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DESIGN MEMORANDUM NO. 7-24

TO: Chief District Engineers
Project Development Branch Managers
Design Engineers
Active Consultants

FROM: Tim Layson, P.E., Director
Division of Highway Design

DATE: August 8, 2024

SUBJECT: Update to Breakover for Superelevation in Shoulders. Including Chapters HD-702.5 Superelevation and HD-1001.10 Shoulders of the Highway Design Guidance Manual

This Design Memorandum updates section HD-702.5 of the Highway Design Manual (Superelevation) and HD-1001.10 (Shoulders). The updated chapters and relevant Exhibits 700-05 and 700-07 are included as part of this design memorandum. This change includes updated guidance on the shoulder design in superelevated sections and provides new guidance for divided roadways.

Effective with this memorandum, design procedures and guidance in the updated version of HD-702.5 and HD-1001.10 should be used for all new projects and the KYTC Project Manager should be consulted to determine if this change should be made on a project not yet advanced through the Final Design phase.

Direct questions about this memorandum to the Division of Highway Design, (502) 564-3280.

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 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 runoff length (L) onto the horizontal curve.
- The point of curvature (P.C.) and the point of tangency (P.T.) will be the controls for this situation and will apply 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:

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

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

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.

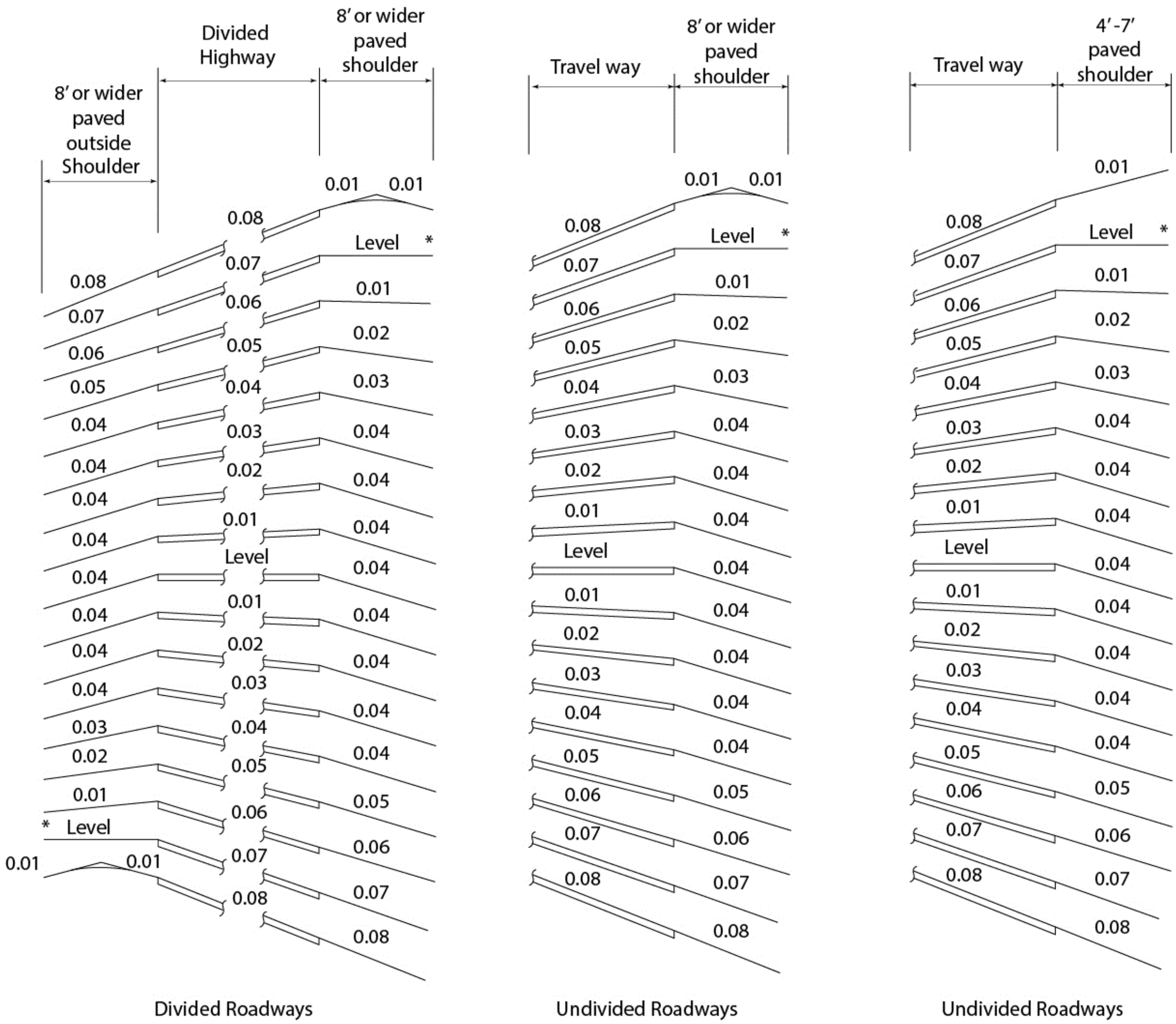
Note: The inside lane(s) do not begin to rotate until the outside lane(s) exceed the normal cross-slope of the inside lane(s). At this point, inside and outside lanes rotate together to full superelevation.

