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HIGHWAY DESIGN	*Chapter* GEOMETRIC DESIGN GUIDELINES
	Subject Introduction

HD-701.1 INTENT OF USE

This chapter includes geometric design guidelines that the Transportation Cabinet commonly uses. Unless otherwise indicated, these guidelines are not intended to be mandatory. They are to provide guidance in safety, operational efficiency, convenience, and environmental quality. The American Association of State Highway and Transportation Officials (AASHTO)'s *A Policy on Geometric Design of Highways and Streets* and engineering judgment are to be used in the design process. This chapter is not to supersede the application of sound engineering principles by experienced design professionals.

An emphasis on the involvement of the public and local communities in our decision-making process has increased. Situations that require increased flexibility in the design process will arise. Goals of the local community, such as environmental quality, aesthetics, and historic preservation, as well as goals of the Cabinet, need to be addressed.

HD-701.2 CHAPTER TOPICS

This chapter contains information on:

- Primary design elements
- General design considerations
- Design exception process
- Design guidance for truck-climbing lanes and emergency escape ramps
- Kentucky Common Geometric Practices sheets (**Exhibits 700-01** through **700-04**)
- Example typical sheets (**Exhibits 700-05** through **700-08**)

HIGHWAY DESIGN	*Chapter* GEOMETRIC DESIGN GUIDELINES
	Subject Primary Design Elements

HD-702.1 OVERVIEW

Contained within this section are several elements typically used in highway design, including basic number of lanes, sight distance, horizontal alignment, superelevations, vertical alignment, and cross-section. Each of these elements is important in the development of a highway design project and is further explained in the American Association of State Highway and Transportation Officials (AASHTO)'s *A Policy on Geometric Design of Highways and Streets*.

HD-702.2 NUMBER OF LANES

The basic number of lanes is the number of designated and maintained lanes over the whole of a highway route or over a significant length of it, irrespective of the changes in traffic volume and requirements of lane balance. It is the constant number of lanes assigned to a route, exclusive of auxiliary lanes.

Additional lanes may be utilized on any given segment of highway based upon analyses such as volume/capacity ratios (V/C). The addition and termination of lanes should be predicated on capacity or lane balance principles.

HD-702.3 SIGHT DISTANCE

Sight distance is the length of highway that is visible ahead of the driver. In highway design, there are four types of sight distance.

Chapter 3 of *A Policy on Geometric Design of Highways and Streets* shows methods for computing these four distances:

- **Stopping Sight Distance:** This is the distance required for a vehicle traveling at or near the design speed to stop safely. It is the sum of brake reaction time and braking distance. In computing and measuring stopping sight distance, the height of the driver's eye is estimated to be 3.5 feet and the object height 2 feet.

- **Decision Sight Distance:** There are cases when stopping sight distance is not sufficient for the driver to avoid unforeseen or unusual occurrences. Typical examples of such occurrences are lane drops, areas of high traffic concentration, and traffic control devices. Under these circumstances, it is recommended that the designer consider decision sight distance. This is the distance required for the driver to detect an unexpected or unusual occurrence, recognize it as a hazard, and initiate and complete a maneuver that will allow the driver to safely and efficiently avoid the hazard. Decision sight distance is based on the same criteria of driver's eye height and object height as stopping sight distance.

- **Passing Sight Distance:** As defined by the *Highway Capacity Manual* (HCM), passing sight distance is the length of highway required to complete normal passing maneuvers in which the passing driver can determine that there are no potentially conflicting vehicles ahead before beginning the maneuver. This is the distance required for a vehicle to safely and successfully pass another vehicle, typically on a two-lane highway. Adequate horizontal and vertical passing sight distances are to be provided frequently. For computing and measuring passing sight distance, the height of the driver's eye is estimated to be 3.5 feet; and the object height, which is based on average vehicle height, is also 3.5 feet.

  Another definition of passing sight distance relates to the level of service and design capacity concepts. Reference to the *Highway Capacity Manual* **(HCM)** may be made for a complete discussion of passing sight distance.

- **Intersection Sight Distance:** This type of sight distance is explored in **HD-900**.

HD-702.4 HORIZONTAL ALIGNMENT

Several components comprise the horizontal alignment design of a highway, including circular curves, tangents, and, in many cases, spiral curves. Considerations such as safety, existing conditions, environmental considerations, economics, and highway classifications influence the horizontal alignment.

HD-702.4.1 Circular Horizontal Curves

Circular curves enable a change in roadway direction. The minimum radius of a curve used for a given design speed is shown in Chapter 3 of *A Policy on Geometric Design of Highways and Streets*. The laws of mechanics that govern vehicle operation on curves, such as friction factors, speed, and the amount of superelevation, help to establish this minimum. The designer is to strive to exceed the minimum radius.

If compound curves are used on the main line, the radius of the flatter curve is not to be more than 1.5 times greater than the radius of the adjacent sharper curve. It is preferable to avoid compound curves.

Horizontal curves in the same direction separated only by a short tangent ("broken-back" curves) and horizontal curves in the opposite direction separated only by a short tangent (reverse curves) should be avoided. Generally, it is preferable to use flatter curves connected by transition curves.

See **HD-900** for information concerning Interchange Ramp Design.

HD-702.4.2 Spiral Transition Curves

In some instances a designer may include a spiral transition curve. A spiral curve is a curve with a variable radius.

Advantages of using spiral curves include:

- Providing a natural path for drivers
- Minimal encroachment on adjoining traffic lanes
- Providing a place to transition superelevation runoff
- Facilitating pavement widening through a curve
- Enhancing the appearance of a highway

On highways with a design speed of 45 mph or greater, spirals are recommended to make the transition from tangent to curve as smooth as possible. As noted in Chapter 3 of AASHTO's *A Policy on Geometric Design of Highways and Streets*, the effect of spiral curve transitions on lateral acceleration is likely to be negligible for larger radii.

HD-702.5 SUPERELEVATION

Maximum rates of superelevation for use on roadways are controlled by the following factors:

- Climate conditions (snow and ice occurrences)
- Terrain (flat, rolling, or mountainous)
- Urban or rural facilities
- Amount of slow-moving traffic

In general, a maximum rate of no greater than 8 percent is to be used on rural roadways due to Kentucky's snow and ice frequencies. A maximum rate between 4 and 6 percent is recommended for use in urban areas, especially on low- speed, high-volume facilities. On low-speed, low-volume facilities superelevation may not be appropriate.

Superelevation tables in Chapter 3 of *A Policy on Geometric Design of Highways and Streets* determine the amount of superelevation to use for a given design speed and radius of curvature. The design engineer is to recommend on a project-by-project basis which values will best suit the conditions of the facility. The accepted method of attaining superelevation may be found by referring to Standard Drawings **RGS-001** and **RGS-002**. Due to the tendency of bridges freezing before roadways, the designer should consider limiting grades and superelevation rates on longer bridges.

Note: Truck-climbing lanes and auxiliary lanes are to be superelevated at the same rate as the adjacent through lanes.

If spiral curves are not used, follow the minimum superelevation runoff lengths are as shown in Chapter 3 of *A Policy on Geometric Design of Highways and Streets*. The transitions between the tangent section and the curve are typically divided as follows:

- Locate 2/3 of runoff length (L) on the tangent section.
- Extend 1/3 of L onto the horizontal curve.
- The point of curvature (P.C.) will be the control for this situation and will apply and applies to both ends of the curve.

When spirals are utilized, the superelevation runoff length (L) may be the same as the length of spiral. Once the spiral runoff length (L) is determined, the tangent runout can be calculated. The runout (R) is the transition from a normal crown section to one in which the outside lane(s) are rotated to a flat section. The formula for this transition length is:

$$\mathbf{R} = \frac{\mathbf{Lc}}{\mathbf{e}}$$

R = Runout length
L = Length of spiral or length of runoff
c = Normal rate of pavement crown (commonly 2 percent)
e = Superelevation rate

Once the roadway is transitioned to this flat section, the template is rotated to full superelevation utilizing the runoff length (L) as the transition length.

Note: The inside lane(s) do not begin to rotate until the outside lane(s) exceed the normal cross-slope of the inside lane(s). At this point, inside and outside lanes rotate together to full superelevation.

After the normal shoulder cross-slope is exceeded, the full width of the inside shoulder is rotated to match the roadway superelevation.

- For shoulder widths less than or equal to 4 feet, the full width of the outside shoulder is rotated to match the roadway superelevation.

- If the shoulder width is greater than four feet, a portion of the outside shoulder (the shoulder on the high side) is not superelevated to match the main line rate. The nonsuperelevated shoulder remains sloped away from the roadway.

- For shoulder widths greater than 4 feet and less than or equal to 6 feet, the nonsuperelevated shoulder width should be 2 feet.

- For shoulder widths greater than 6 feet, the shoulder "break" should occur at the midpoint of the shoulder width. This may not apply to inside shoulders of median sections and multilane facilities.

- For the "roll-over" between superable and nonsuperable shoulder, the algebraic difference in rate of cross-slope is not to exceed 12 percent.

HD-702.6 PAVEMENT WIDENING ON CURVES

Offtracking is common to all vehicle types. When traversing a horizontal curve, the rear wheels of a motor vehicle track inside the front wheels, thereby making it difficult for a driver to hold the vehicle in the center of the lane. These problems become more pronounced when lane widths are narrow and curves are sharp.

A common practice to help offset these conditions is to widen pavement on horizontal curves. Since widening is costly and little is gained from a small amount of widening, a minimum of 2 feet is to be used.

