Chapter

INTERSECTIONS

Subject

General Design Considerations & Objectives

OVERVIEW:

By definition, an intersection is the area in which two or more highways join or cross. This includes the roadway and the appurtenances associated with the intersecting roadways. Intersection design is a key component in the design of a highway system and can affect the efficiency, safety, speed, operating costs, and capacity of the roadway system.

The three general types of intersections are:

- At-grade intersections
- Grade separations without ramps
- Interchanges

The main goal of intersection design is to facilitate the safety, convenience, ease, and comfort of those crossing the intersection, while enhancing the safe and efficient movement of vehicles and pedestrians.

Four basic elements should be considered in intersection design:

- Human factors
- Traffic movement considerations
- Physical elements
- Economic factors

HUMAN FACTORS:

Human factors affecting intersection design include:

- Driving habits
- The driver's ability to make decisions and the driver's expectancy
- Decision and reaction time

Pedestrian and bicycle use also affects intersection design.

CONT.

TRAFFIC CONSIDERATIONS: Traffic issues to consider include:

- Design and capacities
- Turning movements
- Variety of movements
- Vehicle speeds
- Pedestrian and bicycle movements

PHYSICAL ELEMENTS: Several physical elements also affect intersection design. Important issues are:

- Character and use of the adjoining property
- Vertical alignments of the intersecting roadways
- Sight distance
- Angle of the intersection

Other considerations include:

- Conflict area
- Traffic control devices
- Lighting equipment
- Environmental factors
- Crosswalks

ECONOMIC FACTORS: The costs of intersection improvements should be considered as well as the effects of controlling or limiting rights of way on adjoining commercial and residential properties.

◈◈◈

Chapter

INTERSECTIONS

Subject

At-Grade Intersections

OVERVIEW:

The basic intersection configurations are:

- Three-leg “T”
- Four-leg
- Multi-leg

At each specific location, the intersection type is determined by:

- Number of intersecting legs
- Topography of the area
- Character of the intersecting highways
- Traffic volumes and movements
- Speeds
- Desired type of operation

The following design elements are very important in the layout of an at-grade intersection and contribute a great deal to the overall operation of the facility:

- Horizontal and vertical alignment
- Cross-sectional elements
- Adequate sight distance
- Drainage issues

HORIZONTAL & VERTICAL ALIGNMENT:

The horizontal alignment and vertical grades of an intersection should be designed to permit users to visually recognize the intersection and the other vehicles using it and to readily perform the needed maneuvers to pass through the intersection safely.

Generally, the alignments should be as straight and the gradients as flat as feasible. Major grade changes should be avoided at intersections, and adequate sight distance should be provided along both intersecting roads. Ideally, grades exceeding 3 percent on the major road(s) should be avoided in the vicinity of the intersection. Where this is not feasible, grades greater than 6 percent should be avoided.

CONT.

HORIZONTAL & VERTICAL ALIGNMENT (cont.):

The designer/project team should review each intersection thoroughly and determine an acceptable solution. In the design of an intersection, the main line grades/cross-slopes generally are carried through the intersection, and the approach roadways are adjusted to match the main line geometrics. However, there are times when intersection design may be controlled by constraints other than the crossing roadway geometry. The design may need to address such intersection characteristics as:

- Traffic volumes
- Type of design vehicles
- Design speed
- Functional characteristics
- Type of intersection control
- Topographic constraints of the location

Each intersection is to be adjusted at all intersecting legs, as necessary to accommodate adequate sight distance requirements, driver comfort during maneuvers, and any drainage concerns. This adjustment might be accomplished by modification of the main line/approach grade points, cross-slopes, etc.

The goals for an intersection include:

- Smooth and continuous intersection elements
- Smooth transitions for vehicles changing directions
- Grades as level as practical
- Sufficient sight distance to allow drivers to prepare for and avoid potential conflicts

For safety and economic reasons, the intersecting roadways should meet at right angles when feasible. Although a 90-degree intersection is desired, some deviation from this is permissible. Generally, intersection angles between 75 and 90 degrees are preferred. Intersection angles of at least 70 degrees should be provided.

TURNING ROADWAY ELEMENTS:

Turning roadways are created by high-type right-turn radius designs and corner traffic islands. They are typically used at high-speed and/or high-volume intersections and are associated with a high level of service for right-turn vehicles. It is important to provide a turning roadway design that is consistent with the speed and volume characteristics of the turn. The primary design elements of a turning roadway are as follows:

- Radius of turn
- Development of superelevation
- Width of roadway

CONT.

TURNING ROADWAY ELEMENTS (cont.): The relationships between speed and curvature may be found in the exhibit “Minimum Radii for Intersection Curves” in **Chapter 3** of AASHTO’s *A Policy on Geometric Design of Highways and Streets*. Kentucky’s common practice is to use a maximum superelevation of 8 percent. **Note:** The minimum radii indicated in this exhibit should be used as the inner edge of pavement for the turning roadway.

Three-centered compound curves may also be considered as an option when determining an intersection radius. Three-centered compound curves information is available in the exhibit “Typical Design for Turning Roadways” in **Chapter 9** of AASHTO’s *A Policy on Geometric Design of Highways and Streets*.

The turning path of the design vehicle and the angle of turn determine the widths of turning roadways. **Chapter 2** of AASHTO’s *A Policy on Geometric Design of Highways and Streets* details the various types of design vehicles with their dimensions and turning radii. **Chapter 9** of the policy summarizes the minimum edge of traveled way values for various vehicles and turning angles.

ROUNDABOUTS: Roundabouts are a common form of intersection control used throughout the world to improve safety and traffic flow conditions. For detailed discussions concerning roundabouts, please refer to AASHTO’s *Policy on Geometric Design of Highways and Streets* and various publications such as the Federal Highway Administration’s *Roundabouts: An Informational Guide*.

On a case-by-case basis, the Kentucky Transportation Cabinet will consider roundabout use. Once the project team has determined that a roundabout facility could be an option, the Department of Highways or a consultant shall perform a detailed analysis, including geometric layouts, cost estimates, and capacity of the proposed facility. Other types of intersection facilities shall also be evaluated and compared with the roundabout analysis. This analysis shall be included in the Design Executive Summary.

ISLANDS & CHANNELIZATION: An island is the area between traffic lanes that is used to:

- Control vehicle movements (channelization/division of traffic)
- Provide a pedestrian refuge area and a place for traffic control devices
- Contribute to aesthetics

Within an intersection, a median is also considered an island.

Channelizing islands are used at certain intersections to control and direct traffic movements into the proper paths. If an intersection area is spacious, a channelizing island may be utilized to decrease the confusion of the traffic movements. Channelizing islands may be of many shapes and sizes. A common form is the corner triangular shape, which separates right-turning movements.

CONT.

ISLANDS & CHANNELIZATION (cont.):

Central islands may serve as a separation for turning vehicles to operate around.

Divisional islands are often included on undivided highways at intersections. They alert and regulate traffic through the intersection. They may control the location of left-turning vehicles.

Refuge islands are predominantly utilized in urban areas where there are a large number of pedestrians and bicyclists crossing an intersection. The islands aid and protect the pedestrians and bicyclists crossing the roadway. Generally, any of the types of island mentioned above could also serve as a refuge island.

The dimensions and details of an island depend on each intersection's configuration. An island should be of significant size to command attention. Islands can be delineated or outlined by a variety of treatments, depending on the size, location, and function. The type of facility (rural versus urban) in which the intersection is located also controls the island design.

Normally, flush islands are to be used in intersections with large turning radii. Exceptions may be made in instances where the island is large and may be utilized to shield pedestrians or where special signing or poles may be placed in the island. The project team may decide to utilize a raised island in this case. If a raised island is utilized, it should be designed as a mountable island where practical. Barrier curb may be utilized for a traffic island where the project team deems conditions warrant.

Interchanges represent special design considerations. An inherent problem of interchanges is the possibility of a driver's entering one of the exit terminals from the crossroad and proceeding along the major highway in the wrong direction in spite of signing. Islands provide a means of channelizing the traffic into proper paths and can be effectively used for sign placement. The intersection on the crossroad formed by the terminals functions as any other "T" intersection at-grade and should be designed accordingly (further details are provided in AASHTO's *Policy on Geometric Design,* **Chapters 9 and 10**). However, because these intersections have four legs, two of which are one-way, they present a problem in traffic control to prevent wrong-way entry from the crossroad. For this reason, the project team should strongly consider providing a median on the crossroad to facilitate proper channelization. While this median can be a painted median, the project team may also consider the use of a depressed or raised median with sloping curb where conditions are deemed appropriate.

CONT.

ISLANDS & CHANNELIZATION (cont.): Where practical, large islands should be depressed to avoid water and snow melt draining across the pavement. **Chapter 9** of AASHTO's *Policy on Geometric Design of Highways and Streets* and **Chapter HD-702** of the *Highway Design Manual* provide a detailed discussion.

