buildings are incorporated into the neighborhoods design a community and visual "center-piece").

3. The needs of every day life can be achieved with less reliance on auto use, (i.e., there are mixed residential, commercial, business, and recreational uses all within walking access of each other).

4. Multiple modes of transportation can successfully coexist, (i.e. streets are design for bicycles and pedestrians convenience, as well as for automobile usage).

5. Streets are interconnected, allowing locations to be reached via multiple, redundant paths that help to defuse traffic through the entire neighborhood (i.e. streets are interconnect, with grid patterns being encourages and dead-ends and cul-de-sacs being discouraged).

2.3.3 Street Design Elements that Create Neo-traditional Features

A. **Street Width**: Streets tend to be less wide than suburban streets, often built right at minimum design-width standards. Widths are designated for the "reasonably expected uses" verses "possible uses" - which tend to lead to wider streets designed for worst case scenarios. Arterials and major collectors/connectors are not appropriate in a neo-traditional neighborhood. These streets should only be located on the edges of neo-traditional neighborhoods.

RATIONALE: Wider streets tend to lead to higher automobile travel speeds and often fewer pedestrians. Narrow streets encourage pedestrians by being less daunting to cross, and they lead to drivers being both more watchful and less speedy.

B. **Interconnected Street Pattern**: Streets should be designed in an interconnected pattern. Grid patterns and through-streets are encouraged. Neo-traditional projects have more connected streets and more intersections than comparable suburban systems. Cul-de-sacs are not a part of neo-traditional design, except in areas where extreme topographic or wetland conditions preclude connection. Even in these extreme cases, a close street should be used over a cul-de-sac if at all possible and non-vehicular connections for pedestrians and bicycles should still be attempted whenever possible.

RATIONALE: In concept, the connected patterns of narrow, well-designed streets improve community access in spite of low design speeds. The connected pattern also allows multiple route options, tending to disperse traffic. This connected, redundant network will tend to have comparable capacity with less congestion. An added benefit is a reduced need for traffic signals, particularly multi-phase traffic lights.

C. **Traffic Calming and Vista Termination**: These devices are designed to reduce the driver's perception of a long, open street - which tend to encourage higher driving speeds. Devices that encourage traffic calming and vista termination include: central squares that break up road straight-aways, shorter blocks, center islands traffic circles that require the driver to deviate from the roads straight path, and curb narrowing at intersections.

RATIONALE: In addition to providing aesthetic character to a neighborhood, these features force drivers to think more closely about their driving and reduce driving speeds by connecting the driver to the surroundings.

D. **Curb Radii**: Neo-traditional tend to have a much narrower radii that is at our near the minimum allowable and is generally narrower than most "suburban design."

RATIONALE: The radii are set based on the types of vehicles most often to use a street and not the largest expected.

E. **On-street Parking**: Neo-traditional encourages on-street parking, often going so far as to count this parking toward the total space requirements for retail space within a development. Off-street parking is generally no more than one layer deep and is usually built behind stores.

RATIONALE: On-street parking tends to decrease the need for off-street parking and thus increase the space available for green-space within the community. On-street parking also acts as a traffic calming devices, drivers expect to - and often do - make more frequent stops.

F. **Street Design Speed**: Careful street design help to controls vehicles speeds. Features such as narrower streets, encouragement of on-street parking, traffic calming devices, and vista termination all encourage lower average speeds.

RATIONALE: In reality, neo-traditional street design speeds are intended to be similar to the <u>desired</u> speed in other suburban neighborhoods. However, neo-traditional design does not rely on driver "self policing" and caution signs--which have been found to be generally ineffective. Instead, the physical design of the street is intended to reduce the driver's speed, keeping them within designated design limits.

G. Alleyways or Service Lanes: Alleyways, or single-lane service lanes are sometimes utilized in neo-traditional neighborhoods.

RATIONALE: These types of roads that provide access to the rear of properties help to beautify the streets in the community by minimizing street-side driveways.

H. **Trip Generation and Neighborhood Size**: Neo-traditional neighborhood design assumes that land uses may be strategically assembled in order to reduce motorized vehicle trip generation and increase non-motorized trips. That is to say, neo-traditional neighborhoods must be designed on a "pedestrian friendly" scale that will minimize the need for motorized vehicle trips. Neo-traditional neighborhoods should be sized in walkable increments

RATIONALE: Clustering of residential, business, commercial, and recreational uses minimize dependence on automobile usage and fosters a "human scale" development.

I. **Street Trees and Landscaping**: Trees and landscaping form an essential element of the street's landscape in a neo-traditional neighborhood.

RATIONALE: These features help to foster a sense of community and identity.

J. **Sidewalk Width**: Typical minimum sidewalk width is 5 feet. All lots and sites in a neo-traditional neighborhood shall have sidewalk access and an interconnected pedestrian network is of paramount importance.

RATIONALE: This width allows two pedestrians to comfortably walk side-by-side, encouraging walking.

2.4 Approved Streets

Any vehicular way approved by LFUCG as providing access to a property either being a public or private street as follows:

2.4.1 Public Streets

Public streets are streets dedicated to the public use and which are maintained by the LFUCG.

2.4.2 Private Streets

Private streets are streets owned by, and dedicated to use by a specific subdivision or homeowners' association. Private streets may be permitted by the LFUCG. Subdivision plans containing private streets shall conform to all other subdivision regulations. Private streets are streets constructed, used, and maintained under the provisions of the Urban County Government's Subdivision Regulations and have identical design standards as Public Streets. Section 2.4.3 outlines the special requirements for private streets.

2.4.3 Special Requirements for Private Streets

A. **No Disruption to Through Movement**: Private streets may be permitted only if they meet the definition of local streets; if they provide absolutely no present or future impediment to necessary through traffic movement in the general area; and, if adjoining properties and the general area already have, or are capable of providing a proper, efficient and safe street system that will in no way depend upon the private streets.

B. **Right-of-Way Setback**: Private street right-of-ways and building setback lines shall be shown on the plat and shall meet at least the minimum requirements of the Subdivision Regulations and the Zoning Ordinance as required for public streets to assure conformance if such streets are ever accepted for public dedication at a later date.

C. **Street Improvement Standards**: Private streets shall conform to the design standards set for public streets.

D. **Future Acceptance by Government**: Any plan containing permitted private streets shall have such streets so labeled and shall contain the following signed certification by the owner: "*<u>Private Street Responsibilities of the Owners</u> - The owners of this property and any successors in title hereby agree to assume full liability and responsibility for any construction, maintenance, reconstruction, snow removal cleaning or other needs related to the private streets so designated on this plan, and do hereby fully relieve the Lexington-Fayette Urban County Government from any such responsibility. The owners understand that the private streets will not result in any reduction in taxes required by and payable to the Lexington-Fayette Urban County Government. Furthermore, if the owners in the* *future should request that the private streets be changed to public streets, the owners do fully agree that before acceptance of such streets by the Lexington-Fayette Urban County Government the owners will bear full expense of reconstruction or any other action necessary to make the streets fully conform to the requirements applicable at that time for public streets prior to dedication and acceptance. Finally, the owners also agree that these streets shall be dedicated to public use without compensation to the owners and without the owners expense in making such streets conform to the requirements applicable at that time for public streets, if at some future date, the Lexington-Fayette Urban County Government so requests."* (Signed and Dated by Owners.)

E. **Government and Utility Access**: Any plan containing permitted private streets shall show and label all other easements normally required; shall conform to all other applicable sections of the Subdivision Regulations and other local ordinances; and shall contain the owners signed certification: "Government and Utility Access - *The owners of this property hereby agree to grant full rights of access to this property over the designated street, utility, and other easements for governmental and utility agencies to perform their normal responsibilities*." (Signed and Dated by Owners)

F. **Maintenance Responsibility**: Homeowners' association or other mechanism that provides for equitable common responsibility for private street maintenance and repair shall be required to be established by the development's contractor. The contractor's responsibility to create such a mechanism shall be noted on the final plat of the subdivision. A requirement that each property owner be individually responsible for maintenance and repair of the portion of the street abutting the lot shall not be considered as acceptable for fulfilling the requirements of this section.

CHAPTER 3
GEOMETRIC DESIGN STANDARDS

3.1 General

There are three primary elements that determine the geometric characteristics of a roadway. These are:

- Typical cross section
- Horizontal alignment
- Vertical alignment

Although the three primary design elements essentially establish the geometric characteristics of a roadway, there are numerous secondary design elements that must be considered in the total geometric design. Many of these secondary design elements are discussed here.

For any roadway project, the minimum values to use for these primary elements are established based on the design controls and design criteria for the particular roadway. Design controls and design criteria normally considered in the design of a roadway are:

- Functional classification
- Area (urban or rural)
- Volume of traffic (DHV and ADT)
- Percentage of trucks
- Design speed
- Topography (flat or rolling terrain)
- Level of service (*Highway Capacity Manual* for detail)
- Special considerations such as the length of project, the condition of roads in the vicinity of the project, and the likelihood of adjoining segments being improved in the foreseeable future.

In the early stages of a project, geometric design criteria shall be coordinated with the LFUCG. In a few cases, the typical cross-section design may depend also on whether or not the project is to be financed with federal-aid funds.

The Geometric Design Criteria in the Subdivision Regulations for each classification of roadway are used to determine the values for each of the components that make up the typical cross-section (i.e., pavement width and slope, shoulder width and slope, ditch width and slope, and typical earth slopes in cuts and fills for typical street sections.) Also, refer to LFUCG's "*Standard Drawings*."

3.2 Lexington-Fayette Urban County Standard Drawings

The Lexington-Fayette Urban County's "*Standard Drawings*," current edition shall be used in conjunction with this manual. The engineer is referred to these standard drawings for additional information and background material concerning the design criteria presented in this manual.

3.3 Kentucky Department of Highways Standards and Guidelines (KYDOH)

The Kentucky Transportation, Department of Highways "*Standard Drawings*" and "*Standard Specification for Road and Bridge Construction*," current edition has also been approved for use in conjunction with this manual. The engineer is referred to this manual for additional information and background material concerning the design criteria presented in this manual. The engineer is advised that these documents have been prepared using metric units, therefore conversion to English or inch-pound units will be required. Table 3-4 is a metric conversion tables, included at the end of this chapter.

3.4 AASHTO Guidelines

The American Association of State Highway and Transportation Officials (AASHTO) is an organization that investigates and comments on the design policies of all states. The latest edition of AASHTO's "*A Policy on Geometric Design of Highways and Streets*" has been approved for use in conjunction with this manual. The engineer is referred to the AASHTO manual for additional information and background material concerning the design criteria presented in this manual.

3.5 Manual on Uniform Traffic Control Devices

The U.S. Department of Transportation Federal Highway Administration's "*Manual on Uniform Traffic Control Devices (MUTCD)*" current edition has been approved for use in conjunction with this manual. The engineer is referred to this manual for additional information and background material concerning the design criteria presented in the manual.

3.6 Highway Capacity Manual

The Transportation Research Board National Research Council's *Highway Capacity Manual Special Report 209* has been approved for use in conjunction with this manual. The engineer is referred to this manual for additional information and background material concerning the design criteria presented in this manual.

3.7 Typical Cross Section

There are four basic design controls that are used to determine the typical cross-section for a given roadway:

- Functional Classification
- Area (Rural or Urban)
- Volume of traffic
- Design speed

3.8 Horizontal Alignment

There are several components that comprise the total horizontal alignment design of a roadway. These components and their relationships are discussed below:

3.8.1 Circular Horizontal Curves

The minimum radius of a curve that can be used for a given design speed is shown in the Subdivision Regulations. This minimum has been established based on the laws of mechanics. Even though this minimum is allowable, the engineer should always strive to keep horizontal curves as flat as possible.

If compound curves are used, the radius of the flatter curve shall not be more than 50 percent greater than the radius of the adjacent sharper curve.

An alignment where horizontal curves, either in the same direction or opposite direction, are separated by only a short length of tangent should be avoided. This situation creates an alignment that is not pleasing in appearance and also creates problems in superelevation transition. It is preferable to use flatter curves connected by smooth spiral transition curves.

3.8.2 Spiral Transition Curves

When going from a tangent section into a horizontal curve, or vice versa, a motor vehicle does not follow a path that is parallel to the centerline of the road. The minimum length of spiral curves for given conditions is also shown on these tables. These minimum lengths should be rounded up to even lengths that permit simpler calculations. The accepted reference for calculating spiral curves is *Transition Curves for Highways* by Joseph Barnett and AASHTO's "*A Policy on Geometric Design of Highways and Streets.*"

3.8.3 Superelevation

When a motor vehicle traverses a horizontal curve, centrifugal force tends to move the vehicle radially outward. To help offset this force, the roadway is superelevated on horizontal curves.

Superelevation tables indicate the amount of superelevation to use for a given design speed and radius of curve. In general, a maximum rate of 4.0 percent should be used in urban areas. Refer to AASHTO tables for all other applications. In urban and suburban areas where frequent interruptions in traffic flow are anticipated, and the elevation of existing streets and development must be considered, a lesser rate of maximum superelevation may be used.

The superelevation runoff distance (L) should be the length of spiral, if spirals are used.

The tangent runout, the transition distance from a normal crown section to a flat section, shall be calculated by the formula:

$$R = \frac{L \times c}{e}$$

where:

L = Length of spiral or length of runoff
c = Normal rate of pavement crown (1/4 " per foot)
e = Superelevation rate

3.8.4 Pavement Widening on Curves

When traversing a horizontal curve, the rear wheels of a motor vehicle track inside the front wheels. In addition, it is difficult for a driver to hold his vehicle in the center of the lane when rounding a curve. These problems become more pronounced when lane widths are narrow and curves are sharp.

To partially offset these conditions, pavements shall be widened on horizontal curves when the degree of curve is 5 degrees or greater and the normal lane width is less than 12 feet.

Reference should be made to AASHTO'S "*A Policy on Geometric Design of Highways and Streets*," to determine the amount of widening to be used for a particular radius of a curve. When spiral transition curves are used, the widening should be equally divided between the inside and outside edges of pavement. The widening should transition from zero at the tangent to spiral (T.S.) to full widening at the spiral to curve (S.C.).

When spiral transition curves are not used, all the widening should be done on the inside edge of pavement. The widening should transition from zero at the beginning of the tangent runoff (L) to full widening at the point of full superelevation.

3.8.5 Horizontal Sight Distance

Sight distance is the length of roadway that is visible ahead to the driver as he traverses the roadway. In some cases, the sight distance across the inside of horizontal curves is obstructed by objects such as cut slopes, vegetation, buildings, etc. When designing the horizontal alignment, the engineer should check to determine that adequate sight distance is obtained on horizontal curves. In some instances, additional right-of-way may be required. The most recent edition of AASHTO's "*A Policy on Geometric Design of Highways and Streets*" will aid in that determination.

Both stopping sight distance and passing sight distance must be considered. Horizontal sight distance shall be coordinated with the vertical sight distance discussed in the following section of this manual.

Intersection sight distance is an additional subject that is to be considered in roadway design for roads with at-grade intersections. Refer to Chapter 5 of this manual for additional information.

3.9 Vertical Alignment

Vertical Alignment - As with horizontal alignment, there are several components that comprise the total vertical alignment design of a roadway. These components and their relationships are discussed below:

3.9.1 Grades

The grade line is a series of straight lines connected by parabolic vertical curves to which the straight lines are tangent. Under all conditions, these lines should be smooth flowing. Short, choppy grades are unsightly and disrupt roadway and vehicle operating conditions.

Maximum Grade: Maximum grades are determined primarily by the operation characteristics of vehicles on the grades. Nearly all passenger cars can readily negotiate upgrades as steep as seven (7) to eight (8) percent.

The maximum allowable gradient for all roadway classes is based on the design speed and type of terrain. These maximum gradients are shown in the Subdivision Regulations.

Minimum Grade: If it is necessary to maintain a minimum grade in order to provide adequate drainage; a minimum longitudinal grade of at least 0.80% should be maintained in all cut areas.

3.9.2 Vertical Curves

The transition from one rate of grade to another is effected by the introduction of vertical curves. The curve that is used for this purpose is a simple parabola. All standard route surveying textbooks cover the method of calculating vertical curves and that subject is not covered in this manual.

Minimum and desirable lengths of vertical curve for a given design speed are based on sight distance, as shown on Figures 3-1 and 3-2 for design controls for crest and sag vertical curves.

In addition to sight distance, the engineer should consider riding comfort and appearance when selecting a length of vertical curve. Long curves give a more pleasing appearance and provide a smoother ride than short vertical curves.

3.9.3 Sight Distance

Sight distance is the length of roadway visible ahead to the driver. In roadway design, consideration must be given to stopping sight distance and passing sight distance.

3.9.4 Stopping Sight Distance

Stopping sight distance is that distance that is required for a driver to bring their vehicle to a safe stop after the object becomes visible when traveling at the designated design speed.

For crest vertical curves, stopping sight distance is based on a height of eye of 3.50 feet and a height of object of six inches as indicated in Figure 3-1. For sag curves, stopping sight distance is based on a two-foot headlight height and a 1° angle of light spread upward from the headlight beam as indicated in Figure 3-1. The desirable value shall be used unless special circumstances require use of the shorter minimum value.

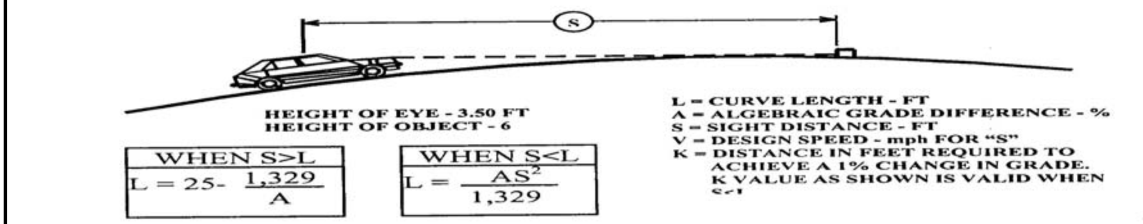
3.9.5 Passing Sight Distance

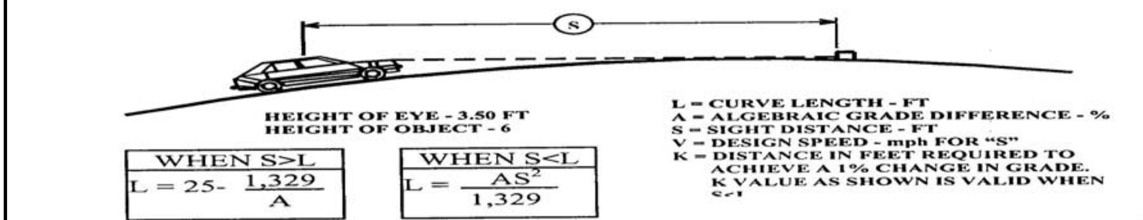
Passing sight distance is the minimum sight distance required for the driver of one vehicle to pass another vehicle safely and comfortably. Passing must be accomplished without reducing the speed of an oncoming vehicle traveling at the design sped should it come into view after the overtaking maneuver is started. The distance available for passing at any place is the longest distance at which a driver whose eyes are 3.5 feet above the pavement surface can see the top of an object 4.25 feet high on the road as indicated in Figure 3-2.

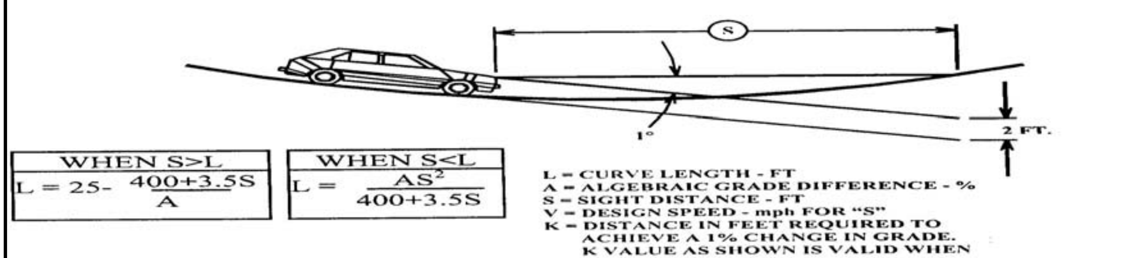
FIGURE 3. 1 - DESIGN CONTROLS FOR VERTICAL CURVES AND FOR STOPPING SIGHT DISTANCE

STOPPING SIGHT DISTANCE ON CREST VERTICAL CURVES

STOPPING SIGHT DISTANCE ON SAG VERTICAL CURVES







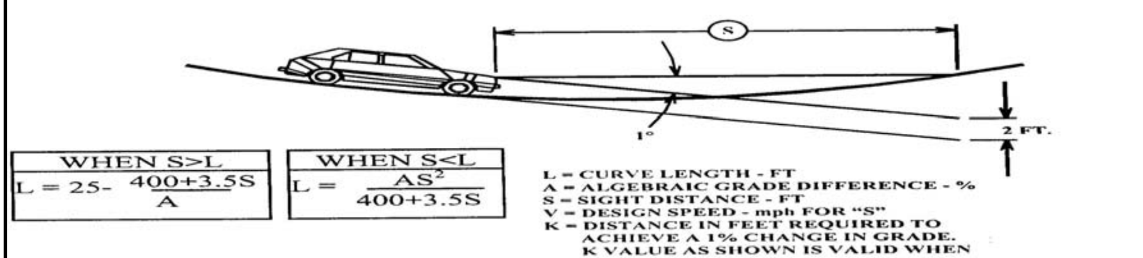
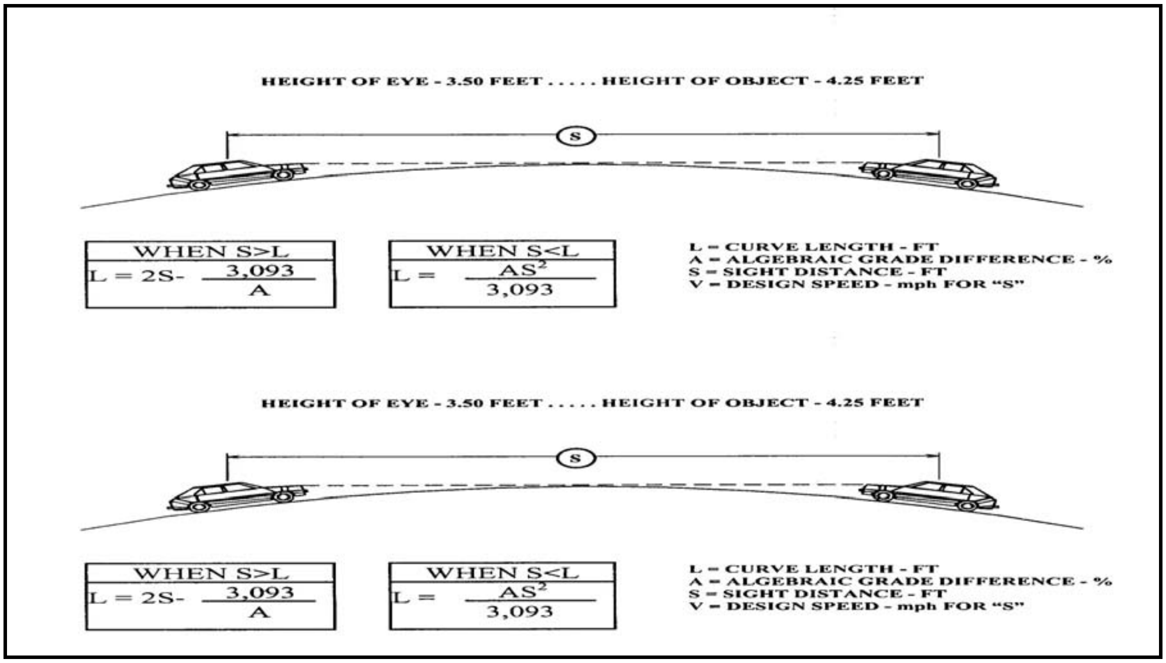


FIGURE 3. 2 - DESIGN CONTROLS FOR CREST VERTICAL CURVES AND FOR PASSING SIGHT DISTANCE



3.10 Cul-de-sacs

Cul-de-sacs shall not generally be longer than one thousand (1000) feet, including the turnaround which shall be provided at the closed end with a right-of-way radius of fifty (50) feet, curb radius of forty (40) feet, and a transition curve radius of seventy-five (75) feet. Longer cul-de-sacs may be permitted because of unusual topographic or other conditions and, in such cases the Planning Commission may require additional paving width if necessary to prevent overloading of street capacity. Temporary turnarounds may be required at the end of stub streets as long as it is retained within the street right-of-way.