The normal shoulder cross-slope is discussed in HD-702.10.2. Once the normal shoulder cross-slope is exceeded, the full width of the inside shoulder is rotated to match the roadway superelevation. The following applies to the outside shoulder:

- **The paved shoulder width is ≤ to 4 feet.**
  - Rotate the full width of the outside shoulder to match the roadway superelevation.

- **The paved shoulder width is > 4 feet and < 8 feet.**
  - Maintain a shoulder slope of 4% until the maximum algebraic difference in the rate of cross-slope between the shoulder and the roadway is 7%.
  - Use similar superelevation transitions for earthen shoulders whose widths are 0-7 feet but maintain a shoulder slope of 8% until the break is 7%.

- **The paved shoulder width is ≥ 8 feet.**
  - Maintain a shoulder slope of 4% (8% for earthen shoulders) until the maximum algebraic difference in rate of cross-slope between the shoulder and the roadway exceeds 7%.
  - As pavement superelevation increases, maintain the 7% break in slope and keep the shoulder flattened until the shoulder slope is level. *
  - Further increasing pavement superelevation requires **(a)** sloping the inside half of the shoulder toward the pavement (+1%), and **(b)** sloping the outer half of the shoulder away from the roadway (-1%), for mainline superelevation rates of 8%. This may not apply to the inside shoulders of median sections and multilane facilities.



*__Note__: To avoid ponding of water, level or 0% shoulder slopes should only occur during the shoulder superelevation transitions. When the transitioning shoulder slope is 0%, the longitudinal gradient at the edge of the traveled way should not be less than 0.5% for proper shoulder drainage. When the maximum superelevation rate of the travel way is at or near 7%, **a)** shoulders from 4 to 7 ft should continue transition to +1% superelevation, **b)** shoulders ≥ 8 ft should continue transitioning to a +1% shoulder slope with a break near the midpoint at a -1% slope.