SUPERELEVATION: The superelevation rates for the through roadway at an intersection are to comply with the appropriate values obtained from the tables in **Chapter 3** of AASHTO's *A Policy on Geometric Design of Highways and Streets*. When traffic control devices are anticipated on any leg of the intersection, the designer may elect to modify the superelevation rates through the intersection area to achieve an acceptable design. The designer should first consider the:

- Vehicle's ability to stop and accelerate during periods of ice and snow
- Right-of-way damages
- Grade on existing street approaches and entrances
- Drainage

The desirable maximum superelevation for horizontal curves through intersections is 4 percent.

Exhibit 10-01 shows a procedure to reduce the sharp breaks in the profile of roads crossing a roadway with a depressed median. It depicts how adjustment of the grade points on the roadway having the depressed median can reduce the severity of the breaks at the inside edges of pavement. The decision whether to use this or a similar procedure should be on an intersection-by-intersection basis.

Superelevated areas adjacent to a through lane having a normal crown or a different superelevation result in a "cross-over line," which can cause a hazardous pitch or sway in a vehicle. An example of where this occurs is a turning roadway (i.e., off ramps) adjacent to a through roadway.

When introducing or removing superelevation rates, refer to **Chapter 3** of AASHTO's *A Policy on Geometric Design of Highways and Streets*.

TRAFFIC CONTROL DEVICES: Traffic control devices regulate, inform, warn, and guide drivers. Such devices include signals, lighting, signing, arrow panels, and changeable message signs. The decision to utilize traffic control devices and their configuration should be discussed and decided by the project team on an intersection-by-intersection basis.

The project manager is ultimately responsible for making sure the appropriate traffic plans are identified and included in the total plan set. To facilitate this process, the project manager should notify the District Traffic Engineer of project team meetings and inspections as early in the process as feasible.

CONT.

TRAFFIC CONTROL DEVICES (cont.): When the project team identifies locations that might require signal, signing, and/or lighting plans, the District Traffic Engineer should notify Central Office Traffic Operations in writing and provide appropriate supporting information.

SIGHT DISTANCE: Sight distance at intersections is provided to allow drivers approaching the intersection to recognize the potential of conflicting vehicles also approaching the intersection. This gives drivers stopped on an approach road adequate view to decide whether or not to turn onto or cross the roadway.

When determining whether an object/structure is obstructing sight distance at an intersection, the designer should consider both horizontal and vertical alignment information for both intersecting roadways. The designer assumes that the driver's eye height is 3.5 feet above the roadway and that the object height is also 3.5 feet above the surface of the roadway. Using 3.5 feet for both the driver's eye and the object height ensures that each driver can see the other's vehicle.

The minimum stopping sight distance at any point within an intersection shall be consistent with the design speed at that point (see Common Geometric Practice sheets for appropriate roadway type).

The recommended dimensions of the sight triangles vary with the type of traffic control used at an intersection because different types of control impose different legal constraints on drivers and, therefore, result in different driver behaviors. Procedures to determine sight distances at intersections are presented in **Chapter 9** of AASHTO's *A Policy on Geometric Design of Highways and Streets*.

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

The desired intersection sight distance is a function of the following:

- Type of control
- Type of design vehicle
- Acceleration rate of design vehicle
- Perception and reaction time
- Width of pavement and, in cases of divided highways, width of median
- Design speeds
- 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.

CONT.

MEDIAN OPENINGS (CROSSOVERS):

Median openings are breaks in the median to allow traffic to cross. These openings facilitate traffic movement and access management. Spacing of the openings should be consistent with the type of access control along the roadway. Median openings should be situated where there is adequate sight distance.

The design of a median opening and the shape of the median ends should be based on traffic volumes, urban/rural characteristics, and types of turning vehicles. The median width, location and length of opening, and the design of the median-end shape are developed in combination to fit the character and volume of both through and turning traffic.

For three- or four-leg intersections on a divided highway, the length of median opening should be as great as the width of the crossroad traveled way plus shoulders. Where the crossroad is a divided highway, the length of the opening should be at least equal to the width of crossroad traveled way plus median width of crossroad.

There are two common shapes utilized at the ends of a median:

- Semicircle, which is satisfactory for narrow medians

- Bullet nose, which closely fits the path of the inner wheel of the design vehicle

  Note: Bullet nose is the preferred shape at approach intersections and should be used for median widths 10 feet or greater.

Chapter 9 of AASHTO's *A Policy on Geometric Design of Highways and Streets* provides specific details of median opening shapes.

AUXILIARY LANES:

An auxiliary lane is the section of the roadway adjacent to the through lanes that is utilized for:

- Speed changes
- Left- and right-turning movements
- Storage
- Weaving maneuvers
- Truck-climbing lanes
- Other various purposes

Auxiliary lanes may also be added to improve the safety and the capacity of an intersection.

CONT.

AUXILIARY LANES (cont.):

The designer should consider many factors when analyzing the need for an auxiliary lane, including:

- Speeds
- Traffic volumes (including opposing volumes)
- Percentage of trucks
- Capacity analysis
- Type of facility
- Location (rural/urban)

The most common types of auxiliary lanes are left- and right-turning lanes. These lanes have three components:

- Bay taper
- Deceleration length
- Storage length

LEFT-TURN LANES:

The following are general guidelines for the use of left-turn lanes:

Signalized Intersection:

- Left-turn lanes are to be considered at all new signalized intersections with analysis of capacity and phasing to accommodate left turns.
- Left-turn lanes are required if the left-turn volume exceeds 20 percent of the total advancing volume or 100 vehicles during the peak hour.
- Consideration should be given to the volume of traffic opposing the left-turn movement (the exhibit "Guide for Left-Turn Lanes on Two-Lane Highways" in **Chapter 9** of AASHTO's *A Policy on Geometric Design of Highways and Streets* provides further information).

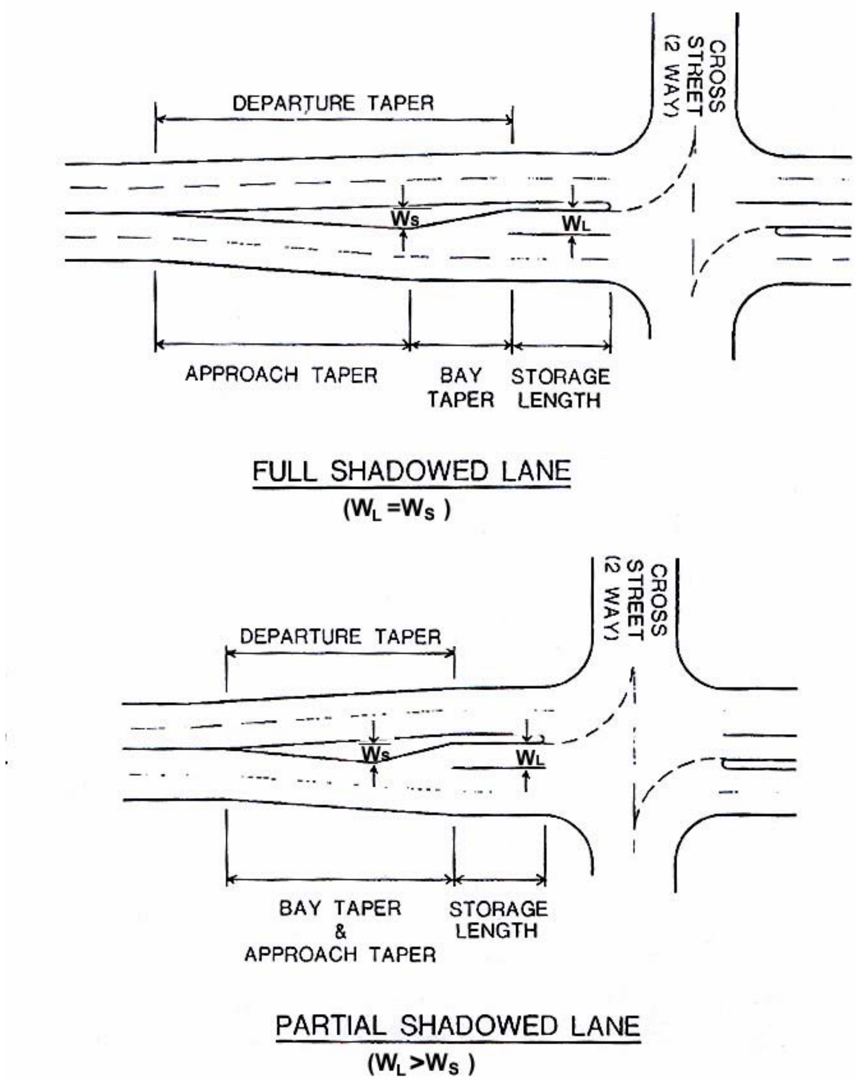
Double left-turn lanes may be utilized at any signalized intersection with high design-hour demand for left turns. A capacity analysis should be used to determine when to utilize double left-turn. As a general rule of thumb, when left-turn volumes exceed 300 vehicles per hour, provision of multiple left-turn lanes should be considered.

Unsignalized Intersection:

- Left-turn lanes should be provided at:
    - Median openings on divided roadways but not at median crossovers on freeways and interstates
    - All non-stopping approaches of rural arterials and collectors
    - All other approaches where required on the basis of capacity, safety, and operational analysis
- Left-turn lanes should be considered where sight distance is limited.

CONT.