FIGURE 3. 3 - CUL-DE-SAC WITH MEDIAN

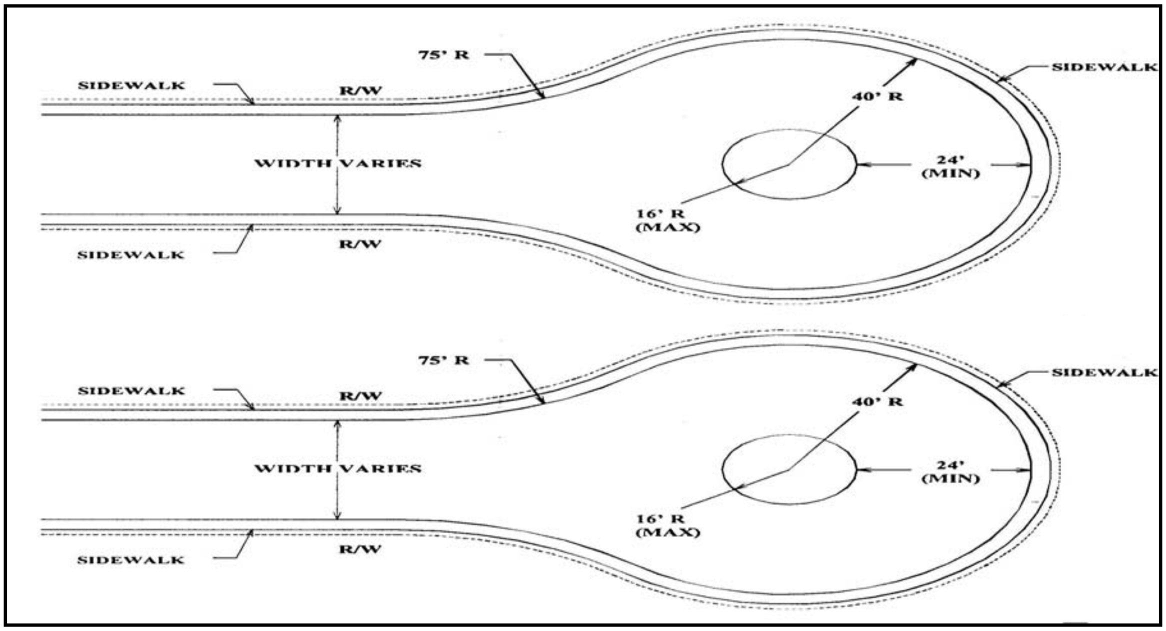
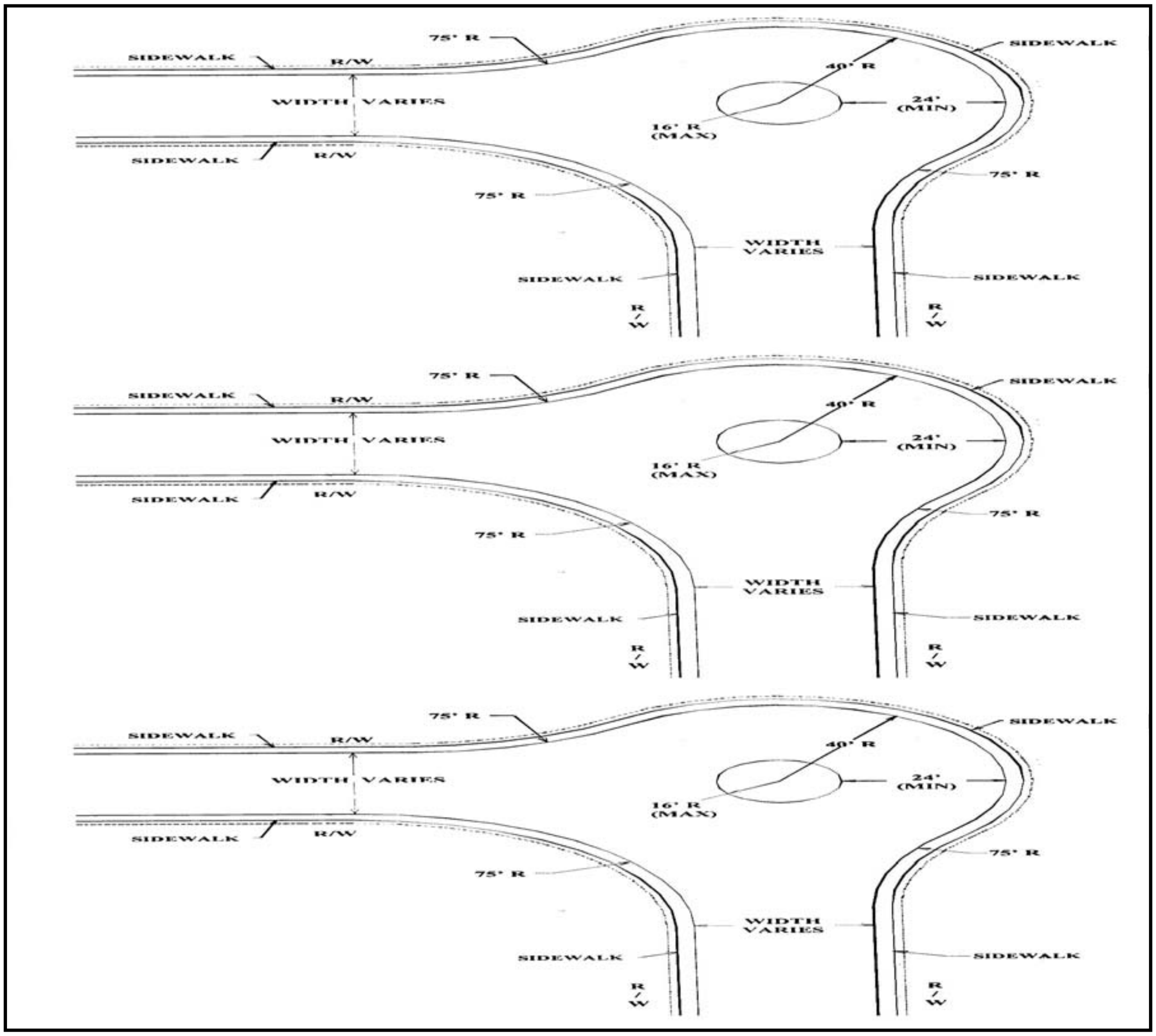


FIGURE 3. 4 - 90° CORNER WITH ADDED CUL-DE-SAC



3.11 Medians

Medians are the portion of a divided roadway that separates the traffic moving in opposite directions. They provide benefits to traffic operation by: providing space for traffic control devices and turn lanes, increasing overall traffic safety, and (if sufficiently wide) provide future roadway expansion space.

Medians may be depressed, raised, or flush with respect to the adjacent roadway. Depressed medians may be edged with raised curbs or they may slope from the edge of the roadway directly. Often sections wider than 16 feet are depressed to collect drainage. Often slopes of 10:1 (with a maximum of 6:1) are preferred to allow for vehicle recovery. Flush medians are typically narrow and paved. They do not prevent access to adjacent property and serve the purpose of separating opposing flows at less cost. Raised medians may be preferred for access control and landscaping purposes where drainage is not a problem. Raised medians also provide a positive visual barrier, which prevents erratic cross-traffic movements.

TABLE 3. 1 - RECOMMENDED MEDIAN WIDTHS FOR SPECIFIC FUNCTIONS

Function:	**Minimum Width (Feet)**	**Desirable Width (Feet)**
Separation of Opposing Traffic (without providing space for turn lanes)	4	6
Pedestrian Refuge and Space for Traffic Control	6	16
Left-Turn, Speed-Change, and Vehicle Turn Storage	14	16
Crossing/Entering Vehicle Protection	20	23
“U”-Turns, Speed Change, and Vehicle Turn Storage	20	23
Channelized “T”, Speed Change, and Storage	20	23-30

TABLE 3. 2 - A. & B. - CONVERSION FACTORS FROM ENGLISH UNITS TO SI (MODERN METRIC) UNITS / CONVERSION FACTORS FROM SI (MODERN METRIC) UNITS TO ENGLISH UNITS

A. APPROXIMATE CONVERSION TO SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in2	square inches	645.2	millimeters squared	mm2
ft2	square feet	0.093	meters squared	m2
yd2	square yards	0.836	meters squared	m2
ac	acres	0.405	hectares	ha
mi2	square miles	2.59	kilometers squared	km2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft3	cubic feet	0.028	meters cubed	m3
yd3	cubic yards	0.765	meters cubed	m3
Note: Volumes greater than 1000 L shall be shown in m3				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE		
°F	Fahrenheit temperature	5(F-32) ÷ 9	Celsius temperature	°C

B. APPROXIMATE CONVERSION FROM SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm2	millimeters squared	0.0016	square inches	in2
m2	meters squared	10.764	square feet	ft2
ha	hectares	2.47	acres	ac
km2	kilometers squared	0.386	square miles	mi2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m3	meters cubed	35.315	cubic feet	ft3
m3	meters cubed	1.308	cubic yards	yd3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE		
°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F

CHAPTER 4
PAVEMENT DESIGN CRITERIA

4.1 Purpose

The purpose of this chapter is to establish the pavement design standard. These pavement design standards must also fully correspond to the appropriate design standards set forth in other sections of this manual.

It is critical to note that prior to the development of this Roadway Manual, Lexington-Fayette County has experienced premature distress on many of the county's heavily traveled streets. In analyzing this problem, it has become apparent that the LFUCG needed to upgrade its pavement design procedure. To that end, there is a need to emphasize in this Manual that the Lexington-Fayette Urban County Government has set a 20-year life cycle standard for the design of all streets in Lexington-Fayette County. The design standards outlined in this chapter, and throughout this manual, are designed specifically to achieve this goal.

4.2 Performance Serviceability Index and Terminal Serviceability Index

4.2.1 Performance Serviceability Index

The functional performance of a pavement concerns how well the pavement serves the user. That is to say, what is the riding comfort and riding quality on a particular road. In order to quantify riding comfort, the serviceability-performance concept was developed by AASHTO. Over time, a road's pavement's serviceability and performance serviceability index decrease. The major factors influencing these losses are traffic, age, and environment.

The serviceability index scale ranges from zero (O) (impassable street) to five (5) (perfect street). Immediately after initial construction, the values that shall be used for the serviceability index are 4.2 for flexible pavement and 4.0 for rigid pavements.

4.2.2 Terminal Serviceability Index

The terminal serviceability index is the lowest acceptable level before resurfacing or reconstruction becomes necessary. The lowest acceptable level is dependent upon the street's functional class. Table 4-1 presents values that shall be used in Lexington-Fayette County.

TABLE 4. 1 - Terminal Serviceability Index for Lexington-Fayette County Roadway Classifications

Classification of Roadway	Terminal Serviceability
Arterials (both Major and Minor)	2.5
Collector/Connectors	2.5
Local Streets	2.0
Alleys	1.0

4.3 Earthwork, Subgrade Preparation, and Soil/Subsurface Investigations

The proper investigation and preparation of subgrade, granular base, and base course are critical in the life of a street's surface course.

4.3.1 Definitions

The following are the basic definitions upon which this section will build:

A. **Subgrade**: The natural soil material upon which the upper roadway layers are constructed.

B. **Modified Subgrade**: Layer designed to augment the subgrade strength. This layer is only used when subgrade strength is below a particular level. It consists of chemically altered or compacted subgrade materials, often in combination to achieve certain strength characteristics required in specific conditions. Additionally, modified subgrade acts to reduce frost and water intrusion actions.

C. **Granular Base**: Constructed on top of the subgrade. It consists of granular material such as crushed stone or gravel. The specifications for the granular base are more rigorous than that for the subgrade in terms of strength, hardness, gradation, and aggregate types. The granular base layer is placed on the subgrade to support an asphalt base course of a portland cement slab.

D. **Pavement**:

1. **Base Course**: The base course is the layer, or layers, of a specified material of designed thickness placed on the granular base. In the case of an asphalt pavement, the base course further serves as a foundation course to support the surface course. In the case of a portland cement pavement, there is only one course of pavement material and the base course and surface course are one and the same.

2. **Surface course**: The purpose of the surface course is to accommodate the traffic load, provide a smooth riding surface, resist the wear and tear from traffic, provide skid resistance to vehicles, and prevent excessive water from penetrating into the base course. In the case of asphalt pavement, the surface course of the pavement section consists of a mixture of mineral aggregates and asphalt materials. In the case of a portland cement pavement, there is only one course of pavement material and the base course and surface course are one and the same.

4.3.2 Testing Requirements

Before a new roadway design is undertaken, appropriate testing of the existing soils and future subgrade must be completed. These tests shall be completed in compliance with the requirements of the Lexington-Fayette County Geotechnical Manual.

The Engineer shall review soil maps, core graphics, and appropriate site-specific geotechnical data prior to completing the roadway's pavement design. In addition, the Engineer shall follow the written recommendations contained in the Geotechnical Report.

4.3.3 Subgrade Analysis

The majority of pavements constructed in Kentucky are constructed on fine-grained soils. Approximately 85% of the soils consist of clay and silt. When first compacted, these fine-grained soils usually have sizable bearing strength. If pavements are constructed immediately after compaction of fine-grained soils, then major problems typically will not be encountered when placing and compacting layers of paving materials. Problems arise, however, when surface and subsurface water penetrates compacted fine-grained soils. Water from rainfall, snowmelt, and groundwater seepage enters the fine-grained soils subgrade, causing swelling and producing a loss of bearing capacity in the subgrade. The most susceptible, adverse period occurs when a fine-grained soil subgrade is exposed to the wetting conditions of winter and early spring.

Because the subgrade's type and condition is so critical to the final life expectancy of a street, proper geotechnical analysis must be completed. A geotechnical analysis shall be completed that complies with the requirements of the Lexington-Fayette County Geotechnical Manual. In particular, this testing will include a California Bearing Ratio (CBR) calculation for the soils. It is noted that all soils with a California Bearing Ratio (CBR) of less than four (4), using the ASTM Method, will require soil stabilization.

4.3.4 Subgrade Preparation

Due to the likelihood for void development, granular base construction directly on a weak natural soil is not permitted. All streets shall be constructed on a compacted or stabilized subgrade. The subgrade is to consist of manually compacted soil or it shall be chemically stabilized.

Methods for mechanical stabilization of subgrade soils include the following approaches:

- Controlling subgrade density-moisture
- Undercutting poor materials and backfilling with granular materials
- Proof rolling and re-rolling of the subgrade
- Using granular layers
- Using granular layers reinforced with geofabrics

Commercially available chemical stabilizers include hydrated lime and portland cement. Both have been demonstrated to be effective in stabilizing subgrade soils as stable paving platforms and are believed to contribute to reducing fatigue and extending the life of pavement structures. Portland cement has been demonstrated to be most suitable for stabilizing more granular, course grained subgrades. Hydrated lime has been demonstrated to be most suitable for stabilizing fine-grained soils with high clay content.

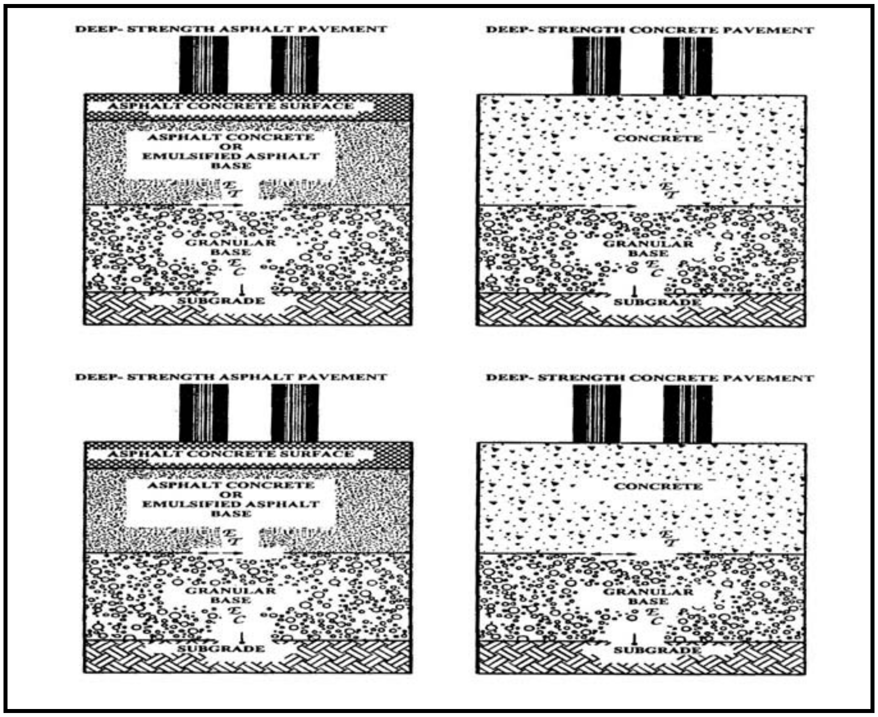
4.3.5 Granular Base and Pavement Design

The Engineer shall design the base and pavement thicknesses using the procedures in the AASHTO Pavement Design Guide. The Engineer shall compare the results of the pavement design to the thicknesses in Table 4-2. In no case shall the thickness of the base and asphalt/portland cement course be less than those shown in Table 4-2. Concrete paving shall be Class A as defined by the Kentucky Transportation Cabinet.

TABLE 4. 2 - Minimum Thickness Standards for Granular Base and Pavement Courses

Street Classification	**Thickness (Inches):**	
	Asphalt Surface Course/ Asphalt Base Course/ Granular Base	**Portland Cement Single Course/ Granular Base**
Arterials and non-residential streets (all classifications)	1 / 6 / 9	8 / 4
Residential collector/connector streets (urban and rural)	1 / 6 / 8	7 / 4
Residential local streets (urban and rural)	1 / 3 / 9	6 / 4
Note: “Full depth” asphalt concrete pavements are not permitted in Lexington-Fayette County. Asphalt pavements must be constructed on a proper depth of granular base.		

FIGURE 4. 1 - Pavement Design



The Lexington-Fayette County Division of Engineering may also approve experimental materials for limited use. It is the responsibility of the design Engineer planning to use these materials to demonstrate their effectiveness and required thickness.

4.4 Pavement Design Procedures

The procedures for designing flexible pavement are listed below:

1. For a residential street, estimate the number of houses that will be served by the street. For a loop/cul-de-sac, it will equal the number of houses on that street. For a continuing street, it will equal the number of houses that will use the street when entering/leaving the subdivision.

2. For a street that will serve industrial or commercial property, estimate the gross floor area for the development. For hotels and motels, estimate the number of rooms.

3. Determine the number of Equivalent Single Axle Loads (ESALs) from Table 4-3 for residential streets, and from Table 4-4 for commercial/industrial streets.

4. Based on the CBR, determine the required Structural Number from Table 4-5. The minimum structural number shall be 2.84 for residential streets, 4.04 for collector streets, and 4.16 for arterial streets.

5. Determine the required thickness of asphalt, DGA, and No. 2 stone to achieve the required Structural Number. The layer coefficients are listed below:

   - Asphalt – 0.44

   - DGA – 0.12

   - No. 2 Stone – 0.08

Following are the minimum thicknesses for asphalt and DGA.

Street Classification	Asphalt	DGA
Residential Local	4”	9”
Residential Collector	7”	8”
Arterial/Non Residential	7”	9”

From November 1 to March 1, a “winter design” may be used with the following minimum thicknesses. A filter fabric shall be placed between the No. 2 stone and the subgrade when using the winter design.

Street Classification	Asphalt	DGA	No. 2 Stone
Residential Local	4”	4.5”	As required to meet SN
Residential Collector	7”	4.0”	As required to meet SN
Arterial/Non Residential	7”	4.5”	As required to meet SN

6. If unstable areas are discovered during the proof roll test, then stabilize the area by removing 4 to 8 inches of the unstable material and replacing it with No. 2 stone. No. 2 stone used to make up the structural number shall be separated from the subgrade by filter fabric. Stabilization is required when the soil subgrade pumps during the proof roll test. A CBR less than 4 does not automatically mean the subgrade is unstable.

TABLE 4. 3 - Equivalent Single Axle Loads for Residential Streets

Number of Houses Served By the Street	Equivalent Single Axle Loads				
	Construction Trucks	Moving Vans	Garbage Trucks	School Buses	Total
0	0	0	6240	12000	18240
20	600	240	6240	12000	19080
40	1200	480	6240	12000	19920
60	1800	720	6240	12000	20760
80	2400	960	6240	12000	21600
100	3000	1200	6240	12000	22440
120	3600	1440	6240	12000	23280
140	4200	1680	6240	12000	24120
160	4800	1920	6240	12000	24960
180	5400	2160	6240	12000	25800
200	6000	2400	6240	12000	26640
220	6600	2640	6240	12000	27480
240	7200	2880	6240	12000	28320
260	7800	3120	6240	12000	29160
280	8400	3360	6240	12000	30000
300	9000	3600	6240	12000	30840
320	9600	3840	6240	12000	31680
340	10200	4080	6240	12000	32520
360	10800	4320	6240	12000	33360
380	11400	4560	6240	12000	34200
400	12000	4800	6240	12000	35040

Notes:
Number of Houses Served By the Street – For a loop/cul-de-sac, it will equal the number of houses on that street. For a continuing local street or a collector, it will equal the total number of houses that will use the street when entering/leaving the subdivision.

Construction Trucks – Based on 20 loaded supply trucks per house and 1.5 ESALs per truck, for a total of 30 ESALs per house.

Moving Vans – Based on each house selling 4 times in 20 years and each transaction involving one loaded moving van for the seller and buyer, for a total of 8 trucks per house. It assumes 1.5 ESALs per truck for a total of 12 ESALs per house.

Garbage Trucks – Based on the following for a 20-year design life:

- 2 garbage trucks/street/wk x 52 wks/yr x 20 yrs x 1.5 ESALs/truck = 3120 ESALs
- 1 rosie recycling truck/street/wk x 52 wks/yr x 20 yrs x 1.5 ESALs/truck = 1560 ESALs
- 1 yard waste recycling truck/street/wk x 52 wks/yr x 20 yrs x 1.5 ESALs/truck = 1560 ESALs

Total of above = 6240 ESALs per street for garbage trucks

School Buses – Based on the following for a 20-year design life:

- 2 school buses/day/street x 200 days/yr x 20 yrs x 1.5 ESALs/truck = 12,000 ESALs per street

TABLE 4. 4 - 20-Year ESALs for Various Industrial and Commercial Developments

Land Use	Gross Floor Area (Sq. Ft.) x 1000											
	1	5	10	20	40	60	80	100	200	300	500	1,000
General Light Industrial (15% Trucks)	80,000	115,000	159,000	246,000	418,000	586,000	752,000	915,000	1,681,000	2,370,000	3,515,000	5,020,000
General Heavy Industrial (20% Trucks)	3,000	16,000	31,000	63,000	126,000	188,000	251,000	314,000	628,000	942,000	1,570,000	3,141,000
Warehousing (25% Trucks)	32,000	123,000	219,000	389,000	692,000	968,000	1,229,000	1,479,000	2,629,000	3,681,000	5,623,000	9,994,000
General Office Building (2% Trucks)	1,000	8,000	17,000	35,000	70,000	105,000	141,000	176,000	354,000	531,000	885,000	1,771,000
Retail <200,000 Sq. Ft. (2% Trucks)	21,000	102,000	201,000	393,000	745,000	1,056,000	1,327,000	1,557,000	2,100,000			
Retail >200,000 Sq. Ft. (2% Trucks)										2,840,000	3,923,000	6,630,000

Land Use	Number of Rooms							
	10	50	100	200	400	600	800	1,000
Hotel (1% Trucks)	3,000	38,000	83,000	171,000	348,000	525,000	702,000	879,000
Motel (1% Trucks)	8,000	47,000	99,000	207,000	433,000	667,000	906,000	1,149,000

Notes:

1. Number of trips generated for each type of development calculated from the Manual of Trip Generation published by the Institute of Transportation Engineers.
2. ESALs calculated by the computer program *PAS 5*developed by the American Concrete Pavement Association.
3. Trucks were assumed to be 50% C5As (TYPE 9) and 50% SU3As (TYPE 6).
4. Loaded Type 9s were assumed to weigh 80,000 pounds. Empty or nearly empty Type 9s were assumed to weigh 50,000 pounds.
5. Loaded Type 6s were assumed to weigh 46,000 pounds. Empty or nearly empty Type 6s were assumed to weigh 30,000 pounds.
6. 50% of both Type 9s and Type 6s were assumed to be empty.
7. The numbers in the table have been rounded to the nearest 1000.

TABLE 4. 5 – STRUCTURAL NUMBERS

	Structural Number						
ESALs	**CBR 1**	**CBR 2**	**CBR 3**	**CBR 4**	**CBR 5**	**CBR 6**	**CBR 7**
1,000	2.15	1.65	1.39	1.23	1.09	1.01	1.00
2,000	2.38	1.84	1.58	1.39	1.27	1.17	1.08
3,000	2.54	1.97	1.69	1.50	1.36	1.26	1.17
4,000	2.65	2.07	1.77	1.58	1.44	1.33	1.24
5,000	2.74	2.14	1.84	1.64	1.50	1.39	1.30
6,000	2.81	2.20	1.89	1.69	1.55	1.43	1.34
7,000	2.88	2.26	1.94	1.74	1.59	1.47	1.38
8,000	2.94	2.31	1.99	1.78	1.63	1.51	1.42
9,000	2.99	2.35	2.02	1.81	1.66	1.54	1.45
10,000	3.03	2.39	2.06	1.85	1.69	1.57	1.47
20,000	3.35	2.65	2.30	2.07	1.90	1.77	1.67
30,000	3.55	2.82	2.44	2.20	2.03	1.89	1.79
40,000	3.70	2.94	2.55	2.31	2.13	1.99	1.87
50,000	3.81	3.03	2.64	2.39	2.20	2.06	1.94
60,000	3.91	3.12	2.71	2.45	2.27	2.12	2.00
70,000	3.99	3.19	2.78	2.51	2.32	2.17	2.05
80,000	4.07	3.25	2.83	2.56	2.37	2.22	2.10
90,000	4.13	3.30	2.88	2.61	2.41	2.26	2.14
100,000	4.19	3.35	2.93	2.65	2.45	2.30	2.17
200,000	4.60	3.70	3.24	2.94	2.72	2.55	2.42
300,000	4.86	3.91	3.43	3.12	2.89	2.71	2.57
400,000	5.04	4.07	3.57	3.25	3.01	2.83	2.69
500,000	5.19	4.19	3.68	3.35	3.11	2.93	2.78
600,000	5.31	4.30	3.78	3.44	3.20	3.01	2.85
700,000	5.42	4.39	3.86	3.52	3.27	3.08	2.92
800,000	5.51	4.47	3.93	3.58	3.33	3.13	2.98
900,000	5.60	4.54	4.00	3.64	3.39	3.19	3.03
1,000,000	5.67	4.60	4.06	3.70	3.44	3.24	3.07
2,000,000	6.19	5.04	4.45	4.07	3.79	3.57	3.40
3,000,000	6.51	5.31	4.70	4.30	4.01	3.78	3.60
4,000,000	6.75	5.51	4.88	4.47	4.17	3.93	3.74
5,000,000	6.93	5.67	5.03	4.60	4.30	4.06	3.86
7,000,000	7.23	5.92	5.25	4.81	4.49	4.25	4.04
10,000,000	7.55	6.19	5.50	5.04	4.71	4.45	4.24

4.5 State and Federal Highways

All streets and rural roadways in Lexington-Fayette County designated as State or Federal Highways must be designed in accordance with the design requirements approved by the Kentucky Department of Highways.

4.6 Pavement Design Requirements for Developments in Phases

For new developments being completed in phases, several special street design requirements apply.

4.6.1 Delay in the Application of the Asphalt Surface Course

The final 1-inch surface course of asphalt shall be applied after all the primary services of utilities have been installed, and in accordance with the following requirements:

1. The final surface course shall be applied within three (3) years of the construction of the original street.

2. The initial base course of asphalt concrete shall be designed such that this layer alone shall provide the required structural strength for the road's first three (3) years of usage.

4.6.2 "True Use" Design Standards

For developments that are designed in phases, streets shall be designed to reflect the usage they will experience over the first three years of the street's life. Therefore, if a street will be a primary access route for construction traffic during a subdivision's site development, this street shall be designed to meet the industrial/commercial street standards, to reflect it's true usage in the first three years of its existence, verses being designed to reflect its eventual usage as a residential street. This standard is required to prevent the premature damaging of the street's pavement and granular base, and to ensure that the 20-year life cycle for Lexington-Fayette County streets is achievable.