Standard Drawing **RGS-001** and Chapter 3 of *A Policy on Geometric Design of Highways and Streets* are to be used to determine the amount of widening for a particular radius of a curve. When spiral transition curves are used, the widening between the inside and outside edges of pavement is typically divided equally. Widening may be done on the inside edge of the spiral when appropriate. Normally, the widening is to transition over the length of the spiral curve.

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

HD-702.7 SIGHT DISTANCE ON HORIZONTAL CURVES

The sight distance on a horizontal curve is measured along the center line of the curve's inside lane. Objects such as walls, longitudinal barriers, cut slopes, vegetation, or buildings may obstruct the sight distance. When designing the horizontal alignment, the designer should try to obtain adequate sight distance on horizontal curves. In some instances, additional right of way may be required.

For horizontal curves, both passing sight distance and stopping sight distance are to be considered. Passing sight distance is recommended for consideration on tangents and very flat curves only; sight distance restrictions prohibit its consideration on sharper curves. Sight distance for horizontal curves is to be coordinated with the sight distance for vertical curves (**HD 702.9**).

Intersection sight distance for roads with at-grade intersections should also be considered. See **HD-902** and AASHTO's *A Policy on Geometric Design of Highways and Streets* for more information.

HD-702.8 VERTICAL ALIGNMENT

The terrain of the traversed land influences the design of the roadway. Terrain is generally classified into three categories: level, rolling, and mountainous. Like horizontal alignment, vertical alignment consists of tangent sections and curves.

HD-702.8.1 Grades

A Policy on Geometric Design of Highways and Streets suggests a maximum grade based upon the Functional Classification, terrain, and design speed (See **Exhibits 700-01, 700-02, 700-03, and 700-04** for suggested maximum grades.)

Vehicle type expected on the roadway and critical length of grade must also be considered in the design process, as the effect of grade is far more pronounced on truck speeds than on the speeds of passenger cars. In addition to the grade percentage, the length of grade is also very important. Chapter 3 of *A Policy on Geometric Design of Highways and Streets* shows how to determine critical lengths of grade, which are used to indicate the maximum length of a designated upgrade on which a loaded truck can operate without an unreasonable reduction in speed.

The maximum design grade is not, however, the most desirable grade for a roadway. Where feasible, it is recommended that grades be less than the maximum allowable. However, grades less than 500 feet in length and one-way downgrades may be approximately 1 percent steeper than the maximum. Such a grade may be increased by 2 percent if on a low-volume rural highway. Steeper grades may also be used where extremely high construction costs would be encountered to produce flatter grades. Care is to be taken when increasing grade in rural areas because the increase may introduce the need for truck-climbing lanes. The project team is to discuss the use of grades steeper than the maximum, and the PDM is to document the use in the Preliminary Line and Grade meeting minutes and Design Executive Summary.

It is necessary to maintain a minimum grade in order to provide adequate drainage. Level grades may be used on uncurbed, nonsuperelevated roadways as long as there is an adequate crown. It is recommended that curbed roadways maintain a minimum grade of 0.50 percent. A grade of 0.30 percent may be considered if there is a high-type, adequately-crowned pavement.

The maximum suggested grades for entrances 50 feet or greater in length are shown in **Standard Drawing RPM-110**.

HD-702.8.2 Vertical Curves

The introduction of vertical curves affects the transition from one rate of grade to another and usually consists of a parabolic curve. Vertical curves are either the crest or sag type, depending on the positive or negative slopes of the intersecting grades.

HD-702.8.3 Curve Length

A common means to determine the minimum length of curve needed for various design speeds is K, the rate of curvature. K is determined by dividing the length of vertical curve (L) by the algebraic difference (A) in grades (L/A). K is the horizontal distance required to effect a 1 percent change in gradient. Special attention is needed to provide proper pavement drainage near the low point of sag vertical curves and the high point of crest vertical curves. When the *K* value of 167 feet per percent grade or greater is used, pavement drainage should be more carefully designed.

After K is found, the minimum length of vertical curve (L) can be calculated by using information in Chapter 3 of *A Policy on Geometric Design of Highways and Streets.* Suggested lengths of vertical curve for a given design speed are based on sight distance for crest vertical curves and on headlight sight distance for sag vertical curves.

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

HD-702.9 SIGHT DISTANCE ON VERTICAL CURVES

The design of both crest and sag vertical curves are dependent on stopping sight distance calculations:

- **Crest Vertical Curves:** The stopping sight distance is based on the height of eye of 3.5 feet and the height of object of 2 feet.

- **Sag Vertical Curves:** The stopping sight distance is based on a 2-foot headlight height and a 1-degree angle of light spread upward from the headlight beam.

The stopping sight distance values for various design speeds listed in Chapter 3 of *A Policy on Geometric Design of Highways and Streets* are to be considered minimum values.

HD-702.10 TYPICAL CROSS SECTIONS

To determine the typical cross-section for a given highway, designers are to use five basic design controls:

- Functional classification
- Area (rural or urban)
- Volume of traffic
- Design speed
- Overall project context

The Common Geometric Practices (**Exhibits 700-01** through **700-04** of this manual) along with AASHTO's *A Policy on Geometric Design of Highways and Streets* should be used to determine the typical section. **Exhibits 700-05** through **700-08** show example typical sections.

Typical section items include, but are not limited to, the following:

- Traveled way width and slope
- Shoulder width and slope
- Barrier placement
- Curb placement
- Typical slopes in cuts and fills
- Medians
- Bicycle/Pedestrian Facilities (see **HD-1500)**

HD-702.10.1 Traveled Way Width and Slope

Traveled ways located in tangent sections usually have a crown or high point located in the center and a cross-slope down to the edges of pavement. Divided multilane highways may be crowned separately as a two-lane highway, or they may have a unidirectional cross-slope across the entire width of the traveled way. The rate of pavement cross-slope is important. Steep slopes minimize ponding of water, but they may be uncomfortable to the driver. The recommended normal pavement cross-slope is 2 percent. Refer to Chapter 4 of AASHTO's *A Policy on Geometric Design of Highways and Streets* for additional information.

Lane widths affect the comfort and safety of driving. The Common Geometric Practices (Exhibits 700-01 through 700-04 of this manual) along with AASHTO's *A Policy on Geometric Design of Highways and Streets* should be used to determine lane width.

It may not be practical to design lane widths of Local and Collector roads and streets that have < 400 ADT utilizing the same criteria that is applicable to higher volume roads. For these very low-volume roadways, it is recommended to refer to AASHTO's *Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400 ADT)*.

HD-702.10.2 Shoulder Width and Slope

A shoulder is the portion of the roadway contiguous to the travel way that serves purposes such as accommodation of stopped vehicles, emergency use, lateral support of the pavement, increased horizontal sight distance, and in certain situations, accommodation of bicycle traffic.

KYTC definitions of the various shoulder components are as follows:

- **Usable Shoulder:** The width available for vehicles to pull off the roadway.

- **Graded Shoulder:** Distance from the edge of the travel lane to the normal slope break. Typically this distance is the usable shoulder plus 2 feet when barriers are not present.

- **Paved Shoulder:** The width of the shoulder paving. This distance may be any portion of the usable shoulder up to the face of the barrier (if present) or to within 2 feet (1 foot minimum) of the normal slope break.

As part of the Typical Section development for a project, the Designer, along with help from the project team, must decide on the Minimum Usable Shoulder Width desired for the project based upon the Functional Classification of the facility, the design speed, the volume of traffic and the composition of the traffic. Various guidance is available to assist in the determination of the Usable Shoulder Width for a particular project, including AASHTO's *A Policy on the Geometric Design of Highways and Streets*, current edition; *Roadside Design Guide*, current edition; *A Guide for Achieving Flexibility in Highway Design*, Section 3.6.2", 2004; *Guidelines* *for Geometric Design of Very Low-Volume Local Roads (ADT 400)*, current edition; *A Policy on Design Standards Interstate System*, current edition; and, the *KYTC Highway Design Manual*, current edition.

HD-702.10.3 Barrier Placement

Once the minimum usable shoulder width is established and it is determined that guardrail is needed, the graded shoulder is the usable shoulder plus 3 feet, with the face of the barrier located at the edge of the usable shoulder. Under normal circumstances, the graded shoulder should not be wider than 13 feet when barrier is present.

Typically on interstate highways with a 4-lane section, the minimum usable shoulder width shall be paved and shall measure not less than 4 feet on the left side and not less than 10 feet on the right side. On sections with 6 or more lanes, a 10-foot paved usable left shoulder should be provided. Where truck traffic exceeds 250 DDHV, a paved (usable) width of 12 feet should be considered.

The usable shoulder on an interchange ramp shall be paved with no less than 4 feet paved on the left side and no less than 6 feet paved on the right side. Where guardrail is utilized on a ramp, the graded shoulder should be 3 feet greater than the usable shoulder.

HD-702.10.4 Curb Placement

Curbs are often used on low-speed urban highways. On such highways it is preferable to offset the curb 1 to 2 feet from the edge of traveled way. If curbs are used on high-speed rural highways, they are to be located outside the edge of the usable shoulder. It is recommended that curbs utilized along the outside edge of the usable shoulder of a high-speed facility be of the mountable type and be limited to a 4-inch height. This design is especially important if the curb is being used in conjunction with other types of traffic barriers.

