Appendix G

Supplemental Horizontal Alignment Information

Appendix G contains supplemental information associated with Chapter 3: Horizontal Alignment, which includes the following:

- Superelevation Axis of Rotation
- Rounding Curve and Alignment Data
- Rounding of Stationing and Bearings
- Compound Curve Applications

G.1 SUPERELEVATION AXIS OF ROTATION

Superelevation axis of rotation should typically be about the centerline profile (Method A below) for all rural or urban roadways, except for those roadways with a median more than 10 feet wide. One of AASHTO Cases I-III should be applied, for roadways with a median more than 10 feet wide. Chapter 3, Section 3.3.5 provides additional details on MDT's approach for axis of rotation. The 2018 *AASHTO A Policy on Geometric Design of Highways and Streets* (Green Book) has four methods for setting the axis of rotation, which are described below.

- **Method A: Rotation about the centerline profile.** This method rotates the traveled way about the centerline profile. The centerline profile remains fixed while the inside-edge profile is dropped below the centerline and the outside-edge profile is raised above the centerline, thus creating the least amount of distortion to the edge of the roadway.
- **Method B: Rotation about the inside-edge of pavement.** This method was the previously preferred method for axis of rotation and rotates the traveled way about the inside-edge profile. The inside edge of traveled way, between the travel lane and shoulder, remains fixed while the centerline is raised above the inside edge and the outside edge is raised above the centerline.
- **Method C: Rotation about the outside-edge profile.** This method rotates the traveled way about the outside-edge profile. It is similar to Method B, except the outside edge of traveled way, between the travel lane and shoulder, remains along a fixed plane while the centerline and inside-edge profile are lowered.

- **Method D: Straight cross slope rotated about the outside-edge profile.** This method rotates the traveled way with a straight cross slope about the outside edge of traveled way profile. This method is most common for divided highway facilities where each direction is sloped to drain to the median.

Exhibits illustrating each method are shown below, which are excerpts from the *AASHTO Green Book*.

Exhibit G-1
Excerpt from *AASHTO Green Book* – Axis of Rotation: Method A

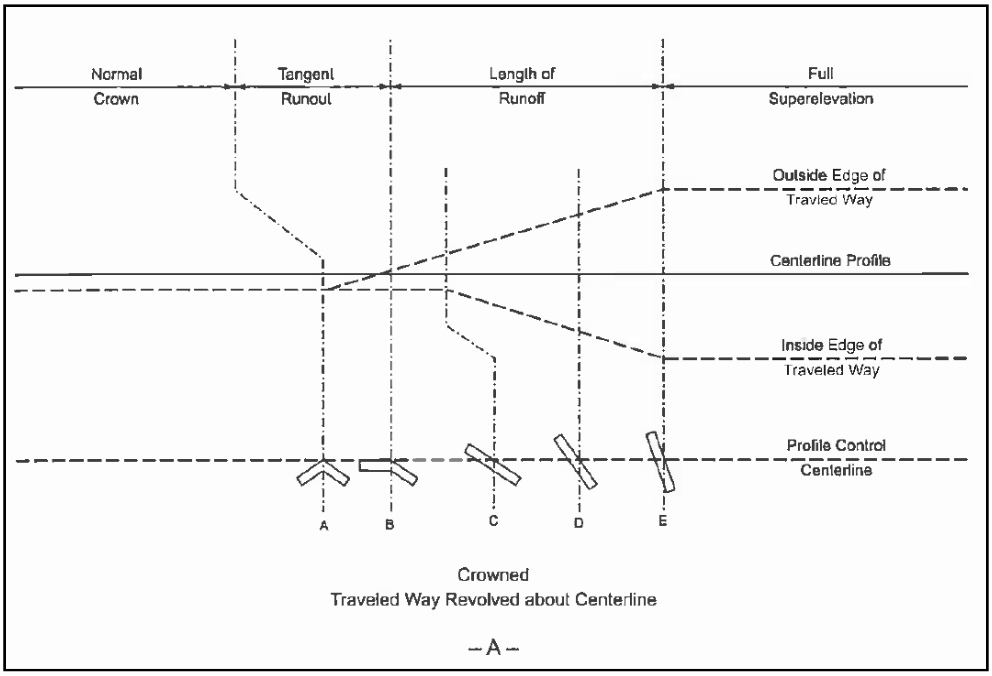
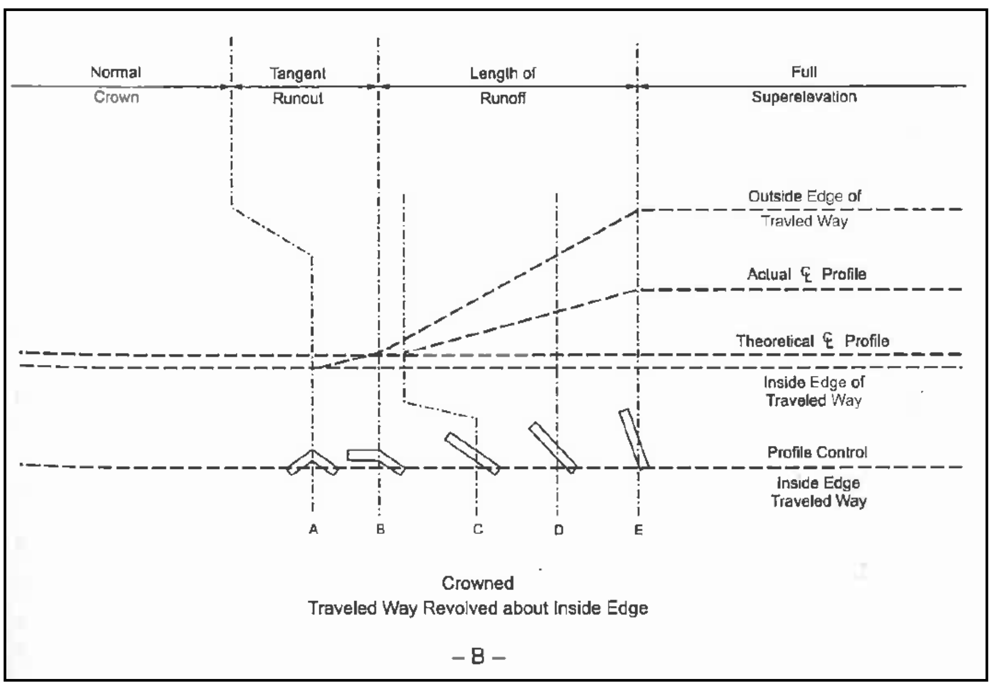