4.7 Curb/Gutter Design and Storm Drainage Capacity Requirements

Curbs and gutters are required for all new streets in the Urban Service Area of Lexington-Fayette County and shall be designed in accordance with the LFUCG Stormwater Manual.

CHAPTER 5
TRAFFIC SIGNS, MARKINGS, SIGNALIZATION, AND NEIGHBORHOOD TRAFFIC MANAGEMENT

5.1 Purpose

The purpose of this chapter is to define standards for traffic control devices based upon The Manual on Uniform Traffic Control Devices (MUTCD) recommendations. Additionally this chapter provides for traffic calming techniques for Neighborhood Traffic Management.

5.2 Traffic Signs, Markings and Signalization Requirements

The intent of this section is to emphasize the standardization of traffic control devices. In this regard, MUTCD standards should be referred to and followed. In general, the Planning and Zoning Regulations define when a traffic study is required utilizing traffic counts provided by LFUCG Division of Traffic that can be used by the Engineer in developing traffic volumes as necessary for use in the design of traffic signs, markings, and signalization. All plans must be approved through the LFUCG and/or Kentucky Department of Highways (KDOH) with regards to traffic signage, markings, and signalization.

5.3 Neighborhood Traffic Management (NTM)

5.3.1 Goals

It is the goal of the Lexington-Fayette Urban County Government to establish procedures and techniques that will promote neighborhood livability by mitigating the negative impacts of automobile traffic on residential neighborhoods. Although livability has no precise definition, it can be thought of as encompassing the following characteristics:

- The ability of residents to feel safe and secure in their neighborhood.
- The opportunity to interact socially with neighbors without the dominance of traffic related distractions or threats.
- The ability to experience a sense of home and privacy.
- A sense of community and neighborhood identity.
- A balanced relationship between the multiple uses and needs of a neighborhood.
- To provide acceptable levels of accessibility for local traffic, discourage excessive speeds, and encourage opportunities for alternate modes, all in recognition of quality of life and the specific objectives of the neighborhood or area plan.

5.3.2 Objectives

The objectives for Neighborhood Traffic Management are as follows:

- To promote safe and pleasant conditions for residents, pedestrians, bicyclists, and motorists on local neighborhood streets.
- To encourage the designed use of the total street system, including the reduction of cut through vehicular traffic on local neighborhood streets.
- To reduce the speed of traffic on local neighborhood streets.
- To preserve and enhance pedestrian and bicycle travel within neighborhoods.

- To encourage citizen involvement in neighborhood traffic management process.
- To achieve efficient and safe movement of traffic within neighborhoods (including emergency vehicles) consistent with the intended function of the neighborhood streets.
- To maintain acceptable levels of service on the city's arterials so as to avoid intrusion/diversion onto local neighborhood streets.

5.3.3 Techniques

There are a number of techniques that may be needed to address differing traffic conditions in Fayette County neighborhoods. Traffic calming techniques generally fall under two categories - physical and psychological. Some traffic calming techniques are designed to physically change the width or surface of the street. Traffic calming may also be achieved by changing the psychological feel of the street. These changes may give motorists cues that they are not longer on a major roadway but are in a different environment that is shares with people.

All traffic calming techniques have a limited range of effectiveness. To achieve traffic calming objectives, some techniques need to be placed every 250 - 400 feet. If traffic calming techniques are used too sparsely, traffic may slow close to the installation, but the overall speed will probably not decrease. One technique may be used multiple times or multiple techniques may be used in conjunction with one another. Most techniques will affect noise, air quality, congestion, fuel consumption, and many other factors. Some can improve these conditions; others may cause these problems to increase.

Emergency vehicle access and response time must be considered when designing and installing traffic calming devices. Emergency vehicles, particularly ambulances, have more difficulty with "vertical" devices such as speed humps than with "horizontal" devices such as neckdowns.

Likewise, bicyclists and pedestrians must be kept in mind when developing a traffic calming strategy, as some devices can obstruct their movements. Many devices can be modified to allow bicyclists and pedestrians to by-pass them. For instance, a diverter can be fitted with a bicycle / pedestrian link to allow for their through movement.

The following pages at the end of this section provide overviews and illustrations of several techniques that help to guide and control neighborhood traffic in the interest of safe, efficient, and environmentally compatible movement of vehicles, bicycles, and pedestrian. These techniques, collectively referred to as “traffic calming,” involve measures to control traffic volume, traffic speed, or both while still allowing for mobility and access. A successful traffic calming device will promote both street safety and surrounding neighborhood livability.

5.3.4 Temporary/Test Traffic Calming Devices

Low cost temporary barrier can be erected to test the effectiveness of a particular traffic calming device at a particular intersection or on a particular street. This method is encouraged as it allows the effectiveness of a device to be tested prior to the more costly construction of a permanent device. Anytime a temporary/test traffic calming device is installed a monitoring period, measurable objectives, and performance measures should be established prior to installation.

APPENDICES

APPENDIX 1 - NEIGHBORHOOD TRAFFIC MANAGEMENT OPTIONS

TYPE 1

Including but not limited to:

Signing for:

A) Stops
B) Yield
C) Speed Limits / Reduction
D) No Parking
E) Residential Permit Parking
F) No Through Trucks
G) No Outlet, Not a Through Street

Striping for:

A) Street Centerline
B) Lane Lines
C) Crosswalks
D) Stop Bars
E) Yellow Curb / Parking Restrictions

TYPE 2

Including but not limited to:

A) Traffic Circles
B) One-Way Diverters
C) One-Way Street
D) Speed Humps
E) Median Barrier
F) Forced Turn Channelization
G) Choker / Chicane

TYPE 3

Including but not limited to:

A) Interdiction / Barricade
B) Cul-de-sacs
C) Road Closure

APPENDIX 2 - SUMMARY OF TRAFFIC MANAGEMENT TECHNIQUES

Mid-Block
- Angled slow points
- Deviation chicanes
- Lane narrowing
- Landscaping
- Mid-block median
- Raised crosswalks
- Road striping
- Speed humps
- Textured pavement

Intersections
- Diagonal road closure
- Forced turn barrier/diverter
- Gateway treatment
- Intersection hump
- Landscaping
- Modified intersection
- Neckdown
- Roundabout
- Textured pavement
- Traversible barrier

Closures / Restricting
- Cul-de-sac
- Partial street closure
- Street closure
- One-way streets

Neighborhood Traffic Management Options - Type 1

Traffic Device	Traffic Reduction	Speed Reduction	Noise & Pollution	Safety	Traffic Access Restriction	Emergency/ Vehicle Access	Maintenance Problems	Level Of Violation	Impact To Bicycles	Impact To Transit/School Buses	Impact To Pedestrians	Costs
Stop Sign	unlikely	none	increase	unclear	none	no problems	none	high	none	none	none	low
No Left/Right Turn Sign	yes	none	decrease	improved	no turns	no problems	vandalism	high	none	no turns	none	low
Yeild Sign	unlikely	unlikely	no change	unclear	none	no problems	none	high	none	none	none	low
Speed Limits/ Reduction	minimal	little to none	slight change	yes	none	some constraint	none	high	none	none	none	low
No Parking	unlikely	unlikely	no change	yes	none	no problems	none	moderate	positive	positive	none	low
Residential Permit Parking	some	unlikely	slight change	unclear	none	no problems	none	low	none	none	none	low
No Through Trucks	yes	unlikely	decrease	yes	through trucks	no problems	none	low	positive	none	none	low
No Outlet/Not A Thru Street	yes	yes	decrease	yes	through traffic	some constraint	none	low	minor constraint	some	none	low
Selective Enforcement	no	yes	no change	some	none	none	none	low	none	none	none	moderate
Radar Speed Monitoring	no	yes	no change	some	none	none	none	moderate	none	none	none	moderate

Neighborhood Traffic Management Options - Type 2

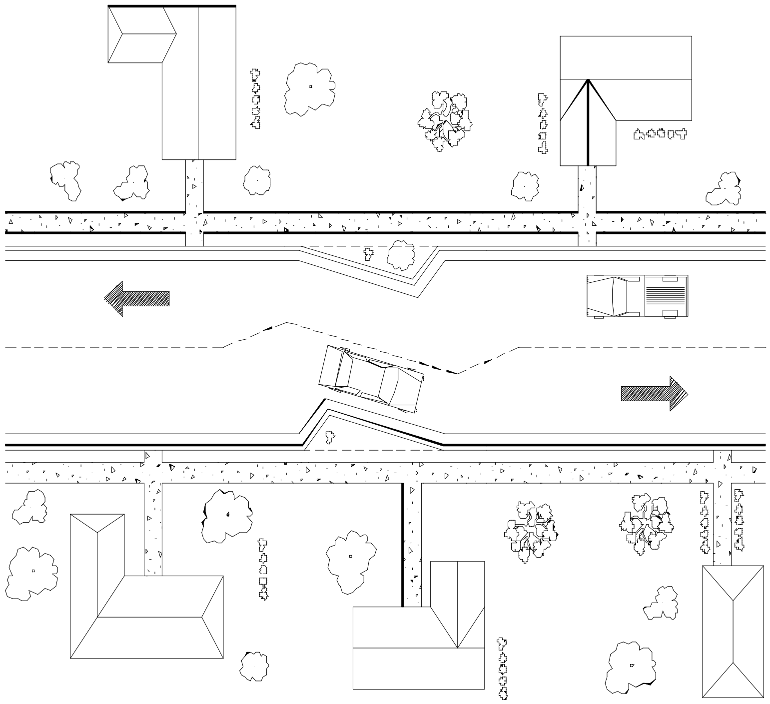
One-Way Street	possible	increases	decrease	improved	one direction	one direction	none	low	one direction	one direction	none	moderate
Chokers	unlikely	minor	no change	improved for pedestrians	none	some constraint	none	low	minor constraint	none	none	moderate
Traffic Circle	minimal	likely	minimal	improves	none	some constraint	vandalism	low	none	restricted	minor constraint	moderate to high
Median Barrier	yes	likely	decrease	improved	right turn only	minor constraint	none	low	minor constraint	none	minor constraint	moderate
Forced Turn Channelization	yes	possible	decrease	improved	some	minor constraint	vandalism	high	some	some	none	moderate
Speed Humps	likely	yes	some increase	yes	none	minor constraint	none	low	minor	minor problems	none	moderate
One-Way Diverter	yes	likely	decrease	improved	one direction	minor constraint	vandalism	high	some	some	none	moderate
Landscaping	no	likely	no change	unclear	some	no problems	some	n/a	minor	minor	some	moderate to high

Neighborhood Traffic Management Options - Type 3

Cul-De-Sac	yes	likely	decrease	improved	total	some constraint	vandalism	low	none	totally restricted	none	high
Interdiction/Barricade	yes	yes	yes	yes	total	some constraint	some	low	some	total	some	high
Road Closure	yes	yes	yes	yes	total	total	some	none	total	total	some	high

ANGLED SLOW POINT(S)

DEFINITION: Angled deviations to deter the path of travel so that the street is not a straight line (by the installation of of offset curb extensions). May be used in a single lane or double lane application, double lane application shown below.



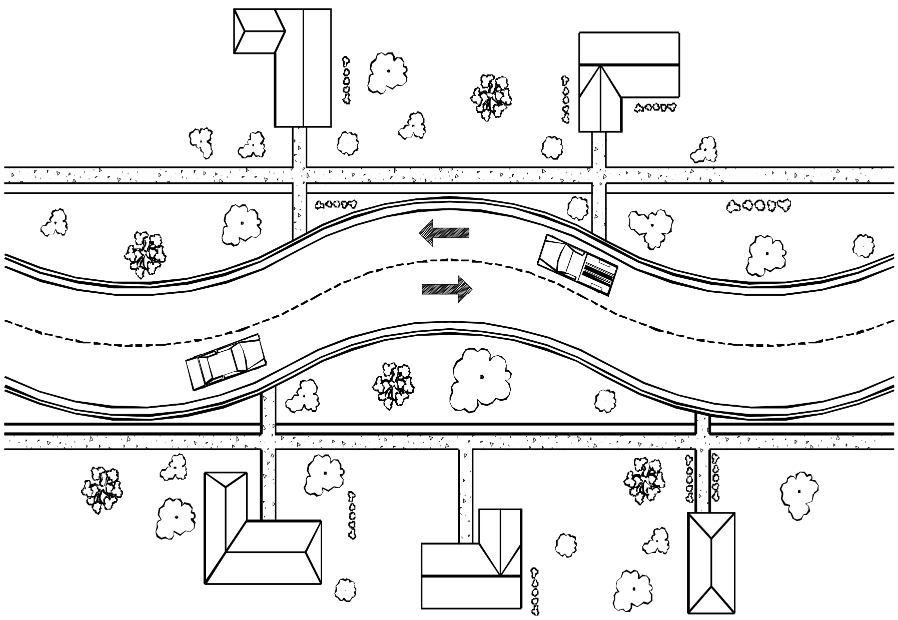
ADVANTAGES	DISADVANTAGES
• **Reduces vehicle speed.** • **More effective when used in a series.** • **Imposes minimal inconveniences to local traffic.** • **Pedestrians have a reduced crossing distance.** • **Provides space for landscaping.** • **Provides a visual obstruction.**	• **Landscaping needs to be controlled to ensure visibility isreduced.** • **Contrary to driver expectation of unobstructed flow.** • **Can be hazardous for drivers and cyclists if not designed and maintained properly.** • **Confrontation between opposing drivers arriving simultaneously may create problems.** • **Double lane application is less effective in controlling speeds than single lane because drivers can create a straighter through movement by driving over centerline.** • **Increases area of landscaping to be maintained by residents.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Yes	Possible	Small Increase	Small Increase	Medium to High	Possible Problems	

DEVIATION/CHICANES

DEFINITION: Mainline deviations to deter the path of travel so that the street is not a straight line (by the installation of offset curb extensions).



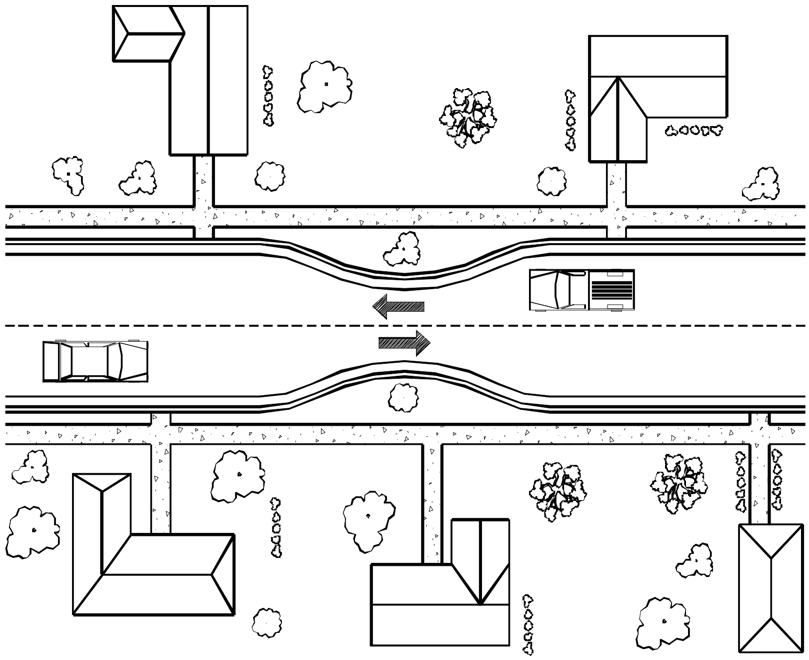
ADVANTAGES	DISADVANTAGES
• **Imposes minimal inconveniences to local traffic.** • **Pedestrians have a reduced crossing distance.** • **Provides large area for landscaping.** • **Provides a greater visual obstruction.** • **Cost of device is limited by length.** • **A very effective method of changing the initial impression of the street. If done correctly drivers will not be able to see through. Appears as a road closure yet allows through movement.** • **Accepted by public as speed control device.** • **Aesthetically pleasing.** • **Reduces speed without significantly impacting emergency response.**	• **Increases the area of landscaping to be maintained by residents** • **Cost is greater than many other devices, therefore better to be installed in conjunction with street reconstruction or initial design.** • **May create opportunities for head-on conflicts on narrow streets.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Yes	Possible	Small Increase	Small Increase	Medium to High	Possible Problems	

LANE NARROWING

DEFINITION: Street physically narrowed to expand sidewalks and landscaped areas; possibly adding medians, on street parking, etc. (Similar to Neckdowns but used at mid-block).



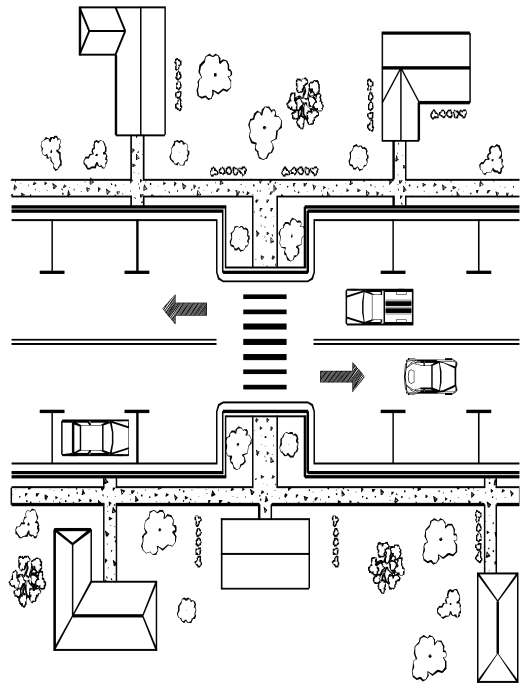
ADVANTAGES	DISADVANTAGES
• **Minor inconveniences to drivers.** • **Minimal inconveniences to local traffic.** • **Good for pedestrians due to shorter crossing distance.** • **Provides space for landscaping.** • **Slows traffic without seriously affecting emergency response time.** • **Effective when used in a series.** • **Single lane narrowing reduces vehicle speed and through traffic.**	• **Double lane narrowing not very effective at reducing speeds or diverting through traffic.** • **Only partially effective as a visual obstruction.** • **Unfriendly to cyclists unless designed to accommodate them.** • **Conflict between opposing drivers arriving simultaneously could create problems.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Yes	Possible	Small Increase	Small Increase	Medium to High	No Effect	

LANE NARROWING - TYPE 2

DEFINITION: Street physically narrowed to expand sidewalks and landscaped areas; possibly adding medians, on street parking, etc. (Similar to Neckdowns but used at mid-block).



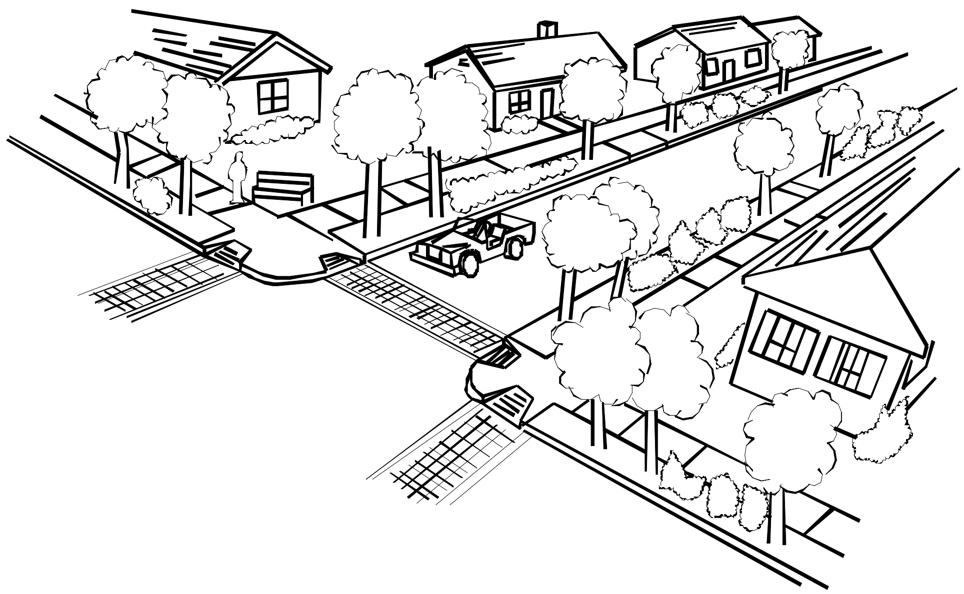
ADVANTAGES	DISADVANTAGES
• **Minor inconveniences to drivers.** • **Minimal inconveniences to local traffic.** • **Good for pedestrians due to shorter crossing distance.** • **Provides space for landscaping.** • **Slows traffic without seriously affecting emergency response time.** • **Effective when used in a series.** • **Single lane narrowing reduces vehicle speed and through traffic.**	• **Double lane narrowing not very effective at reducing speeds or diverting through traffic.** • **Only partially effective as a visual obstruction.** • **Unfriendly to cyclists unless designed to accommodate them.** • **Conflict between opposing drivers arriving simultaneously could create problems.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Yes	Possible	Small Increase	Small Increase	Medium to High		

LANDSCAPING

DEFINITION: Self-explanatory (i.e. street trees, median treatment, corner treatments, decorative signs, park benches, pathways, color).



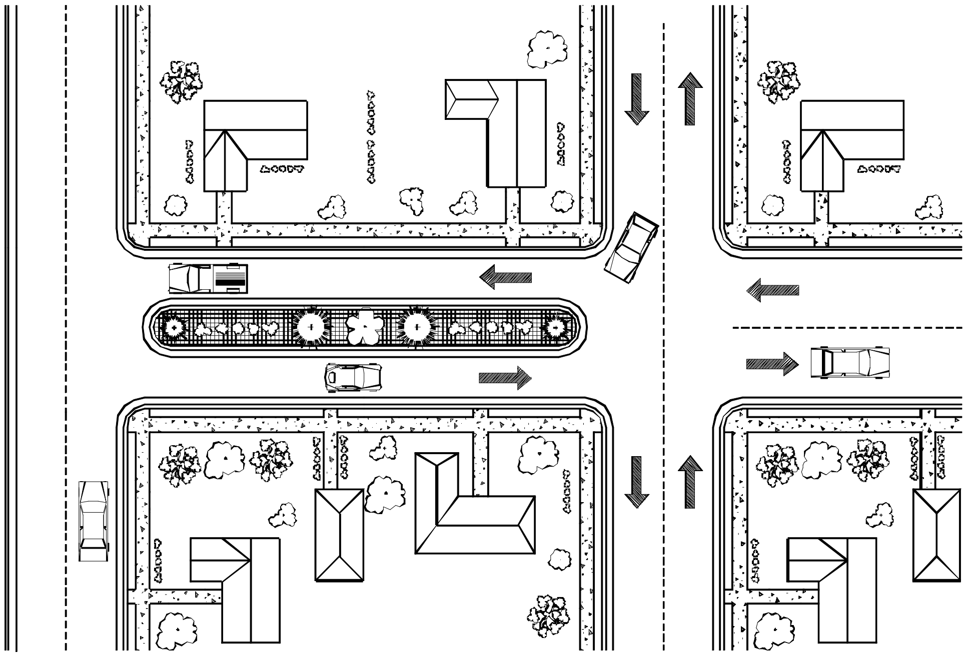
ADVANTAGES	DISADVANTAGES
• **Can be used to make drivers aware of speed.** • **Improve aesthetics and gives neighborhood an opportunity to be creative with their response to traffic concerns.** • **Alerts drivers to change in conditions.**	• **High maintenance responsibility. This can be eliminated if the community is responsible to maintaining the landscaping.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Possible	No	No Change	No Effect	Varies	No Effect	

MID-BLOCK MEDIAN

DEFINITION: An island or barrier in the center of a street that serves to segregate traffic.



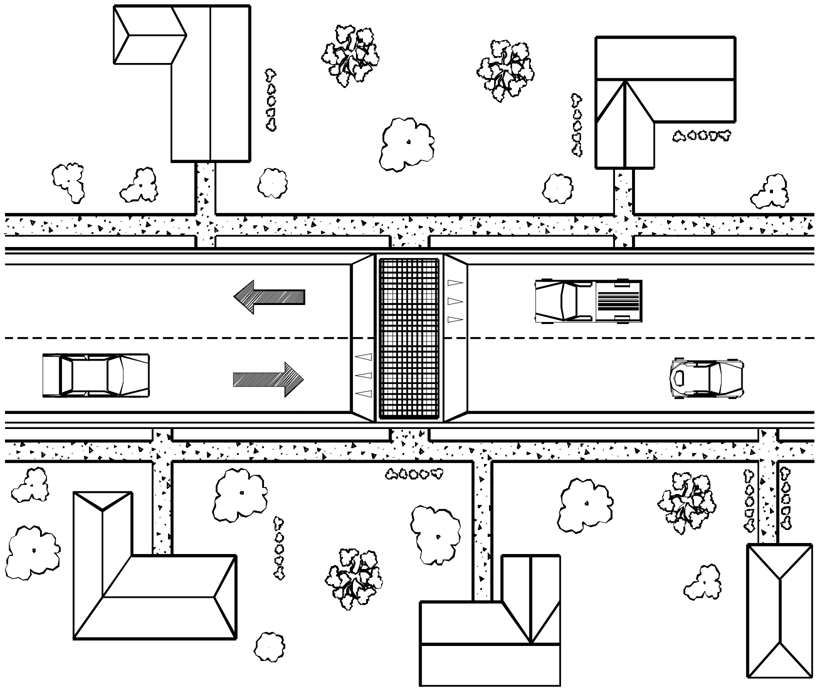
ADVANTAGES	DISADVANTAGES
• **Provides a refuge for pedestrians and cyclists.** • **May improve streetscape if landscaped.** • **Provides barrier between lanes of traffic.** • **May produce a limited reduction in vehicle speeds.**	• **May reduce site lines if over landscaped.** • **Increased maintenance.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	No	Possible	No effect	No effect	Varies	Possible Problems	

RAISED CROSSWALKS

DEFINITION: A speed hump designed as a pedestrian crossing, generally used at mid-block locations.