LEFT-TURN LANES (cont):



Elements of Left turn channelization

When adding a left-turn lane, the designer is to use an approach taper to widen the pavement to the required width. The approach taper should be as follows:

SPEED: 45 mph or greater, Taper length $L = W \times S$

40 mph or less, Taper length $L = \frac{WS^2}{60}$

where

- L = Taper length in feet
- W = Width of roadway offset for taper in feet
- S = Speed in miles per hour (mph)

CONT.

LEFT-TURN LANES (cont.):

Bay tapers are utilized to direct turning vehicles into the auxiliary lane. For left-turn lanes, it is recommended to use bay taper rates between 8:1 and 15:1.

On low-speed streets or in areas with limited space, the bay and approach tapers may be combined. The total taper produces a partially shadowed left-turn lane, as illustrated on the preceding page. With the partially shadowed left-turn lanes, the offset created by the approach taper does not entirely project or "shadow" the turn lane.

The length of a left-turn lane is based on the deceleration requirements, storage requirements, or both. Based on AASHTO criteria, for design speeds of 30, 40, 45, 50, and 55 mph, the limiting deceleration lengths of auxiliary lanes are 170, 275, 340, 410, and 485 feet, respectively. Adding the deceleration distance to the storage length can result in a longer left-turn lane that may entice drivers into the lane, not realizing it is a left-turn lane. Common practice is to accept a moderate amount of deceleration within the through lanes and to consider the bay taper as a part of the deceleration length. Where intersections occur as many as four per mile, it is customary to forgo most of the deceleration length and to provide only the storage length plus bay taper. It is more important to provide adequate storage length to avoid blocking the through traffic lanes. The AASHTO guidelines for storage length are as follows:

- Unsignalized intersection: The storage length, exclusive of tapers, may be based on the average number of left-turning vehicles likely to arrive in a two-minute period of the peak hour. When conditions warrant, a minimum storage length should be provided for two passenger cars, or when there is 10 percent or greater truck/bus traffic, the minimum length should be one car and one truck/bus. Storage lengths of 25 feet per passenger car and 75 feet per truck/bus are assumed.
- Signalized intersection: The storage length, exclusive of tapers, should usually be based on 1½ to 2 times the average number of vehicles that would arrive during an average cycle length in the design hour. A nomograph for estimating storage length at signalized intersections is provided on the following page.

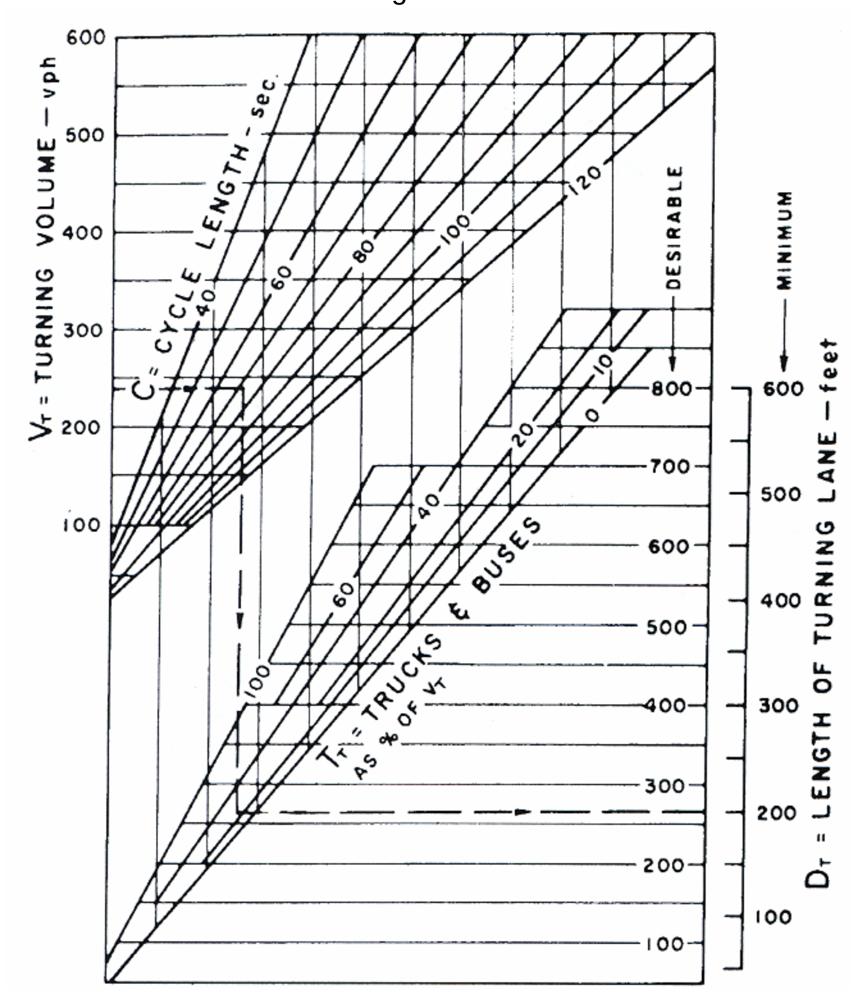
The example shown on the nomograph is as follows:

Conditions:	240 vph left-turn 72-second cycle 10 percent trucks
Solutions:	Minimum storage = 200 ft Desirable storage = 260 ft

CONT.

LEFT-TURN LANES (cont.):

Nomograph: Storage for a Single Turn Lane
at a Signalized Intersection



The departure taper should begin opposite the beginning of the full-width left-turn lane and extend to the beginning of the approach taper.

RIGHT-TURN TREATMENTS:

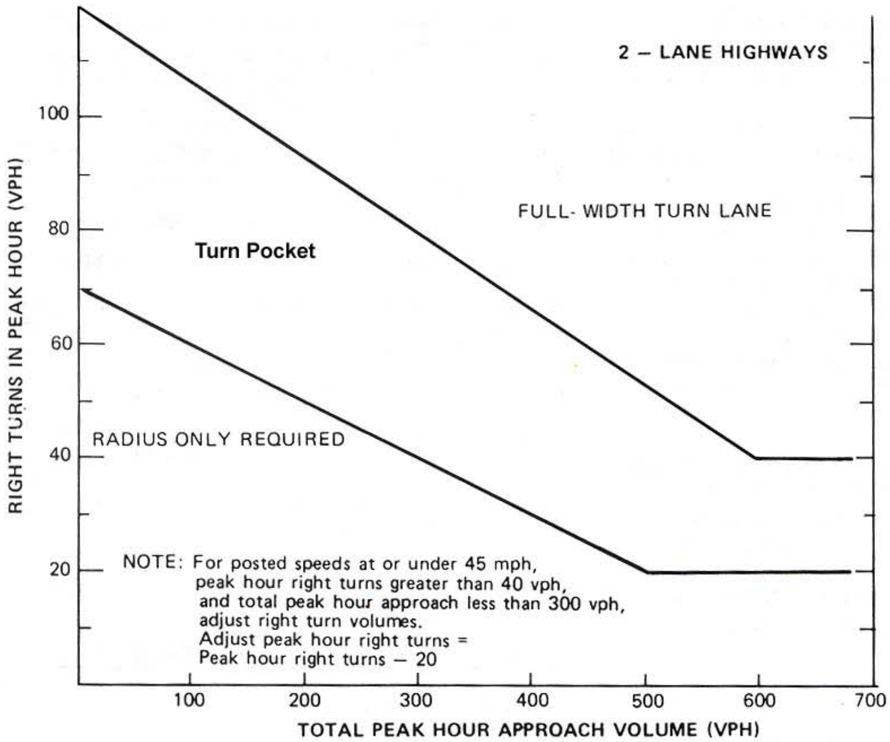
Three treatments that can be utilized to enhance the right-turning movements at an intersection:

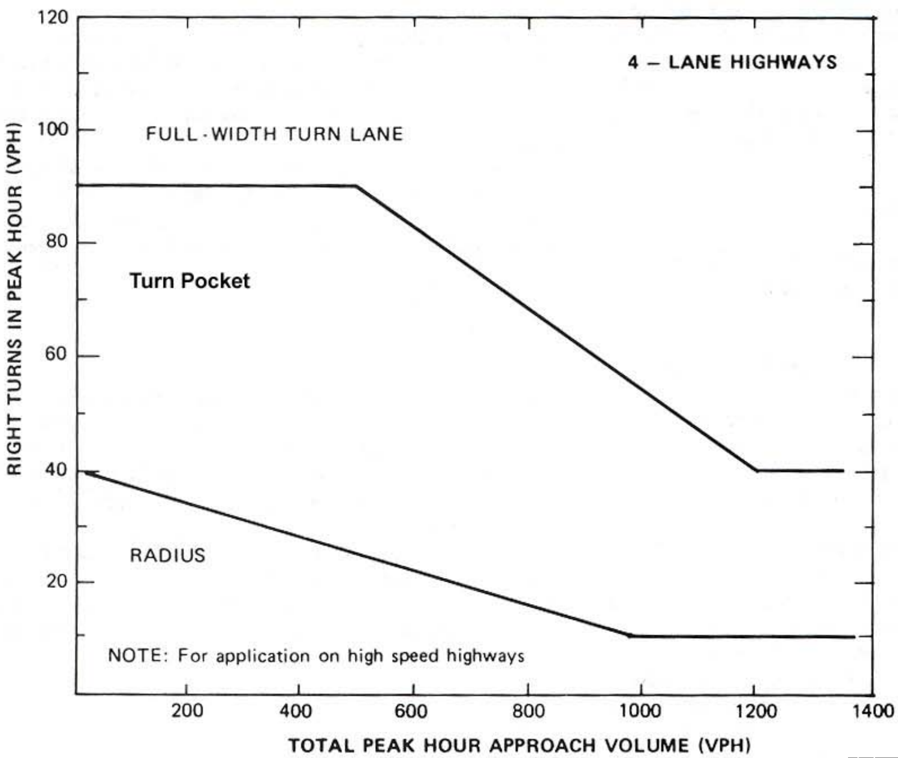
- Corner radius
- Right-turn pocket
- Right-turn lane

The graphs on the next page provide traffic-volume guidelines for the design of right-turn treatments.