HD-702.10.5 Typical Slopes in Cuts and Fills

Ditches and embankment slopes are not geometric design elements, therefore they are not subject to the design exception process. Roadside ditches are to be evaluated on the basis of their ability to function hydraulically. The choices of fill slopes and ditch configurations must consider the effects on roadside safety. The AASHTO *Roadside Design Guide* defines 4:1 slopes as recoverable, 3:1 slopes as non-recoverable, and steeper than 3:1 slopes as critical. Flatter fill slopes are desirable whenever practical. The effect of slope combinations on the potential trajectories of vehicles that run off the road is also an important consideration of designing the roadside. **HD-800** and AASHTO*'s Roadside Design Guide* provide additional information.

The PDM in consultation with the geotechnical branch is to determine the level of geotechnical investigation required. Typically this varies from advisory to full-scale geotechnical analysis. Generally, when embankments are to be constructed over existing ground slopes of 15 percent or greater, embankment foundation and/or transverse (profile) benches are to be constructed in the existing slopes. The Transportation Cabinet's ***Standard Drawings Manual*** provides specific details. Ditch benching and overburden and/or weathered zone benching details are outlined in the Transportation Cabinet's ***Geotechnical Manual**.*

HD-702.10.6 Medians

A median is the portion of a highway separating opposing directions of travel. The median width is the dimension between the edges of the traveled way and includes any left, inside shoulders. It has been demonstrated that there is a benefit derived from any type of traffic separation on multilane facilities. Wider medians are desirable at rural, unsignalized intersections; however, at urban/suburban signalized intersections, medians wider than 60 feet may lead to inefficient signal operation. Further detailed information on median design can be found in Chapter 4 of AASHTO's *A Policy on Geometric Design of Highways and Streets.*

Below are some of the various functions of medians:

- Separate opposing traffic flow
- Provide a recovery area for out-of-control vehicles
- Provide a stopping area in case of emergencies
- Minimize headlight glare from oncoming vehicles
- Provide width for future turn lanes
- Provide storage for left-turning or crossing vehicles from an approach road
- Open green space (urban areas)
- Refuge for pedestrians (urban areas)
- Control of left-turning/U-turning movements
- Provide area for plowed snow

There are three types of medians: depressed, flush, and raised. The details of the project (environmental, maintenance, right of way, utilities, pedestrians, cost, and other considerations) will affect selection of the median type. Described below are the different types of medians:

- **Depressed Medians:** Depressed medians provide traffic separation, accommodate roadway drainage, facilitate maintenance activities, and provide storage for snow and ice removed from the roadway. Depressed medians are generally utilized in areas where there is sufficient right of way available, the need for constructed median crossovers are relatively few, and the roadway has either partially or fully-controlled access. A depressed median can also be used with partial control facilities where access is fairly limited or is restricted to right turns in and out, with the exception of specific median crossover locations. The median side-slopes and any drainage structures located within the median area should follow the recommendations of AASHTO's *Roadside Design Guide.* Depressed medians should have a minimum width of 36 feet.

- **Flush Medians:** Flush medians provide traffic separation, accommodate traffic movement, facilitate maintenance activities, and provide storage for snow and ice removed from the roadway. Flush medians are generally utilized on urban facilities with widths varying from 4 feet minimum to 16 feet maximum. The median should be sloped to accommodate drainage. (See AASHTO's *A Policy on Geometric Design of Highways and Streets*.) Flush medians should be delineated according to guidance found in the ***Manual on Uniform Traffic Control Devices (MUTCD)***.

  Note: Flush medians and two-way left-turn lanes (TWLTLs) have different functional characteristics and are to be addressed accordingly. The TWLTL operation may be appropriate where the speed on the roadway is relatively low (45 mph or less) and there are no heavy concentrations of left-turning traffic. Desirably, a 12-foot to 14-foot flush median should be utilized for a TWLTL. TWLTLs shall be striped according to guidance found in the *MUTCD*. See **HD 900** for more information on TWLTLs.

  - **Raised Medians:** There are three types of raised medians:

    - **Mountable Medians:** Mountable medians may be utilized to address channelization, aesthetics, or drainage issues. **Standard Drawings** RPM-011, RPM-012, and RPM-015 show specific details of mountable medians.

    - **Nonmountable Medians:** Nonmountable medians (barrier medians) are typically utilized for traffic separation, pedestrian havens, channelization, or access management. Barrier medians typically use curbs to separate the median from the traveled way. Standard Drawing RPM-010 shows details. When used in close proximity to traffic ($\leq$ 2'), barrier medians may create safety concerns at higher speeds (> 45mph) and are to be considered in context with other project design elements and costs.

    - **Median Barriers**: Median barriers typically may be used in high-speed applications to address traffic separation and channelization. Median barriers are detailed in Standard Drawings RBM-001, RBM-003, RBM-006, RBM-050, and RBM-053. AASHTO's *Roadside Design Guide* shows use and placement of median barriers.

HD-702.11 CROSSOVERS

Emergency/maintenance crossovers are breaks in the median to allow emergency and maintenance traffic to cross. To avoid extreme adverse travel for emergency, law-enforcement, and maintenance vehicles, emergency/maintenance crossovers on rural freeways are normally provided where interchange spacing exceeds five miles. Care should be taken in the design of these to ensure they do not present an undue hazard for through traffic. The "Intersection" chapter of AASHTO's "*A Policy on Geometric Design of Highways and Streets"* gives design details.

HD-702.12 BRIDGE WIDTHS

The approach roadway width should be maintained across all new structures. The minimum width of a bridge on a two-lane bidirectional roadway is 22 feet. For roads with ADT≤400, see AASHTO's *Geometric Design Guidelines for Very Low-Volume Local Roads (ADT≤400)*.

The minimum usable shoulder widths should be continued across all new structures. Per AASHTO Guidance, on long bridges in excess of 200 feet where cost per square yard is greater than the cost on short-span structures, widths that are less than ideal may be acceptable; however, economy alone should not be the governing factor in determining structure widths. The structure width should be evaluated based on incremental structure costs. For example, determine how much shoulder can be provided before an additional support beam is necessary. Any exceptions are to be documented in the Design Executive Summary and detailed in the Advanced Situation Folder.

A 4-foot minimum inside shoulder is required across bridges on four-lane divided highways. This requirement means that the inside shoulder on the roadway is to be widened near the bridge end to accommodate barriers (see **Standard Drawing RBB-002**). The width of the outside shoulder on the bridge is to be equal to the distance from the roadway shoulder to the face of the barrier.

Refer to the Transportation Cabinet's ***Bridge Design Manual*** concerning detailed bridge geometric design information.

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HIGHWAY DESIGN	*Chapter* GEOMETRIC DESIGN GUIDELINES *Subject* General Design Considerations

HD-703.1 OVERVIEW

While the criteria differ for each functional classification of roadway, certain factors are always important in the design process. The suggested design criteria for each classification can be found in AASHTO's *A Policy on Geometric Design of Highways and Streets*. Criteria for interstates shall adhere to AASHTO's *A Policy on Design Standards Interstate System*, current edition.

In the early stages of a project, typically after the preliminary line and grade approval, a Design Executive Summary (DES) is submitted that documents the design decisions made on a project. **HD-203** provides specific information on the DES submittal.

HD-703.2 DESIGN CONTROLS AND CRITERIA

For any highway project, the design controls and design criteria establish the minimum values for the primary elements of a particular highway. The following design controls and design criteria are normally considered in the design of a highway:

- Design functional classification (proposed project)
- Area (urban or rural)
- Operational and safety performance, including crash history and type
- Volume of traffic (DHV [design hourly volume], and ADT [average daily traffic], turning movements, percent trucks)
- Design vehicle
- Design speed
- Topography (flat, rolling, or mountainous terrain)

- Highway capacity (See Chapter 2 in AASHTO's *A Policy on Geometric Design of Highways and Streets* and the *Highway Capacity Manual.*)
- Environment
- Other modes of transportation (bicycles, pedestrians, transit, etc.)
- Economic considerations
- Scope, schedule, and budget
- Special considerations such as the length of the project, the condition of roads in the vicinity of the project, and the likelihood of adjoining segments being improved in the foreseeable future

HD-703.3 OTHER FACTORS AFFECTING DESIGN

There are other factors to consider during the design process. The following are suggestions that promote good design practices:

- Do not design horizontal and vertical alignments independent of each other. The coordination of these elements is to begin early in the design process.
- Create alignments consistent with the existing topography and preserving property and community values.
- A flowing line that conforms generally to the natural topography is preferable to one with long tangent sections that cuts through the terrain.
- Attempt to utilize flat curves with radii greater than the suggested minimum values, using the suggested minimum values for the most difficult conditions.
- An alignment is to be as consistent as possible. If possible, avoid introducing sharp curves at the end of long tangents and sudden shifts from flat curvature to sharp curvature.
- Vertical curves that fall within the limits of horizontal curves, or vice versa, generally result in a more pleasant roadway facility.
- Create horizontal and vertical alignments as straight and flat as practical at intersections due to the need to provide appropriate sight distance along both intersecting roadways.

- Do not automatically utilize the minimum suggested values for design elements.

HD-703.4 ROADWAY CLASSIFICATION

The "functional classification" of a roadway is the grouping together of roadways by the type of service they provide based upon land use and type of traffic being generated along a corridor. This classification has been developed as a means of communication within the transportation industry. The determination of a facility's functional classification is one of the first steps in the design process.