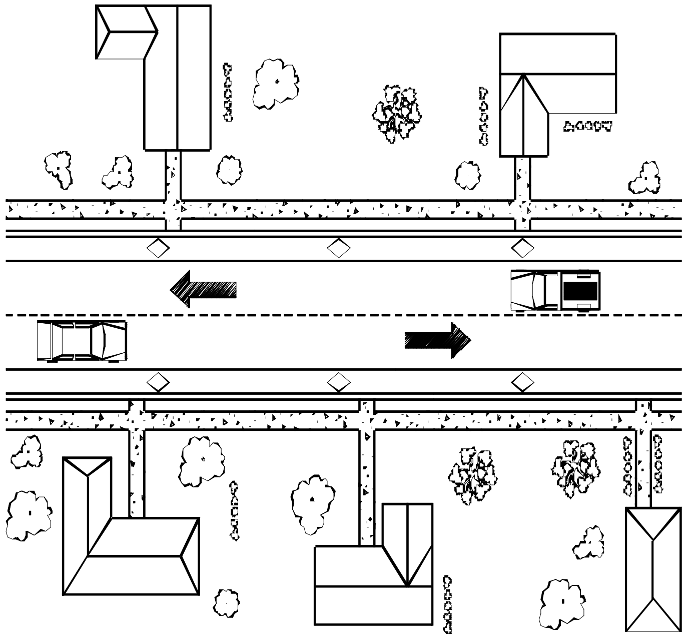
ADVANTAGES	DISADVANTAGES
• **Effective speed control at the installation.** • **Effective pedestrian amenity.** • **May be designed to be aesthetically pleasing.**	• **May create noise, particularly if there are loose items in the vehicle or trailer.** • **May be a problem for emergency vehicles.** • **May impact drainage.** • **Drivers may speed up between humps.** • **May increase volumes on other streets.** • **Requires signage that may be considered unsightly.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Yes	Possible	Small Increase	Small Increase	Low to Medium	Possible Problems	

ROAD STRIPING

DEFINITION: Highlighting various areas of the road to increase the driver's awareness of certain conditions, (e.g., edge of road striping to create a narrowing/slowing effect while defining space for cyclists).



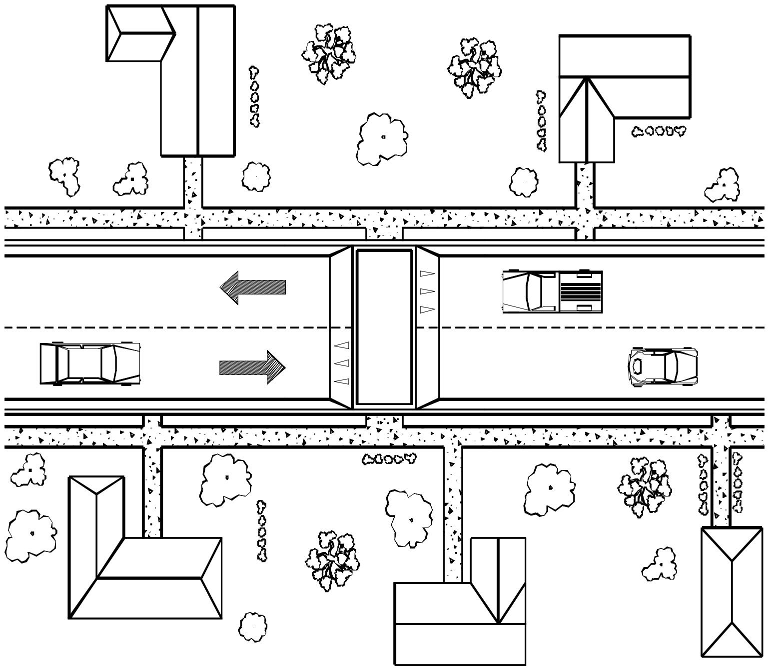
ADVANTAGES	DISADVANTAGES
• **Inexpensive.** • **May reduce speed.** • **Edge treatment increases safety of cyclists and pedestrians.** • **Low maintenance.**	• **May not be as effective as other more structured techniques.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Possible	No	No effect	No effect	Low	No effect	

SPEED HUMPS

DEFINITION: Speed humps are wave-shaped paved humps in the street. The height of the speed hump determines how fast it may be navigated without causing discomfort to the driver or damage to the vehicle. Discomfort increases as speed over the hump increases. Typically speed humps are placed in a series rather than singularly.



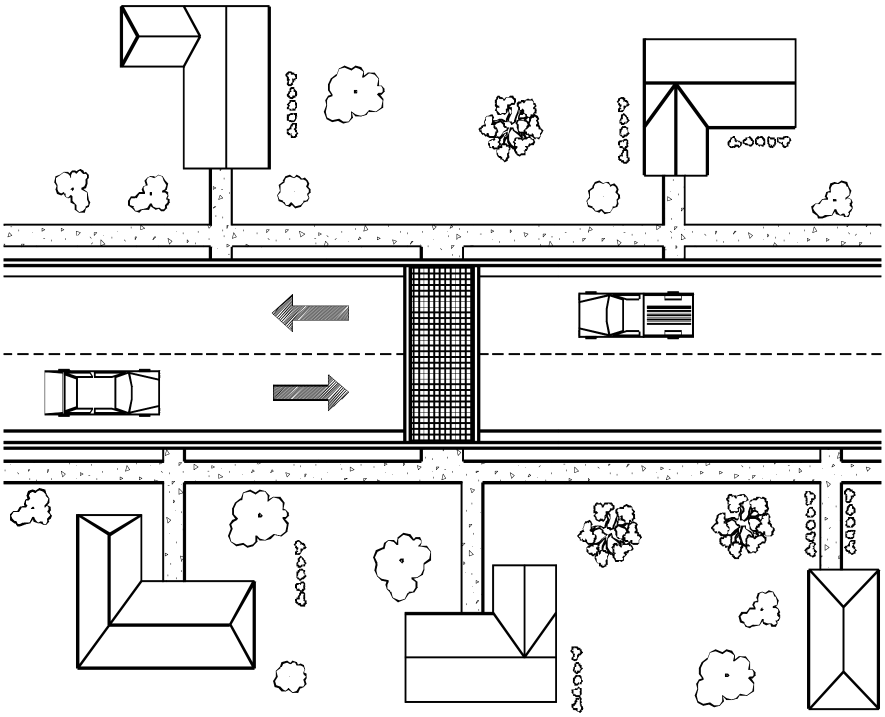
ADVANTAGES	DISADVANTAGES
• **Reduces vehicle speeds in the vicinity of the hump without increasing crashes. Better if used in a series at 300' to 500' spacing.** • **Self enforcing.** • **Relatively inexpensive.**	• **May create noise, particularly if there are loose items in the vehicle or trailer.** • **If not properly designed, drivers may try to skirt around to avoid impact.** • **May be a problem for emergency vehicles.** • **May impact drainage.** • **Drivers may speed up between humps.** • **May increase volumes on other streets.** • **Difficult to properly construct.** • **Requires signage that may be considered unsightly.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Yes	Possible	Small Increase	Small Increase	Low to Medium	Possible Problems	

TEXTURED PAVEMENT

DEFINITION: A change in pavement texture (e.g., asphalt road to brick crossing) that helps to make drivers aware of a change in the driving environment.



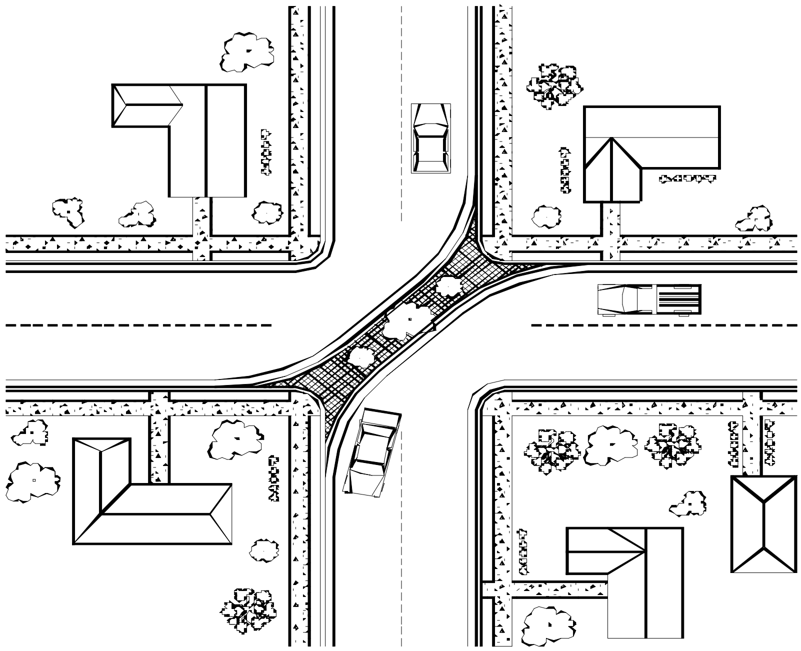
ADVANTAGES	DISADVANTAGES
• **May be aesthetically pleasing.** • **May be used to define pedestrian crossing.**	• **Increased maintenance.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Possible	No effect	No change	No Effect	Low to Medium	Possible Problems	

DIAGONAL ROAD CLOSURES

DEFINITION: A barrier placed diagonally across a four legged intersection, interrupting traffic flow across the intersection. This type of barrier may be used to create a maze-like effect in a neighborhood.



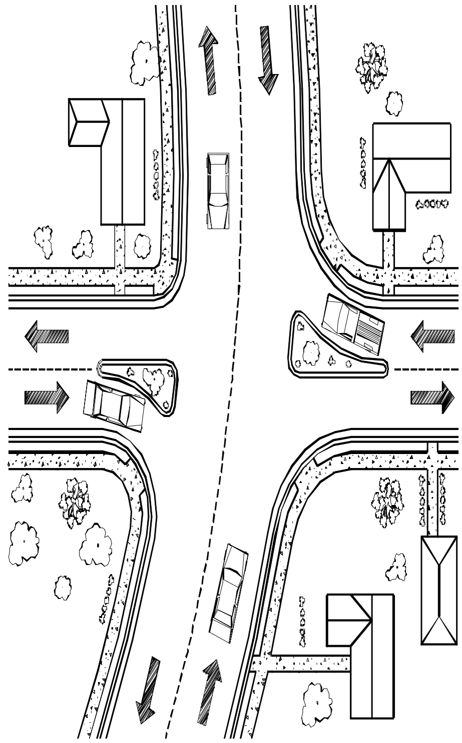
ADVANTAGES	DISADVANTAGES
• **Eliminates through traffic.** • **Provides area for landscaping.** • **Reduces traffic conflict points.** • **Increases pedestrian safety.** • **Can include bicycle path connection.**	• **May inconvenience residents gaining access to their properties.** • **May inhibit access by emergency vehicles.** • **May divert through traffic to other local streets.** • **Altered traffic patterns may increase trip length.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Yes	Yes	Slight Increase	Small Increase	Medium	Possible Problems	

FORCED TURN BARRIERS/DIVERTERS

DEFINITION: Small traffic islands installed at intersections to channel turning movements.



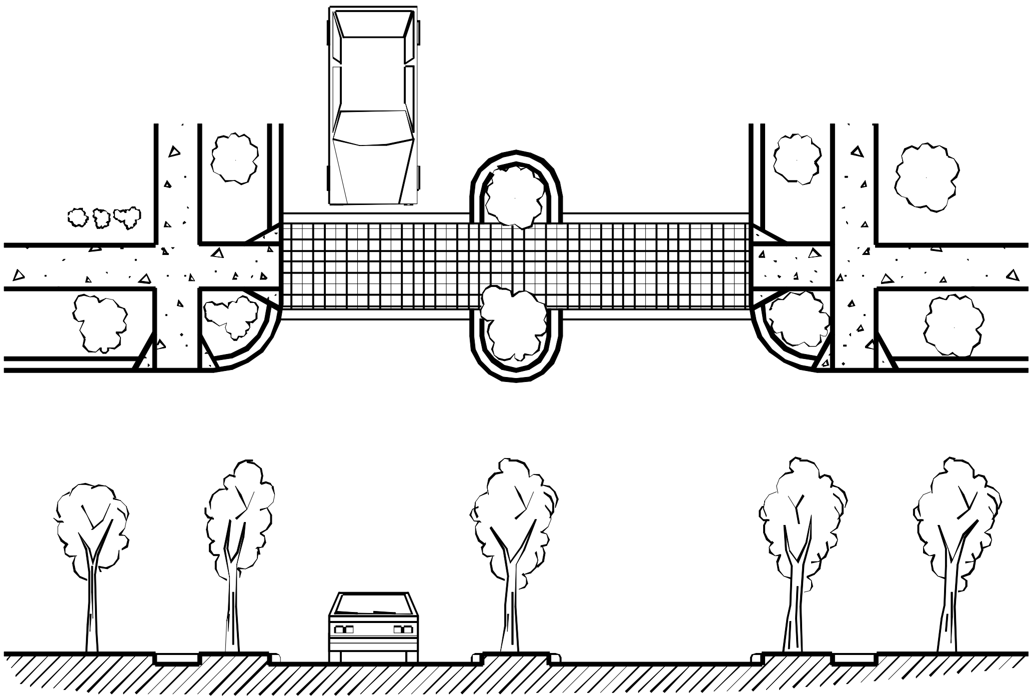
ADVANTAGES	DISADVANTAGES
• **Changes driving patterns.** • **May reduce cut through traffic.** • **May be attractive if landscaped.**	• **May increase trip length for some drivers.** • **Can be asthetically unattractive if not landscaped.** • **May increase response times for emergency vehicles.** • **Maintenance responsibility if lanscaped.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Possible	Yes	Small Increase	Small Increase	Low to Medium	Possible Problems	

GATEWAY TREATMENT

DEFINITION: Treatment to a street that includes a sign, banner, landscaping or other structure that helps to communicate a sense of neighborhood identity.



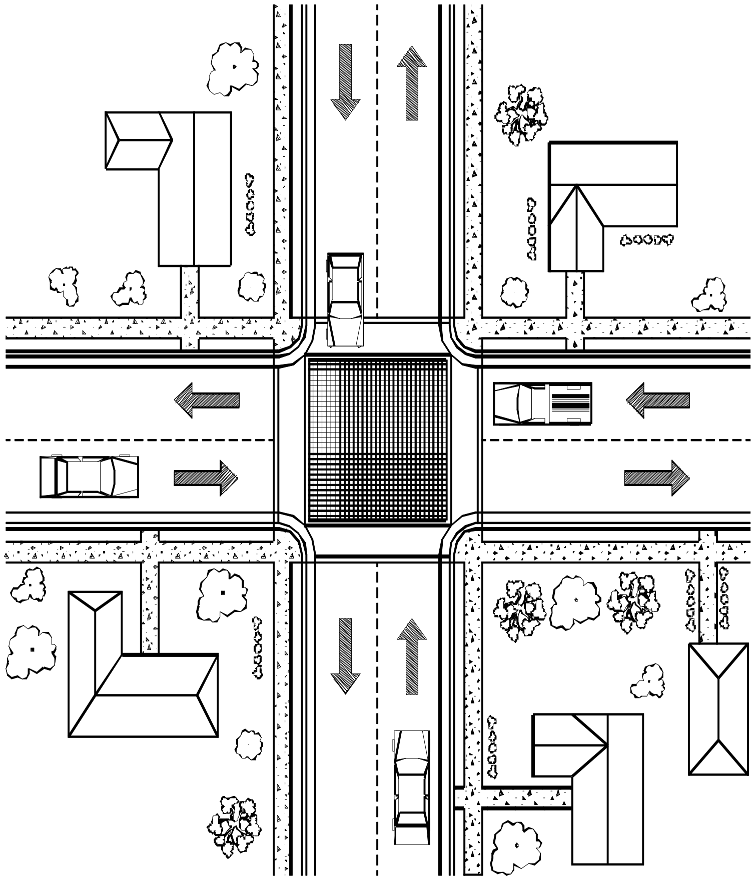
ADVANTAGES	DISADVANTAGES
• **Positive indication of a change in environment from arterial road to residential street.** • **Reduces entry speed.** • **Reduces pedestrian crossing distances.** • **On very wide streets provides space for landscaping the median.** • **Helps give neighborhood a sense of identity.** • **Allows neighborhood creativity and participation in design.**	• **Maintenance responsibility.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Unlikely	Mixed Results	No change	No effect	Medium to High	Possible Problems	

INTERSECTION HUMP

DEFINITION: A raised plateau where roads intersect. The plateau is generally 4" above the surrounding street.



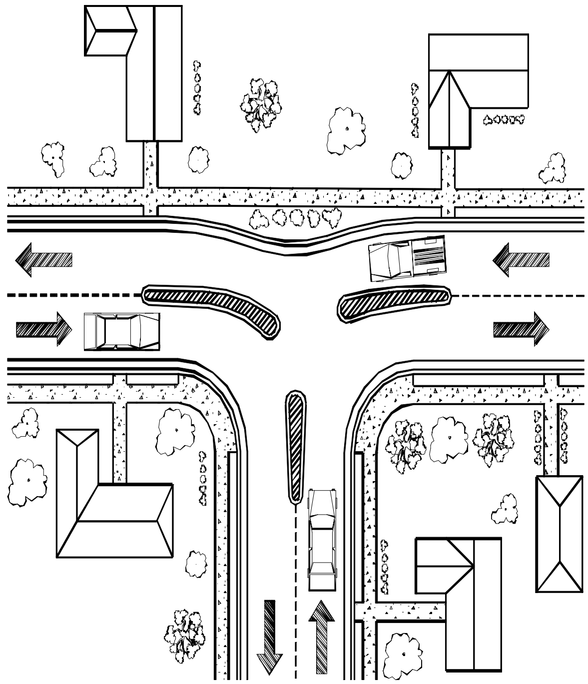
ADVANTAGES	DISADVANTAGES
• **Slows vehicle in the most critical area and therefore helps to make conflict avoidance easier.** • **Highlights intersection.** • **Excellent pedestrian safety treatment.** • **Aesthetically pleasing if well designed.** • **Effective speed reduction, better for emergency vehicles than speed humps.**	• **Increases difficulty of making a turn.** • **Increased maintenance.** • **Requires adequate signage and driver education.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible	Yes	Possible	Small Increase	Small Increase	Medium to High	Possible Problems	

MODIFIED INTERSECTION

DEFINITION: Self explanatory.



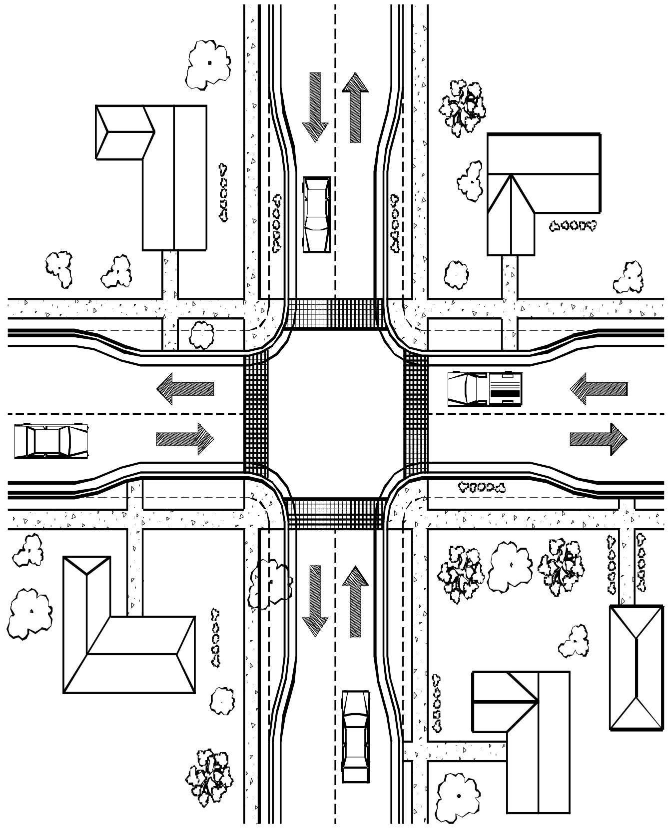
ADVANTAGES	DISADVANTAGES
• **Reduces vehicle speed.** • **Reduces through traffic along top of tee.** • **Necessary to enforce changes in priority from one street to another.** • **May provide space for landscaping.**	• **Can cause confusion regarding priority movements.** • **Increased maintenance if landscaped.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Yes	Possible	Small Increase	Small Increase	Medium to High	No Effect	

NECK DOWN(S)

DEFINITION: Physical curb reduction of road width at intersections. Similar to lane narrowing but used at intersection(s). Widening of street corners at intersections to discourage cut-through traffic and to help define neighborhoods. (Multiple application shown below.)



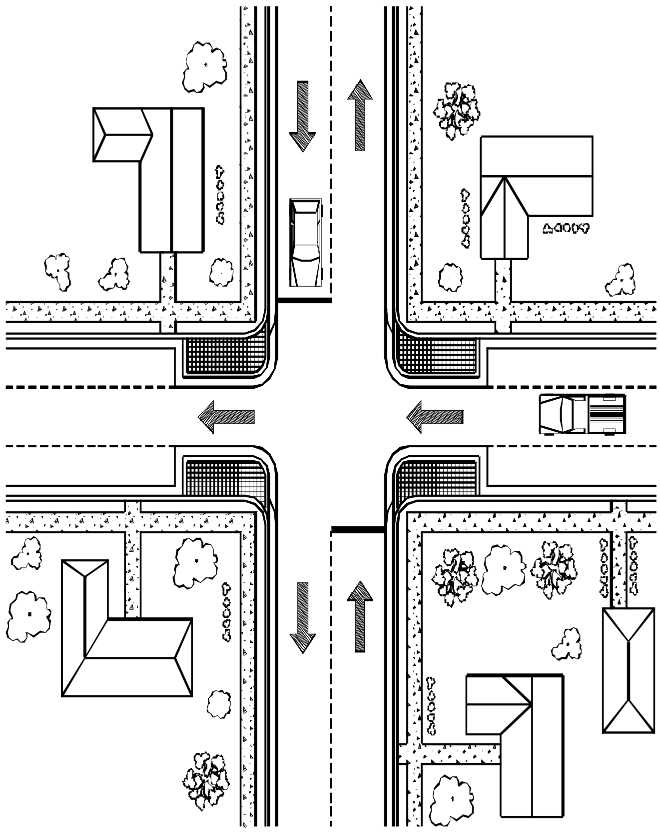
ADVANTAGES	DISADVANTAGES
• **May be aesthetically pleasing, if landscaped.** • **Good for pedestrian due to shorter crossing distance.** • **Can be used in multiple applications or on a single segment of roadway.**	• **Unfriendly to cyclists unless designed to accommodate them.** • **Landscaping may cause sight line problems.** • **Increased maintenance if landscaped.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Yes	Possible	Small Increase	Small Increase	Medium to High	No effect	

NECK DOWN(S) - TYPE 2

DEFINITION: Physical curb reduction of road width at intersections. Similar to lane narrowing but used at intersection(s). Widening of street corners at intersections to discourage cut-through traffic and to help define neighborhoods. (Multiple application shown below.)



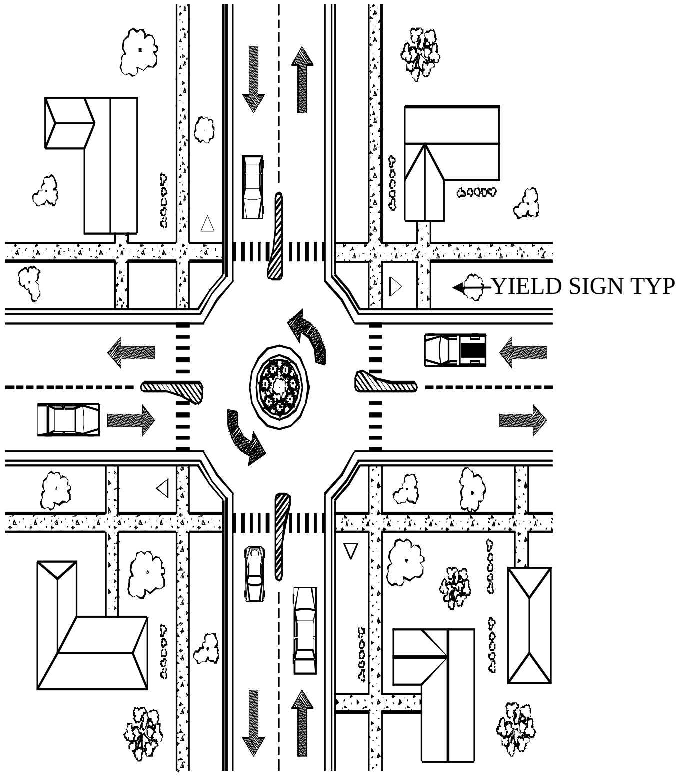
ADVANTAGES	DISADVANTAGES
• **May be aesthetically pleasing, if landscaped.** • **Good for pedestrian due to shorter crossing distance.** • **Can be used in multiple applications or on a single segment of roadway.**	• **Unfriendly to cyclists unless designed to accommodate them.** • **Landscaping may cause sight line problems.** • **Increased maintenance if landscaped.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Yes	Possible	Small Increase	Small Increase	Medium to High	No effect	

ROUNDABOUTS

DEFINITION: Roundabouts are raised circular areas (similar to medians) placed at intersections. Drivers travel in a counter-clockwise direction around the circle. Modern roundabouts are “yield upon entry,” meaning that cars in the circle have the right of way and cars entering the circle must wait to do so until the path is clear. When a roundabout is placed in an intersection, vehicles may not travel in a straight line.



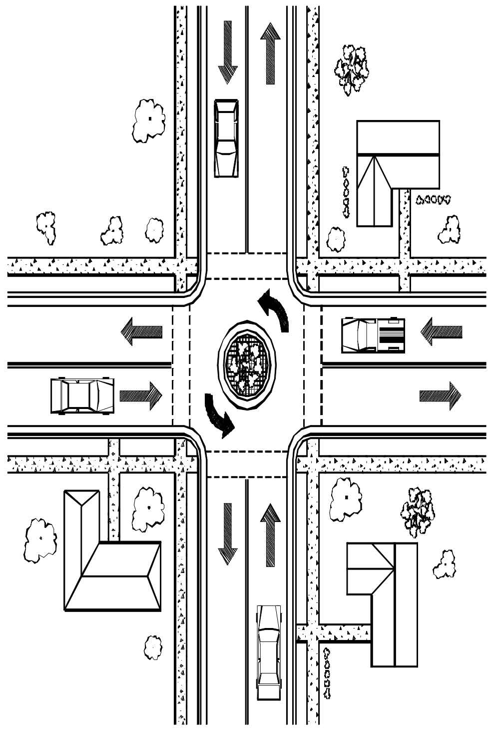
ADVANTAGES	DISADVANTAGES
• **Reduces crashes by 50 to 90 percent when compared to 2-way, 4-way stop signs and traffic signals by reducing the number of conflict points at intersections.** • **Reduces speed at intersection approach.** • **Longer speed reduction influence zones.** • **Provides space for landscaping.** • **Cheaper to maintain than a traffic signal.** • **Effective at multi-leg intersections.** • **Provides equal access to intersections for all drivers.** • **Provides a good environment for cyclists.** • **Does not restrict movements, but makes them more difficult.**	• **May be restrictive for larger vehicles if designed to a low speed. Providing a mountable apron minimizes this limitation.** • **May require additional lighting and signage.** • **If left turns by large vehicles are to be accommodated then right of way may have to be purchased.** • **Initial safety issues drivers adjust.** • **May increase volumes on adjacent streets.** • **Maintenance responsibility if landscaped.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Improved	Yes at Intersection	Possible	No Effect	Slight Increase	High	Possible Problems	

ROUNDABOUTS - TYPE 2

DEFINITION: Roundabouts are raised circular areas (similar to medians) placed at intersections. Drivers travel in a counter-clockwise direction around the circle. Modern roundabouts are "yield upon entry," meaning that cars in the circle have the right of way and cars entering the circle must wait to do so until the path is clear. When a roundabout is placed in an intersection, vehicles may not travel in a straight line.



