Topics Presented

- Requirements

- Design Parameters
  - Design Speed
    - Stopping Sight Distance
  - Curve Geometry
    - Length and Algebraic Difference
  - K-Values
    - Design vs most restrictive

- County Spreadsheet

- Vertical Curves at Intersections
Vertical Curve Requirements

Vertical Curve Design required for changes in grade with algebraic difference greater than 1.5 [See UDC 35-506(d)(2)]

These can occur:

- Along street grades
- At street intersections
- At driveways
# Design Speed

<table>
<thead>
<tr>
<th>Street Type</th>
<th>Local Type A</th>
<th>Local Type B</th>
<th>Collector</th>
<th>Secondary Arterial&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Primary Arterial&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Speed (mph)</td>
<td>30</td>
<td>30–35</td>
<td>40–45</td>
<td>45</td>
<td>45</td>
</tr>
</tbody>
</table>

**UDC 35-506 (d)(12) Design Speed.**

**A. Applicability.** The design speed values listed in table 506-3 shall be used in conjunction with the American Association of State Highway & Transportation Officials (AASHTO) Policy on Geometric Design of Highways and streets, or latest revision thereof in the design of the streets horizontal and vertical alignment to include but not limited to:

- Intersection sight distance; vertical K-values;
- Horizontal obstruction offset values;
- Stopping sight distance;
- Transition distance; and
- Turn bay design.
Stopping Sight Distance

Determined by calculating decision distance and braking distance required for the design speed and tangential grade on wet pavement

\[ d = 1.47Vt + \frac{V^2}{30(\frac{a}{32.2}) \pm G} \]

- \( V \) = design speed, mph
- \( t \) = brake reaction time, 2.5 sec.
- \( a \) = deceleration rate, \( \text{ft/s}^2 \) – 11.2 \( \text{ft/s}^2 \)
- \( G \) = percent of grade divided by 100

*AASHTO 2004 Policy on Geometric Design of Highways and Streets aka “Green Book”*
Curve Geometry

AASHTO 2004 Policy on Geometric Design of Highways and Streets aka “Green Book”
S is stopping sight distance

A is Algebraic Difference between grades

Eqn simplified for $h_1 = 3.5\text{ft}$ and $h_2 = 2.0\text{ft}$

AASHTO 2004 Policy on Geometric Design of Highways and Streets aka “Green Book”
For overall safety, a sag vertical curve should be long enough that the light beam distance is nearly the same as the stopping sight distance. AASHTO indicates it is appropriate to use stopping sight distances for different design speeds as the value of S in the equations.

**US Customary**

When \( S \) is less than \( L \),

\[
L = \frac{AS^2}{200\left[2.0 + S(tan1')\right]} \quad (3-47)
\]

or,

\[
L = \frac{AS^2}{400 + 3.5S} \quad (3-48)
\]

When \( S \) is greater than \( L \),

\[
L = 2S - \frac{200\left[2.0 + S(tan1')\right]}{A} \quad (3-49)
\]

or,

\[
L = 2S - \left(\frac{400 + 3.5S}{A}\right) \quad (3-50)
\]

where:

- \( L \) = length of sag vertical curve, ft;
- \( S \) = light beam distance, ft;
- \( A \) = algebraic difference in grades, percent

AASHTO 2004 Policy on Geometric Design of Highways and Streets aka “Green Book”
**K Values**

K Value represents the horizontal distance for a 1% of grade change

\[ K = \frac{L}{A} \]

Minimum K-value required must provide for the maximum stopping sight distance encountered on the vertical curve being designed.

\(-g = -2\%\)

\(+g_2 = +3\%\)
### Sight Distance

**Exhibit 3-2. Stopping Sight Distance on Grades**

AASHTO 2004 Policy on Geometric Design of Highways and Streets aka “Green Book”
Vertical Curve Spreadsheet

- Developed as a guide and check for vertical curve design to ensure the “worst case” stopping sight distance is accommodated

- Uses AASHTO equations for stopping sight distance (SSD)

- Calculates SSD and K-values for the design speed of the road classification and the parameters of the curve being designed and can be applied for the direction of travel for grade separated roadways
Enter Parameters in Grey Fields

Can be used to determine minimum cover over utility lines and culverts

<table>
<thead>
<tr>
<th>Street Name</th>
<th>Plat #:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</table>

| Length of Vertical Curve (ft) | 700.00 |
| Elevation of P.V.C.           | 1513.31 |
**K-Value Determination (Crest Curve, S>L)**

<table>
<thead>
<tr>
<th>Design Speed:</th>
<th>Design K-value:</th>
<th>Most Restrictive K-value:</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>13.33</td>
<td>26</td>
</tr>
</tbody>
</table>

- **G1 Uphill Minimum K-value:** 17
- **G2 Downhill Minimum K-value:** 26

**USE CREST CURVE S<L CALCULATION SHEET**

**Determination of Vertical Curve Elevations**

*(Symmetrical Parabolic)*

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<table>
<thead>
<tr>
<th>Length of Vertical Curve (ft)</th>
<th>Elevation of PVC (ft)</th>
<th>Grade (g) (%)</th>
<th>Distance From PVC at Which Elevations to be Calculated (ft)</th>
<th>Elevation at Descent Location is</th>
</tr>
</thead>
<tbody>
<tr>
<td>200.00</td>
<td>1511.75</td>
<td>-10.000</td>
<td>55.00</td>
<td>1513.31</td>
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**USE CREST CURVE S=L CALCULATION SHEET**

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Vertical Curves at Intersections

Determining K-values at intersections

- For local street intersections, where the K-value is on the street that has a stop sign control, a minimum design speed of 15 mph shall be used.

- For local street or driveway intersections connecting to a Collector street or higher, where the K-value is on the street that has a stop sign control and does not have the potential of begin signalized, a minimum design speed of 20 mph shall be used.