Note: Over time, the functional classification of a highway can change depending on the intensity of development and the type of traffic being generated by the development of the corridor. Any changes to the existing functional classification should be documented in the DES.

The basic types of functional classifications are:

- **Rural/Urban Local Roads and Streets:** Local roads and streets have relatively short trip lengths, and because property access is their main function, there is limited need for mobility or high operating speeds. The use of a lower design speed and level of service reflects this function. Local roads and streets are discussed in Chapter 5 of AASHTO's *A Policy on Geometric Design of Highways and Streets.*

- **Rural/Urban Collectors:** Collectors serve a dual function in accommodating shorter trips and feeding arterials. They must also provide some degree of mobility and serve abutting property. Thus, an intermediate design speed and level of service are appropriate. Collectors are discussed in Chapter 6 of AASHTO's *A Policy on Geometric Design of Highways and Streets.*

- **Rural/Urban Arterials:** Arterials provide a high degree of mobility for longer trip lengths. Therefore, they may provide a high operating speed and level of service. Since access to abutting property is not their primary function, some degree of access control is desirable to enhance mobility. Arterials are discussed in Chapter 7 of AASHTO's *A Policy on Geometric Design of Highways and Streets.*

- **Freeways:** A freeway is normally classified as a principal arterial that has unique geometric criteria. Freeways are discussed in Chapter 8 of AASHTO's *A Policy on Geometric Design of Highways and Streets.*

- **Interstate:** The interstate system in the most important highway system in the United States. It carries more traffic per mile than any of the other comparable highway systems. Interstates are designed to provide safety and mobility with fully controlled access. For guidance on interstates refer, to AASHTO's *A Policy on Design Standards Interstate System*, current edition.

The geometric design of very-low-volume local roads presents a unique challenge, as the very low traffic volumes and reduced frequency of crashes make designs normally applied on higher-volume roads less cost-effective. The guidance by AASHTO's *Geometric Design Guidelines for Very Low-Volume Local Roads (ADT≤400)* addresses the unique needs of such roads and the geometric designs appropriate to meet those needs. These guidelines can be considered on low volume roadways.

Chapter 1 of AASHTO's *A Policy on Geometric Design of Highways and Streets* gives a more detailed discussion of roadway classifications.

HD-703.5 DESIGN SPEED

Design speed is a selected speed used to determine the various geometric features of the roadway. The selected design speed should be a logical one with respect to the anticipated operating speed, topography, adjacent land use, and functional classification of the highway. In selecting the design speed, every effort should be made to attain a desired combination of safety, mobility, and efficiency within the constraints of environmental impacts, economics, project scope, aesthetics, and social or political impacts.

The selected design speed should be consistent with the speed that drivers are likely to expect on a given highway facility. See AASHTO's *A Policy on Geometric Design of Highways and Streets* for further discussion of the philosophy of design speed.

Justification for design speeds should be documented in the Design Executive Summary (**HD-704).** This justification should consider all project conditions including maximum service and safety benefits for the dollar invested, compatibility with adjacent sections of the existing roadway, and the probable time before reconstruction of the adjacent sections due to increased traffic demands or changed conditions. When requesting exceptions, include a discussion of safety requirements and the related crash data associated with the site. Mitigation measures should be considered when the design speeds are less than the regulatory or posted speed.

HIGHWAY DESIGN	*Chapter* GEOMETRIC DESIGN GUIDELINES
	Subject Design Exception Process

HD-704.1 USE OF DESIGN EXCEPTION PROCESS

Although the range of values suggested in this design manual and in AASHTO's *A Policy on Geometric Design of Highways and Streets* provide a flexible range of design features, there will be situations in which the use of the minimum suggested criteria would result in unacceptable right-of-way, utility, environmental, historical impacts, and project costs. For these situations, the design exception process is to be utilized to determine and document the reasons or justifications for the exceptions.

HD-704.2 CONTROLLING CRITERIA

The Federal Highway Administration has established 10 controlling criteria. All 10 controlling criteria apply to high speed, $\geq$ 50 MPH, National Highway System (NHS) routes.

- Design speed
- Lane width
- Shoulder width
- Horizontal curve radius
- Superelevation rate;
- Stopping sight distance (SSD), which applies to horizontal and vertical alignment except in the case of sag vertical curves
- Maximum grade
- Cross-slope
- Vertical clearance
- Design loading structural capacity

FHWA only applies two of these criteria to NHS routes with design speeds <50 MPH.

- Design speed
- Design loading structural capacity

KYTC applies these controlling criteria as follows:

- Controlling criteria for high-speed roadways, defined as Interstates, other freeways, and roadways with a design speed $\geq$ 50 mph are:
    - Design speed
    - Lane width
    - Shoulder width
    - Horizontal curve radius
    - Superelevation rate;
    - Stopping sight distance (SSD), which applies to horizontal and vertical alignment except in the case of sag vertical curves
    - Maximum grade
    - Cross-slope
    - Vertical clearance
    - Design loading structural capacity

- Controlling criteria for all other roadways (design speed < 50 mph) are:
    - Design speed
    - Design loading structural capacity

Exhibits 700-01 through 700-04 represent Kentucky Common Geometric Practices. The values in these exhibits are not to be construed as a basis for determining design exceptions. The designer is to refer to AASHTO's *A Policy on Geometric Design of Highways and Streets* and AASHTO's *Geometric Design Guidelines for Very Low-Volume Local Roads (ADT≤400), and* AASHTO's *A Policy on Design Standards Interstate System*.

HD-704.3 EXCEPTION PROCESS

Exceptions to the controlling criteria, as applied above to projects, should be identified early in the design process. Documentation of recommendations and discussions are to be included in meeting or inspection reports. The Project Development Manager (PDM) is to document design exceptions in the Design Executive Summary (DES) when submitted for approval by including a detailed, written discussion of the recommendation and justification for the exceptions. When design exceptions are pursued, mitigation strategies to abate the effect of the exceptions should be considered in the design process.

Note: On Projects of Divisional Interest (PODIs) and Projects of Corporate Interest

(POCIs), design exceptions must be submitted to FHWA. HD-203 provides specific information on the DES submittal and approval procedures.

HD-704.4 VARIANCE PROCESS

Any deviation from the common geometric practices of items that are not part of the controlling criteria should be considered a variance and justified with any mitigation strategies in the DES.

HIGHWAY DESIGN	*Chapter* GEOMETRIC DESIGN GUIDELINES
	Subject Truck-Climbing Lanes & Emergency Escape Ramps

HD-705.1 TRUCK-CLIMBING LANES

Besides being limited to passing sections, heavily loaded vehicles on sufficiently long upgrades adversely affect the safety and operating speed of traffic on two-lane highways. Truck-climbing lanes are commonly included in original construction or added on existing highways as safety- and capacity-improvement projects. AASHTO's *A Policy on Geometric Design of Highways and Streets,* and the *Highway Capacity Manual* contain additional information on truck-climbing lanes.

HD-705.1.1 Warrants for Truck-Climbing Lanes

The following three criteria, reflecting economic considerations, should be satisfied to justify a truck-climbing lane:

1. Upgrade traffic flow rate more than 200 vehicles per hour

2. Upgrade truck flow rate more than 20 vehicles per hour

3. Meet one of the following conditions:
   - Expect a 10-mph or greater speed reduction for a typical heavy truck
   - Ensure that a level of service E or F exists on the grade
   - Experience a reduction of 2 or more levels of service when moving from the approach segment to the grade

Note: Safety considerations alone may justify the addition of a climbing lane regardless of grade or traffic volumes.

The Project Development Manager (PDM) is to consider justification for climbing lanes when exceeding the critical length of grade based on a highway capacity analysis.

HD-705.1.2 Shoulders on Truck-Climbing Lanes

Preferably, the shoulder on the outer edge of a climbing lane should be as wide as the shoulder on the normal 2-lane section, particularly where there is bicycle traffic. When adding the climbing lane to an existing highway and conditions dictate, a usable shoulder width of 4 feet or greater is acceptable.

HD-705.2 EMERGENCY ESCAPE RAMPS

On long descending grades, an emergency escape ramp should be considered. The type of escape ramp is dependent on the existing conditions. See AASHTO'S *A Policy on Geometric Design of Highways and Streets* for further discussion on selection and methods of design.