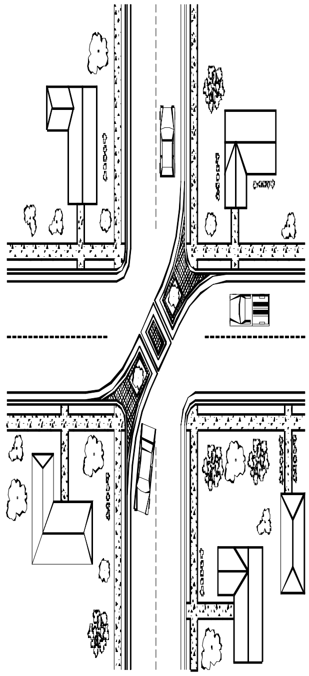
ADVANTAGES	DISADVANTAGES
• **Reduces crashes by 50 to 90 percent when compared to 2-way, 4-way stop signs and traffic signals by reducing the number of conflict points at intersections.** • **Reduces speed at intersection approach.** • **Longer speed reduction influence zones.** • **Provides space for landscaping.** • **Cheaper to maintain than a traffic signal.** • **Effective at multi-leg intersections.** • **Provides equal access to intersections for all drivers.** • **Provides a good environment for cyclists.** • **Does not restrict movements, but makes them more difficult.**	• **May be restrictive for larger vehicles if designed to a low speed. Providing a mountable apron minimizes this limitation.** • **May require additional lighting and signage.** • **If left turns by large vehicles are to be accommodated then right of way may have to be purchased.** • **Initial safety issues drivers adjust.** • **May increase volumes on adjacent streets.** • **Maintenance responsibility if landscaped.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Improved	Yes at Intersection	Possible	No Effect	Slight Increase	High	Possible Problems	

TRAVERSABLE BARRIERS

DEFINITION: A barrier placed across any portion of a street that is tranversable by bikes, pedestrians, in-line skaters, and emergency vehicles, but not by motor vehicles.



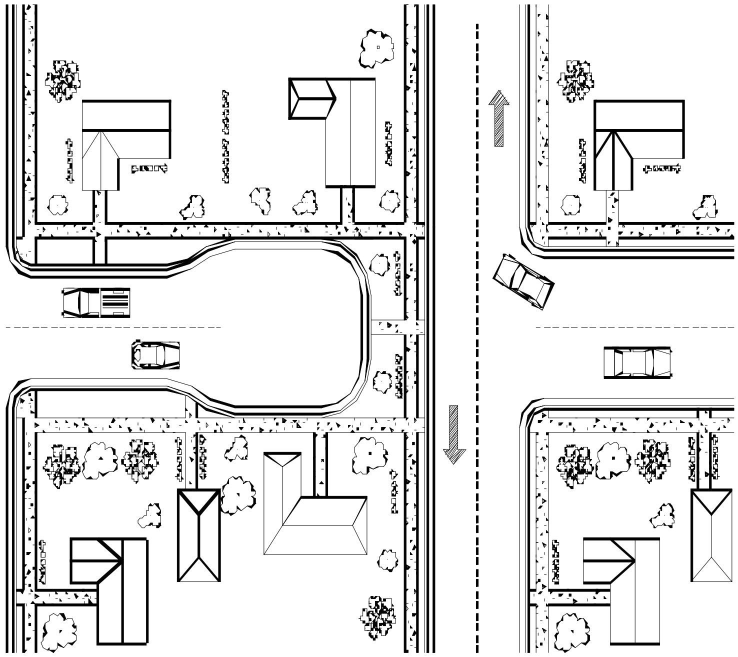
ADVANTAGES	DISADVANTAGES
• **Reduces or eliminates cut through traffic.**	• **May inconvenience residents gaining access to their properties.** • **Depending on design may be subject to violation by unauthorized vehicles.** • **Altered traffic patterns may increase trip length.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Improvement	Yes	Yes	Slight Increase	Small Increase	Medium	No Effect	

CUL-DE-SAC

DEFINITION: Street closed to motor vehicles using planters, bollards, or barriers, etc.



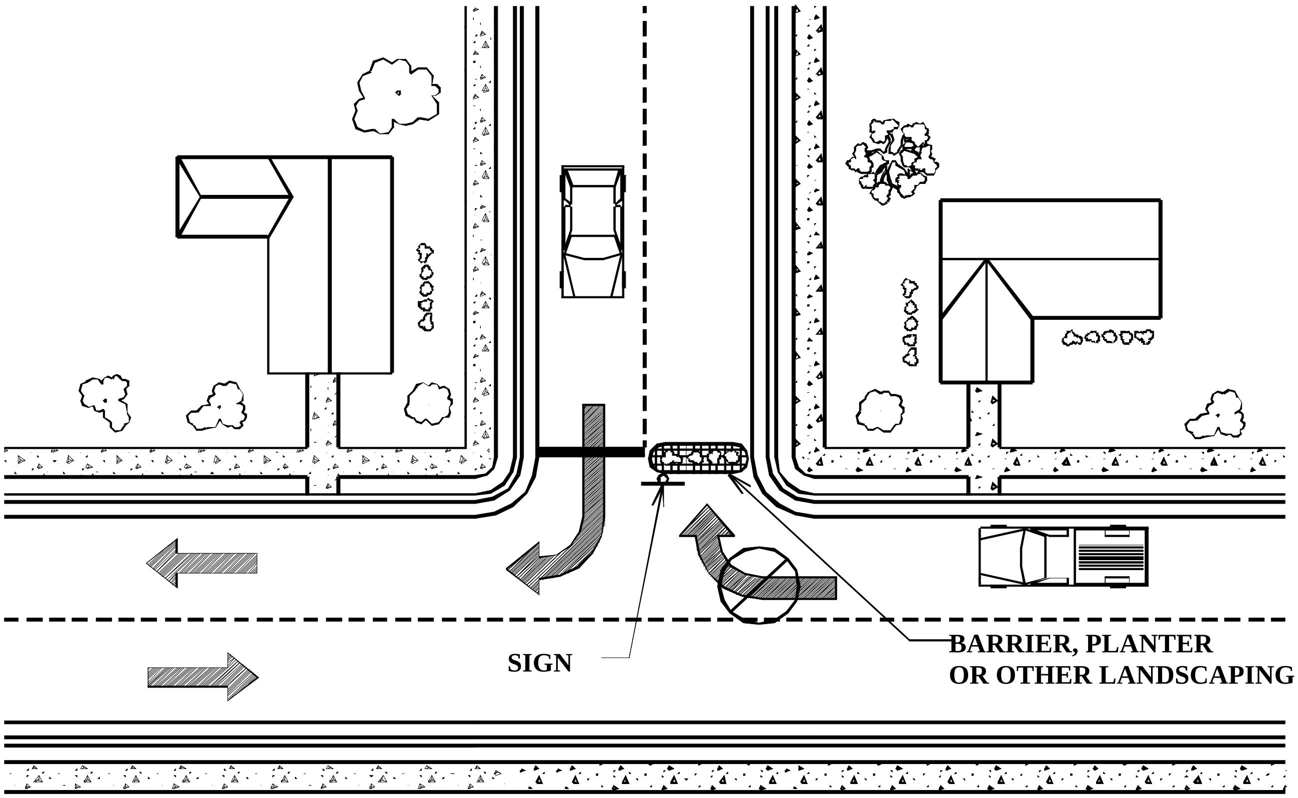
ADVANTAGES	DISADVANTAGES
• **Eliminates through traffic.** • **Reduces speed of the remaining vehicles.** • **Improves safety for all the street users.** • **Pedestrian and bike access maintained.**	• **Reduces emergency vehicle access.** • **Reduces access to properties for residents.** • **May be perceived as inconvenience by some neighbors and an unwarranted restriction by the general public.** • **May increase trip lengths.** • **May increase volumes on other streets.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Yes	Yes	Slight Increase	No effect	Low to Medium	Possible Problems	

PARTIAL STREET CLOSURE

DEFINITION: Physical blockage of one direction of traffic on a two way street. The open lane of traffic is signed "One way" and traffic from the blocked lane is not allowed to go around the barrier through the open lane.



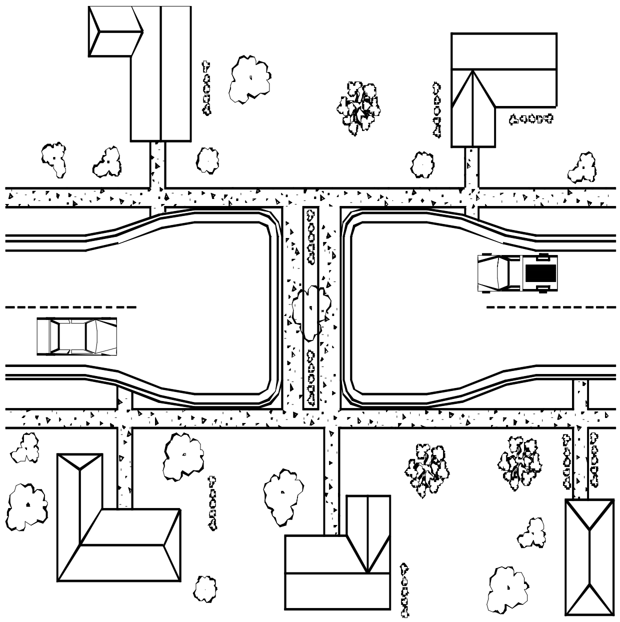
ADVANTAGES	DISADVANTAGES
• **Reduces through traffic in one direction and possibly in the other.** • **Allows two way traffic in the remainder of the street.** • **Good for pedestrians due to shorter crossing distance.** • **Provides space for landscaping.** • **Can be designed to provide two way access for bicyclists.**	• **Reduces access for residents.** • **Emergency vehicles are only partially affected as they have to drive around partial closure with care.** • **Compliance with semi-diverters is not 100%.** • **May increase trip length for some residents.** • **Maintenance responsibility of landscaped.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Improved Pedestrian crossing	Possible	Yes	Small Increase	Small Increase	Low to Medium	No effect	

STREET CLOSURE

DEFINITION: Street closed to motor vehicles using planters, bollards, or barriers, etc.



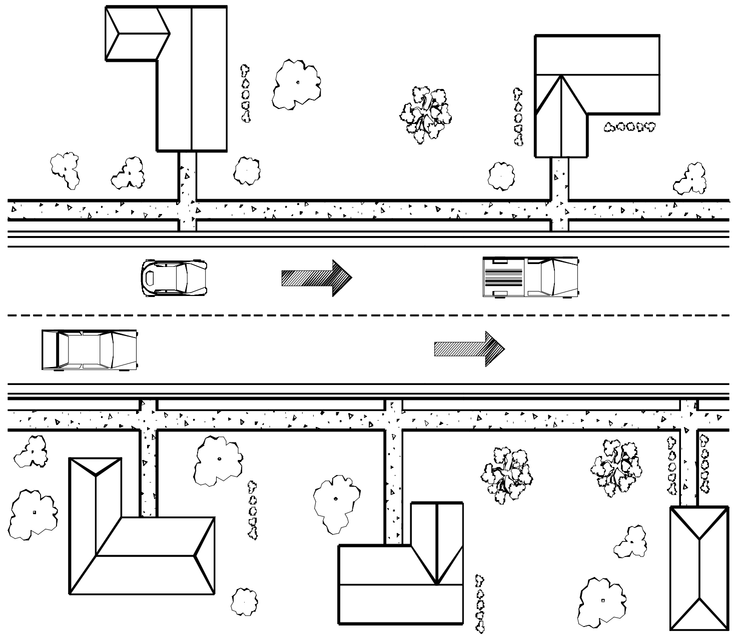
ADVANTAGES	DISADVANTAGES
• **Eliminates through traffic.** • **Reduces speed of the remaining vehicles.** • **Improves safety for all the street users.** • **Pedestrian and bike access maintained.**	• **Reduces emergency vehicle access.** • **Reduces access to properties for residents.** • **May be perceived as inconvenience by some neighbors and an unwarranted restriction by the general public.** • **May increase trip lengths.** • **May increase volumes on other streets.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	Yes	Yes	Slight Increase	No effect	Low to Medium	Possible Problems	

ONE-WAY STREETS

DEFINITION: Self-explanatory. (changing the traffic flow pattern with one way streets should be considered only in areas where there is a documented high percent of cut through traffic and where alternative routes exist.)



ADVANTAGES	DISADVANTAGES
• **Tends to be safer due to lack of friction from opposing traffic flow.** • **Can facilitate traffic flow through an area.** • **Can open up narrow streets for more resident parking.** • **Increases pedestrian safety.** • **Maintains reasonable access for emergency vehicles.** • **Maze effect of one-way traffic can discourage through traffic.**	• **Can lead to increased vehicle speeds.** • **May result in longer trip lengths.** • **May increase emergency response time.** • **May increase volumes on other streets.** • **Initial safety concerns as drivers adjust.**

EVALUATION CONSIDERATIONS

Safety	Speed Reduction	Traffic Reduction	Fuel Consumption	Pollution	Cost	Emergency Services	Other
Possible Improvement	No	Possible	No Change	No effect	Low	No Effect	

NEIGHBORHOOD TRAFFIC MANAGEMENT TECHNIQUES

Device	Definition	Volume Reduction	Speed Reduction	Change In % Trucks	Environmental/Pollution Changes In Conditions: Noise	Environmental/Pollution Changes In Conditions: Air	Safety: Vehicle Conflicts	Safety: Pedestrian	Safety: Bicycles	Emergency/ Service Vehicle Access/Delay	Dependence On Police Enforcement	Level Of Violation	Local Street Access	Impact On Adjacent Arterial	Use On Bus Route	Use With Driveways On Street	Use With Curbs & Gutters	Construct Cost/ Problems	Maintenance Cost/ Problems	Aesthetics/ Landscaping Potential	Useful For Spot/Areawide Problems
Bicycle Lanes	Lanes reserved for bicycles	No	No	No	No Change	No Change	-	-	Improved	No Effect	-	Low	Yes	No	Yes	Plan With Care	-	Low	Low	-	Both
Crosswalks	Painted pedestrian crossing areas midblock or at intersections	No	No	No	No Change	No Change	No Change	No Change	No Change	-	-	Low	Yes	No	Yes	Yes	Yes	Low	Low	No	Both
Curb Extensions (Entry, Exit, Midblock)	Extension of the curb into the roadway to create a narrower travel lane to protect parking strip or shorten pedestrian crossing distance	No	Slight	No	Slight Improvement	No Change	No Effect	Improved	Plan With Care	No Problems	-	-	Yes	No	No	Yes	Yes	Moderate	Low To Moderate	Yes	Both
Diagonal Diverters	Barrier placed diagonally across an intersection to force drivers to make a sharp turn but not allow other movements	Yes	Likely	Yes	Reduction	Improved	Improved	Varies	Varies?	Minor Constraint	Self Enforcing	-	Yes	Yes	Plan With Care	Yes	Yes	Low	Moderate	Yes	Usually Areawide
Enforcement (Visible & Active Police Presence)	Extensive traffic enforcement, “emphasis patrols.”	Not Likely	Yes, Temporary	Not Likely	Possible Reduction	No Change	-	Improved	Improved	-	High	Low	Yes	Yes	Yes	Yes	-	-	Moderate	-	Both
Forced Turn Islands, Barriers, Channelization	Traffic islands or curbs specifically designed to prevent traffic from executing specific movements at an intersection	Yes	Likely	Yes	Reduction	No Change	Improved	Improved	Varies?	Minor Constraints	-	Low	Yes	Yes	No Major Effect	Yes	Yes	Can Be Complex	Low	Optional, Depends Upon Priority	Both
Median Barriers	Barrier along the center line of a roadway to prohibit left turns or cross traffic	Yes	No	Possible	Reduction	Decrease	Improved	Varies	?	Minor Constraints	-	Low	Yes	No	Possible	Plan With Care	Yes	Complex	Varies	Varies	Both
Median Entry/Exit Islands	Traffic islands used to create narrower roadway at entry/exit point	Possible	No	Possible	Possible Reduction	Possible Decrease	Improved	Improved	?	Minor Constraints	-	Low	Yes	No	No	Yes	Yes	Low	Varies	Yes	Both
Median Mid Block Islands	Traffic islands between intersections to create a narrower roadway or provide refuge for crossing pedestrians	No	Slight	Slight	No Change	No Change	Improved	Improved	?	Minor Constraints	-	Low	Yes	No	Possible	Plan With Care	Yes	Low	Low	Varies	Both
Mid-Block Slow Points, Chicanos	Curbed islands or curb extensions protruding into the roadway, leaving a single-lane or narrow two-lane gap, often at an angle to the centerline	Yes	Yes	Likely	Reduction	Decrease	Improved	Improved	?	Minor Constraints	Self Enforcing	-	Yes	No	Yes	Avoid Near Driveways	Yes	Moderate	Moderate To High	Yes	Both
Neighborhood Traffic Safety/Campaign Program (Education)	Distribute safety information, special pedestrian safety classes for children	No	Not Likely	Not Likely	No Change	No Change	-	Possible Improvement	Possible Improvement?	-	-	-	-	-	-	-	-	-	-	-	Both
Neotraditional Neighborhood Design	Integrated land use and transportation design to increase transit and non-motorized travel to non-residential destinations within the neighborhood	Likely	Likely	Likely	Likely Reduction	Unknown	Improved	Improved	Improved	No Constraint	-	Low	Yes	Yes	Yes	Yes	Yes	Can Be High	Varies	High	Area
One-Way Entry/Exit Chokers, Half Closures, Semi-Diverters	A barrier to traffic in one direction of a street which permits traffic in the opposite direction to pass through	Possible	Yes	Not Likely	Reduction	No Change	Improved	Improved	Improved	Minor Constraint	Initially High	Varies	Yes	Possible	Plan With Care	Yes	Yes	Low	Moderate	Yes	Both
One-Way Streets And Signs	Restricted entry/exit to/from neighborhoods, one-way street patterns	Yes	Varies	Possible	Reduction	Improved	Improved	Improved	Improved	Plan With Care	Low	Low	Yes	Yes	Plan With Care	Yes	-	Low	Low	-	Usually Areawide
Parking Variants Class I (Zones, Signs, Striping, Timed, Resident Restricted)	Parking areas create narrower roadways and increased activity leading to increased attention by drivers	Possible	Likely	Likely	Possible Reduction	No Change	Possible Improvement	Possible Improvement	?	No Effect	Low	Varies	Yes	Yes	Yes	Yes	-	Low	Low	-	Both
Parking Variants, Class II (Shifting Traveled Way)	Alternating parking from one side of street to the other, parallel or diagonal	Possible	Likely	Not Likely	Possible Reduction	No Change	Increased Conflicts	Possible Improvement	Varies?	No Effect	-	-	Yes	No	No	Yes	Yes	Low	Low	Yes	Spot
Pavement Treatment, Class II (Texture/Composition, Patterns, Color)	Special pavement compositions and markings to alert drivers of special conditions	Not Likely	Possible	Possible	Possible Reduction	No Change	-	Possible Improvement	Varies?	No Constraint	-	-	Yes	No	Yes	Yes	-	Low	Low	-	Both
Pavement Treatments, Class I Marking And Striping & Color	Special pavement markings at entries, hazard locations or crosswalks to alert drivers of special conditions	No	Possible	Not Likely	No Change	No Change	-	Possible Improvement	?	No Effect	-	-	Yes	No	Yes	Yes	-	Low	Low	Yes	Both

Raised Crosswalks	Crosswalks raised transversely across the Pavement	Possible	Yes	Not Likely	No Change	No Change	-	Improved	Plan With Care	Minor Constraint	Self Enforcing	-	Yes	Yes	Plan With Care	Yes	Yes	Moderate	Low To Moderate	Yes	Site
Speed Alert w/Warning	Residents use radar to clock speeds, record license plate numbers, police send notice to drivers	No	Varies	Not Likely	Slight, Temporary, Reduction	No Change	-	Slight, Temporary, Improvement	No Change?	-	High	-	Yes	No	Yes	Yes	-	-	Low	-	Both
Speed Humps (About 2.75-4" H X 12')	Raised sections of pavement across the traveled way with curved transitions	Possible	Yes	Possible	No Change	No Change	-	Improved	Plan With Care ?	Minor Constraint	Self Enforcing	_	Yes	Yes	Yes	Yes	Yes	Low	Low To Moderate	Yes	Both
Speed Limit Signs	"25 MPH in residential areas", etc.	No	No	No	No Change	No Change	No Change	No Change	No Change?	-	High	High	Yes	No	-	-	-	Low	Low	No	Both
Speed Tables (3-4"H X 22')	Speed humps with a long flat section, often used as crosswalks	Possible	Yes	Possible	No Change	No Change	-	Improved	Plan With Care?	Minor Constraint	Self Enforcing	-	Yes	Yes	Plan With Care	Yes	Yes	Moderate	Low To Moderate	Yes	Both
Speed Watch	Illuminated display shows actual speed to passing drivers	No	Varies	Not Likely	Slight Temporary, Reduction	No Change	-	Slight, Temporary, Improvement	No Change?	-	None	-	Yes	No	Yes	Yes	-	-	Low	-	Spot
Stop Signs	Stop signs, two way or four way, used to assign right-of-way at intersections	Seldom	Varies	Not Likely	Increased Noise	Increase	Varies	Varies	Varies?	No Constraint	Low	Varies	Mutcd Guidelines	No	Yes	Yes	-	Low	Low	-	Both
Street Closures, Cul-De-Sacs	A complete barricade of a street at an intersection or a dead end street	Yes	Yes	Yes	Reduction	Improved	No	Improved	Improved	Significant Constraints	-	-	Yes	Yes	No	Yes	-	Moderate	Moderate To High	Yes	Both
Traffic Circles; Roundabouts	These geometric design features force traffic at intersections into circular maneuvers	Possible	Yes, Near Circle	Yes	No Change	No Change	Improved	Varies	Varies?	Minor Constraint	Self Enforcing	-	Yes	Yes	Plan With Care	Yes	Yes	Low	Moderate	Yes	Both
Truck Prohibitions	"No trucks over 10,000 lbs", etc.	Minor	No	Yes	Likely Reduction	Slightly Improved	Improved	Improved	Improved	-	-	Low	Yes	Yes	-	-	-	Low	Low	No	Area

CHAPTER 6
BICYCLE ROUTES, SHARED-USE PATHS, AND PEDESTRIAN WALKWAYS

6.1 Purpose

The purpose of this chapter is to establish the minimum and preferred design standards for sidewalks, other pedestrian facilities, and bicycle facilities. The outlined standards in this chapter include both minimum and preferred design standards with clarifications regarding when it is appropriate to apply the range of standards presented.

6.2 Pedestrian Sidewalks

Pedestrian walkways are required on both sides of all roads in the Lexington-Fayette County Urban Service Area, unless a type of street is specifically exempted or a special exception is granted by the LFUCG. Most pedestrian walkways are generally equivalent to the traditional sidewalk model, however this manual allows for innovative walkway designs, such as a shared-use path. Both traditional sidewalks and these alternative designs are discussed further in this section.

In today's subdivisions, sidewalks have the following functions:

- Provision for maximum safety of children playing on their block
- Protection of children walking to and from schools, neighbors, and parks
- Provision for adults to walk to and from parks, neighborhood shopping, and transit stops
- Provide safe travel pathways for handicapped individuals

6.2.1 Conventional Sidewalk Design

A. General Requirements: Sidewalks should be constructed in accordance with the Lexington-Fayette County Standards and Specifications and in accordance with applicable provisions of the Americans with Disabilities Act.

   Sidewalk design considerations must include:

   - Providing a roughened surface to ensure proper traction
   - Establishing a maximum grade consistent with local conditions, with an absolute maximum grade set at 1:12
   - Providing a lateral draining slope of 2 percent
   - Providing curb cuts that comply with the Americans with Disabilities Act Accessibility Guidelines

B. **Standard Alignment/Typical Cross Section**: Sidewalks must be constructed between the curb line and the right-of-way limit/line. The standard alignments for sidewalks are listed below in the following table.

TABLE 6. 1 - STANDARD SIDEWALK ALIGNMENTS/TYPICAL CROSS SECTION

Street Classification:	**Widths (Feet):**	
	Distance from Roadway	**Width of Sidewalk**
Non-Residential and Industrial Collector/Connectors (40' street width)	10.5	6.0
Non-Residential and Industrial Collector/Connectors (51' street width)	5	6.0
Residential Collector/Connectors and Industrial Locals	5.5	6.0, 8.0 in high use area*
Local residential	5.5	5.0
Local residential cul-de-sac	7.0	5.0
Arterial Major and Minor	7.0	6.0, 8.0 in high use area*

* Downtown and urban environments, near shopping centers, schools, civic centers, etc.

Should the available right of way between the curb and adjacent property line be of insufficient size to accommodate the requirements of this section, alternative designs of the sidewalk may be constructed only with the approval of the Lexington-Fayette Urban County Government. It should be noted that the absence of curbs and gutters on a street is not sufficient justification for the elimination of sidewalks.

When right-of-way restrictions and lack of yard easement necessitate a sidewalk next to the curb, and additional sidewalk width of 2 feet is desirable.

C. **Special Alignments with Standard Sidewalks**: Depending on utility placement, a meandering sidewalk alignment within the border area may be considered. Such an alignment is more visually appealing and may save trees or other major plantings, avoid rock outcroppings, etc. However, this should not be used as a justification for locating long sections of sidewalk near the edge of the street.