CONT.

RIGHT-TURN TREATMENTS (cont.):





:

Traffic volume guidelines for design of right-turn lanes.

CONT.

RIGHT-TURN TREATMENTS (cont.):

Corner Radii Design: Adequate corner radii for vehicle movements should balance the needs of the vehicle, pedestrian or bicycle traffic, and the ability to acquire the necessary right of way. Ideally, corner radii on high-speed approaches should be designed to accommodate moderate- to high-speed right turns when pedestrian or bicycle movements are not present. Low-speed right turns are desirable at intersections with heavy pedestrian or bicycle traffic, such as in dense urban areas. For corner radii design, multicentered curves and circular curves with tangent offsets are useful alternatives to simple circular curve designs. **Chapters 2, 3,** and **9** of AASHTO's *A Policy on Geometric Design of Highways and Streets* provide more details and exhibits.

Right-Turn Pocket: A right-turn pocket may be used at any minor intersection not requiring a deceleration lane. A right-turn pocket consists of an 8:1 bay taper with 50-foot storage for rural areas and 100-foot storage for urban areas. The shoulder width may be reduced in the area adjacent to the right-turn pocket to a minimum width of four feet.

Right-Turn Lane: Although right turns usually involve fewer and less-severe conflicts and tend to have less influence on the through-traffic movements at intersections, there are times that the added cost of providing a right-turn lane is justified by the improvements to the traffic flow.

In addition to the above guidelines, the project team should consider the following items when determining the need for right-turn lanes at an intersection:

- In urban areas: the amount of approach volume turning right, presence of pedestrians and bicycles that would conflict with the right-turning vehicles, and severe skew or grade that increases the difficulty of right turns

- In rural areas and on high-speed suburban-type facilities: solution for the reduction of potential rear-end collisions and high volumes of right turns generated by adjacent land use

- Exclusive right-turn lanes when the right-turn volume exceeds 300 vph and the adjacent through-lane volume exceeds 300 vph for the design hour

- Reduction of full shoulder width adjacent to the right-turn lane to a minimum width of four feet

CONT.

RIGHT-TURN TREATMENTS (cont.):

The design of a right-turn lane is similar to that of a left-turn lane. A right-turn lane consists of a bay taper, deceleration length, and/or storage length. As with left-turn lanes, it is acceptable to include the taper as part of the deceleration length. Also, where intersections occur as many as four per mile, it is customary to forgo most of the deceleration length and to provide only the storage length plus bay taper.

For right-turn lanes, it is recommended to use bay taper rates between 8:1 and 15:1.

The following chart shows acceptable deceleration lengths.

Design Values for Length of Deceleration for Design Speed of Corner Radius (mph)			
Highway Design Speed (mph)	**Stop Condition (assumes right-turn lane on approaches to stop signs and traffic signals)**	**15 mph (assumes use of 50-foot corner radius)**	**20 mph (assumes use of 90-foot corner radius)**
30	235	185	160
40	315	295	265
50	435	405	385
60	530	500	490
65	570	540	530
70	615	590	570

The guidelines for determining storage length for a right-turn lane are the same as those for determining storage length for a left-turn lane.

For guidance on auxiliary lanes, AASHTO's *A Policy on Geometric Design of Highways and Streets* contains a helpful discussion. Also, NCHRP Synthesis 225, TRB, **"**Left-Turn Treatments at Intersections," and NCHRP Report 279, TRB, **"**Intersection Channelization Design Guide," are useful resources for assessing the need for and geometrics of an auxiliary lane. The *Highway Capacity Manual* should be consulted for analysis of intersection capacity.

DRIVEWAYS/ ENTRANCES:

Ideally, driveways/entrances are not to be located within the functional area of an intersection, which would include the limits of any auxiliary lanes being utilized.

As with other types of intersections, driveways/entrances are to intersect the roadway at a 90-degree angle whenever feasible. KYTC Standard Drawings RPM-110, RPM-150, and RPM-152 show details. Also, **Chapters 4** and **9** of AASHTO's *A Policy on Geometric Design of Highways and Streets* contain further discussions concerning driveways.

CONT.

PEDESTRIANS & BICYCLES:

Since the Department of Highways promotes the safe and efficient movement of both vehicles and pedestrians, each intersection is to receive consideration based on conditions existing at individual locations. Considerations include:

- Vehicular flow, including percentage and types of trucks
- Pedestrian movement (i.e., heavy, moderate, light)
- Presence of pedestrian generators (schools, malls, etc.)
- Project team's recommendation

When intersection conditions indicate heavy traffic volume and negligible pedestrian movement, the designer may use enlarged radii, including free-flow movement on right-turn lanes. If a decision is made to allow free-flowing movements, consideration is to be given to encourage pedestrian movements in other locations outside the intersection area. The Cabinet's *Pedestrian and Bicycle Travel Policy* provides additional information.

In areas where sidewalk is utilized, the facility is to comply with the Americans with Disabilities Act (ADA). Sidewalk ramp types and details are shown in KYTC Standard Drawings RPM-160 through RPM-172. The *Manual of Uniform Traffic Control Devices* is also to be consulted for details of intersection striping and signing for pedestrian traffic.

Bicycles, unlike pedestrians, can safely share the roadways with motor vehicles when appropriate consideration is made during the design and construction of new or reconstructed roadways. When bicycle lanes are to be provided at an intersection, the Cabinet's *Pedestrian and Bicycle Travel Policy* and this manual's chapter on "Additional Highway Design Topics" provide a detailed discussion.

◈◈◈

KYTC Highway Design	*Chapter* INTERSECTIONS
	Subject Grade Separation without Ramps

OVERVIEW: Grade-separation facilities provide for the safest, most efficient movement of vehicles, pedestrians, and bicycles across intersecting roadways. Conflict points between the facilities are eliminated when one of the roadways is taken either over or under the other facility, depending on the terrain of the project area. The ability to use this type of facility is usually based upon:

- Type of terrain
- Type of facility being constructed
- Type of access control being utilized on the facility
- Economic considerations

There is no minimum spacing along a corridor or no limit to the number of grade-separated facilities along a roadway.

VERTICAL CLEARANCE: In selecting the alignment and grades of intersecting roadways, a major control is vertical clearance under overpasses. For various types of roadways, the following minimum vertical clearances apply:

TYPE OF ROADWAY	MINIMUM CLEARANCE* (Feet)	DESIRABLE CLEARANCE (Feet)
Interstate, federal aid primary in rural areas	16.5	17.5
Strategic Highway Network	16.5	17.0 - 17.5
All others	14.5	17.0 - 17.5

*For rehabilitation/reconstruction work involving existing bridges, vertical clearance can be reduced by 0.5 feet from above minimum clearances.

CONT.

VERTICAL CLEARANCE (cont.):

The Strategic Highway Network (STRAHNET) comprises all rural interstates and selected urban interstates. In Kentucky, the selected urban interstates are the following:

- Louisville: I-65, I-71, I-264 from I-64 to I-71
- Covington: I-75 north to I-275 east, I-275 east to I-75 north in Ohio

The chart on the preceding page applies to both grade-separation and interchange facilities. The minimum clearances are required across the entire roadway width, including the usable shoulder.

Where practicable, the desirable clearance under bridges on the interstate should be used to accommodate future overlays.

HORIZONTAL CLEARANCE:

Minimum horizontal clearances vary, depending upon the functional classification of the roadways. The designer shall consult the *Bridge Design Manual* for specific details and design criteria. Horizontal clearance and clear zones are not interchangeable. For clear zones, the designer should consult the AASHTO *Roadside Design Guide*.

Chapter

INTERSECTIONS

Subject

Interchanges

DEFINITION: According to AASHTO, an interchange is “a system of interconnecting roadways in conjunction with one or more grade separations that provides for the movement of traffic between two or more roadways or highways on different levels.”

DESIGN CONSIDERATIONS: Once it is determined that an interchange is going to be utilized (based upon highway classification, traffic types and movements, design speeds, access control type, economics, etc.) alternative configurations should be studied and discussed at the project team meetings. Generally, minor roadways should pass over major roadways. This configuration takes advantage of the ability of off-ramp traffic to decelerate on the upgrade and of on-ramp traffic to accelerate on the downgrade.