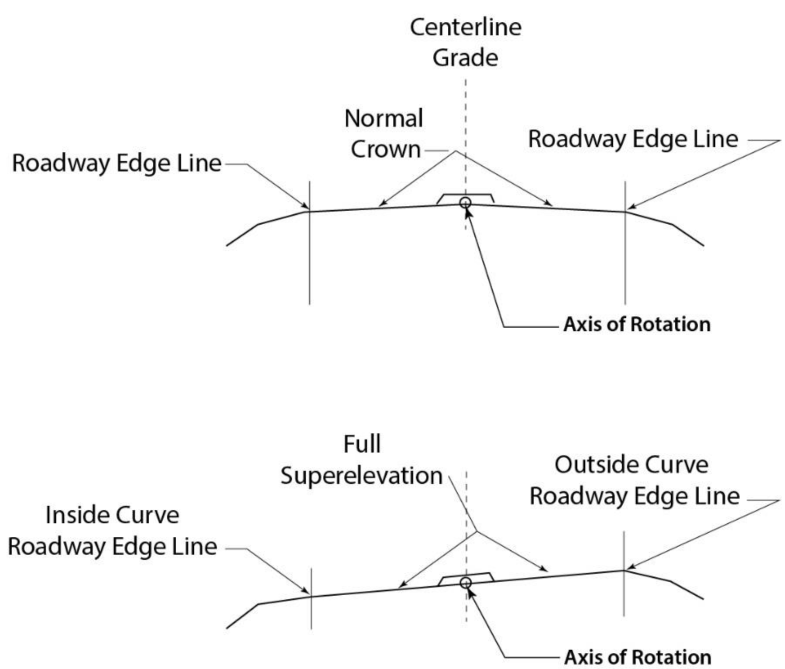
Superelevation for Multilane Divided Highways

On multilane divided highways, designers must carefully consider the details of superelevation. When deciding on the amount of superelevation to use, designers need to consider the same factors as they would for a two-lane road, including design speed, curve radius, and desired maximum superelevation rate. But in addition to these factors the designer must also select an axis of rotation. Axes of rotation are points on the cross section around which the pavement slope is gradually rotated to modify the superelevation slope.

Where the axis of rotation should be located varies based on characteristics of the typical section and project area characteristics such as drainage, adjacent land elevations, and roadside development. The axis of rotation should be clearly shown on the typical sections.

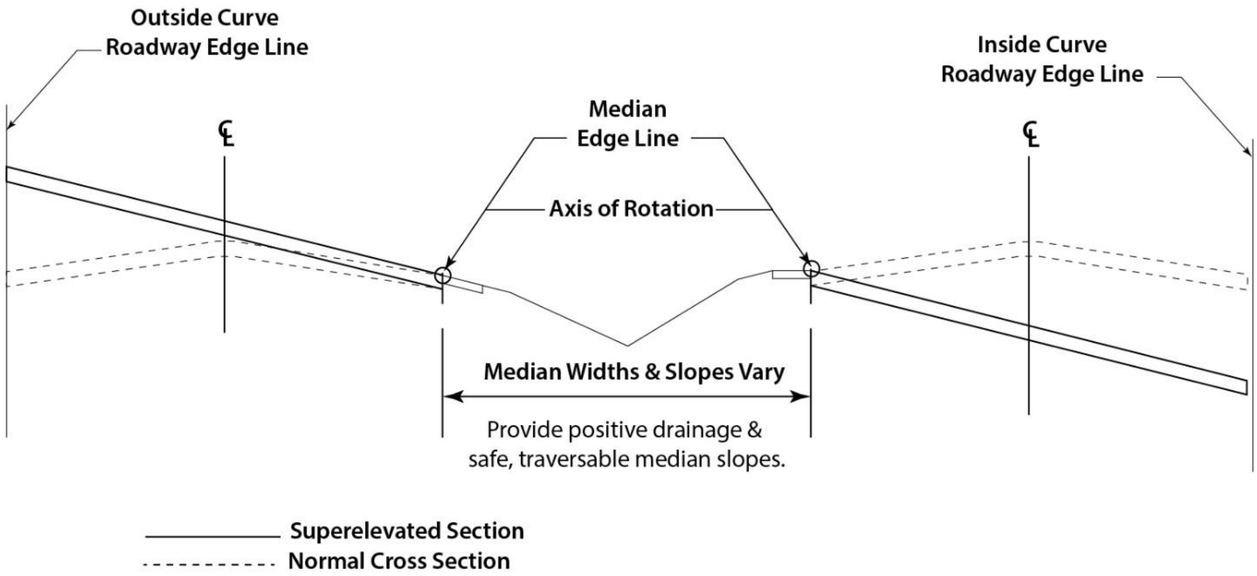
On multilane highways three methods are used to locate the superelevation's axis of rotation:

1. **The axis of rotation is at the centerline.** With this method, the centerline pivot point remains at the profile grade and elevation. On multilane divided highways, the centerline is in the median. This method is often used on divided highways with relatively narrow medians when medians are flush, raised, or have a median barrier. Its use on wider medians is discouraged since it may lead to drainage issues or can result in critical, non-recoverable slopes in the median.