Factors to be considered in selecting specific sites for an escape ramp on new or existing facilities include:

- Topography
- Length and percent of grade
- Potential speed
- Economics
- Environmental impacts
- Crash experience/data

EXHIBIT 700-01

COMMON GEOMETRIC PRACTICES
RURAL LOCAL ROADS

	TERRAIN	TRAFFIC VOLUME UNDER 50 A.D.T.	50-250 A.D.T.	250-400 A.D.T	400-1500 A.D.T.	1500-2000 A.D.T.	OVER 2000 A.D.T.
MINIMUM DESIGN SPEED (M.P.H.) ⑥ ⑦	LEVEL	30		40	50		
	ROLLING	20	30		40		
	MOUNTAIN	20			30		

	DESIGN SPEED	UNDER 400 A.D.T.	400-1500 A.D.T.	1500-2000 A.D.T.	OVER 2000 A.D.T.
LANE WIDTH (FEET) ④ ⑧	15 MPH	9	10 ⑨	10	11
	20 MPH			11	12 ⑪
	25 MPH				
	30 MPH				
	40 MPH				
	45 MPH	10	11		
	50 MPH				
	55 MPH	11		12 ⑪	
	60 MPH				
MIN. USABLE SHOULDER WIDTH (FEET) ⑤	ALL SPEEDS	2	5⑨⑩	6	8
MIN. CLEAR ROADWAY WIDTH OF NEW AND RECONSTRUCTED BRIDGES	ALL SPEED	TOTAL WIDTH OF LANES +2' (EACH SIDE)	TOTAL WIDTH OF LANES +3' (EACH SIDE)		TOTAL WIDTH OF LANE + USABLE SHOULDER WIDTHS ⑫

	DESIGN SPEED	eMAX. 4%	eMAX. 6%	eMAX. 8%
MINIMUM RADIUS (FEET)	20 MPH	86	81	76
	25 MPH	154	144	134
	30 MPH	250	231	214
	35 MPH	371	340	314
	40 MPH	533	485	444
	45 MPH	711	643	587
	50 MPH	926	833	758
NORMAL PAVEMENT CROSS SLOPES ③	RATE OF CROSS SLOPE = 2%			
NORMAL SHOULDER CROSS SLOPES	EARTH = 8%		PAVED = 4%	

	M.P.H.	20	25	30	35	40	45	50
MAXIMUM GRADE (PERCENT)	LEVEL	8	7					6
	ROLLING	11		10			9	8
	MOUNTAIN	16	15	14		13	12	10
MINIMUM STOPPING SIGHT DISTANCE ①	(FEET)	115	155	200	250	305	360	425
MINIMUM PASSING SIGHT DISTANCE ②	(FEET)	400	450	500	550	600	700	800

① MINIMUM STOPPING SIGHT DISTANCE BASED ON HEIGHT OF EYE OF 3.5 FT AND HEIGHT OF OBJECT OF 2.0 FT. CONSIDER BOTH HORIZONTAL AND VERTICAL ALIGNMENT.
② MINIMUM PASSING SIGHT DISTANCE BASED ON HEIGHT OF EYE OF 3.5 FT AND HEIGHT OF OBJECT OF 3.5 FT. CONSIDER BOTH HORIZONTAL AND VERTICAL ALIGNMENT.
③ NORMAL PAVEMENT CROSS SLOPES ON BRIDGES IS 2%.
④ CONSIDER CURVE WIDENING ON PROJECT WHEN TRUCKS AND/OR HORIZONTAL CURVATURE INDICATE A NEED.
⑤ GRADED SHOULDER = USABLE SHOULDER +2 FT. WIDEN GRADED SHOULDER 1 FT FOR GUARDRAIL.
⑥ WHERE SELECTED DESIGN SPEED IS > 50 MPH, USE COMMON GEOMETRIC PRACTICES EXHIBIT 700-02 FOR RURAL COLLECTOR ROADS.
⑦ JUSTIFICATION FOR THE CHOSEN DESIGN SPEED SHOULD BE DOCUMENTED IN THE DESIGN EXECUTIVE SUMMARY.
⑧ FOR ROADS < 400 ADT, REFER TO AASHTO'S "GEOMETRIC DESIGN GUIDELINES FOR VERY LOW-VOLUME LOCAL ROADS (ADT≤400)".
⑨ FOR ROADS IN MOUNTAINOUS TERRAIN WITH DESIGN VOLUME OF 400 TO 600 VEH/DAY, USE 9 FT LANE WIDTH AND 2 FT SHOULDER WIDTH.
⑩ MAY BE ADJUSTED TO ACHIEVE LANES + USABLE SHOULDER WIDTH OF 30 FT FOR DESIGN SPEEDS > 40 MPH.
⑪ WHERE THE LANE WIDTH IS SHOWN AS 12 FT, THE WIDTH MAY REMAIN AT 11 FT ON RECONSTRUCTED HIGHWAYS WHERE SAFETY RECORDS AND ALIGNMENT ARE SATISFACTORY.
⑫ FOR BRIDGES IN EXCESS OF 100 FT IN LENGTH, THE MINIMUM WIDTH OF LANES + 3 FT (ON EACH SIDE) MAY BE ACCEPTABLE.

EXHIBIT 700-02

COMMON GEOMETRIC PRACTICES
RURAL COLLECTOR ROADS

		TRAFFIC VOLUME		
	TERRAIN	UNDER 400 A.D.T.	400-2000 A.D.T.	OVER 2000 A.D.T.
MINIMUM DESIGN SPEED (M.P.H.) (7)	LEVEL	40	50	60
	ROLLING	30	40	50
	MOUNTAIN	20	30	40

	DESIGN SPEED	UNDER 400 A.D.T.	400-1500 A.D.T.	1500-2000 A.D.T.	OVER 2000 A.D.T.
LANE WIDTH (FEET) (1) (8)	20 MPH	10 (9)	10	11	12
	25 MPH				
	30 MPH				
	35 MPH		11		
	40 MPH				
	45 MPH	10			
	50 MPH				
	55 MPH	11		12	
	60 MPH				
MINIMUM USABLE SHOULDER WIDTH (FEET) (6)	ALL SPEEDS	2	5 (10)	6	8
MIN. CLEAR ROADWAY WIDTH OF NEW AND RECONSTRUCTED BRIDGES	ALL SPEEDS	TOTAL WIDTH OF LANES + 2' (EACH SIDE)	TOTAL WIDTH OF LANES + 3' (EACH SIDE)	TOTAL WIDTH OF LANES + 4' (EACH SIDE)	TOTAL WIDTH OF LANES + USABLE SHOULDER WIDTHS (11)
MINIMUM RADIUS (FEET)	DESIGN SPEED	eMAX. 4%	eMAX. 6%		eMAX. 8%
	20 MPH	86	81		76
	25 MPH	154	144		134
	30 MPH	250	231		214
	35 MPH	371	340		314
	40 MPH	533	485		444
	45 MPH	711	643		587
	50 MPH	926	833		758
	55 MPH	1190	1060		960
	60 MPH	1500	1330		1200
NORMAL PAVEMENT CROSS SLOPES (4)	RATE OF CROSS SLOPE = 2%				
NORMAL SHOULDER CROSS SLOPES	EARTH = 8%			PAVED = 4%	

MAXIMUM GRADE (PERCENT) (5)	M.P.H.	20	25	30	35	40	45	50	55	60
	LEVEL	7						6		5
	ROLLING	10		9		8		7		6
	MOUNTAIN	12	11	10				9		8
MINIMUM STOPPING SIGHT DISTANCE (2)	(FEET)	115	155	200	250	305	360	425	495	570
MINIMUM PASSING SIGHT DISTANCE (3)	(FEET)	400	450	500	550	600	700	800	900	1000

(1) WIDEN PAVEMENT ON CURVES IN ACCORDANCE WITH APPROVED DESIGN STANDARDS. REFER TO CURRENT STANDARD DRAWING FOR ADDITIONAL DETAIL.
(2) MINIMUM STOPPING SIGHT DISTANCE BASED ON HEIGHT OF EYE OF 3.5 FT AND HEIGHT OF OBJECT OF 2.0 FT. CONSIDER BOTH HORIZONTAL AND VERTICAL ALIGNMENT.
(3) MINIMUM PASSING SIGHT DISTANCE BASED ON HEIGHT OF EYE OF 3.5 FT AND HEIGHT OF OBJECT OF 3.5 FT. CONSIDER BOTH HORIZONTAL AND VERTICAL ALIGNMENT.
(4) NORMAL PAVEMENT CROSS SLOPES ON BRIDGES IS 2%.
(5) MAY USE ONE PERCENT STEEPER MAXIMUM GRADES ON SHORT LENGTHS (LESS THAN 500 FT) AND ON ONE-WAY DOWN GRADES; FOR LOW-VOLUME RURAL COLLECTORS, THE MAXIMUM GRADE MAY BE 2% STEEPER.
(6) GRADED SHOULDER = USABLE SHOULDER +2 FT. WIDEN GRADED SHOULDER 1 FT FOR GUARDRAIL.
(7) JUSTIFICATION FOR THE CHOSEN DESIGN SPEED SHOULD BE DOCUMENTED IN THE DESIGN EXECUTIVE SUMMARY.
(8) ON ROADWAYS TO BE RECONSTRUCTED, 11 FT LANES MAY BE RETAINED WHERE SAFETY RECORDS AND ALIGNMENT ARE SATISFACTORY.
(9) 18 FT MINIMUM WIDTH (9 FT LANES) MAY BE USED FOR ROADWAYS WITH DESIGN VOLUMES UNDER 250 A.D.T.
(10) SHOULDER WIDTH MAY BE REDUCED FOR DESIGN SPEEDS GREATER THAN 30 MPH PROVIDED A MINIMUM WIDTH OF LANES + USABLE SHOULDER OF 30 FT IS MAINTAINED.
(11) FOR BRIDGES IN EXCESS OF 100 FT IN LENGTH, THE MINIMUM WIDTH OF LANES + 3 FT (ON EACH SIDE) MAY BE ACCEPTABLE.