Every interchange is unique. The project team should take great care in deciding the most appropriate interchange configuration, based upon, but not limited to, the following:

- Route continuity/lane balance
- Capacity of interchange
- Uniform/consistent exit patterns
- Weaving considerations
- Cost
- Impacts to surrounding properties
- Environmental considerations
- Maintenance of traffic issues

A general guideline for minimum spacing of interchanges is one mile in urban areas and two miles in rural areas. For design standards for interchanges on interstate routes, the designer can refer to AASHTO’s *A Policy on Design Standards—Interstate System*.

CONT.

HORIZONTAL & VERTICAL ALIGNMENT: The horizontal and vertical alignments of the intersecting roadways are controlled by the design speed and class of road for each roadway, as detailed in **Chapter HD-700** of this manual and in AASHTO's *A Policy on Geometric Design of Highways and Streets*. However, if practicable, the roadways should intersect at 90 degrees in tangent sections with grades as flat as possible.

RAMPS: Ramps are turning roadways that connect two or more legs at an interchange. In general, the horizontal and vertical alignments of ramps are designed on the basis of a design speed lower than those of the intersecting roadways.

- **Horizontal Alignment:** The minimum radius of 230 feet is to be used at any point on a non-loop ramp, which corresponds to a 30-mph design speed. However, at the exit terminal from the major roadway, the desirable design speed of the first curve on the ramp should be 70 percent of the main line design speed. If this is not practicable, lesser design speeds are permissible if lengthening the deceleration taper on the mainline. **Chapters 3** and **10** in AASHTO's *A Policy on Geometric Design of Highways and Streets* provides additional information.

  For compound curves, as in the design of loop ramps, the radius of any curve should be no less than one-half the radius of the preceding curve. For adequate transition for multiple compound curves, the length of arc for each curve should be as follows:

  LENGTHS OF CIRCULAR ARC FOR COMPOUND CURVES ON RAMPS WHEN FOLLOWED BY A CURVE OF ONE-HALF RADIUS OR PRECEDED BY A CURVE OF DOUBLE RADIUS

	Length of circular arc (ft)	
Radius (ft)	Minimum	Desirable
100	40	60
150	50	70
200	60	90
250	80	120
300	100	140
400	120	180
500 or more	140	200

- **Vertical Alignment:** Ramp grades should not exceed 6 percent. If large volumes of trucks are present, upgrades should be limited to 4 percent.

CONT.

RAMPS (cont.):

- **Ramp Lane Widths:** Single-lane ramps shall have a minimum pavement width of 15 feet, with a 6-foot usable shoulder right and a 4-foot usable shoulder left. Two-lane ramps shall have a minimum pavement width of 24 feet, with a 6-foot usable shoulder right and a 4-foot usable shoulder left. (Typical section examples are included in the exhibits at the end of **Chapter HD-900.)**

Pavement widths can vary, depending on ramp radii, traffic conditions, etc. Therefore, the designer is advised to refer to **Chapter 10** in AASHTO's *A Policy on Geometric Design of Highways and Streets* for additional guidance.

SUPERELEVATION: Superelevation on the main line, minor roadway, and ramp proper is to be in accordance with **Chapter HD-702** of this manual and AASHTO's *A Policy on Geometric Design of Highways and Streets*.

SPEED-CHANGE LANES: To minimize the interference with the through traffic and to decrease the accident potential, deceleration and acceleration lanes should be provided within the interchange area. These lanes are generically referred to as speed-change lanes.

The speed-change lane should be of sufficient length to allow the driver to maneuver comfortably and safely from the roadway to the ramp. The two general types of speed-change lanes are taper and parallel.

Chapter 10 of AASHTO's *A Policy on Geometric Design of Highways and Streets* provides detailed discussions, charts, and drawings concerning speed-change lanes **(Exhibits 10-69, 10-70, 10-71, 10-72, and 10-73)**.

Chapter	INTERSECTIONS
Subject	Procedures

OVERVIEW: The basic procedures the Transportation Cabinet follows when designing at-grade, grade-separation, and interchange facilities are:

- Assembling basic data
- Preparing alternative studies
- Submitting alternatives to the project development teams

ASSEMBLING BASIC DATA:

Traffic Data: The designer should (1) request both current-year and projected-design-year traffic information from the Division of Planning and (2) take the above data and perform a detailed traffic analysis based upon the guidelines presented in the *Highway Capacity Manual*.

Site Data: All appropriate topographic, planimetric (including utilities), property-ownership, and environmental data are to be collected. This information is critical to the evaluation of different alternatives.

Crash Data: This information is a major consideration when redesigning an existing facility. The designer should request crash data from the Division of Traffic Operations and any other appropriate source.

PREPARING ALTERNATIVE STUDIES:

The designer is to prepare studies of alternative configurations and alignments for the intersecting roadways. Some of the major items to consider are as follows:

- **Proposed Horizontal and Vertical Alignment of Intersecting Roadways:** The designer should carefully study the alignment of the intersecting facilities. Appropriate considerations include, but are not limited to:
  - Intersection angle between 70 and 120 degrees between roadways
  - Horizontal/vertical curvature
  - Potential environmental, utility, and right-of-way impacts
  - Intersection sight distance

CONT.

PREPARING ALTERNATIVE STUDIES (cont.):

- ♦ Capacity analysis
- ♦ Grades
- ♦ Stopping sight distance
- ♦ Determination of which facility should pass over and which facility should pass under for grade-separated roadways, along with vertical clearance requirements

Realignments of existing facilities are to be considered to provide quality intersection design.

- **Proposed Road Crossings with Depressed Medians: Exhibit 900-01** shows a procedure to reduce the sharp breaks in the profile of roads crossing a roadway with a depressed median. It depicts how adjustment of the grade points on the roadway having the depressed median can reduce the severity of the breaks at the inside edges of pavement. The decision to use this or a similar procedure should be made on an intersection-by-intersection basis.

- **Channelization Details:** When at-grade intersections are utilized, the designer shall evaluate each intersection to determine the need for channelization. Any of the following conditions may warrant the channelization of an intersection:

  - ♦ High crash frequency
  - ♦ Dense vehicular traffic
  - ♦ High-speed vehicular traffic
  - ♦ Complex intersection
  - ♦ Wide roadway
  - ♦ Pedestrian movements
  - ♦ Difficulty in providing adequate control by use of standard signs and markings

- **Maintenance of Traffic Movement during Construction:** The designer should develop a scheme for maintaining traffic movement through the intersections. The scheme is to detail:

  - ♦ Maintenance of traffic lanes
  - ♦ General sequence of construction phasing
  - ♦ Any required detours or temporary pavement widening

- **Right-of-Way Widths:** The designer should exercise care to provide adequate right of way for:

  - ♦ Sight distance
  - ♦ Traffic signal supports
  - ♦ Signing
  - ♦ Lighting
  - ♦ Potential utility location

CONT.

PREPARING ALTERNATIVE STUDIES (cont.):

- **Proposed Drainage:** The designer should assess existing and proposed drainage systems and their potential effects on the proposed design.

- **Evaluation of Utility Impacts:** The designer is to evaluate the impacts on both existing and relocated utilities within the proposed intersection. The designer should consider impacts to all utility companies, both private and public, when evaluating the effect of the project on the utilities. In some cases, it may be necessary to alter the alignment or grade to avoid relocation of major utilities.

- **Pedestrian Facilities:** The project team is to determine the need for pedestrian facilities in accordance with the Cabinet's *Pedestrian & Bicycle Travel Policy*.

- **Cost Estimates:** For each alternative studied, the designer is to prepare preliminary cost estimates, including those for construction, right-of-way acquisition, utility relocation, and other significant needs.

SUBMITTING ALTERNATIVES:

Each alternative submitted to the project team is to include:

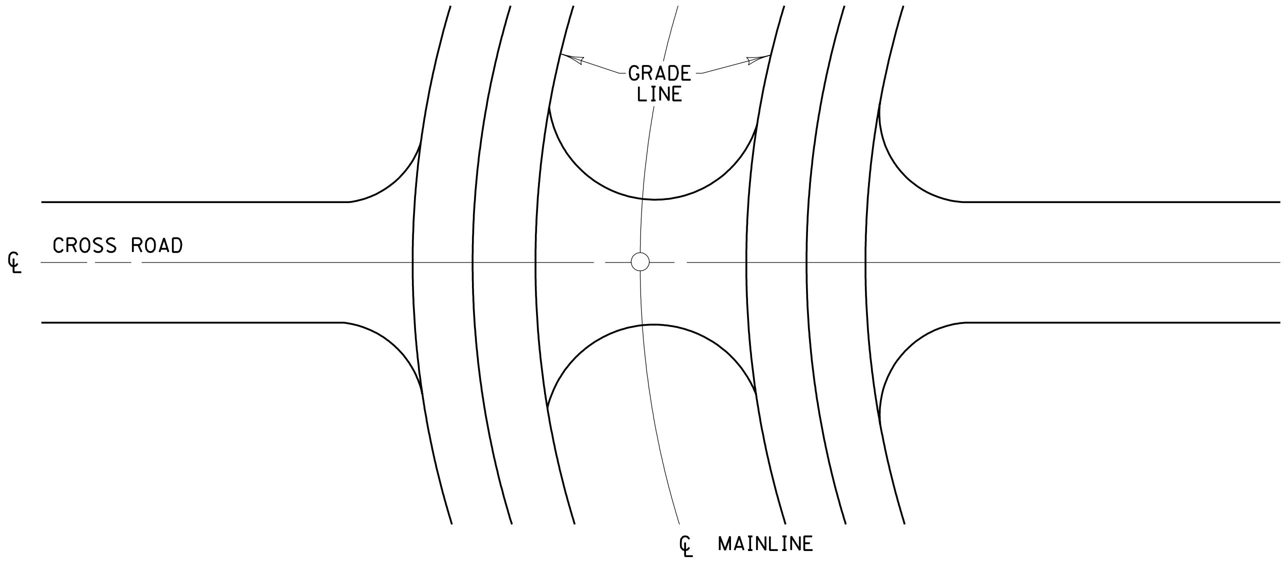
- Plan and profile details of the intersecting roadways
- Traffic analysis
- Cost estimates
- Discussion of the pros and cons of each alternative
- Other information the team believes to be beneficial

For interchanges, the project team is to recommend its chosen alternative to the Director of the Division of Highway Design. The director is to decide the appropriate selection/approval documentation required.