Exhibit G-2
Excerpt from *AASHTO Green Book* – Axis of Rotation: Method B



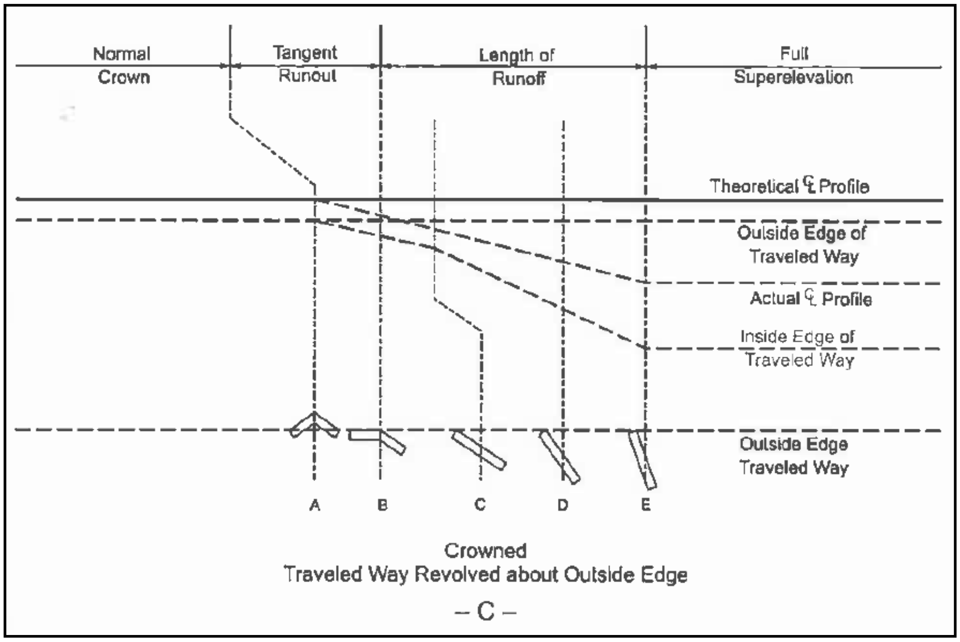


Exhibit G-3
Excerpt from *AASHTO Green Book* – Axis of Rotation: Method C

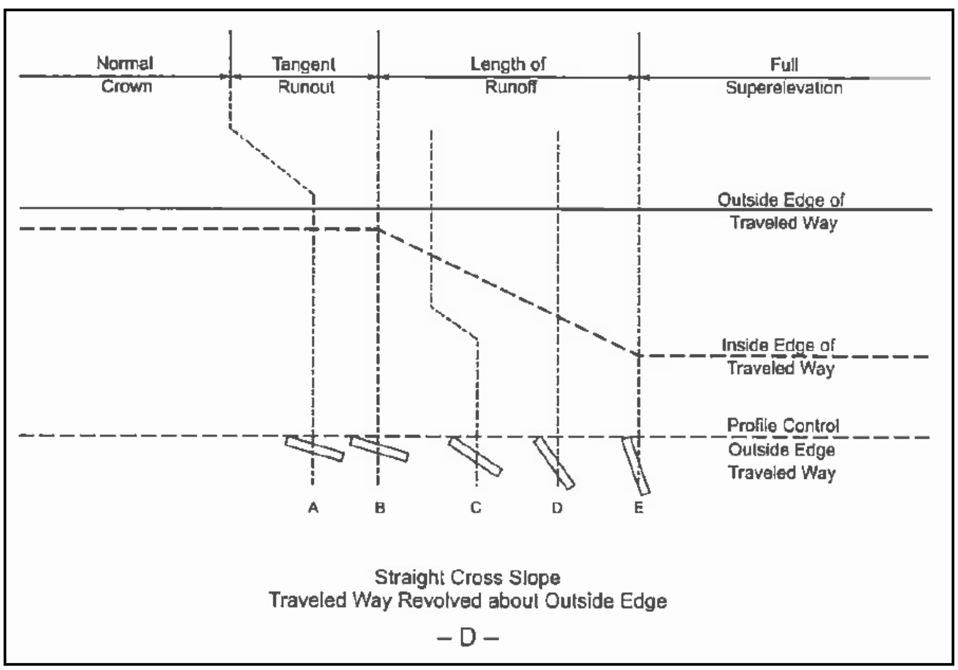


Exhibit G-4
Excerpt from *AASHTO Green Book* – Axis of Rotation: Method D

G.2 ROUNDING CURVE AND ALIGNMENT DATA

G.2.1 For a New Horizontal Curve

The following summarizes MDT's practices for presenting data for a new horizontal curve on the roadway plans:

1. **Deflection Angle**. These should be displayed to a second of a degree.
2. **Linear Distances (Between PIs)**. These should be designed to the one hundredth of a foot (i.e., two decimal places).
3. **Curve Radii**. Radii should be designed using 5-foot increments.

When using computer-generated curve data, consider the implications of rounding off the data according to the above criteria. To ensure mathematical consistency, the following procedure should be used when defining the horizontal alignment.

G.2.2 For an Existing Horizontal Curve

For existing horizontal curves, MDT's rounding practices for presentation on the roadway plans are:

1. **Deflection Angle.** These should be recorded in degrees rounded to the nearest second of a degree.

2. **Linear Distances.** These should be recorded in feet rounded to the nearest one hundredth of a foot (i.e., two decimal places).

3. **Curve Radii.** Rounding will be determined by the Project Scope of Work as follows:

   a. **Overlay and Widening.** Where an existing metric horizontal curve will be retained in the project, calculate the US Customary radius from the known radius and round to three decimal places. The *T* and *L* distances are then calculated based on the US Customary radius and rounded to the nearest 0.01 of a foot.

   b. **Reconstruction.** Where the alignment for a reconstruction project will approximate the existing alignment, the radii of the reconstructed curve may be rounded to the nearest 5 feet. The *T* and *L* distances are then calculated based on the US Customary radius and rounded to the nearest 0.01 of a foot.

G.3 ROUNDING OF STATIONING AND BEARINGS

The following will apply to projects where control points are used to establish horizontal alignment:

1. **Rounding.** All stationing will be rounded to the nearest hundredth of a foot (i.e., two decimal places). All bearings will be rounded to the nearest second of a degree. When rounding computer-generated bearings, ensure that the rounded numbers for bearings are mathematically consistent.
2. **Coordinates**. Prepare a table of coordinates for the notes sheet. The table will illustrate the coordinate values for all control points for either the staked centerline or control traverse survey and for the projected centerline. The control points will include the project beginning and ending points; the PC, and PT for simple curves; the TS, SC, CS and ST for spiral curves; and all equations. All coordinates must be computed to at least four decimals and rounded in the table to the nearest three decimals (.001).