EXHIBIT 700-03

COMMON GEOMETRIC PRACTICES
RURAL ARTERIAL ROADS (OTHER THAN FREEWAYS) ④ ⑦

<table>
<tr><td></td><td>TERRAIN</td><td colspan="4"></td></tr>
<tr><td rowspan="3">DESIGN SPEED (M.P.H.) ⑥</td><td>LEVEL</td><td colspan="4">60 - 70</td></tr>
<tr><td>ROLLING</td><td colspan="4">50 - 60</td></tr>
<tr><td>MOUNTAIN</td><td colspan="4">40 - 50</td></tr>
<tr><td></td><td></td><td colspan="4">TRAFFIC VOLUME</td></tr>
<tr><td rowspan="8">LANE WIDTH (FEET) ⑧</td><td>DESIGN SPEED</td><td>UNDER 400 A.D.T.</td><td>400-1500 A.D.T.</td><td>1500-2000 A.D.T.</td><td>OVER 2000 A.D.T.</td></tr>
<tr><td>40 MPH</td><td rowspan="4">11</td><td rowspan="4">11</td><td rowspan="2">11</td><td rowspan="7">12</td></tr>
<tr><td>45 MPH</td></tr>
<tr><td>50 MPH</td><td rowspan="5">12</td></tr>
<tr><td>55 MPH</td></tr>
<tr><td>60 MPH</td><td rowspan="3">12</td><td rowspan="3">12</td></tr>
<tr><td>65 MPH</td></tr>
<tr><td>70 MPH</td></tr>
<tr><td>MIN. USABLE SHOULDER WIDTH (FEET) ⑤ ⑨</td><td>ALL SPEEDS</td><td>4</td><td>6</td><td>6</td><td>8</td></tr>
<tr><td>MIN. CLEAR ROADWAY WIDTH OF NEW AND RECONSTRUCTED BRIDGES</td><td>ALL SPEED</td><td colspan="4">TOTAL WIDTH OF LANES + USABLE SHOULDER WIDTHS ⑩</td></tr>
</table>

<table>
<tr><td rowspan="10">MINIMUM RADIUS (FEET)</td><td>DESIGN SPEED</td><td>eMAX. 4%</td><td>eMAX. 6%</td><td>eMAX. 8%</td></tr>
<tr><td>30 MPH</td><td>250</td><td>231</td><td>214</td></tr>
<tr><td>35 MPH</td><td>371</td><td>340</td><td>314</td></tr>
<tr><td>40 MPH</td><td>533</td><td>485</td><td>444</td></tr>
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<tr><td>50 MPH</td><td>926</td><td>833</td><td>758</td></tr>
<tr><td>55 MPH</td><td>1190</td><td>1060</td><td>960</td></tr>
<tr><td>60 MPH</td><td>1500</td><td>1330</td><td>1200</td></tr>
<tr><td>65 MPH</td><td>–</td><td>1660</td><td>1480</td></tr>
<tr><td>70 MPH</td><td>–</td><td>2040</td><td>1810</td></tr>
<tr><td>NORMAL PAVEMENT CROSS SLOPES ③</td><td colspan="4">RATE OF CROSS SLOPE = 2%</td></tr>
<tr><td>NORMAL SHOULDER CROSS SLOPES</td><td colspan="2">EARTH = 8%</td><td colspan="2">PAVED = 4%</td></tr>
</table>

<table>
<tr><td rowspan="4">MAXIMUM GRADE (PERCENT)</td><td>M.P.H.</td><td>30</td><td>35</td><td>40</td><td>45</td><td>50</td><td>55</td><td>60</td><td>65</td><td>70</td><td>75</td><td>80</td></tr>
<tr><td>LEVEL</td><td colspan="2">–</td><td colspan="2">5</td><td colspan="2">4</td><td colspan="5">3</td></tr>
<tr><td>ROLLING</td><td colspan="2">–</td><td colspan="2">6</td><td colspan="2">5</td><td colspan="5">4</td></tr>
<tr><td>MOUNTAIN</td><td colspan="2">–</td><td>8</td><td colspan="2">7</td><td colspan="2">6</td><td colspan="4">5</td></tr>
<tr><td>MINIMUM STOPPING SIGHT DISTANCE ①</td><td>(FEET)</td><td>200</td><td>250</td><td>305</td><td>360</td><td>425</td><td>495</td><td>570</td><td>645</td><td>730</td><td>820</td><td>910</td></tr>
<tr><td>MINIMUM PASSING SIGHT DISTANCE ②</td><td>(FEET)</td><td>500</td><td>550</td><td>600</td><td>700</td><td>800</td><td>900</td><td>1000</td><td>1100</td><td>1200</td><td>1300</td><td>1400</td></tr>
</table>

① MINIMUM STOPPING SIGHT DISTANCE BASED ON HEIGHT OF EYE OF 3.5 FT AND HEIGHT OF OBJECT OF 2.0 FT. CONSIDER BOTH HORIZONTAL AND VERTICAL ALIGNMENT.

② MINIMUM PASSING SIGHT DISTANCE BASED ON HEIGHT OF EYE OF 3.5 FT AND HEIGHT OF OBJECT OF 3.5 FT. CONSIDER BOTH HORIZONTAL AND VERTICAL ALIGNMENT.

③ NORMAL PAVEMENT CROSS SLOPES ON BRIDGES IS 2%.

④ FOR GUIDANCE ON FREEWAYS, REFER TO AASHTO, “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS”, CURRENT EDITION.

⑤ GRADED SHOULDER = USABLE SHOULDER +2 FT. WIDEN GRADED SHOULDER 1 FT FOR GUARDRAIL.

⑥ JUSTIFICATION FOR THE CHOSEN DESIGN SPEED SHOULD BE DOCUMENTED IN THE DESIGN EXECUTIVE SUMMARY.

⑦ FOR GUIDANCE ON INTERSTATES, REFER TO AASHTO, “A POLICY ON DESIGN STANDARDS INTERSTATE SYSTEM”, CURRENT EDITION.

⑧ ON ROADWAYS TO BE RECONSTRUCTED, EXISTING 11 FT LANES MAY BE RETAINED WHERE THE SAFETY RECORDS AND ALIGNMENT ARE SATISFACTORY.

⑨ PREFERABLY, USABLE SHOULDERS ON ARTERIALS SHOULD BE PAVED; HOWEVER, WHERE VOLUMES ARE LOW OR IN AREAS WHERE WIDE PAVED SHOULDERS ARE UNDESIRABLE, THE PAVED PORTION MAY BE A MINIMUM OF 2 FT, PROVIDED BICYCLE ACCOMMODATIONS ARE NOT BEING PROVIDED.

⑩ ON BRIDGES IN EXCESS OF 200 FT IN LENGTH, OFFSETS TO PARAPET, RAIL, OR BARRIER MAY BE AT A MINIMUM OF 4 FT FROM EDGE OF TRAVELED WAY ON BOTH SIDES.

EXHIBIT 700-04

COMMON GEOMETRIC PRACTICES
URBAN ROADWAYS (OTHER THAN FREEWAYS AND INTERSTATES) ⑬ ⑯

		URBAN LOCAL STREETS ①③	URBAN COLLECTOR STREETS ②③	URBAN ARTERIAL STREETS ②③
DESIGN SPEED ⑭		20 M.P.H. – 30 M.P.H.	MIN. 30 M.P.H.	30 M.P.H. – 60 M.P.H.
NUMBER OF LANES		DESIRABLE 2	MINIMUM 2 ④	MINIMUM 2 ④
LANE WIDTH	RESIDENTIAL	MIN. 10’	MIN. 10’	10’: < 35 MPH SPEEDS AND LOW TRUCK AND BUS VOLUME 11’: ≤ 45 MPH (INTERRUPTED FLOW CONDITIONS) 12’: > 45 MPH DESIRABLE ON HIGH SPEED, FREE FLOWING, PRINCIPAL ARTERIALS
	COMMERCIAL	MIN. 10’	MIN. 10’	
	INDUSTRIAL	MIN. 12’	MIN. 12’	
SIDEWALK		MINIMUM 4’ DESIRABLE 8’ ⑮		
MIN. CLEAR ROADWAY WIDTH OF NEW AND RECONSTRUCTED BRIDGES ⑪		MINIMUM CURB TO CURB WIDTH		
BORDER AREA ⑤		5’ - 11’	8’ – 12’	
MINIMUM RADIUS (FEET)		100’	⑥	
MAXIMUM GRADE (PERCENT)		RESIDENTIAL: 15 COMMERCIAL: 8 ⑫ INDUSTRIAL: 8	(see grades below)	(see grades below)
NORMAL PAVEMENT CROSS SLOPES ⑧		2%		
NORMAL SHOULDER CROSS SLOPES		EARTH = 8%	PAVED = 4%	
SUPERELEVATION		⑩ 4% MAX.	6% MAX.	⑥

MAXIMUM GRADE (PERCENT) – URBAN COLLECTOR STREETS

M.P.H.	30	35	40	45	50
LEVEL	9			8	7
ROLLING	11	10		9	8
MOUNTAIN	12			11	10

MAXIMUM GRADE (PERCENT) – URBAN ARTERIAL STREETS

⑨ M.P.H.	30	35	40	45	50	55	60
LEVEL	8	7		6		5	
ROLLING	9	8		7		6	
MOUNTAIN	11	10		9		8	

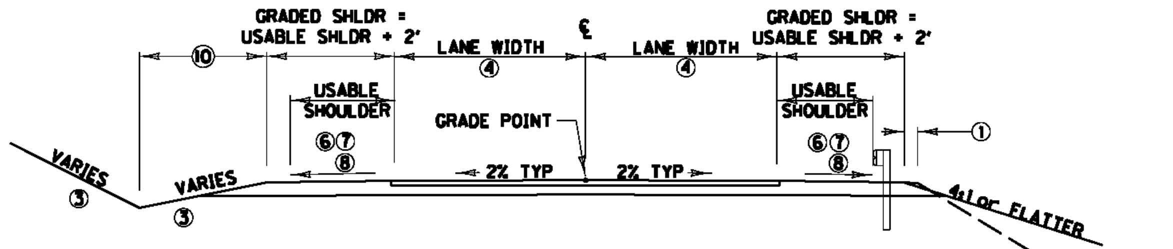
MINIMUM STOPPING SIGHT DISTANCE ⑦ (FEET)