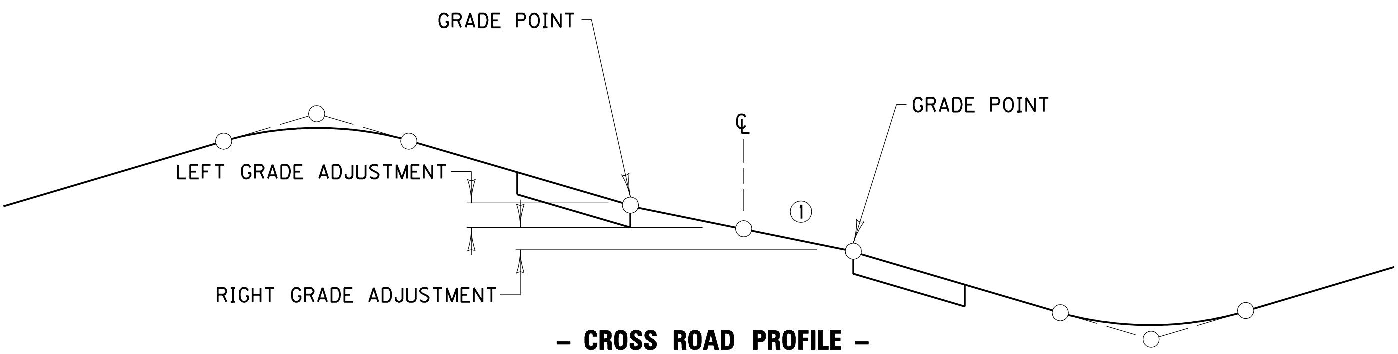
Upon submission of its interchange design, the designer is to include an original plot of the geometric layout sheet with a block for a recommendation signature of the project manager and approval signatures of the directors of the Division of Highway Design and the Division of Traffic Operations. This layout sheet may show all ramps, lane widths, tapers, curve data, and typical sections of all roadways. The layout sheet may include right-of-way widths, significant drainage structures, major utilities, and access control information if contributing to the interchange geometric decisions. For grade-separation/interchange projects on interstates, the FHWA shall be involved in the decision process, and the geometric layout sheet shall be submitted to that agency for approval.

EXHIBIT 900-01

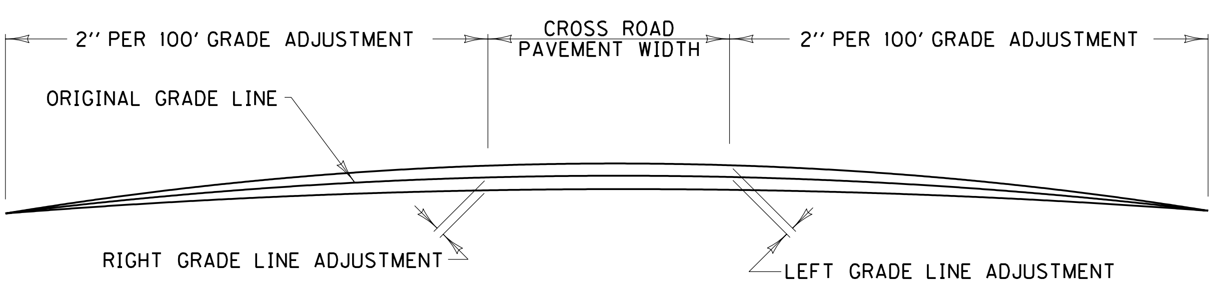
COMMON PRACTICES FOR CROSS ROAD PROFILE ADJUSTMENT



– PLAN –



– CROSS ROAD PROFILE –
(ADJUSTED)



– MAINLINE PROFILE –

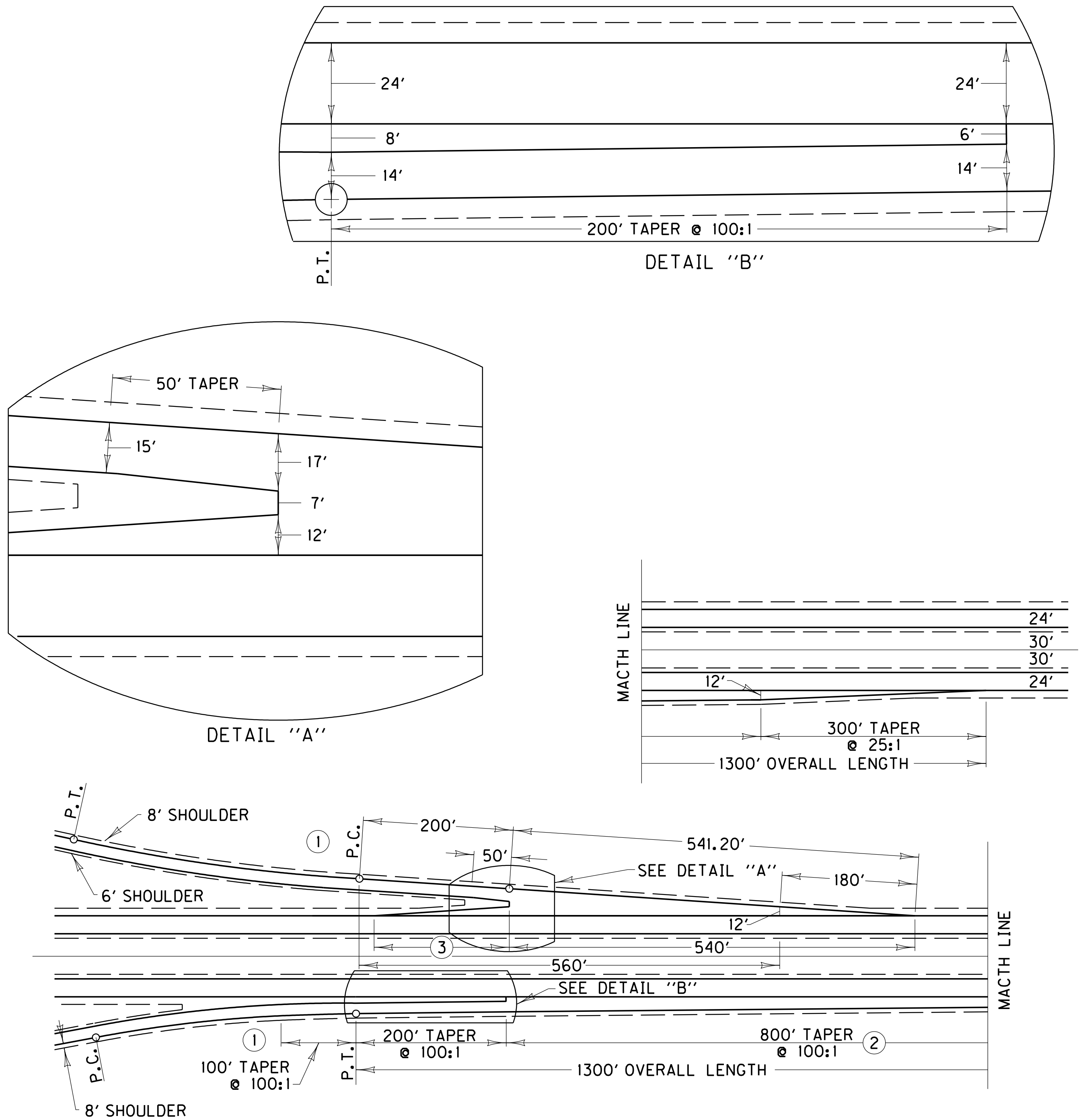
① IF LEFT TURN STORAGE IS REQUIRED, THE SUPERELEVATION OF THE LEFT TURN LANE IS TO BE TRANSITIONED FROM THE SUPERELEVATION OF THE CURVE TO THE SUPERELEVATION CREATED BETWEEN THE TWO MAINLINE PAVEMENTS AT THE CROSS ROAD.