Axis of Rotation at Centerline

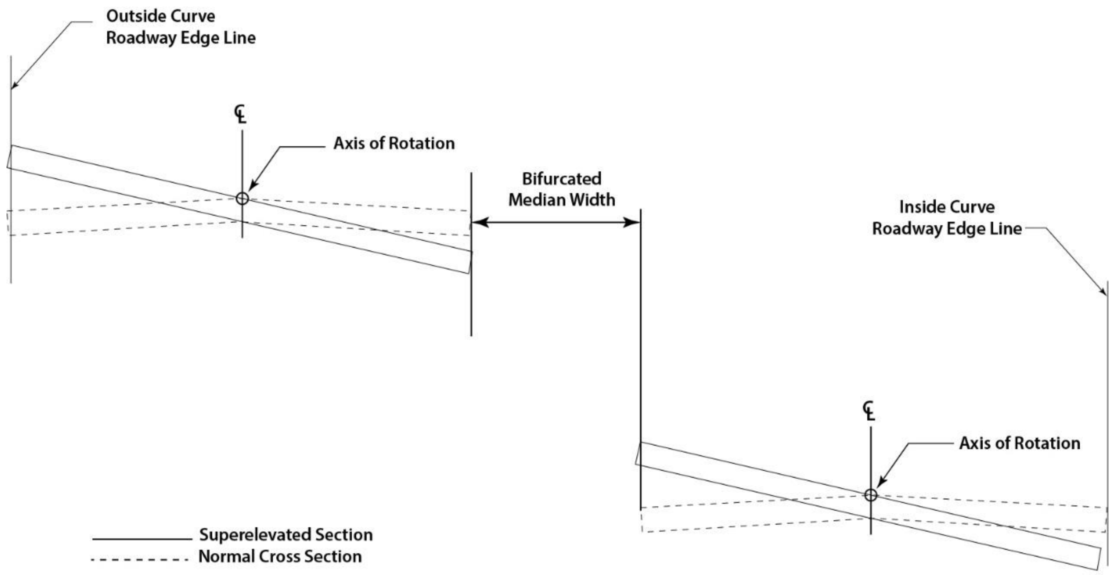
2. **Axes of rotation are at the inside lane lines (i.e., median edges of traveled way).** With this method, the profile grade at both median edges remains at the same elevation as roadway lanes transition through superelevated sections. The median cross section remains relatively uniform, and designers establish superelevation characteristics for each side of the road independently. Multi-lane roadways with depressed and wider medians should be superelevated with axes of rotation placed at the median edges. This method should also be used for two-lane roadways that will ultimately become one direction of a divided highway (i.e., two-lane initial, four-lane ultimate projects).



The Axis of Rotation for Multi-lane Highways with Depressed Medians

3. **Axes of rotation are in the center of both roadways (e.g., between the two lanes on both sides of the four-lane divided highway).** To reduce costs, multilane highways are sometimes bifurcated, with lanes in opposing directions separated and designed as two distinct roadways. On these facilities, independent horizontal and vertical alignments are established at the center of each roadway and may be superelevated as two-lane undivided highways if the resulting median cross section is acceptable.

4.



Axis of Rotation in the Center of Both Roadways

Designers must exercise special care when designing medians throughout superelevated sections. Positive drainage in the median should be provided throughout the horizontal curve, and median slopes should be recoverable for errant vehicles that enter the median. Median slopes steeper than 3H:1V are termed critical and may need to be shielded.

For more guidance, see KYTC Standard Drawing RGS-002 *Superelevation for Multilane Pavement*.