M.P.H.	20	25	30	35	40	45	50	55	60
MIN.	115	155	200	250	305	360	425	495	570

① TURNING LANES: 9’ MINIMUM-12’ DESIRED; PARKING LANES: RESIDENTIAL- 7’MINIMUM; COMMERCIAL & INDUSTRIAL- 8’ MINIMUM.
② TURNING LANES: 10’ MINIMUM-12’ DESIRED; PARKING LANES: RESIDENTIAL- 7’ – 8’; COMMERCIAL & INDUSTRIAL- 8’ – 11’.
③ VERTICAL CURBS WITH HEIGHTS OF 4” OR GREATER ADJACENT TO TRAVELED WAY SHOULD BE OFFSET A MINIMUM OF 1 FOOT. WHEN A CURB AND GUTTER SECTION IS PROVIDED, THE GUTTER PAN WIDTH, NORMALLY 2 FEET, SHOULD BE USED AS THE OFFSET DISTANCE.
④ THE NUMBER OF LANES TO BE PROVIDED ON STREETS WITH A CURRENT ADT OF 2000 OR GREATER SHOULD BE DETERMINED BY A HIGHWAY CAPACITY ANALYSIS OF THE DESIGN TRAFFIC VOLUMES. SUCH ANALYSIS SHOULD BE MADE FOR FUTURE DESIGN TRAFFIC. (DESIRABLE)
⑤ THE BORDER AREA, MEASURED FROM THE FACE OF CURB, BETWEEN THE ROADWAY AND THE RIGHT-OF-WAY LINE SHOULD BE WIDE ENOUGH TO SERVE SEVERAL PURPOSES, INCLUDING SERVING AS A BUFFER SPACE BETWEEN PEDESTRIANS AND VEHICULAR TRAFFIC; A SIDEWALK; AND AN AREA FOR UTILITIES.
⑥ REFER TO CHAPTER 3 OF AASHTO’S “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS” CURRENT EDITION.
⑦ MINIMUM STOPPING SIGHT DISTANCE BASED ON HEIGHT OF EYE OF 3.5 FT AND HEIGHT OF OBJECT OF 2.0 FT. CONSIDER BOTH HORIZONTAL AND VERTICAL ALIGNMENT.
⑧ NORMAL PAVEMENT CROSS SLOPES ON BRIDGES SHALL BE 2%.
⑨ ARTERIALS WITH LARGE NUMBER OF TRUCKS AND OPERATING NEAR CAPACITY SHOULD CONSIDER GRADES FLATTER THAN THOSE IN RURAL SECTIONS TO AVOID UNDESIRABLE REDUCTIONS IN SPEED.
⑩ SUPERELEVATION MAY NOT BE REQUIRED ON LOCAL STREETS IN RESIDENTIAL AND COMMERCIAL & INDUSTRIAL AREAS.
⑪ THE BRIDGE WIDTH FOR URBAN ROADWAYS WITH SHOULDERS SHOULD NOT BE LESS THAN WIDTHS SHOWN FOR RURAL ROADS APPROVED ROADWAY WIDTHS.
⑫ MAXIMUM GRADES OF SHORT LENGTHS (LESS THAN 500’) AND ON ONE-WAY DOWN GRADES MAY BE TWO PERCENT STEEPER.
⑬ FOR GUIDANCE ON FREEWAYS, REFER TO AASHTO’S, “A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS.”
⑭ INTERMEDIATE DESIGN SPEEDS (5 MPH INCREMENTS) MAY BE APPROPRIATE WHERE TERRAIN AND OTHER ENVIRONMENTAL CONDITIONS DICTATE.
⑮ REFER TO AASHTO’S “GUIDE FOR DEVELOPMENT OF BICYCLE FACILITIES”, CURRENT EDITION, WHEN COMBINING A PEDESTRIAN SIDEWALK WITH A BICYCLE PATH.
⑯ FOR GUIDANCE ON INTERSTATES, REFER TO AASHTO’S “A POLICY ON DESIGN STANDARDS INTERSTATE SYSTEM”, CURRENT EDITION.

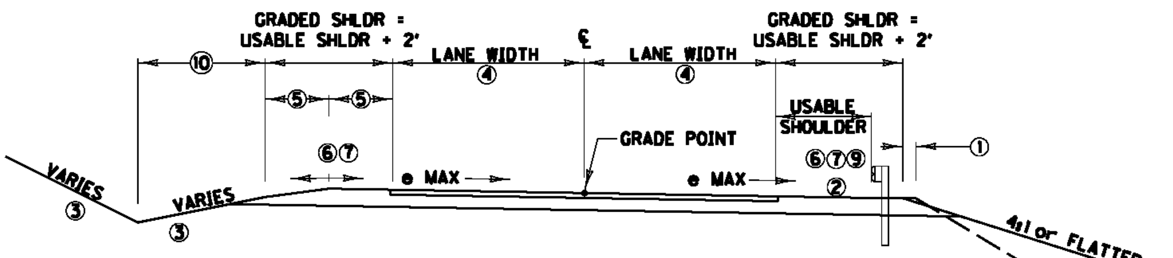
EXHIBIT 700-05

TYPICAL SECTIONS



NORMAL SECTION

RURAL TWO-LANE



SUPERELEVATED SECTION

RURAL TWO-LANE

① SHOULDERS SHALL BE WIDENED 1 FOOT WHERE GUARDRAIL IS TO BE INSTALLED. FACE OF GUARDRAIL TO BE INSTALLED AT EDGE OF USABLE SHOULDER.

② SUPERELEVATED SHOULDERS - CONSTRUCT TO STANDARD SUPERELEVATION, EXCEPT NOT FLATTER THAN THE SLOPE INDICATED FOR NORMAL SECTION.

③ REFER TO AASHTO'S "ROADSIDE DESIGN GUIDE", CURRENT EDITION, FOR SPECIFIC SLOPE GUIDANCE.

④ REFER TO KYTC COMMON GEOMETRIC PRACTICE EXHIBITS (700-01 THRU 700-04) AND AASHTO'S "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS", CURRENT EDITION, FOR SUGGESTED LANE WIDTHS OF THE VARIOUS ROADWAY CLASSIFICATIONS. FOR ROADWAYS WITH ADT <= 400, REFER TO AASHTO'S "GEOMETRIC DESIGN GUIDELINES FOR VERY LOW-VOLUME LOCAL ROADS".

⑤ IF THE SHOULDER WIDTH IS GREATER THAN 4 FEET, A PORTION OF THE OUTSIDE SHOULDER, THE SHOULDER ON THE HIGH SIDE, IS NOT SUPERELEVATED TO MATCH THE MAINLINE RATE. THE NON-SUPERELEVATED SHOULDER REMAINS SLOPED AWAY FROM THE ROADWAY. FOR SHOULDER WIDTHS GREATER THAN 4 FEET AND LESS THAN OR EQUAL TO 6 FEET, THE NON-SUPERELEVATED SHOULDER WIDTH WILL BE 2 FEET. FOR SHOULDER WIDTHS GREATER THAN 6 FEET, THE SHOULDER "BREAK" IS TO OCCUR AT THE MIDPOINT OF THE SHOULDER WIDTH. THIS REQUIREMENT MAY NOT HAVE APPLICATION TO INSIDE SHOULDERS OF MEDIAN SECTIONS AND MULTILANE FACILITIES. FOR THE "ROLL-OVER" BETWEEN SUPERABLE AND NONSUPERABLE SHOULDER, THE ALGEBRAIC DIFFERENCE IN RATE OF CROSS-SLOPE IS NOT TO EXCEED 12.0 PERCENT.

⑥ USABLE SHOULDER - THE ACTUAL WIDTH AVAILABLE FOR VEHICLES TO PULL OF THE ROADWAY. GRADED SHOULDER = USABLE + 2'

⑦ SHOULDER MAY BE PAVED TO WITHIN 2 FEET (1' MINIMUM) OF THE SLOPE BREAK OR TO THE FACE OF THE BARRIER.

⑧ NORMAL SHOULDER CROSS SLOPE: EARTH = 8%, PAVED = 4%

⑨ AFTER THE NORMAL SHOULDER CROSS-SLOPE IS EXCEEDED, THE FULL WIDTH OF THE INSIDE SHOULDER IS ROTATED TO MATCH THE ROADWAY SUPERELEVATION.

⑩ WIDTH VARIES PER DRAINAGE/"ROADSIDE DESIGN GUIDE" REQUIREMENTS.