DRAWING NOT TO SCALE

3-25-2004

EXHIBIT 900-02

COMMON PRACTICE FOR RAMP TAPERS



① DESIRABLE DESIGN SPEED OF CURVE IS ≥ .7 OF MAINLINE DESIGN SPEED. IF DESIGN SPEED OF CURVE IS < .7 OF MAINLINE DESIGN SPEED, MAKE AN ANALYSIS (IN ACCORDANCE WITH THE CURRENT AASHTO GREEN BOOK CRITERIA) WITH APPROPRIATE LENGTHENING OF SPEED CHANGE LANE.

② WHEN USING MAINLINE DESIGN SPEED IF ≥ 60 MPH AND MAINLINE GRADE OF ≥ 4% CONCURRENTLY. MAKE AN ANALYSIS (IN ACCORDANCE WITH THE CURRENT AASHTO GREEN BOOK CRITERIA) WITH APPROPRIATE LENGTHENING OF SPEED CHANGE LANE.

③ REQUIRED LENGTH OF NOSE TAPER BASED ON DESIGN SPEED OF MAINLINE:

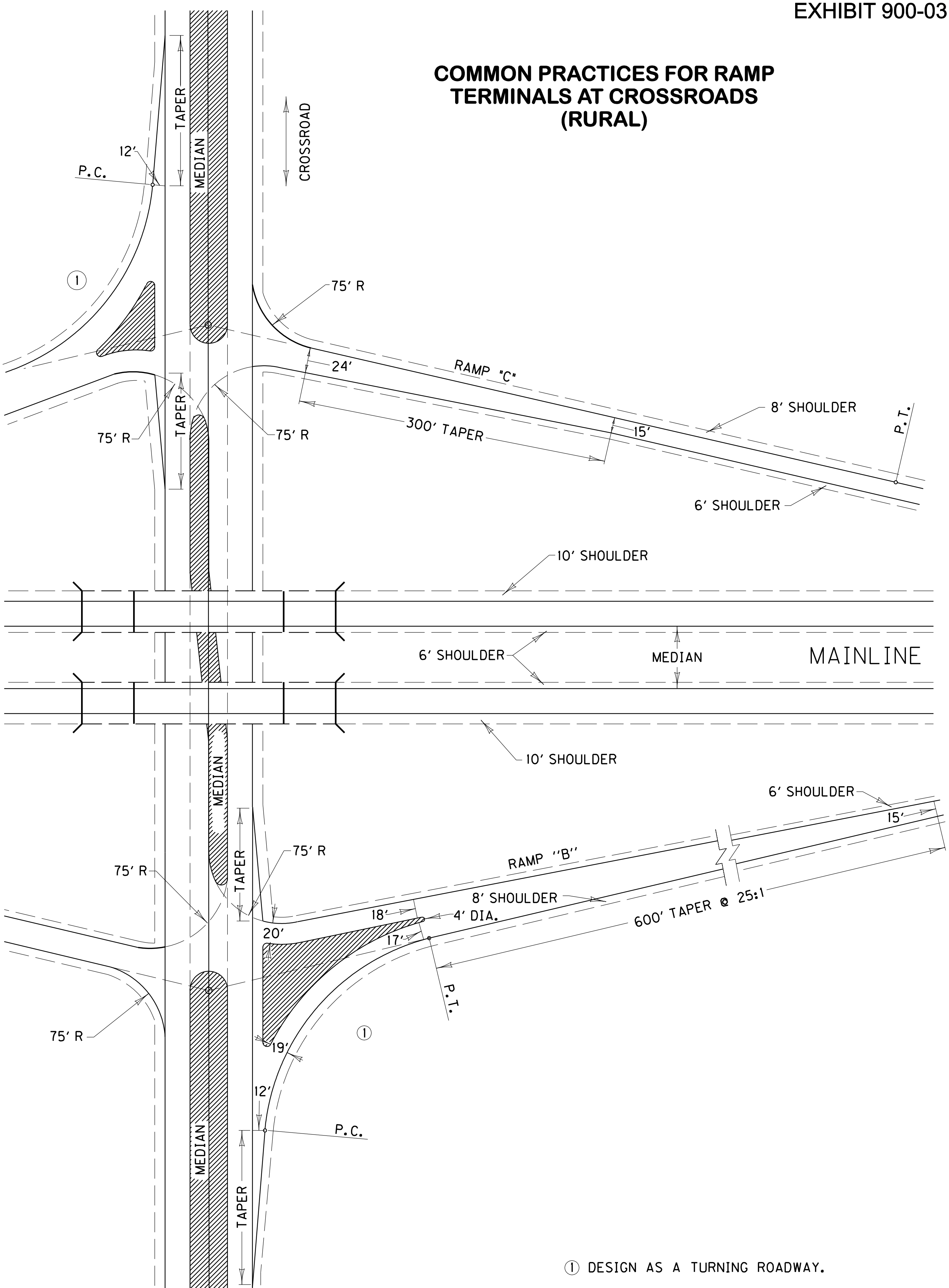
MAINLINE DESIGN SPEED	LENGTH OF NOSE TAPER
≥ 30 MPH	180 FT.
40 MPH	240 FT.
50 MPH	300 FT.
≥ 60 MPH	360 FT.

DRAWING NOT TO SCALE

3-25-2004

EXHIBIT 900-03

COMMON PRACTICES FOR RAMP TERMINALS AT CROSSROADS (RURAL)

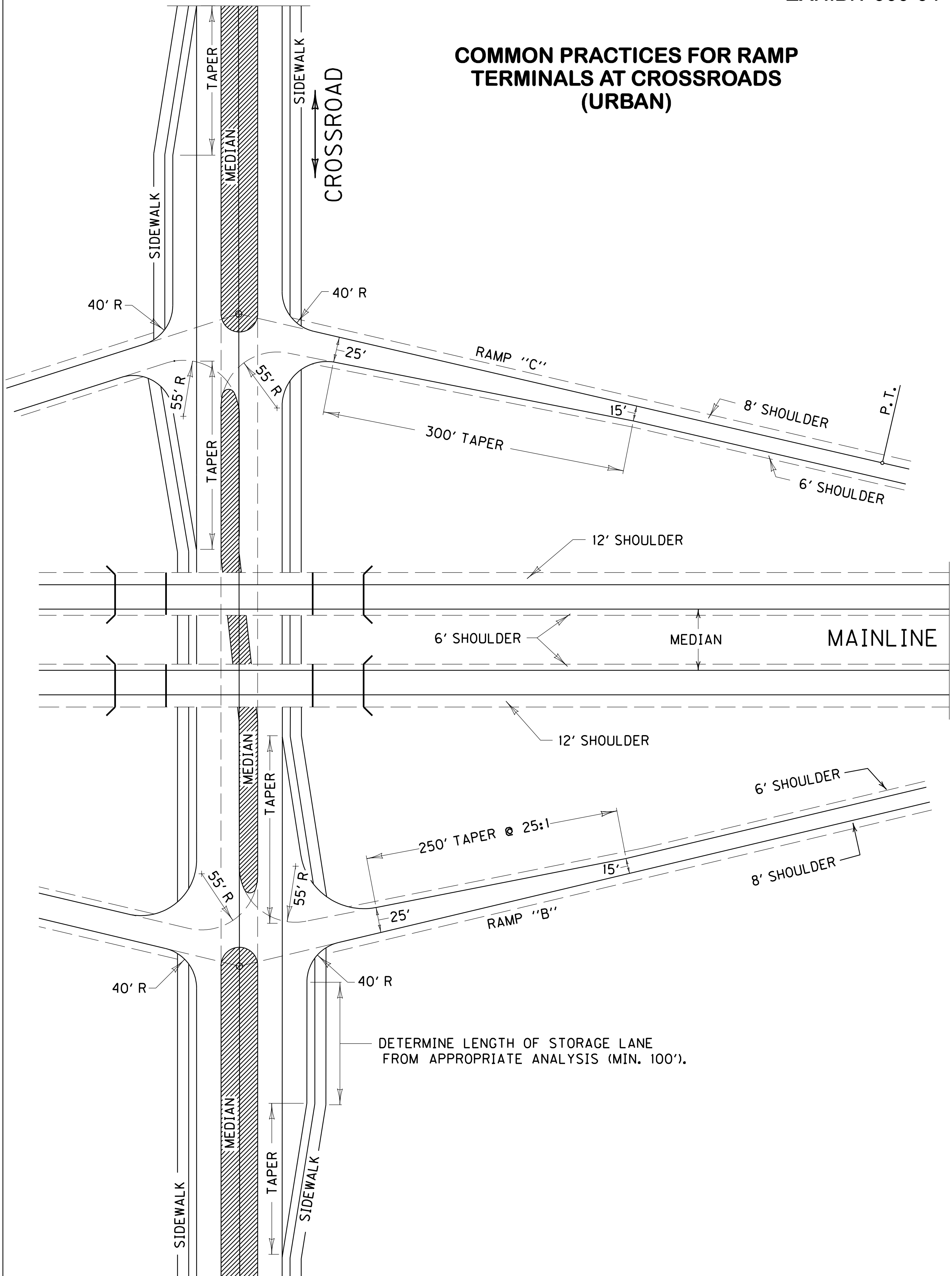


① DESIGN AS A TURNING ROADWAY.