On multilane divided highways when a median opening is to be built on a horizontal curve, designers must adjust the mainline profile to establish a smooth transition through the crossover. This is especially important where crossroads are found at the median opening. If the mainline profile is not adjusted, vehicles traveling through the crossover will traverse an abruptly rolling or hidden dip profile. For more information see the *Highway Design Guidance Manual* Exhibit 900-03 (*Cross Road Profile Adjustment*).

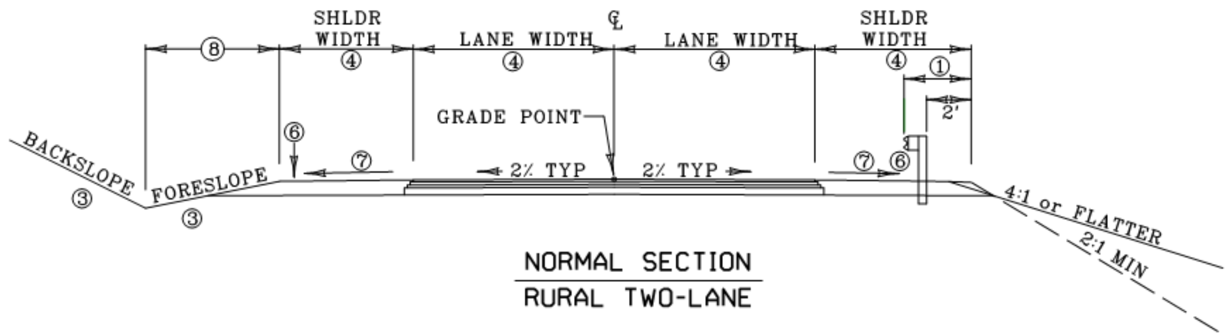
HD-1001.10 SHOULDERS

Show the shoulder pavement thickness in the pavement design document. The cross-slope for a 4-foot or less paved shoulder is to be the same as the mainline pavement. For shoulders greater than 4 feet that are not paved monolithically with the mainline, use a 4 percent cross-slope in normal sections. Full-width DGA shoulders are not recommended and should not be utilized without prior approval from the Pavement Design Branch Manager. For paved shoulders 4 feet or less in width, specify the same mix as used for the mainline pavement. Thickness should be determined to insure adequate structural support is provided to meet any anticipated shoulder traffic. Typically, shoulders should be designed to accommodate a minimum of 20 percent of the mainline AADTT. This generally correlates to carrying the top asphalt base and surface courses onto the shoulder with full-depth DGA below.

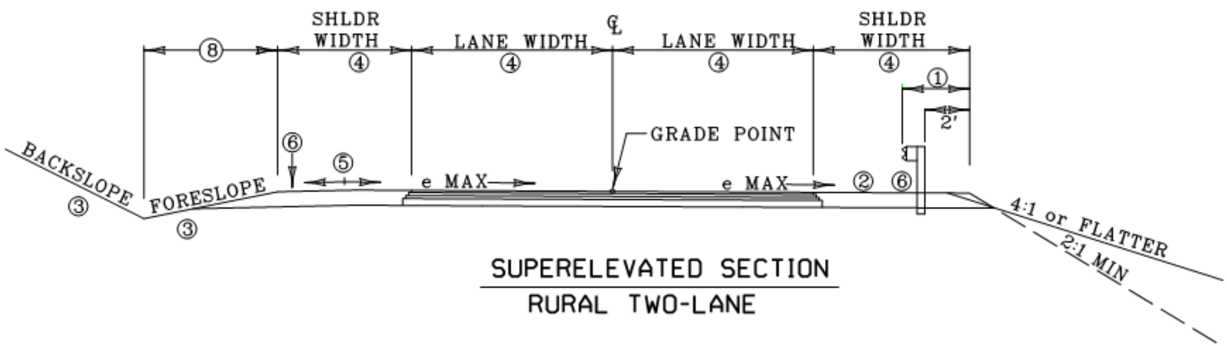
Note: Extend the surface course under the guardrail wedge curb as required. When the useable shoulder is paved and guardrail is used, consideration should be given to extending the pavement to the face of the guardrail.