D. **Bridges**: Where sidewalks are required on bridges, they shall be a minimum width of eight (8) feet of "barrier free" space.

6.2.2 Curb Ramp Guidelines

Sidewalks constructed to the requirements herein shall include a curb ramp wherever an accessible route crosses a curb. Curb ramps shall be designed and constructed in accordance with the Lexington-Fayette County Standards and Specifications and as required by the American with Disabilities Act (ADA). If there are cases of conflict, ADA standards shall apply. Work within the right-of-way shall be constructed in accordance with the details shown on the plans

The following curb ramp specifications are established for Lexington-Fayette County:

- Curb ramps shall be located so that they are not obstructed by parked vehicles and shall not intrude into vehicular traffic lanes.

- The least possible slope shall be used for any curb ramp. Curb ramp shall not exceed a 1:12 rise to horizontal run ratio. Curb ramp wings not exceed a 1:10 rise to horizontal run ratio. If space limitations prohibit the use of a 1:12 slope or less, a flat landing 60 inches deep and as wide as the ramp area must be located at the top of each curb ramp. In existing right-of-way or street locations where each existing property lines do not allow for this 60-inch deep landing the wings or flared sides of the ramp must have a slope of 1:12 maximum.

- Sloped surfaces shall be stable, firm, and slip-resistant. Ramp surface may need a detectable warning surface system integral to the walking surface.

- The width of the curb ramp shall be 60 inches exclusive of flared sides or wings. On existing sidewalks only, where 60 inches is not feasible, a minimum width of 48 inches, exclusive of flared sides or wings shall be allowed. If a curb ramp is located where pedestrians must walk across the ramp, or where handrails or guardrails do not protect it, it shall have flared sides. Curb ramps with returned curbs may be used where pedestrians would not normally walk across the ramp.

- Curb ramps shall be located so as to provide a continuous accessible path of travel.

6.2.3 Non-conventional Sidewalks

With the approval of the LFUCG Planning Commission, an alternative sidewalk design (such as a shared-use path) may be substituted for a conventional sidewalk, provided that maintenance and public access agreements are provided and that the alternative design is accessible to persons with disabilities as defined and required in the Americans With Disabilities Act.

A. **Meandering Sidewalks**: Meandering sidewalks are encouraged in order to avoid trees or other natural features, provided that sufficient right-of-way is dedicated to accommodate them.

B. **Paved Trails**: In some residential areas, a paved trail may be used in lieu of or in addition to the conventional sidewalk. Sidewalks are typically adjacent and parallel to streets, whereas paved trails meander along natural pedestrian circulation routes.

C. **Mid-block access trails**: Mid-block access trails are an appropriate non-conventional sidewalk design. These pedestrian-ways usually run between two houses along a right-of-way established solely for pedestrian traffic. Because of their proximity to houses, special consideration to a resident's privacy should be taken into account.

right-of-way established solely for pedestrian traffic. Because of their proximity to houses, special consideration to a resident's privacy should be taken into account.

6.3 Bicycle Compatible Facilities Construction

This section is designed to outline the criteria necessary to successfully accommodate bicycle compatible facilities. There are five types of bicycle facilities to be discussed: 1) shared roadways, 2) signed shared roadways, 3) bike lanes, 4) shared use paths, and 5) other considerations. The preferred method of providing bicycle travel depends on the type of user and the primary purpose of the travel area. In most circumstances, bicycles share the road with other vehicles, but in some circumstances no bicycle traffic on a road or a dedicated bicycle path are the preferred travel methods.

6.3.1 Shared-Use Paths

A shared-use path is distinguished from other bicycle routes in that it is a motorized vehicle-free-route. It should be located as far from a road as is practical. Intersections with shared-use paths and roads should be kept to an absolute minimum and should be designed to minimize conflicts.

A. **Geometric Design Criteria for Shared-Use Paths**: One of the most important considerations in the design of shared-use path is that it is, in essence, a mini-roadway and should be designed and constructed as such. Additionally, it has been found nationally that it is virtually impossible to prevent pedestrian usage of bicycle paths. Therefore, throughout this manual the term "bicycle path" is not used. Instead, the term shared-use path is used and design standards are based on the assumption that additional path width is desirable whenever feasible.

   For shared-use paths, a horizontal and vertical alignment must be calculated for the appropriate design speed. This alignment should be staked in the field for construction, just as would be provided for a similar roadway project. Subgrade, Granular Base, and pavement courses should be provided in a similar fashion to that for a road construction project.

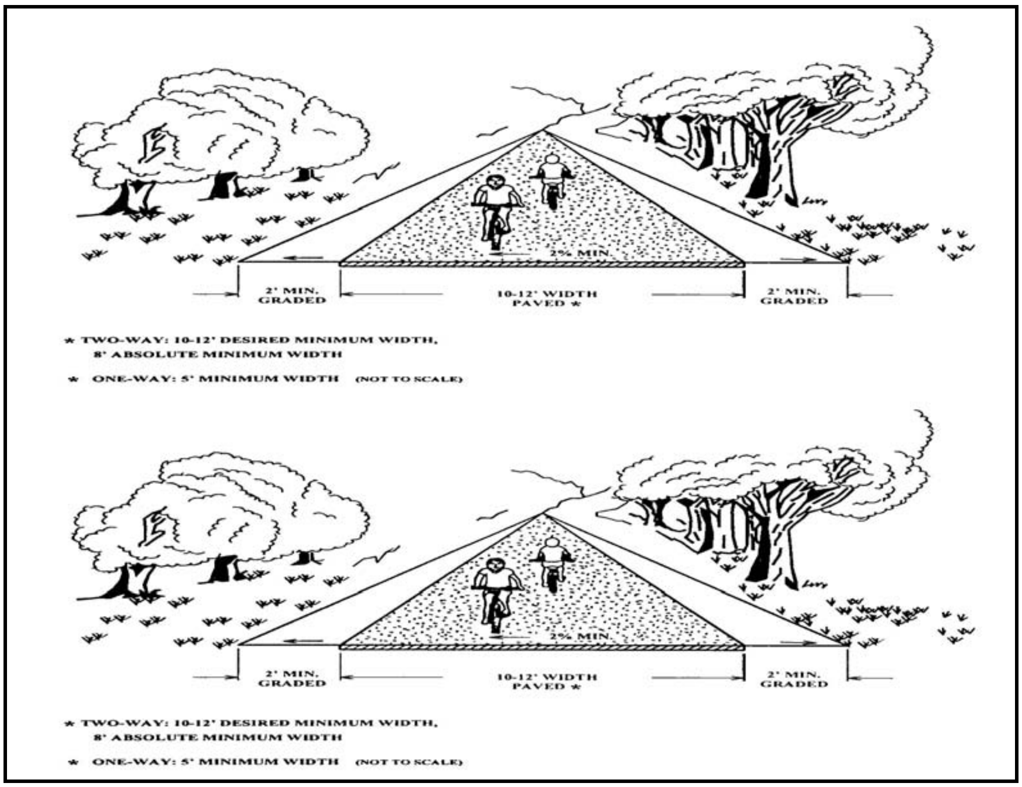
B. **Width**: If a shared use path must be in a road's right-of-way, there should be a minimum distance of 5 feet separating the shared use path from the road. If this is not possible, a suitable physical barrier is recommended. One-way traffic on the path, in the same direction as the adjacent traffic flow, is strongly encouraged. It should be recognized, however, that one-way paths will often be used as two-way facilities unless effective measures are taken to assure one-way operation. Without such measures, it shall be assumed that shared use paths will be used as two-way facilities and designed accordingly.

   For all shared-use paths separation from pedestrians by lane designations or adjacent sidewalk is also desirable where feasible.

   A desirable width for bicycle paths is 10 to 12 feet as these widths allow better bicycle flow and are wide enough for occasional maintenance vehicle usage. Logically, the higher the projected bicycle volume, the wider the path's design. In addition to the pavement width, the need to provide an adequate graded shoulder and vertical/lateral clear distances are another important consideration. A minimum of 2 feet graded grass area is the recommended area to be maintained adjacent to both sides of the pavement.

A minimum of 8 feet for two-way traffic and 6 feet for one-way traffic is suitable if the following conditions are met:: (i) bicycle traffic is expected to be low, even on peak days or during peak hours, (ii) pedestrian use of the facility is expected to be no more than occasional, (iii) there will be good horizontal and vertical alignment providing safe and frequent passing opportunities, (iv) maintenance vehicles will not be used.

FIGURE 6. 1 - SHARED-USE PATH ON A SEPARATED RIGHT-OF-WAY



Reference: Adapted from the AASHTO Guide for the Development of Bicycle Facilities, 1999.

C. **Clearance Distances**: A minimum vertical clear distance of 8 feet is required. A minimum vertical clear distance of 10 feet is recommended for two reasons. (1) It provides the minimum horizontal clearance that will be required by maintenance vehicles. (2) There is a "psychological shy minimum" perceived by bicyclists. With a minimum of 10 feet of clearance, bicyclists have a comfortable perception while riding under a structure. At less than 10 feet of clearance, bicyclists become uncomfortable and begin to "shy away" from the overhead structure.

An absolute minimum horizontal clear distance of 2 feet is required for all obstructions/hazards. Three feet is the recommended minimum horizontal clear for poles, trees, fences, and all other solid objects. Five feet is the recommended minimum horizontal clear distance for all embankments.

D. **Design Speed**: The speed that a cyclist travels is dependent upon the geometric features of the traveled way, type of bicycle, weather conditions, and physical condition of the rider. In determining the design speed for a shared-use path, the geometric features of curvature, superelevation, grade, and width of the traveled way are used to produce traveling speed that is at least as high as the preferred speed of the fastest traveler. Nearly all bicyclists travel within a speed range of 7 to 20 miles per hour, with an average at approximately 15 miles per hour. Design speeds should usually be 20 miles per hour, except on long downgrades where they should be 30 miles per hour or more.

E. **Curvature**: For a given design speed of a shared-use path, consideration should be given to the minimum radius of curvature, table 6-2 provides these minimums. It should be noted that the superelevation should never exceed 2% standard cross slope.

TABLE 6. 2 - Minimum Radii For Paved Shared Use Paths Based On 2% Superelevation Rates And 20% Lean Angle

Design Speed – V (mph)	Friction Factor - f	Minimum Radius - R (feet)
20	0.28	90
25	0.25	155
30	0.21	260
35	0.19	390
40	0.17	565

Reference: Adapted from the AASHTO Guide for the Development of Bicycle Facilities, 1999.

F. **Drainage**: A 2% cross section slope should be provided for drainage. This sloping shall be in one direction and not in a crown-type design. The Engineer should evaluate local conditions to determine which direction to slope the path.

G. **Grade**: Whether or not a shared-use path is favorable to cyclists is largely dependent upon the grade and alignment of the bicycle path. The amount of energy a cyclist expends in using a bikeway will affect the usage of the bicycle path. Therefore, the grades should be kept to a minimum.

A shared-use path's grade should not be greater than 6%. Grades over 6% are considered acceptable for distances less than 400 feet long, when higher speeds are acceptable, and additional width is provided. However, due to Lexington-Fayette County's topography, grades up to 10% may be warranted for short distances in some instances. For all shared-use paths, grades should not exceed 3% within 50 feet of an intersection.

H. **Shared-Use Path Pavement Structure**: Shared-use paths shall be machine laid using the following design standards. This standard will allow for continuous use of the path by bicycles and pedestrians as well as provide sufficient strength for occasional use by maintenance and safety vehicles.

TABLE 6. 3 - Shared-Use Path Minimum Thickness Standards For Granular Base And Pavement Courses

Pavement Layer:	Thickness (Inches):
Asphalt Surface	1.25
Asphalt Base	1.75
Granular Base	8 inches of DGA
Subbase	3 inches of #2 and #3 stone (if needed)

Because smooth riding surface is so critical to shared-use paths, portland cement is not considered an acceptable design material for shared-use paths in Lexington-Fayette County.

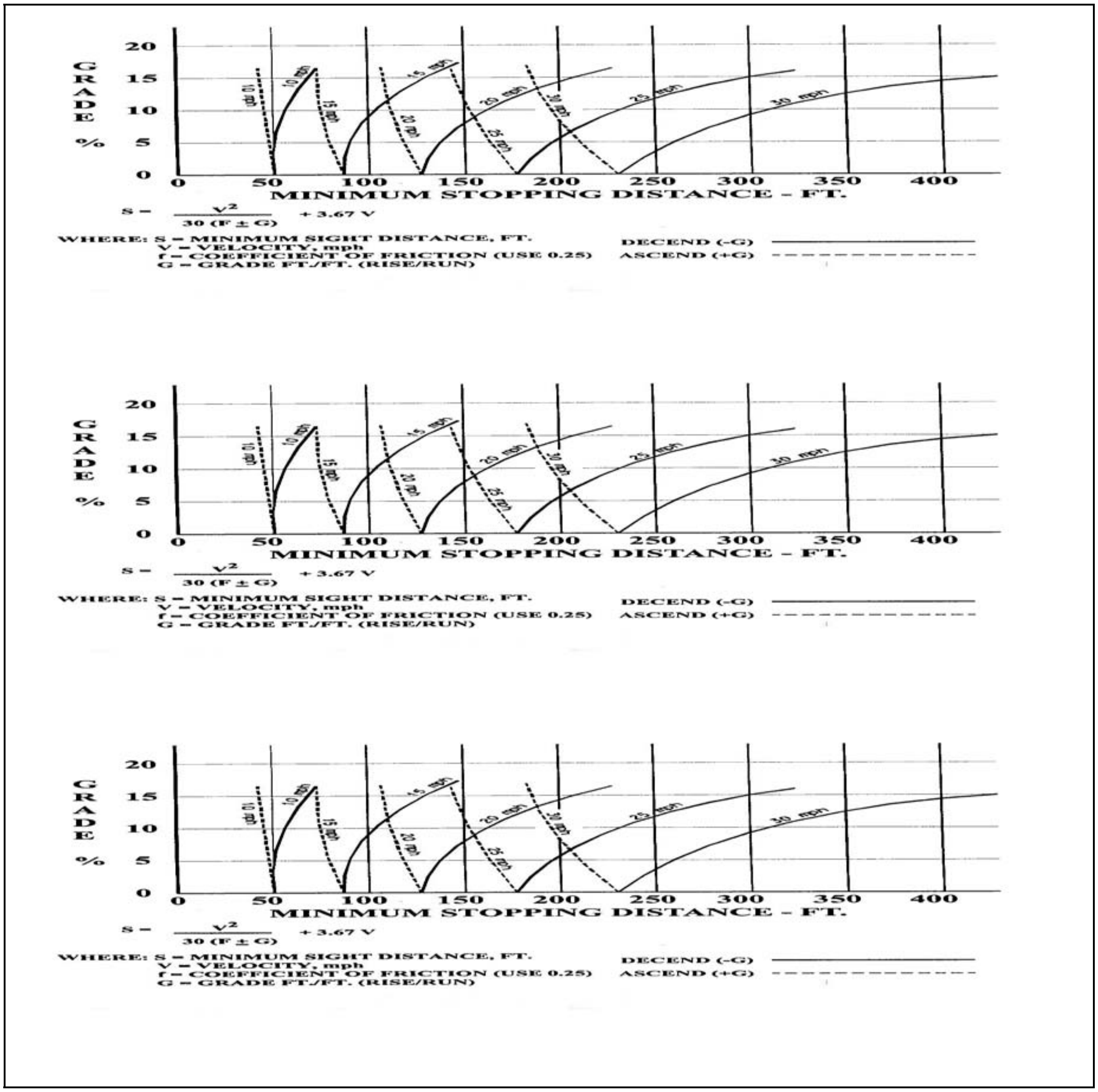
I. **Site Distance**: Shared-use paths shall be designed with adequate stopping sight distances, to provide bicyclists with an opportunity to see and react to the unexpected. The stopping distance for a bicycle is a function of a bicyclist's break reaction time, the initial speed of the bicycle, the coefficient of friction between the tires and the pavement, and the breaking ability of the bicycle. The following three figures assist in calculating the stopping site distance.

Figure 6-2 is to be used to select the minimum stopping sight distance for various speeds and grades based on a total perception and break reaction time of 2.5 seconds and coefficient of friction of 0.25, this is to account for the poor wet weather braking characteristics of many bicycles.

Figure 6-3 is to be used to select the minimum length of vertical curve necessary to provide minimum stopping distance at various speeds on crest vertical curves. For this figure, the eye height for the bicyclist is assumed to be 4.5 feet and the object height is assumed to be zero.

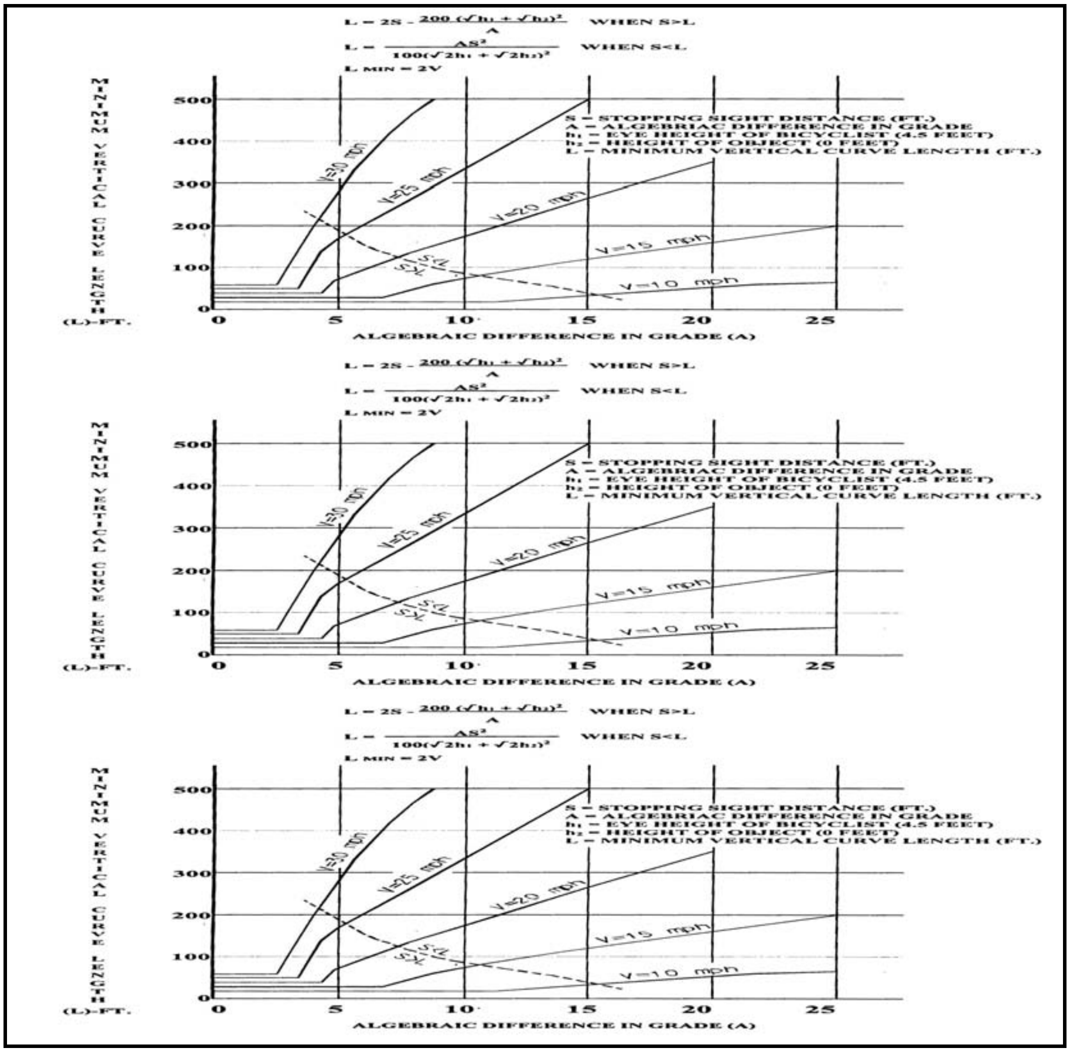
Figure 6-4 is to be used to select the minimum clearance that should be used for line of sight obstructions for horizontal curves. The lateral clearance is obtained by entering Figure 6-4 with the stopping sight distance from figure 6-2 and the proposed horizontal radius of curvature.

FIGURE 6. 2 - MINIMUM STOPPING SIGHT DISTANCE



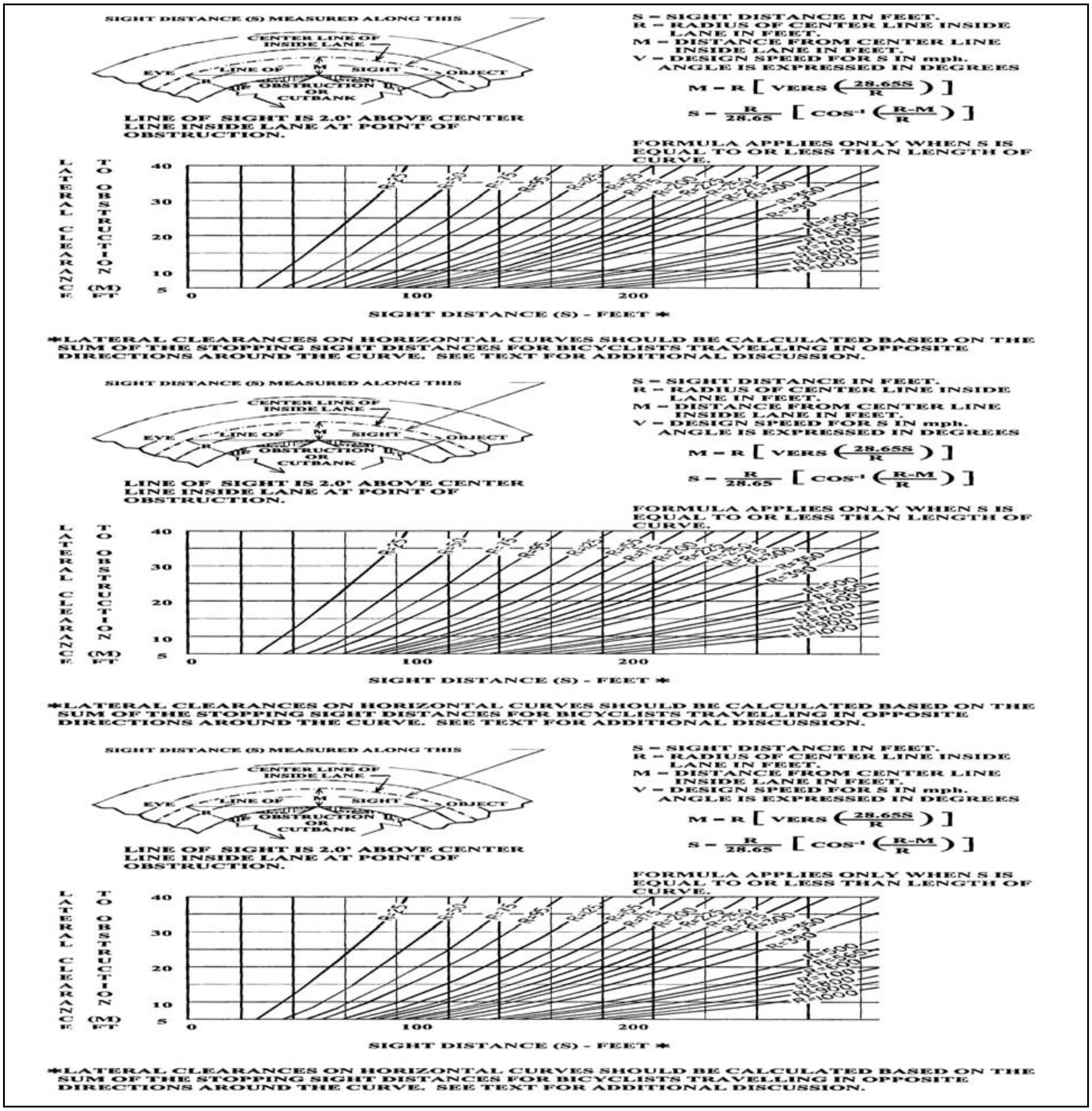
Reference: Adapted from the AASHTO Guide for the Development of Bicycle Facilities, 1999.

FIGURE 6. 3 - MINIMUM LENGTH OF VERTICAL CURVES



Reference: Adapted from the AASHTO Guide for the Development of Bicycle Facilities, 1999.

FIGURE 6. 4 - MINIMUM LATERAL CLEARANCES ON HORIZONTAL CURVES



Reference: Adapted from the AASHTO Guide for the Development of Bicycle Facilities, 1999.

6.3.2 Bicycle Lanes

A street or roadway with a bicycle lane has a designated outside lane located within the vehicular roadway that is intended for the preferential or exclusive use of bicycles. The bicycle lane is usually 4-5 feet wide and is delineated by means of pavement markings. Typically, bicycle lanes should not be used on roads that allow parking unless designed to accommodate both uses. Bicycle lanes should be designed to allow cyclists to flow through intersections. Bicycle lanes shall always be one-way in the same direction as the traffic flow.

Geometric Design for Bicycle Lanes: A Street with bicycle lanes must following the following geometric design standards.

A. **Drainage Grates**: Drainage inlet grates with openings large enough to entrap a narrow wheel are prohibited on streets with bicycle lanes. Suitable drainage grate designs include, but are not limited to, diagonal bars at 45-degree angles, slotted grates with cross bars, or slanted bars transverse to traffic. Long slotted grates with one (1) inch or more wide openings parallel to traffic cannot be used on streets with bicycle lanes. All such grates and covers should be kept out of the bicyclist's expected path.

B. **Railroad Grade Crossings**: The road-surface should be within one-half (1/2) inch of the track height and the slot between road and track should be less than one (1) inch wide. The street should be designed so that the cyclist can cross the tracks at a perpendicular angle. Where this is not possible, commercially available compressible flange fillers must be used. Crossing guards must be utilized in the track areas. Concrete crossing guards or rubber crossing guards are preferred. Asphalt and timber crossing guards are discouraged.