DRAWING NOT TO SCALE

11-30-2004

COMMON PRACTICES FOR RAMP TERMINALS AT CROSSROADS (URBAN)

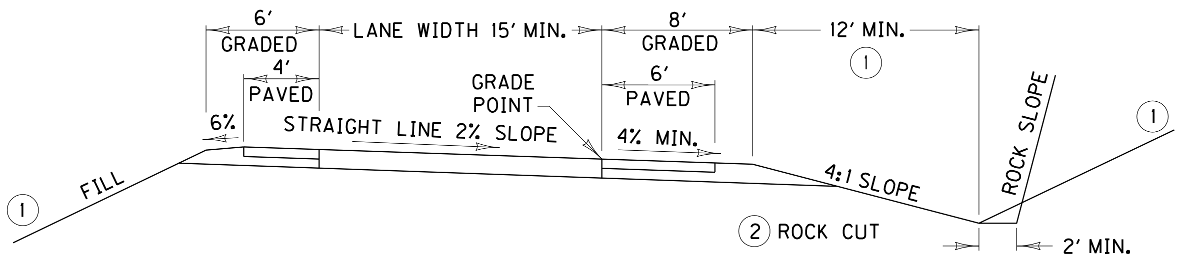


DRAWING NOT TO SCALE

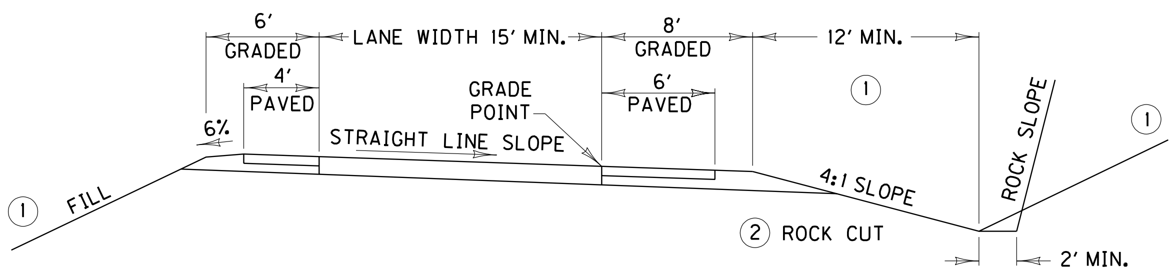
3-25-2004

TYPICAL SECTIONS

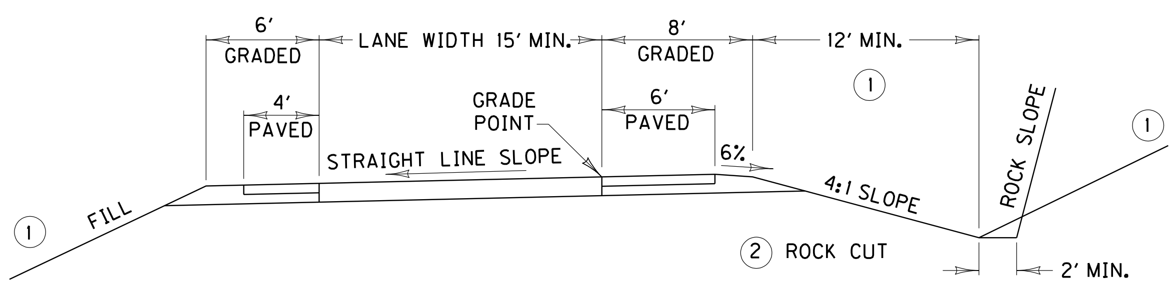
ONE LANE RAMPS
FILL, EARTH CUT OR ROCK CUT



NORMAL SECTION



SUPERELEVATED RIGHT



SUPERELEVATED LEFT

THESE TYPICALS ARE COMMONLY UTILIZED IN THE DESIGN OF RAMP TEMPLATES FOR NORMAL OR SUPERELEVATED SECTIONS IN FILL, EARTH CUT OR ROCK CUT SITUATIONS. THE DESIGN ENGINEER IS DIRECTED TO USE THE CURRENT EDITION OF AASHTO'S "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS" FOR PROJECT SPECIFIC INFORMATION.

(1) SEE AASHTO ROADSIDE DESIGN GUIDE. CONTOUR GRADING PLANS SHALL GOVERN SLOPES AND DIMENSIONS OUTSIDE THE SHOULDER POINT WHERE NOT IN CONFLICT WITH AASHTO ROADSIDE DESIGN GUIDE.

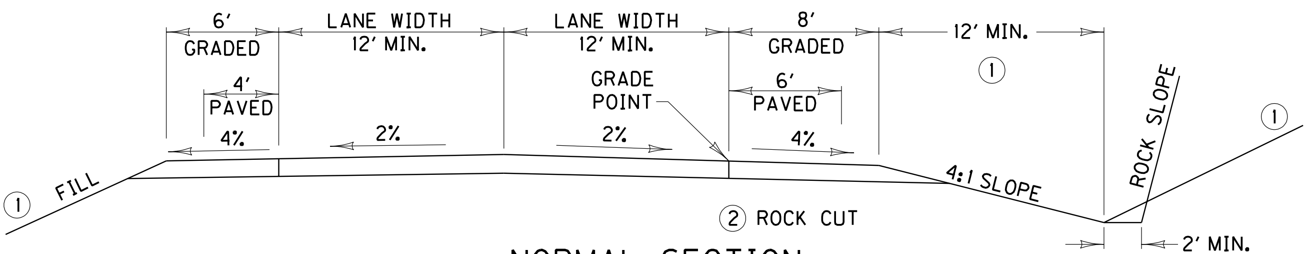
(2) SEE MAINLINE TYPICAL SECTIONS FOR NOTES PERTAINING TO ROCK CUT SITUATIONS.

DRAWING NOT TO SCALE

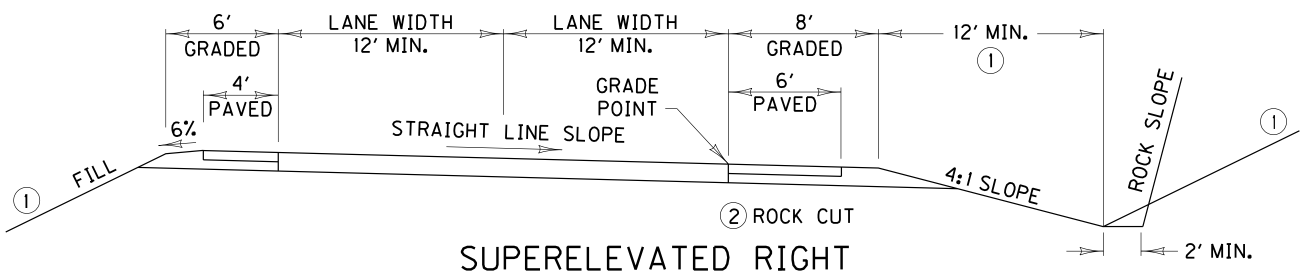
3-25-2004

TYPICAL SECTIONS

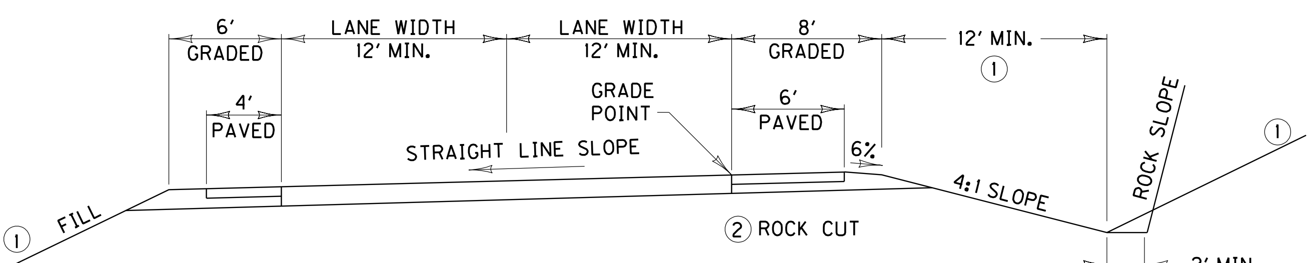
TWO LANE RAMPS
FILL, EARTH CUT OR ROCK CUT



NORMAL SECTION



SUPERELEVATED RIGHT



SUPERELEVATED LEFT

THESE TYPICALS ARE COMMONLY UTILIZED IN THE DESIGN OF RAMP TEMPLATES FOR NORMAL OR SUPERELEVATED SECTIONS IN FILL, EARTH CUT OR ROCK CUT SITUATIONS. THE DESIGN ENGINEER IS DIRECTED TO USE THE CURRENT EDITION OF AASHTO'S "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS" FOR PROJECT SPECIFIC INFORMATION.

(1) SEE AASHTO ROADSIDE DESIGN GUIDE. CONTOUR GRADING PLANS SHALL GOVERN SLOPES AND DIMENSIONS OUTSIDE THE SHOULDER POINT WHERE NOT IN CONFLICT WITH AASHTO ROADSIDE DESIGN GUIDE.

(2) SEE MAINLINE TYPICAL SECTIONS FOR NOTES PERTAINING TO ROCK CUT SITUATIONS.

DRAWING NOT TO SCALE