For projects using the as-built plans as the basis of horizontal alignment (typically overlay projects), retain the degree of accuracy shown on the as-built plans for US Customary as-builts. If as-builts are metric, soft convert the as-built stationing to US Customary and round as described above. Also, when existing right-of-way (R/W) plans are used to describe additional R/W acquisition, ensure that the accuracy of the stationing and bearings matches that of the old R/W plans.

G.4 COMPOUND CURVE APPLICATIONS

Compound curves are a series of two or more horizontal curves with deflections in the same direction immediately adjacent to each other. Compound curves are most commonly used for transitioning low-speed roadways at intersections (for example, ramps, slip lanes), but can also be used on the mainline of low-speed urban roadways, particularly as a practical design alternative to spiral transitions. The design team should avoid a curve radius misleading the motorist’s expectation of the sharpness of another curve radius within the compound curve. Therefore, compound curves on the mainline should be designed such that the radius of the flatter curve is no more than 1.5 times the radius of the sharper curve ($R_1 \leq 1.5R_2$, where R_1 is the flatter curve). Superelevation transition lengths can be applied to the approaching and exiting curves in the same manner as applied to single curves. See Appendix K for examples of the application and calculation of compound curves.

The design team should exercise caution using compound curves. Compound curves are generally not a preferred horizontal alignment design feature. However, circumstances do arise that preclude other preferred curve options from being feasible. Geographic features, such as railroads, waterways and topography and/or right-of-way restrictions are some conditions that can introduce substantial project risk. Compound curves can be an appropriate response strategy in these circumstances to mitigate risk. When compound curves are applied, they should be discussed at the milestone reviews and justified in the milestone reports. See Chapter 3, Section 3.1.1 for design guidance.

The most common use of compound circular curves is in the design of turning roadways, such as slip lanes and interchange ramps, where vehicles are moving from one roadway to another, and a change in design speed is anticipated. An interchange loop ramp for example, may utilize a three-centered compound curve of decreasing, then increasing radii to provide for a large turning movement with varying speed as shown in Exhibits G-5 and G-6. The radii correspond to the vehicle's deceleration and subsequent acceleration through the maneuver.

Exhibits G-5 and G-6 show examples for both three-centered and two-centered compound curves.

Exhibit G-5
Three-Centered Compound Curve

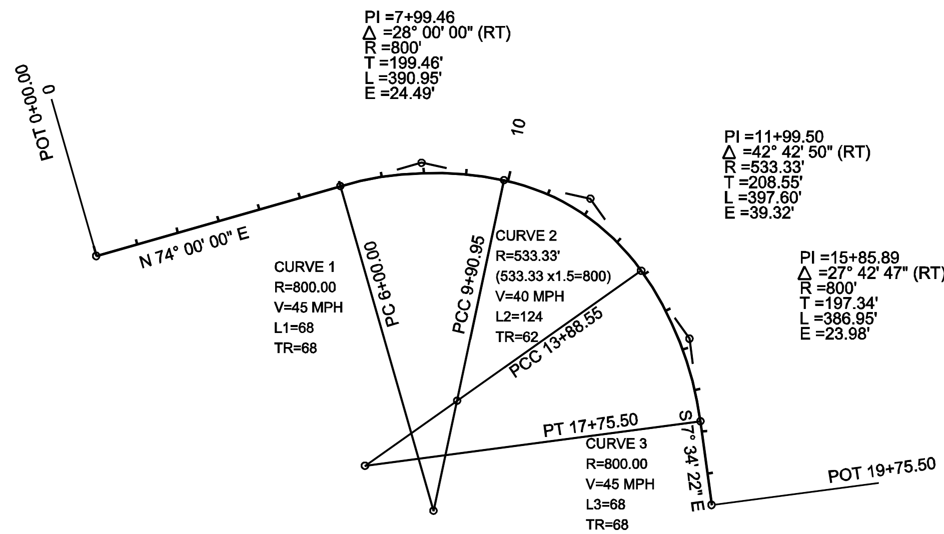


Exhibit G-6
Two-Centered Compound Curve