When using aggregate at the outside edge of the paved shoulders, an asphalt seal is required from the outside edge of the paved shoulder to a point at least two feet down the ditch or fill slope. See *Pavement Design Guide* for more details.

TYPICAL SECTIONS



NORMAL SECTION
RURAL TWO-LANE



SUPERELEVATED SECTION
RURAL TWO-LANE

① SHOULDERS SHALL BE WIDENED 3 FEET 5 INCHES WHERE GUARDRAIL IS TO BE INSTALLED ALLOWING FOR 2 FEET OF FILL BEHIND THE POSTS. IF IT IS NOT PRACTICAL TO WIDEN THE SHOULDER BY 2 FEET, THEN LONGER POSTS MAY BE USED.

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 FOR FORSLOPE AND BACK SLOPE.

④ REFER TO KYTC COMMON GEOMETRIC PRACTICE EXHIBITS 700-01 TO 700-04 AND AASHTO'S "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS", CURRENT EDITION, FOR RECOMMENDED LANE AND SHOULDER WIDTHS OF THE VARIOUS ROADWAY CLASSIFICATIONS. FOR LOCAL AND COLLECTOR ROADWAYS WITH ADT EQUAL TO OR LESS THAN 2000, REFER TO AASHTO'S "GUIDELINES FOR GEOMETRIC DESIGN OF LOW-VOLUME ROADS".

⑤ FOR A PAVED SHOULDER WIDTH LESS THAN OR EQUAL TO 4 FEET, NO BREAK IN SLOPE IS REQUIRED. FOR A PAVED SHOULDER WIDTH GREATER THAN 4 FEET, THE MAXIMUM ROLLOVER BETWEEN THE TRAVEL WAY AND SHOULDER SHOULD NOT EXCEED 7 PERCENT. FOR A PAVED SHOULDER WIDTH GREATER THAN OR EQUAL TO 8 FEET, THE BREAK IN SLOPE ON THE HIGH SIDE IS TO OCCUR AT THE MIDPOINT, OR AS APPROPRIATE. REFER TO HD-702.5.

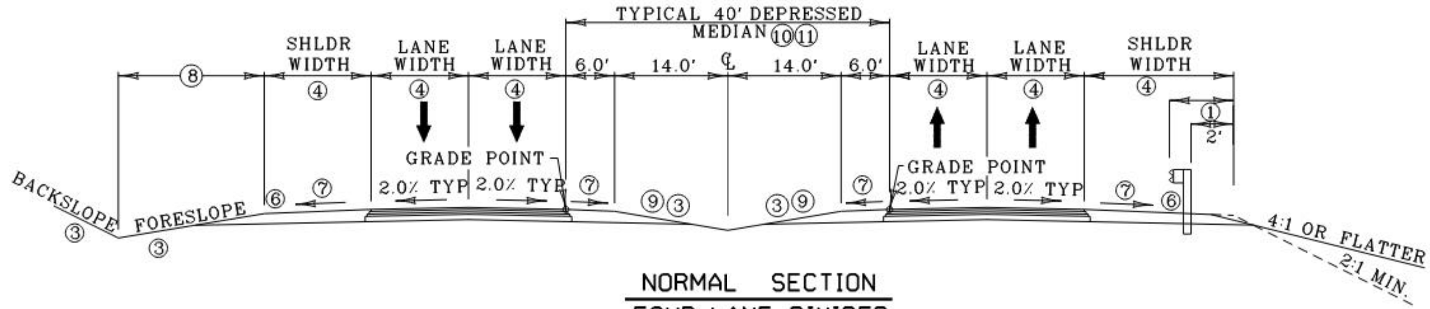
⑥ SHOULDER MAY BE PAVED TO WITHIN 2 FEET (1 FOOT MINIMUM) OF THE SLOPE BREAK OR TO THE FACE OF THE BARRIER.