C. **Bicycle Lane Width**: The following bicycle lane widths are the minimums for a street with "bicycle lane" designation:

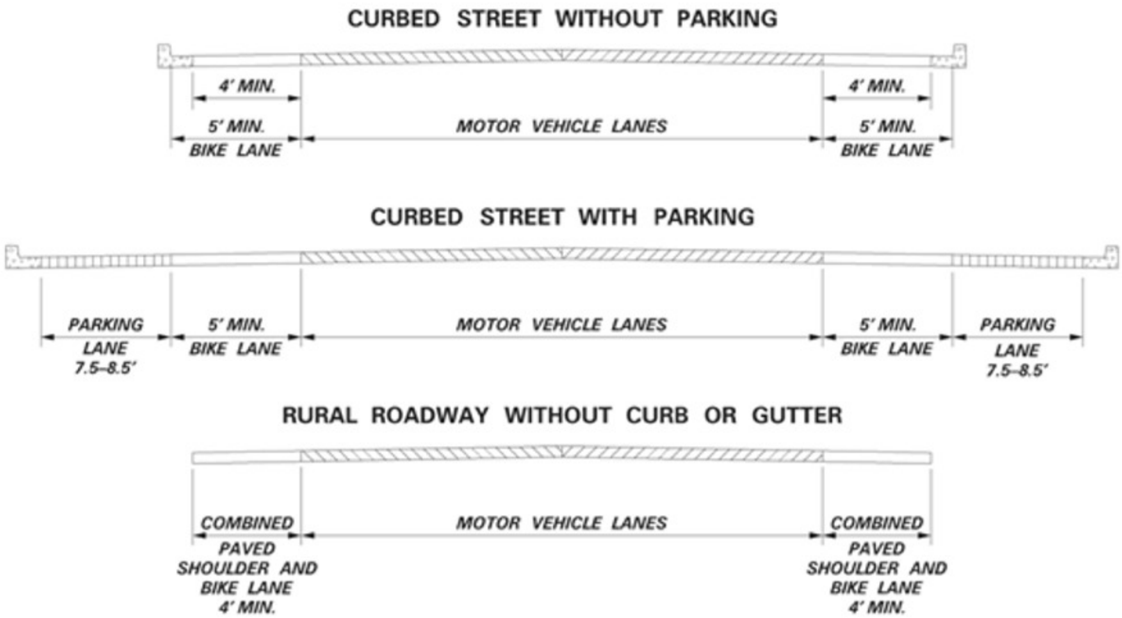
- **Streets without on-street parking**: 5 feet minimum bicycle lane width measured from the face of the curb

- **Streets with on-street parking**: 7.5 to 8.5 feet for parking lane width and 5 feet minimum for bicycle lane width

- **Streets with speed limits greater than 35 mph**: Additional widths are preferable when motor vehicle speeds exceed 35 mph, or when substantial truck traffic is present

- **Rural Roadways**: A shoulder width of 4 feet minimum should be used on rural roadways intended to accommodate bicycle travel.

FIGURE 6. 5 - TYPICAL BICYCLE LANES CROSS SECTIONS



Reference: Adapted from the AASHTO Guide for the Development of Bicycle Facilities, 1999.

D. **At-Grade Intersections**: Intersections timing cycles should be adjusted to account for the bicycle lane. Timing for the traffic signal cycle should assume that a bicyclist's speed through an intersection will be approximately 10 MPH.

   Loop detectors with sensitivity designed for bicycles should be installed in bicycle lanes at intersections. As an absolute minimum alternative, a signal call button for bicyclists (not the same as the pedestrians' button) shall be installed.

6.3.3 Bicycle Route Streets

These streets are designed in a manner to be compatible with bicycle traffic, without providing any special pavement markings for bicycles. Street routes with signs designating them "Bicycle Routes" should be constructed in a manner that meets the design requirements discussed below, however only the Lexington-Fayette Urban County Government can make a final designation of a "bicycle route," even if a street meets the following geometric standards.

Geometric Design for Bicycle Route Streets: For a street to receive a designation as a bicycle route, the following geometric design modifications should be made.

A. **Drainage Grates**: Drainage inlet grates with openings large enough to entrap a narrow wheel are prohibited on streets with a “bicycle route” designation. Suitable drainage grate designs include, but are not limited to, diagonal bars at 45-degree angles, slotted grates with cross bars, or slanted bars transverse to traffic. Long slotted grates with one (1) inch or more wide openings parallel to traffic cannot be used on streets with “bicycle route” designation.

B. **Railroad Grade Crossings**: The road-surface should be within one-half (1/2) inch of the track height and the slot between road and track should be less than one (1) inch wide. The street should be designed so that the cyclist can cross the tracks at a perpendicular angle.

C. **Outer Lane Width**: The following outer lane widths are the minimums for a street with “bicycle route” designation:

D. **Local Streets**: Can often be compatible for bicycles without additional pavement.

E. **Collector/Connector Streets**: Should provide an outer lane with a minimum width of 14 feet.

F. **Arterial Streets**: Should provide an outer lane with a minimum width of 14 feet.

6.3.4 Bicycle Signs and Pavement Markings

In order to ensure the safe and efficient operation of shared-use paths and bicycle compatible streets, there must exist adequate signs and markings to warn bicyclists of hazardous conditions or obstacles, to delineate bicycle rights-of-way, to exclude undesired vehicles from the route, and to warn motorists and pedestrians of the presence of bicycle traffic. For bicycle paths and bicycle compatible streets that meet the requirements laid out in this section, appropriate standard signs should be used to designate bicycle routes and denote appropriate warnings and hazards.

These standards are referenced in Guide for the Development of Bicycle Facilities, AASHTO 1999 and MUTCD.

CHAPTER 7
INTERSECTION DESIGN REQUIREMENTS

7.1 Intersections

An intersection is defined as the general area where two or more roads meet or cross, including the road and roadside facilities for traffic movement within it. An intersection is an important part of a road because the efficiency, safety, speed, cost of operation and capacity depend on its design.

There are three general types of intersections:

1. Intersections at-grade

2. Grade separations without ramps

3. Interchanges

At-grade intersections will be discussed in this guidance manual. For information on grade separations without ramps and interchanges, as well as additional information regarding at-grade intersection design, the Engineer is referred to the current edition of AASHTO's *A Policy on Geometric Design of Highways and Streets*, and KDOH’s *Design Manual and Standard Drawings*. The Engineer should also consult the Urban County Government’s *Bridge Manual* for specific bridge details and criteria as required for grade separation.

7.1.1 General Design Considerations and Objectives for At-Grade Intersections

The main objective of intersection design is to reduce the severity of potential conflicts between vehicles, bicycles, pedestrians, and facilities while facilitating the convenience, ease, and comfort of drivers in making the necessary maneuvers at intersections. Four basic elements enter into design considerations of at-grade intersections:

A. Human Factors

- Driving Habits
- Ability to make decisions
- Driver expectancy
- Decision and reaction time
- Conformance to natural paths of movement
- Pedestrian use and habits

B. Traffic Considerations

- Design and actual capacities

- Design-hour turning movements
- Size and operating characteristics of vehicle
- Movements (diverging, merging, weaving, and crossing.)
- Vehicle speed
- Transit involvement
- Accident Experience

C. Physical Elements

- Character and use of abutting property
- Vertical alignments at the intersection
- Sight distance
- Angle of intersection
- Conflict area
- Speed-change lanes
- Geometric features
- Traffic control devices
- Lighting equipment
- Safety features
- Bicycle traffic

D. Economic Factors

- Cost of improvements
- Effects of controlling or limiting right-of-way on abutting residential or commercial properties where channelization restricts or prohibits vehicular movements

- Energy consumption

7.1.2 Types of At-Grade Intersections

The basic types of at-grade intersections are:

A. **T-intersections**: A point where two roads intersect, with one of these two roads terminating at this point.

B. **Four-leg intersection**: The most commonly found intersection, where two roads intersect, usually at 90-degree angles, and then both roads continue after the crossing.

C. **Multi-leg intersection**: An intersection where more than two roads intersect, usually at unusual angles. This type of intersection is greatly discouraged.

In each particular case, the type is determined primarily by the number of intersecting legs, classification of the intersecting streets, the topography, the traffic patterns, and the desired type of operation.

7.1.3 Capacity Analysis

The capacity analysis is one of the most important considerations in the design of intersections. Refer to the most recent edition of AASHTO's *A Policy on Geometric Design of Highways and Streets* and the *Highway Capacity Manual* for complete coverage of capacity of intersections, including procedures for making capacity computations.

7.1.4 Vertical and Horizontal Alignment

Both vertical and horizontal curves should be avoided within an intersection, if at all possible; to reduce the potential problems caused by superelevation, drainage, and sight distance. In addition to the grades being as flat as practical, the roads should intersect at 90°, if possible. Intersection angles as small as 80° are acceptable; however, when the intersection angle becomes less than 80°, the Engineer should give consideration to re-alignment of one or both roads. The sight distance should be equal to or greater than the minimum values for specific intersection conditions.

7.1.5 Sight Distance

Each intersection contains several potential vehicle conflicts. The possibility of these conflicts actually occurring can be greatly reduced through the provisions of proper sight distances and appropriated traffic controls. Thus, intersections should be planned and located to provide as much sight distance as possible.

The operator of a vehicle approaching an intersection at-grade should have an unobstructed view of the entire intersection and sufficient lengths of the intersecting road to permit control of the vehicle to avoid collisions. A basic requirement is that drivers must be able to see control devices well in advance of performing required actions.

The minimum stopping sight distance at any point within an intersection shall be consistent with the design speed at that point. Listed below are the minimum stopping distances. Higher values should be used whenever possible. Refer to Chapter IX, AASHTO's *A Policy on Geometric Design of Highways and Streets* for additional information on sight distance.

TABLE 7. 1 - MINIMUM SAFE STOPPING DISTANCE

Design Speed, MPH	10	15	20	25	30	35	40	45	50	60
Safe Stopping Distance, Feet	45	75	125	150	200	250	325	400	475	650

Reference: Adapted from ITE and AASHTO standards.

There are four types of controls that apply to at-grade intersections. These types are:

A. **Yield Control** (vehicles on the minor intersecting road must yield to vehicles on the major intersecting road.)

B. **Stop Control** (traffic on the minor road must stop prior to entering the major road.)

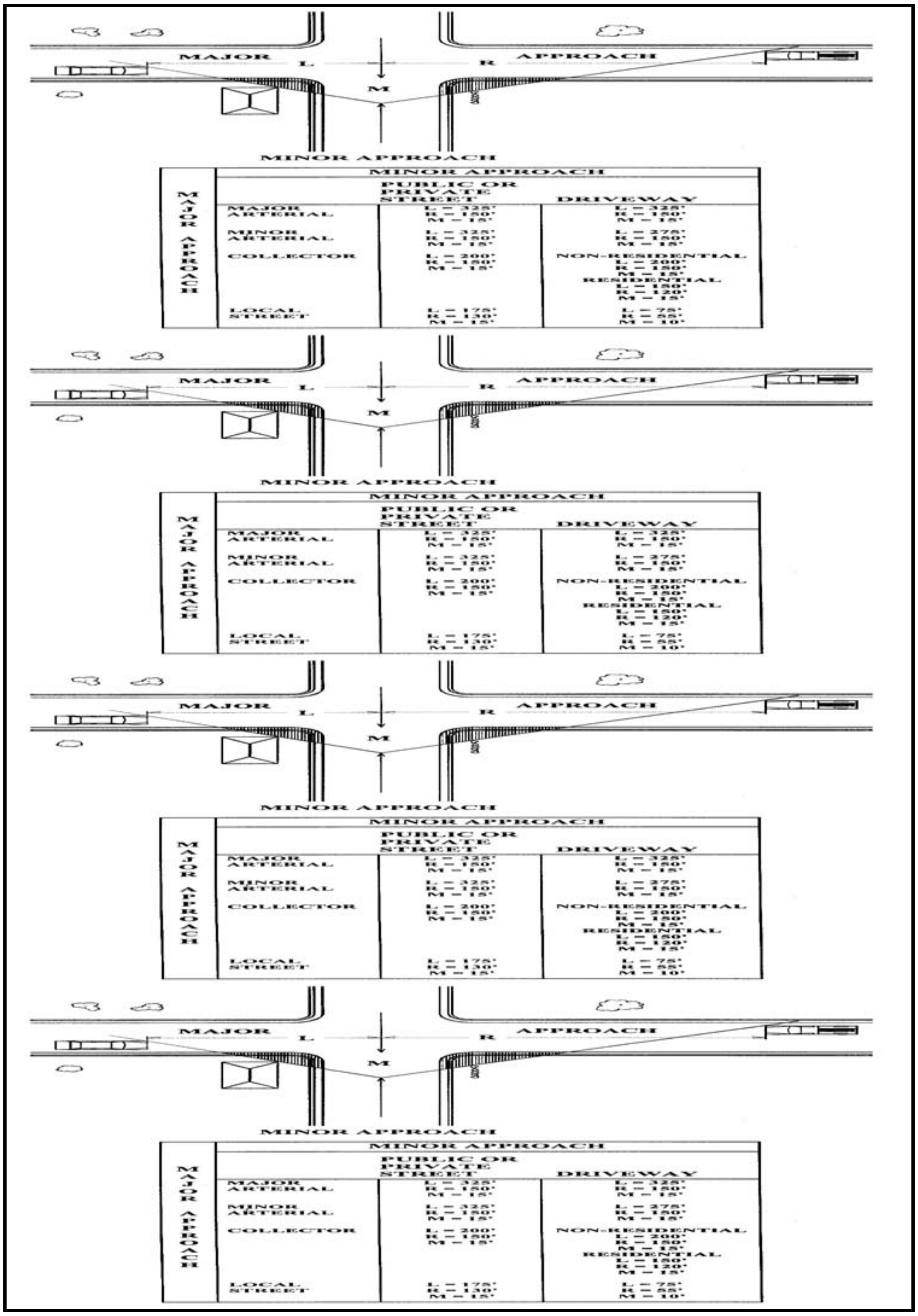
C. **Traffic Calming Control** (traffic must yield and follow established patterns of particular traffic calming device in use at the given intersection.)

D. **Signal Control** (all legs of the intersecting roads, at specific interval times, required to stop based on the intersection's is controlled by signals.)

At intersections where cross traffic is controlled by a stop sign, additional stopping sight distance must be provided for the vehicles on the major road because of the conflicts between vehicles on the through road and the cross road.

Intersection sight distance is a function of (1) the type of control, (2) the length of the design vehicle, (3) the acceleration rate of the design vehicle, (4) perception and reaction time, (5) the width of pavement and in cases of divided roadways/highways the width of the median, (6) design speeds, and (7) skew angle of intersection and gradient of roadways. AASHTO's *A Policy on Geometric Design of Highways and Streets* contains a thorough discussion of intersection sight distance with accompanying tables and charts. This publication should be consulted for guidance.

FIGURE 7. 1 - SIGHT TRIANGLES AT INTERSECTIONS



	MINOR APPROACH	
	PUBLIC OR PRIVATE STREET	DRIVEWAY
MAJOR ARTERIAL	L = 325' R = 150' M = 15'	L = 325' R = 150' M = 15'
MINOR ARTERIAL	L = 325' R = 150' M = 15'	L = 275' R = 150' M = 15'
COLLECTOR	L = 200' R = 150' M = 15'	NON-RESIDENTIAL L = 200' R = 150' M = 15' RESIDENTIAL L = 150' R = 120' M = 15'
LOCAL STREET	L = 175' R = 130' M = 15'	L = 75' R = 55' M = 10'

Reference: Adapted from ITE, Guidelines for Urban Major Street Design, 1983.

7.1.6 Lane Width

The width of the traffic lanes on intersecting roads is controlled by the geometrics approved by LFUCG. For channelized turning movements, the following lane widths shall be used for the turning road:

TABLE 7. 2 - CURVATURE AND LANE WIDTH (CHANNELIZATION ONLY)

Speed, MPH	15	20	25	30	35	40	45
Radius, Ft.	50	90	150	230	310	430	550
Lane Width, Ft.	18	17	16	16	15	15	15
(Widen lanes one foot for each barrier curb used)							

Reference: Adapted from AASHTO "Green book."

7.1.7 Superelevation

The superelevation rates for the through road at an intersection should comply with the appropriate values. At signalized intersections in urban areas, the Engineer may elect to use either reverse crown superelevation or no superelevation, after consideration of (a) vehicle's ability to stop and accelerate during periods of ice and snow, (b) right-of-way damages, (c) grade on existing street approaches and entrances, and (d) drainage.

When introducing or removing superelevation rates, the maximum gradients between pavement edge and centerline profiles from the following table should be used:

TABLE 7. 3 - DESIGN RATE OF CROSS SLOPE CHANGE FOR CURVES AT INTERSECTIONS

Design Speed, MPH	15 & 20	25	30	35 or more
Change in Superelevation Rate (Ft. per Ft.) per 100'	0.075	0.071	0.067	0.065

Reference: Adapted from AASHTO "Green book."

Superelevated areas adjacent to a through lane having a normal crown or a different superelevation results in a "cross-over line" which can cause a hazardous pitch or sway in a vehicle. The maximum difference in superelevation for a road turning away from a through lane is as shown in the following table:

TABLE 7. 4 - MAXIMUM ALGEBRAIC DIFFERENCE IN PAVEMENT CROSS SLOPE AT TURNING ROADWAY TERMINALS

Design Speed of Exit or Entrance Curve, MPH	Maximum Algebraic difference in cross slope at cross over crown line, foot per foot
15 and 20	0.05 - 0.08
25 and 30	0.05 - 0.06
35 and over	0.04 - 0.05

Reference: Adapted from AASHTO “Green book.”

7.2 Turning Radii

As the turning radii are increased, all of the following are also increased: paving costs, intersection area required, distance pedestrians will need to traverse. Additionally, increased turning radii encourage higher turning speeds. Substandard radii result in unnecessary lane encroachment and increased traffic conflict and accident potential. For left and right turns, the following are considered to be reasonable ***minimum*** turning radii:

A. **For standard local-local residential street intersections**: 25 feet radius, based on a curb clearance of three (3) feet and without lane encroachment for a typical street width, using the AASHTO design passenger vehicle.

B. F**or neo-traditional local-local residential street intersections**: 15 feet radius, based on a curb clearance of three (3) feet, using box curbs only, and without lane encroachment for a typical street width, using the AASHTO design passenger vehicle.

C. **For commercial local-local street intersections**: 35 feet radius.

D. **For local-collector/connector or collector/ connector-collector/connector intersections**: 25 feet radius, based upon a desire to slightly improve maneuverability of a vehicle in entering or leaving a collector/connector.

E. **For collector/connector-arterial intersections**: 35 feet radius.

F. **For arterial-arterial intersections:** 35 feet radius. However, the radii should be no larger than 55 feet where pedestrian traffic is present and 75 feet for all other intersections.

Vehicle turning templates should be used to verify the adequacy of turning movements in an intersection. Where right-of-way is restricted, the use of either taper curves or three-centered curves, as described in AASHTO's *A Policy on Geometric Design of Highways and Streets* is recommended.

For all turn radii designs stormwater drainage inlets must be designed and placed outside of the turn radius and no type “A” drainage inlets within 100 feet.

7.3 Deceleration Lane Tapers

Tapers or deceleration lanes for vehicles turning from the major road into the minor road are highly desirable for both safety and added capacity. A long radius with no taper is preferable to a short radius and an inadequate taper. On high-speed facilities, taper rates should conform to AASHTO's *A Policy on Geometric Design of Highways and Streets*. However, on most urban intersections, much shorter tapers are satisfactory. Minimum taper rates of 8:1 for speeds up to 30 mph and 15:1 for operating speeds up to 50 mph may be used.

7.4 Pedestrian Conflicts

Intersection design must promote the safe and efficient movement of both vehicles and pedestrians. Documentation should consist of (1) the vehicular flow, including percentage and types of trucks, (2) pedestrian movement (i.e., heavy, moderate, light), (3) the presence of pedestrian generators (i.e., the downtown area, schools, malls, etc.), and (4) the Urban County Government Division of Traffic Engineering's recommendation. If the Division feels that there is an amount of pedestrian activity that may affect final design of an intersection, the Division shall arrange for counts of the existing pedestrian movements to be made.

Intersections shall be designed to accommodate pedestrians when: (1) pedestrian activity is considered heavy, (2) special conditions (such as a school) exist, and (3) the project team determines that the need to accommodate the pedestrian is greater than the concerns for vehicular movement. However, when conditions indicate that an approach to an intersection will generate heavy traffic volumes and that pedestrian movements will be negligible in comparison to the vehicular volumes, enlarged radii, including free flow movement on right turn lanes may be used. If a decision is made to allow free flowing movements, consideration should be given to discourage pedestrian movements in those locations by relocating sidewalks or, where practicable, adding fences or other blockades to prevent pedestrians from entering the road area. If moderate pedestrian activity exists, but the need to handle vehicular flow is still greater, the left and right turning radii should be designed for the yield condition, but still be enlarged to accommodate the largest vehicle that would regularly be expected to use the intersection.

7.5 Procedure for Design of an At-Grade Intersection

The following procedures are to be used in designing at-grade intersections.

7.5.1 Assembling Basic Data

A. Traffic Analysis

As the first step in design of an intersection, the Engineer shall request both current and projected traffic volumes. Current counts are available from the LFUCG Division of Traffic Engineering and projected volumes are available from the LFUCG Planning Office. Included in this information will be the design hour volume (DHV) of the turning movements within the intersection for the design year (generally 20 years hence).

If the size of the intersection warrants, the Engineer shall then perform a detailed traffic analysis based on the guidelines contained within the *Highway Capacity Manual*. This analysis will determine the lengths of storage lanes required and the type of traffic control device needed.

Following are general guidelines for the use of left-turn storage lanes on multi-lane and two-lane roads:

1. *Multi-Lane Roads:*

All projects where the median is 16 feet through 24 feet in width, left turn lanes should be designed at the following locations:

- Existing and proposed street and road intersections
- All major traffic generators such as schools, churches, shopping centers, etc.

The geometrics of the storage lane shall be determined by the criteria in AASHTO's *A Policy on Geometric Design of Highways and Streets.*

2. *Two-lane Roads:*

Left storage lanes on two-lane arterial and collector/connector roads should be considered for each of the traffic conditions listed below:

- *Left Turn DHV Less Than 50* - Channelization is not justified with these volumes unless severe sight distance restrictions and unusual traffic conditions are encountered. In the event that the Urban County Government determines that channelization of an intersection with left turn movements in this category is needed; the justifications for the channelization shall be documented along with the estimated construction and right-of-way costs.

- *Left Turn DHV 50-200* - Channelization at intersections with these left turn volumes is desirable in the event that sight distance is restricted by alignment or grade and the construction of such channelization does not involve large quantities of excavation or borrow, bridge widening, or other expensive items. In the event that high costs are involved in the construction of a channelized intersection in this left turn volume category; justifications along with cost estimates shall be documented.

- *Left Turn DHV Over 200* - Channelization should be provided at intersections with these turning volumes unless otherwise approved by the Urban County Engineer.

Before a decision is made to eliminate channelization of an intersection with left turn volumes of more than 50 DHV on the basis of excessive costs; consideration should be given to the volume of traffic opposing the left turn movement. In cases where opposing volume is sufficiently large, a more in-depth study may be warranted. The results of this study could offset, to a certain degree, the high construction cost and justify the channelization of a particular intersection.

B. Site Topography:

Sufficient site data should be collected to obtain the following:

- All topography, which should be plotted on either a 1" = 50' or 1" = 20' scale, depending on the area involved and the site condition requirements

- Profiles on the intersecting roads

- Property ownership

- Sufficient cross-sections or contours for studying right-of-way damages, sight distances, and potential drainage problems

C. Accident Data:

When re-designing an existing intersection, the Engineer shall request accident records from the Division of Police, Traffic. These records very often indicate a specific problem area within an intersection, such as inadequate sight distance, etc., which must be addressed in the re-design.

7.5.2 Preparing Alternate Studies

After assembling the above-described data, the Engineer shall prepare studies of alternate plans for the intersection. The major items that should be included in these studies follow:

A. **Proposed Alignment of the Intersecting Roads**: The Engineer shall carefully study the alignment of any existing intersections to determine if realignment is required. Realignment should definitely be considered if any of the following conditions exist:

- The intersection angle is less than 80°
- Excessive horizontal curvature exists
- Savings in the cost of right-of-way acquisition could be realized by shifting the alignment
- Intersection sight distance is restricted

B. **Proposed Grades of the Intersecting Roads**: The Engineer shall evaluate grades at existing intersections, and consider modifying existing grades if any of the following conditions occur:

- Excessively steep grades exist
- Less than desirable stopping sight distance exists
- Savings in the cost of right-of-way acquisition could be realized by raising or lowering grades

C. **Proposed Road Crossings with Depressed Medians**: In an effort to reduce the sharp breaks in the profile of roads crossing a proposed road with a depressed median, a procedure has been developed as shown in KDOH's *Standard Drawings* Exhibit 10-01. It allows the grade points on the road having the depressed median to be adjusted to reduce the severity of the breaks at the inside edges of pavement. The use of this procedure on initial and ultimate construction projects shall be decided on a case-by-case basis at the preliminary line and grade inspection.

D. **Channelization Details**: Each intersection must be evaluated to determine the need for channelization. Any of the following conditions may warrant channelizing of an intersection:

- High accident frequency
- Dense vehicular traffic
- High-speed vehicular traffic
- Complex intersection
- Wide road

- Difficulty in providing adequate control by standard signs and markings

  Specific warrants cannot be stated. Each location calls for special study.

  When the decision is made to channelize an intersection, the design of traffic islands should be as simple as possible. This is to avoid confusing traffic. Each island should have a definite purpose and there should be as few as possible. The Urban County Government's policy is to normally provide only flush islands. Exceptions to this policy may be made in cases where the island is large and may be utilized to shield pedestrians or where placement of special signing or poles may be required. When a decision is made to utilize a raised island, the matter should be discussed at an inspection. Documentation is to be provided as part of the inspection report. If all parties agree that the raised island is acceptable, the island should be designed as a mountable island.

E. **Maintenance of Traffic during Construction**: The Engineer shall develop a plan for maintaining traffic during construction for each alternate studied. This plan shall be developed sufficiently to detail traffic lanes that are to be maintained, a general sequence of construction phasing, and any detours or temporary pavement widening which will be required.

F. **Right-of-Way Widths**: The Engineer shall exercise great care in the establishment of vertical and horizontal alignments in order to minimize right-of-way damages. In commercially developed areas, right-of-way widths shall be held to a minimum and construction easements utilized where practicable. The Engineer shall make provisions for the replacement of existing entrances, curbs, sidewalks, etc., where possible, in order to minimize damages.

G. **Proposed Drainage**: The type of proposed drainage system (storm sewer or open ditch) to be utilized shall be determined. A preliminary size and location shall be specified for all drainage structures larger than a 36” diameter pipe culvert. A careful evaluation shall be made of the effects that proposed realignments and/or grade changes would have on drainage of the intersection. Refer to the Urban County Government’s *Stormwater Manual* for additional information.