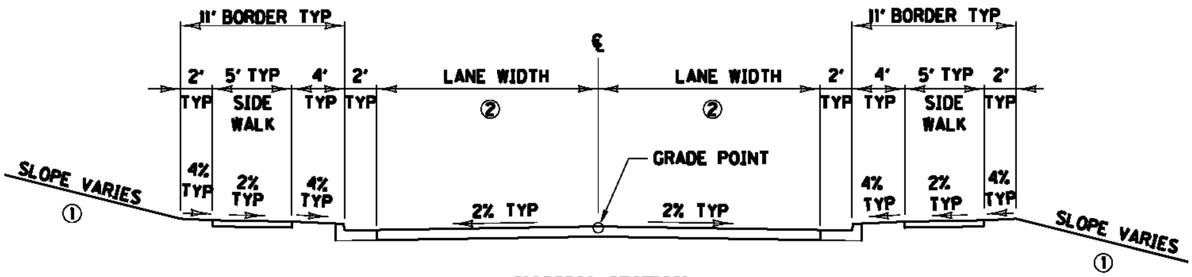
DRAWING NOT TO SCALE

3-25-2004

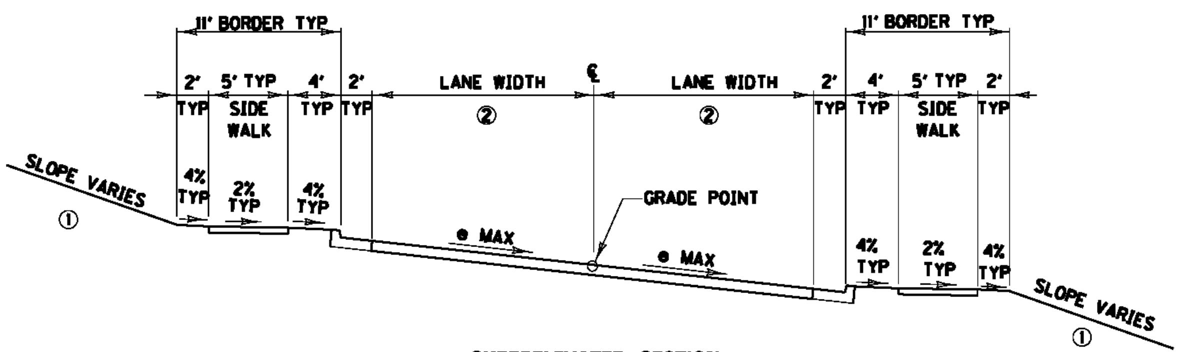
Exhibit 700-06

EXHIBIT 700-06

TYPICAL SECTIONS



NORMAL SECTION
CURB AND GUTTER
URBAN TWO-LANE



SUPERELEVATED SECTION
URBAN TWO-LANE
CURB AND GUTTER

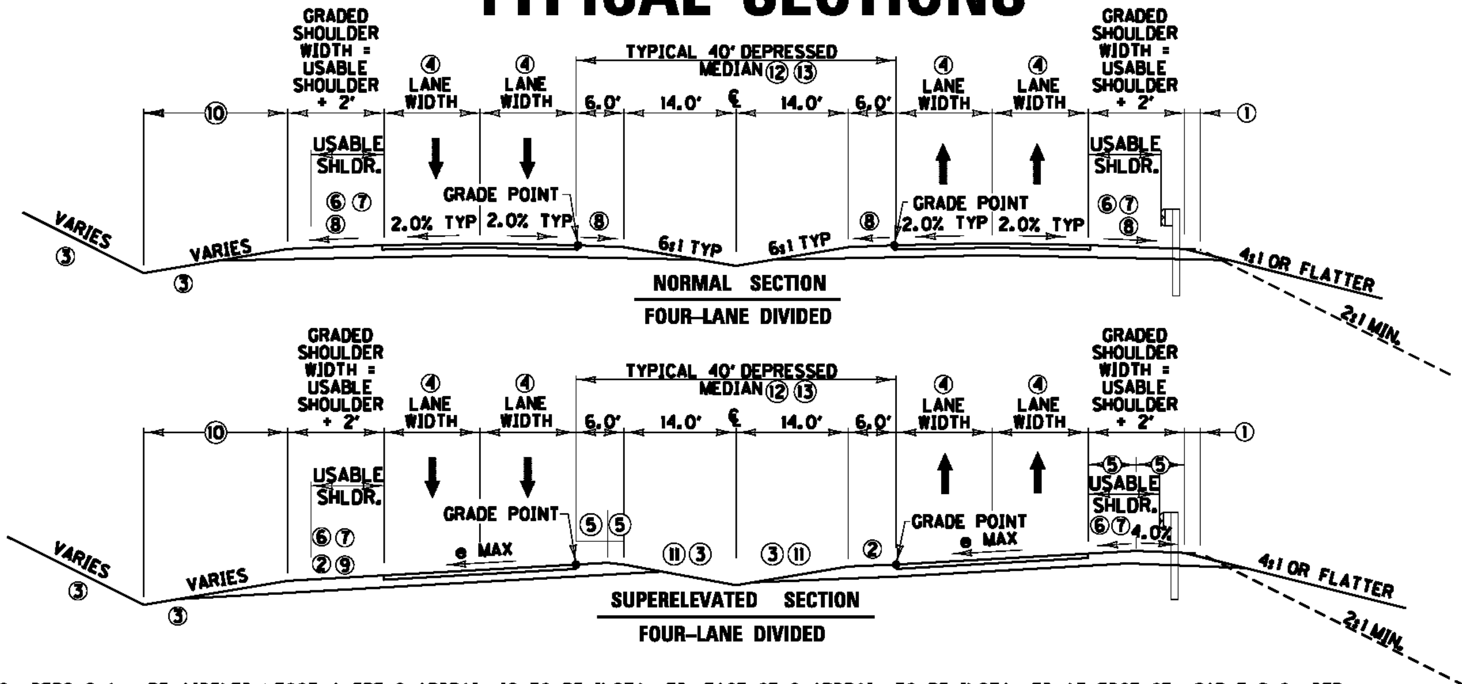
① REFER TO AASHTO'S "ROADSIDE DESIGN GUIDE", CURRENT EDITION, FOR SPECIFIC SLOPE GUIDELINES.

② REFER TO: KYTC COMMON PRACTICES EXHIBITS AND AASHTO'S "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS", CURRENT EDITION, FOR SUGGESTED LANE WIDTHS OF THE VARIOUS ROADWAY CLASSIFICATIONS. FOR ROADWAYS WITH ADT <= 400, REFER TO AASHTO'S "GEOMETRIC DESIGN GUIDELINES FOR VERY LOW-VOLUME LOCAL ROADS".

DRAWING NOT TO SCALE

EXHIBIT 700-07

TYPICAL SECTIONS



1. SHOULDERS SHALL BE WIDENED 1 FOOT WHERE GUARDRAIL IS TO BE INSTALLED. FACE OF GUARDRAIL TO BE INSTALLED AT EDGE OF USABLE SHOULDER
2. SUPERELEVATED SHOULDERS - CONSTRUCT TO STANDARD SUPERELEVATION, EXCEPT NOT FLATTER THAN THE SLOPE INDICATED FOR NORMAL SECTION.
3. REFER TO AASHTO'S "ROADSIDE DESIGN GUIDE", CURRENT EDITION, FOR SPECIFIC SLOPE GUIDANCE.
4. REFER TO AASHTO'S "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS", CURRENT EDITION, FOR SUGGESTED LANE WIDTHS OF THE VARIOUS ROADWAY CLASSIFICATIONS.
5. IF THE SHOULDER WIDTH IS GREATER THAN 4 FEET, A PORTION OF THE OUTSIDE SHOULDER, THE SHOULDER ON THE HIGH SIDE, IS NOT SUPERELEVATED TO MATCH THE MAINLINE RATE. THE NON-SUPERELEVATED SHOULDER REMAINS SLOPED AWAY FROM THE ROADWAY. FOR SHOULDER WIDTHS GREATER THAN 4 FEET AND LESS THAN OR EQUAL TO 6 FEET, THE NON-SUPERELEVATED SHOULDER WIDTH WILL BE 2 FEET. FOR SHOULDER WIDTHS GREATER THAN 6 FEET, THE SHOULDER "BREAK" IS TO OCCUR AT THE MIDPOINT OF THE SHOULDER WIDTH. THIS REQUIREMENT MAY NOT HAVE APPLICATION TO INSIDE SHOULDERS OF MEDIAN SECTIONS AND MULTILANE FACILITIES. FOR THE "ROLL-OVER" BETWEEN SUPERABLE AND NONSUPERABLE SHOULDER, THE ALGEBRAIC DIFFERENCE IN RATE OF CROSS-SLOPE IS NOT TO EXCEED 12.0 PERCENT.
6. USABLE SHOULDER - THE ACTUAL WIDTH AVAILABLE FOR VEHICLES TO PULL OFF THE ROADWAY. GRADED SHOULDER = USABLE + 2'
7. SHOULDER MAY BE PAVED TO WITHIN 2 FEET (1' MIN) OF THE SLOPE BREAK OR TO THE FACE OF THE BARRIER.
8. NORMAL SHOULDER CROSS SLOPE: EARTH = 8%, PAVED = 4%
9. AFTER THE NORMAL SHOULDER CROSS-SLOPE IS EXCEEDED, THE FULL WIDTH OF THE LOW SIDE SHOULDER IS ROTATED TO MATCH THE ROADWAY SUPERELEVATION.
10. WIDTH VARIES PER DRAINAGE/"ROADSIDE DESIGN GUIDE" REQUIREMENTS.
11. 4:1 MINIMUM; 6:1 DESIRABLE
12. WHEN MEDIANS ARE LESS THAN 40' BARRIERS SHOULD BE CONSIDERED.
13. WHEN LEFT TURN LANES OCCUPY A PORTION OF THE MEDIAN, SEE CROSSROAD PROFILE EXHIBIT 900-01.

DRAWING NOT TO SCALE

Exhibit 700-08