⑦ NORMAL SHOULDER CROSS SLOPE: EARTH = 8%, PAVED = 4%

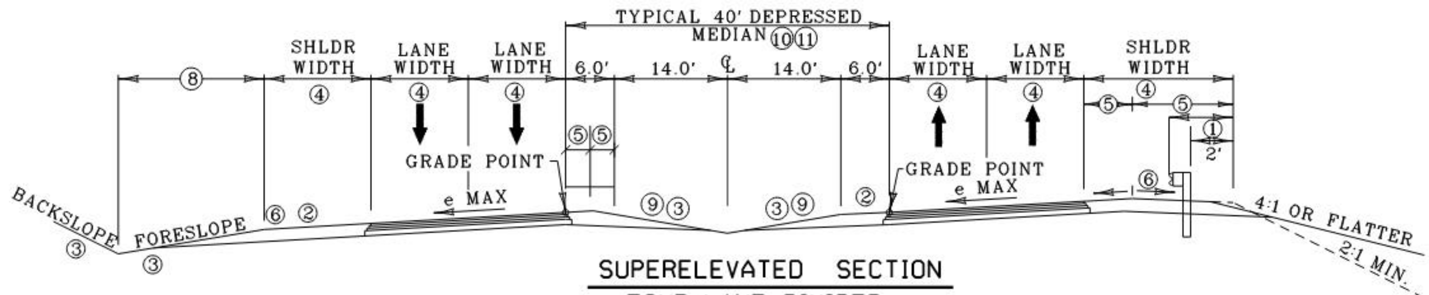
⑧ WIDTH VARIES PER DRAINAGE/"ROADSIDE DESIGN GUIDE" REQUIREMENTS.

Exhibit 700-07

TYPICAL SECTIONS



NORMAL SECTION
FOUR-LANE DIVIDED



SUPERELEVATED SECTION
FOUR-LANE DIVIDED

① SHOULDERS SHALL BE WIDENED 3 FEET 5 INCHES WHERE GUARDRAIL IS TO BE INSTALLED ALLOWING FOR 2 FEET OF FILL BEHIND THE POSTS. IF IT IS NOT PRACTICAL TO WIDEN THE SHOULDER BY 2 FEET, THEN LONGER POSTS MAY BE USED.

② SUPERELEVATED SHOULDERS - CONSTRUCT TO STANDARD SUPERELEVATION, EXCEPT NOT FLATTER THAN THE SLOPE INDICATED FOR NORMAL SECTION. AFTER THE NORMAL SHOULDER CROSS-SLOPE IS EXCEEDED, THE FULL WIDTH OF THE INSIDE SHOULDER IS ROTATED TO MATCH THE ROADWAY SUPERELEVATION.

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

④ REFER TO KYTC COMMON GEOMETRIC PRACTICE EXHIBITS 700-1 THRU 700-4 AND AASHTO'S "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS", CURRENT EDITION, FOR RECOMMENDED LANE AND SHOULDER WIDTHS OF THE VARIOUS ROADWAY CLASSIFICATIONS. FOR LOCAL AND COLLECTOR ROADWAYS WITH ADT EQUAL TO OR LESS THAN 2000, REFER TO AASHTO'S "GUIDELINES FOR GEOMETRIC DESIGN OF LOW-VOLUME ROADS".

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⑦ NORMAL SHOULDER CROSS SLOPE: EARTH = 8%, PAVED = 4%

⑧ WIDTH VARIES PER DRAINAGE/"ROADSIDE DESIGN GUIDE" REQUIREMENTS.

⑨ 4:1 MINIMUM; 6:1 DESIRABLE

⑩ WHEN MEDIANS ARE LESS THAN 40 FEET, BARRIERS SHOULD BE CONSIDERED.

⑪ WHEN LEFT TURN LANES OCCUPY A PORTION OF THE MEDIAN, SEE CROSSROAD PROFILE EXHIBIT 900-01.