H. **Evaluation of Major Utility Relocations**: All major existing utilities such as water lines, gas lines, sanitary sewers, underground telephone cables, and overhead electric transmission facilities shall be shown on the plans. In many cases, it may be necessary to alter the alignment and/or grade in order to avoid relocation of major utilities.

I. **Pedestrian Facilities**: The Engineer shall make a determination of the need for pedestrian facilities such as sidewalks, wheelchair ramps and, in some cases, pedestrian overpass structures.

7.5.3 Obtaining Cost Estimates

After alternate plans for the intersection have been studied, the Engineer shall select the most feasible alternates and obtain estimated costs for right-of-way acquisition, utility relocation, and construction for each.

7.5.4 Submitting the Recommended Alternate to the Urban County Government

Signalized intersections, intersections signalized for pedestrians, channelized intersections and intersections on urban projects shall be submitted to the LFUCG Division of Traffic Engineering for approval. Submittals shall be after preliminary line and grade and prior to final plans-in-hand inspection. Some intersections (interchanges or complicated intersections) will require a separate geometric layout sheet that should include an approval signature block. Urban projects with multiple intersections may be submitted with a cover letter that includes a listing of the intersections by either name or centerline station and the approval signature block with a copy of the plan and profile sheets of all intersections listed.

The Engineer shall select the preferred alternate for submittal to the Urban County Government Division of Traffic Engineering. In cases where there is no clear-cut preferred alternate, it may be necessary to submit several alternates for consideration.

The following data shall be submitted for each plan:

- Plan sheets or sheets detailing channelization, right-of-way widths, drainage, curbs, utilities, etc.
- Profiles
- Traffic Analysis
- Cost Estimates
- A report detailing other plans studied and the reasons they were not adopted
- A polyester film copy of the geometric layout sheet of the intersection with a block for the signatures of the Urban County Engineer and Division of Traffic Engineering

After Urban County Government approval, the Engineer shall incorporate the approved design into the final plans and include the approved and signed layout detail sheet.

7.6 At-Grade Intersection and Access Spacing Requirements

The following guidelines shall be the basis for the determination of proper spacing for street intersections and driveway access. It is recognized that these guidelines will not be able to be adhered to in all cases, especially in areas where existing development is present. The LFUCG Planning Commission shall attempt in all cases, however, to apply these guidelines to the greatest extent feasible in order to create safe and efficient traffic movement systems.

7.6.1 Spacing Measurement Definition

Distance shall be defined as the distance between the centerlines of intersecting streets and roads. However, in the case of an interchange, distances shall be measured from the centerline of any intersecting road to the closest near edge (projected) of the ramp road or in the case of a free flow ramp terminal to the gore of the nearest ramp.

7.6.2 Access Standards by Functional Classification

A. **Expressways**. Expressways shall have intersections with arterials and/or other expressways. There shall be no intersections with lower type facilities. All intersections shall be of the grade-separation interchange type. The spacing of interchanges on expressways within the Urban County shall be determined jointly by the Lexington-Fayette Urban County Government and the Kentucky Department of Transportation.

B. **Principal Arterials**. Principal arterials shall have intersections with expressways, other principal arterials, minor arterials, and collector/connector streets. Intersections shall be signalized as warranted. Any access to a principal arterial must be located at a minimum of 1,600 feet from any other access along that principal arterial (i.e., principal arterials, minor arterials, collectors/connectors, major commercial or industrial driveway accesses). No new residential driveway access shall be allowed on a principal arterial. Protected left and right turn lanes with ample storage space must be provided at all intersections. The Kentucky Department of Transportation shall be consulted when state maintained roads are involved.

C. **Minor Arterial**. Minor arterials shall have intersections with expressways, principal arterials, other minor arterials, and collector/connector streets. Intersections shall be signalized as warranted. No new residential driveway access shall be allowed on a minor arterial. Commercial or industrial driveways shall be treated according to the nonresidential spacing formula. Adequate provisions for left and right turn lanes shall be determined by the Urban County Government, Division of Traffic Engineering, and the Kentucky Department of Transportation for state maintained facilities. The spacing of intersections along a minor arterial shall be as follows:

- Between an intersection with an expressway and an intersection with a principal or minor arterial the distance shall be a minimum of 1600’

- Between an expressway and a collector/connector -- minimum 1400’
- Between one principal or minor arterial and another -- minimum 1400’
- Between a principal or minor arterial and a collector/connector -- minimum 1200’
- Between a collector/connector and another collector/connector -- minimum 1000'

D. **Collector/Connector Streets**. Collector/Connector streets shall have intersections with arterials, collectors/connectors, and locals. Collector/connector streets shall be designed for system continuity and traffic flow. The spacing of intersections along collectors/connectors shall be as follows:

- Between a principal or minor arterial and another, the distance shall be a minimum of 1400'
- Between a principal or minor arterial and a collector/connector -- minimum 1000’
- Between one collector/connector and another -- minimum 800'
- Between one principal or minor arterial and a local -- minimum 500’
- Between a collector/connector and a local -- minimum 400’
- Between a local and another local -- minimum 250’

E. **Local Streets**. Local streets shall have intersections with collectors/connectors and other local streets. Some designs may warrant exceptions. The spacing of intersections on local streets shall be as follows:

- Between one collector/connector and another collector/connector -- minimum 800'
- Between a collector/connector and a local -- minimum 250'
- Between a local and another local -- minimum 250'

CHAPTER 8
DESIGN PROCEDURES

8.1 New Road Construction Requirements

New road construction shall meet the criteria set forth within this manual and must conform to adopted Lexington-Fayette Urban County Government's standards and policies for design and construction.

8.2 Existing Road Improvement Requirements

Existing road improvements shall meet the criteria set forth within this manual, shall conform to the adopted LFUCG standards and policies for design and construction, and shall conform to the initial/ultimate design plans approved when the original road was constructed.

8.3 Preparation of Plans for All Road Construction Projects

8.3.1 Design Computer Programs Available

Various road design programs are available from the Kentucky Department of Highways Division of Information Technology and the Kentucky Division of Highway Design as well as other design programs available from commercial sources. KYCOGO, which deals with coordinate geometry, deed preparation, cross-section plots, templates, earthwork, graphics interfaces, and data collector interfaces, is available through the Division of Information Technology. Software to support Computer Aided Design and Drafting is also available through that office. For information on the availability of all other computer programs relating to highway design, contact the Division of Information Technology. Information can also be accessed through the Department's Internet address http://www.kytc.ky.gov.

8.3.2 Layout Sheet

The layout sheet is the cover or title sheet for the set of plans. The layout sheet shall contain the following information:

- Proper headings (LFUCG, for example)
- Project title
- Construction number
- Sheet number
- Checked by
- Record plans/construction plans box
- Index of sheets and sheets not included
- List and/or check applicable standard drawings and show total standard drawings
- Show total bridge sheets
- Type of work (grade, drain, and surfacing)
- Control of access
- Design criteria
- Location map
- North arrow

- Project limits, begin, and end stations
- Location of bridges
- Equations
- Check breakouts, section lengths and project length
- Scale
- Urban County Engineer's signature
- Consultant seal and signature
- Date

8.3.3 General Notes Sheets

General note sheets shall contain a revised listing of current special notes, special provisions, general notes, and other such items. Special notes unique to the project, whether plan notes or proposal notes, along with traffic notes and utility notes, shall be provided. All special proposal notes shall be prepared as follows:

- The project number and note title shall be on the first sheet of notes or cover sheet
- Sheet number
- Utility Agencies involved

8.3.4 Typical Section Sheets

The typical section to be used on a project is generally determined by the basic geometric criteria for the functional classification of the road. The typical section sheet shows the geometric and pavement details for each project. In addition to geometric and pavement details, the typical section sheet shall show the pay limits of road excavation for solid rock undercut and removal of low bearing soils which shall be utilized in the cross sections. The following information shall also be included:

- Tangent and superelevated sections
- Pavement design
- Undercut and subgrade lines
- Guardrail location

- Note pertaining to slopes outside limits of shoulder

- Edge details (step-outs, keys)

8.3.5 Summary Sheets

Sheets for general summary, pipe drainage summary, right-of-way summary, paving quantities, and paving areas can be used to provide uniformity. All items shall be shown on the general summary.

- LFUCG bid item titles and, if applicable, KDOH bid item codes are required on all summary sheets for all bid items that have been assigned code numbers in the current listing

- Pipe quantities shall be summarized to the nearest foot length

- Vertical elongation of culvert pipe represents an additional cost to the supplier. Therefore, reference notes shall be used to specify when vertical elongation is required, in accordance with current KDOH's Standard Drawings.

- Entrance pipe, perforated pipe and non-perforated pipe shall not be shown by location but by quantities only; however, entrance pipe thirty feet or greater is classified as culvert pipe and shall be shown as such by location with the quantity shown as entrance pipe.

8.3.6 Plan and Profile Sheets

Plan sheets may be either full size with separate profile sheets or the conventional half-plan, half-profile sheets. The first plan sheet shall contain the standard symbols. Each plan sheet shall show the beginning and ending stations for each plan sheet, a north arrow, and station equations for main line and approach intersections. Lengths of proposed structures shall be shown. The direction of centerline stationing shall run from south to north and from west to east. The alignment shall be a heavy line with the centerline stationing shown at 100-foot intervals. All P.I.'s, P.O.S.T.'s, P.O.T.'s, and triangulation points shall be shown by stationing vertically. Each tangent shall have its calculated bearing shown and all curve data must be shown. The P.C., P.T., T.S., S.C., C.S., and S.T. must be drawn with the station number shown on a line drawn perpendicular to the point. Curve data shall be shown for all simple and spiral curves consisting of the following:

- *Simple Curves*

  P.I. Station
  Δ = Delta Angle
  T = Tangent Distance
  L = Length of Curve

R = Radius of Curve
E = External Distance
e = Rate of Superelevation
Runoff = Runoff Distance
Runout = Runout Distance

- *Spiral Curves*

P.I. Station
Δ = Delta Angle
Ts - Tangent Distance Spiral Curve
Ls = Length of Spiral Curve
Lc = Length of Simple Curve
Os = Spiral Angle
LT = Long Tangent Spiral Curve
ST = Short Tangent Spiral Curve
R = Radius of Simple Curve
Es = External Distance Combination of Simple and Spiral Curve
e = Rate of Superelevation
Runoff = Runoff Distance
Runout = Runout Distance

Plan sheets shall show as a minimum the following information:

- Sheet numbers
- North arrow
- Scale
- Topographic information
- Vertical controls and origin of levels
- Horizontal control
- Curve data
- Centerline and stationing
- Intersection stations
- Curb lines, gutter lines, and right-of-way lines
- Sidewalks and/or bicycle paths

- Storage lanes and tapers
- Shoulders
- Subdrainage
- Channelization islands
- Pavement markings
- Property lines, easements and ownership, source of title including deed book and plat
- Disturbed limits
- Drainage systems and structures
- Erosion control measures
- Approach roads
- Entrances
- Utilities (existing and proposed)

Profile sheets shall also show proposed structures with construction notes for the location, type, size and skew, surface ditches and description of all benchmarks. The first plan/profile sheet shall indicate the source of elevations used along with a summary of all USGS, USC & GS, and LFUCG markers within the limits of the project, and the earthwork calculations for the entire project, and utility owner (with address).

Profile sheets shall show as a minimum the following information:

- Sheet number
- Vertical curve data, grades, sight distances
- Roadway stationing
- Proposed grade elevations
- Existing profile elevations
- Surface ditching

- Drainage structures
- Utility crossings
- The plans shall extend at least 300 beyond the project limit

8.3.7 Scales

Alignment and topography on plan sheets shall be plotted using a scale of 1 inch = 50 feet in rural areas and urban areas of sparse topography. Urban areas of dense topography shall be at a scale of 1 inch = 20 feet. Profile sheets shall be plotted on the same horizontal scale as the plan and the ratio of the vertical scale to the horizontal scale shall be 1:10. Groundline and gradeline elevations shall be shown at 50-foot intervals.

Detour plan and profile shall be included and numbered with the plan and profile sheets.

8.3.8 Utility Plans

Utility plans are required for each project if any utilities are involved. Utility plans may be either separate plans for utilities or construction plan sheets showing utilities, depending upon the complexity of the project and the number of utilities involved. The Engineer is referred to KDOH's *Utilities Guidance Manual* for specific procedures to be followed and for the consideration that shall be given to the effect of utility installations with regard to safety, aesthetics, operational characteristics of the highway and cost of utility construction and maintenance. The Engineer shall coordinate with the LFUCG Division of Engineering to assure compliance with all applicable local, state, and federal permits and regulations.

8.3.9 Detail Sheets

Detail sheets shall consist of all other sheets not classified in the layout sheet's index of sheets and include special drawings, standard drawings not yet in the *Standard Drawings Manual*, elevation development sheets, interchange and intersection layout sheets and contour grading plans.

8.3.10 Reference Sheets

Reference points may be plotted on the plan sheets if they are few and the plan sheets are not crowded. Otherwise, all reference points shall be plotted on a separate sheet containing only reference points.

8.3.11 Soil Profile Sheets

Soil profiles on 1" = 100' horizontal and 1" = 10' vertical scales shall be required for all functional classifications of roads. The soil profile is for the use of the Engineer in establishing cut and fill slopes, CBR for pavement design, cut and embankment stability sections, rock refill, and shrinkage and swell factors. Refer to Urban County Government's *Geotechnical Manual* for additional requirements.

8.3.12 Pipe Drainage Sheets

All inlets, manholes, pipes, and culverts with the exception of entrance pipe and longitudinal pipe shall be plotted on standard cross-section sheets with slope lengths and sizes shown. Pertinent data such as discharge, high-water elevations, and material quantities shall be shown. Refer to Urban County Government's *Stormwater Manual* for additional requirements.

8.3.13 Cross-section Sheets

Cross-sections grading plans can be used. A scale of either 1" = 10' or 1" = 5' shall be used on urban arterial, collector, and local roads. Templates, end areas, grade elevations, volumes, and sheet totals shall be shown. If cross-sections have been developed from aerial photography, the general notes sheet and first cross-section sheet shall carry the following note: "Cross-sections for this project developed from aerial photography."

8.4 Initial / Ultimate Design Plans

Some projects are designed with a geometric design typical section calling for two-lane initial and four-lane ultimate construction. In these cases:

- Centerline and grade shall be established to fit both initial and ultimate construction and to insure a symmetrical median and conformity to superelevation.
- Initial and ultimate construction shall be shown using solid and broken lines for all drainage, structures, special detail sheets, and cross-section templates.
- Construction notes, quantities, earthwork distribution, and general summary shall be for initial construction only.
- Disturbance limits shall be shown for initial construction; however, the outside limits for ultimate construction must be determined and shall be shown for right-of-way determination.

Right-of-way acquisition and utility relocation, if necessary, shall be for ultimate construction.

8.4.1 Roadway Plan Review by the Engineer

The primary function of this section is the final review, checking, correcting, and updating of road plans to current standards and specifications immediately prior to letting of projects to contract. This requires gathering and coordinating of all the information needed for preparing bid proposals, including the plans, quantities, standard drawings, special provisions, and notes. It also requires requesting and incorporating input and recommendations from the Division of Engineering.

The following checklist outlines the items that are checked during the review process:

A. General Summary

- Check all quantities, bid items, and units (use Item Code Index).
- Check to be sure that Specifications, Standard Drawings, or Detail Sheets cover all bid items.
- Make sure breakouts are correct and agree with those shown on the Layout Sheet for project lengths.
- Include Erosion Control item(s).

- After summary has been inked in its final form, call all quantities back to the work sheets in the project folder, and make a final check of addition, project sub-totals, and totals.

- Make sure all applicable reference notes are shown.

- Paving Areas Summary

- Compute paving areas from Plan and Profile and applicable detail sheets.

- Check earthwork areas.

- Check to see that all culvert pipe shown is in agreement with Pipe Sheets. Check for Flood Evaluation Data.

- Check construction notes for general items such as guardrail, perforated pipe, removal items, etc.

- Be sure control of access points are shown.

B. Detail Sheet

- Check for any other special drawings that may be required (construction items not covered by Standard Drawings).

C. Soil Profile Sheets

- Check to ensure that the Geotechnical Engineering recommendations have been incorporated into the plans.

- Be sure Classification Note is shown on first sheet.

D. Pipe Sheets

- Pipe alternates

- Classes and schedules of pipe

- Pipe lengths (scaled)

- Concrete and steel reinforcement quantities for headwalls

E. Cross Section Sheets

- When applicable, cross-section sheet shall carry the following note: "Cross-sections for this project developed from aerial photography."

8.5 Right of Way

Sufficient right-of-way should be acquired in order to avoid the expense of purchasing developed property or the removal of other physical encroachments from the highway right-of-way. A wide section of right-of-way must be given careful consideration for a balanced design. The selection of a width based on minimum or desirable dimensions is typically established with respect to facility type and surround conditions.

8.6 Easements

Construction Easements - Whenever a proposed subdivision affects an existing or proposed road in such a way that will necessitate cuts and fills in adjoining property, construction easements on such adjoining property shall be required.

CHAPTER 9
PLANNING APPROVAL/DISAPPROVAL PROCEDURES AND DESIGN SUBMITTAL CHECKLIST

9.1 Introduction

The planning approval/disapproval procedures to be followed in the design of new roads for Lexington follow the Articles of the Lexington-Fayette County Land Subdivision Regulations. The primary objective of all subdivision design projects in to provide maximum livability. Transportation considerations, including the physical layout and the geometric design standards, are influenced by four overall factors: (a) safety, for motorized vehicles, bicycles, and pedestrians; (b) efficiency of service; (c) livability of amenities; and (d) economy--of land use and construction/maintenance costs.

9.2 Traffic/Roadway Elements to be Included in Improvement Plans

In designing new roads and applying for plan approval, the Engineer shall ensure that the items in the following checklist are included in the Improvement Plans.

1. General Requirements

a. Street names are in compliance with the LFUCG's street-naming standard and shall not be the same (or close in spelling or phonetics) to the name of an existing street in Fayette County.

b. Street numbers are to be assigned to each lot by the LFUCG, in order to provide a separate and distinct address for each lot.

2. Existing Conditions:

a. All contiguous land owned by the contractor to be included in the plat drawing

b. Include existing structures

c. Include building setbacks to property lines

d. Include public streets and right-of-ways on and adjacent to the property, including curbs, sidewalks, driveways, and other pedestrian/bicycle paths

e. Ground elevations at appropriate contour intervals on the property and on adjacent property within 100 feet of the property

f. Easements of record, indicating location, width, and purpose

g. Utilities on and adjacent to the property

h. Wooded areas, wooded fencerows, and isolated trees greater than 1 foot in diameter (showing full tree canopy size on drawing, not merely trunk location)

i. Grasslands, marshes, and wetlands

j. Water courses, ponds, or other water features

k. Walls, rock outcroppings, mounds, and historic features

3. Grading, Drainage Plan, and Erosion Control Plan

a. Existing and proposed contours at appropriate intervals

b. Retaining walls

c. Estimated volume of soil proposed to be moved, removed, and/or imported

d. Cut and fill plan showing depth of cuts or fills, in appropriate intervals and a cross section showing existing and proposed ground elevations

4. Street Easements, Lot Lines, and Utility Easements

a. Show all proposed public streets and alleys. For street and alley right-of-ways, show the names, bearing angles, angles of intersection, and width

b. For arc shaped streets, show the length, radii, points of curvature, and tangent bearings

c. For lot lines, show dimensions in feet and hundredths, and bearing and angles to minutes if other than right angles to the street lines

d. All easements are to be shown and clearly labeled as to their width and purpose

e. All of the following existing and proposed utility information is to be included: water mains, fire hydrants, valves, storm sewers, sanitary sewers, catch basins/sediment traps, gas lines, electric lines, and cable television lines, and telephone lines; as appropriate, these lines need to show pipe size and type, invert elevations, manhole elevations, and catch basin elevations

5. Street Profiles and Cross Sections

a. Plan and profile of each proposed street

b. Existing and proposed ground and street grade surface on the tract and 300 feet beyond the tract

c. Centerlines and elevations at all grade change points, vertical curves and grades

d. Standard and any special cross-sections

e. Use same horizontal scale as for the approved preliminary plan

f. Use a vertical scale of 1/10 of the horizontal scale

6. Street Geometrics

a. Conform to geometric design standards?

b. Conform to cross-section design standards?

c. Conform to sight triangle and minimum sight distance requirements?

d. Local streets conform to a geometric design standard that discourages high-speed use by its very design and not by relying solely on signage?

7. Street Continuity

a. Streets are designed in a manner that is overall continuous in nature?

b. Collector/Connector streets conform to an interconnected design standard by connect to existing Collector/Connector or arterial roads?

c. Street design conforms to the “no land-locking” standard for any tract of land? (If an access easement is indicated on the plan, is this truly THE ONLY practical design alternative for the given property?)

8. Street Names

a. Streets in obvious alignment with existing streets bearing same name?

b. New streets do not duplicate existing street names?

9. Planning for Conflicting Traffic or Land Use

a. Streets are designed in a manner to minimize negative impacts from neighboring and conflicting land uses?

10. Half Streets and Reserve Strips

a. Street design conforms to rules against the use of half streets and reserve strips?

b. All temporary stub streets include a temporary cul-de-sac design?

11. Cul-De-Sacs

a. All Cul-de-sacs are designed to a length no longer than one thousand (1000) feet?

b. All Cul-de-sacs are designed with proper bulb geometrics?

c. Use of Cul-de-sacs in the design is not excessive?

12. Medians

a. Medians meet geometric design standards for the road type on which they are being used?

b. Provisions for maintenance of median areas, and their associated landscaping and plantings, are provided for in subdivision plan?

c. Landscaping and plantings are of a nature that they will not conflict with road sight distances?

13. Pedestrian Walkways

a. Sidewalk design requirements are met?

b. Alternative pathways, including mid-block pedestrian cut-throughs, bicycle/multi-use paths, and bicycle lanes on road are provided--as appropriate or desired?

14. Private Streets (If Applicable)

a. All private streets in the plan meet all LFUCG special requirements for this street classification?

15. Street Pavement Design

a. Grades and embankments are appropriate to the site?

b. If excavation is required, plan sufficiently meets LFUCG regulations?

c. Subgrade and granular base preparation for the road are appropriate for both the site and the proposed street design and meet applicable standards?

d. Base course design is appropriate for both the site and the proposed street design and meet applicable standards?

e. Surface course (paving) design is appropriate for both the site and the proposed street design and meet applicable standards?

f. Proper street crown is incorporated into road design?

g. Proper curb and gutter design are included in the roadway design?

16. Intersections and Access Standards

a. Intersections are designed to conform to LFUCG standards?

b. Both access by road classification and access spacing protocols are followed?

17. Landscaping

a. Landscape planning protocols have been followed?

18. Stamping of Drawings

a. Documents are appropriately stamped by a Kentucky licensed professional engineer?

CHAPTER 10
ROADWAY CONSTRUCTION SPECIFICATIONS

10.1 General

All roads in Fayette County shall be constructed in accordance with the following sections of the Kentucky Transportation Cabinet's (KTC) Standard Specifications for Road and Bridge Construction. Items not covered by the KTC specifications shall require a special design by the Engineer and shall be approved by the Division of Engineering.

Embankment – Division 200

Excavation – Division 200

Subgrade – Division 200

Dense Graded Aggregate – Division 300

Bituminous Concrete – Division 400

Concrete Paving – Division 500

Chemical Stabilization – Division 200

10.2 Subgrade

The subgrade shall be free from ruts, large stones, and excessive dust. The subgrade shall be subjected to a subgrade proof-roll test so that soft, wet, or pumping areas may be identified. The minimum total weight of the loaded dump truck shall be 37 tons. The truck shall be operated at walking speed over the entire subgrade. Any excessive deflections such as rutting or pumping shall be stabilized as directed by the Engineer.

Typical treatments of soft or wet areas of the pavement subgrade include removal and replacement (undercutting), "working-in" No. 2 stone, or installation of a geogrid/geotextile system and crushed stone. The extent and performance requirements of such improvements shall be set forth in the Contract Documents or as directed by the Engineer. Other means to stabilize the subgrade, such as lime stabilization or cement modification as described in KTC Section 304, may be necessary.

The pavement subgrade shall be compacted to a uniform density throughout according to the requirements of the Contract Documents. If the density of the subgrade has been diminished by exposure to weather, after having been previously compacted, it shall be recompacted to the required density and moisture content.

Subgrade drainage systems or perforated pipe underdrains shall be installed in accordance with LFUCG Standard Drawings where indicated on the Improvement Plans.

10.3 Granular Base Course

The granular base course shall consist of compacted dense-graded aggregate (DGA) meeting the requirements set forth in Kentucky Transportation Cabinet's (KTC) Standard Specifications for Road and Bridge Construction. The Contractor shall submit to the Engineer the results of physical tests performed on the material to verify that it meets the requirements referenced above.

The DGA shall be applied in thicknesses of no less than 3 inches and no more than 6 inches in thickness. Each lift of DGA shall be compacted to a density no less than 84 percent of the solid volume density based on the oven-dry bulk specific gravity as determined by KM 64-607. A field density test of the DGA placement shall be conducted. The tests shall be conducted at a frequency of one test per 2,000 square feet with a minimum of one test per shift during which DGA is placed. The DGA shall be compacted using a vibratory roller or vibratory plate. The DGA shall be placed to achieve a moisture content less than 5%, and shall be stable with no rutting or pumping.

Before arriving at the site, the DGA shall be adequately mixed with water in a pugmill. During transportation and storage on site, the DGA shall be covered to prevent loss of moisture. If drying of the DGA occurs, the Contractor shall add water to the DGA and shall thoroughly mix the material before its placement.

10.4 Asphalt Base and Surface Courses

The materials and methods for construction for the asphalt base course and surface course shall meet the requirement of Kentucky Transportation Cabinet's (KTC) Standard Specifications for Road and Bridge Construction. The Contractor shall submit test results of the aggregate gradation and asphalt content to the Engineer.

The pavement course thicknesses and construction tolerances shall be specified in the Contract Documents. The surface of each course shall be checked with templates, straightedges, and/or stringlines for uniformity. All irregularities exceeding the allowable tolerances must be repaired as required by the Contract Documents or as directed by the Engineer.

10.5 Tack Coat

The tack coat shall be type SS-1h. Before applying the tack coat, the area to receive pavement shall be cleaned. The tack coat shall be applied well in advance of the paving operation to allow all water to evaporate before the surface course is placed. Work shall be planned so that no more tack coat than is necessary for the day's operation is placed on the surface.