Geometric Design of Highway Facilities

Chapter 16

Geometric Design Standards

- National Criteria published by:
- Each State and Local Agencies adopts guidelines and practices from the National Criteria and these guideline must be approved by the Federal Highway Administration (FHA)
- Tennessee Department of Transportation (TDOT) publishes their own guidelines.
- City of Memphis and Shelby County have their own guidelines as well for roadway design.
Geometric Design of Highways

• Design Controls and Criteria include:
  - Functional classification
  - Projected traffic volumes and composition
  - Design speed and design vehicle
  - Topography
  - Available Funding
  - Driver performance factors
  - Safety
  - Politics
  - Social and environmental impacts
  - Right-of-Way (ROW)
  - Costs

Functional Classification of Highways

• Hierarchial system based on purpose and level of importance
  - Principal arterials
  - Minor arterials
  - Major collectors
  - Minor collectors
  - Local roads and streets

Each functional classification can be termed either urban or rural depending on the location of the planned highway.
Highway Design Standards

Major Traffic Elements:

- Average Annual Daily Traffic (AADT) or Average Daily Traffic (ADT)
- k factor
- Design Hourly Volume (DHV)
- Directional Distribution (D)
- Percentage of Trucks and RVs
- Design Flowrate (V) - Peak 15-minute flowrate

Traffic Considerations:

DHV = ADT (k)

- k factor represents the percentage of traffic occurring during the peak hour during an average weekday.
- The DHV represents the 30th highest hourly volume during a year.
- AASHTO recommends a k value of 8 to 12 percent for urban facilities and 12 to 18 percent for rural facilities.
Highway Design Standards

Traffic Considerations:

\[ V = \frac{DHV}{PHF} \]

The design peak 15-minute flowrate \( V \) is computed by dividing the design hourly volume \( DHV \) by the peak hour factor \( PHF \).

The \( PHF \) is a function of the population in the surrounding area.

The design peak 15-minute flowrate in the more heavily traveled direction is computed using the directional distribution \( D \).

The directional distribution \( D \) ranges from 55 to 80 percent with an average value of 67 percent for rural roads.

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Highway Design Standards

Traffic Considerations:

The directional distribution \( D \) for urban facilities tends to approximate an equal split in each direction \( D = .50 \).

The composition of heavy vehicles \( T \) in the traffic stream during the design hour typically varies from 5 to 10 percent but in some cases can be as high as 25 percent.
Highway Design Standards

Design Speed:

AASHTO defines design speed as "a selected speed to determine the various geometric features of a roadway"

Design Speed depends on the functional classification of the highway, the topography of the area and the adjacent land use.

Topography:
Level
Rolling
Mountainous

Design Speeds range from 20 mph to 70 mph in increments of 10 mph.

Highway Design Standards

Design Speed:

Freeways are designed for 60 to 70 mph speeds.

Design speeds are selected to achieve a desired level of operation and safety on a highway.

In the future you may see higher design speeds than 70 mph for interstate systems.

See Tables 16.1 and 16.2 on pages 678 and 679 in your textbook.
Highway Design Standards

Design Vehicle:

Design vehicles are selected to represent all vehicles on the highway. The vehicle type selected is typically the largest vehicle likely to use the highway with considerable frequency.

The weight, physical dimensions, and operating characteristics of the design vehicle will be used to establish the geometric features of the highway.

See guidelines listed on pages 679 and 680 in your textbook.

Highway Design Standards

Cross-Section Elements:

Travel lanes
Shoulders
Medians
Roadside barriers
Guardrails
Side Slopes
Curb and Gutter (in urban areas)
Highway Design Standards

Cross-Section Elements:

Travel lane widths vary from 9 feet to 12 feet.

12-foot lanes are desirable for all new facilities.
Design of the Alignment

Vertical Alignment:

<table>
<thead>
<tr>
<th>Type of Terrain</th>
<th>Metric Grades (%)</th>
<th>US Customary Grades (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>4 4 3 3 3 3</td>
<td>4 4 3 3 3 3</td>
</tr>
<tr>
<td>Rolling</td>
<td>5 5 4 4 4 4</td>
<td>5 5 4 4 4 4</td>
</tr>
<tr>
<td>Mountainous</td>
<td>6 6 6 6 6 6</td>
<td>6 6 6 6 6 6</td>
</tr>
</tbody>
</table>

* Grades 1% steeper than the value shown may be used for extreme cases in urban areas where development precludes the use of flatter grades and for one-way downgrades except in mountainous terrain.

Exhibit 8-1. Maximum Grades for Rural and Urban Freeways


Design of the Alignment

Vertical Alignment:

<table>
<thead>
<tr>
<th>Type of Terrain</th>
<th>20 30 40 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>7 7 7 6</td>
</tr>
<tr>
<td>Rolling</td>
<td>10 9 8 7</td>
</tr>
<tr>
<td>Mountainous</td>
<td>12 10 10 9</td>
</tr>
</tbody>
</table>

* Design Speed as determined by conditions on the majority of the project.

Table 1-4

From: TDOT - Roadway Design Guidelines

For curb & gutter sections a minimum of 0.50% grade should be used.
Design of the Alignment

Vertical Curves:
- Must provide minimum stopping sight distance
- Adequate drainage
- Comfortable operation
- Pleasant appearance

Sag curves must meet these four criteria.
Crest curves must only satisfy the first criteria.

Design of the Alignment

Crest Vertical Curves:

<table>
<thead>
<tr>
<th>Metric</th>
<th>US Customary</th>
</tr>
</thead>
<tbody>
<tr>
<td>When $S$ is less than $L$, $L = \frac{AS^2}{100(\sqrt{2L} + \sqrt{2h_u})}$</td>
<td>When $S$ is less than $L$, $L = \frac{AS^2}{100(\sqrt{2L} + \sqrt{2h_u})}$</td>
</tr>
<tr>
<td>When $S$ is greater than $L$, $L = \frac{2S}{\sqrt{2(b_u + \sqrt{h_u})}}$</td>
<td>When $S$ is greater than $L$, $L = \frac{2S}{\sqrt{2(b_u + \sqrt{h_u})}}$</td>
</tr>
</tbody>
</table>

where:
- $L$ = length of vertical curve, m;
- $S$ = sight distance, m;
- $A$ = algebraic difference in grades, percent;
- $b_u$ = height of eye above roadway surface, m;
- $h_u$ = height of object above roadway surface, m.

Exhibit 3-74. Parameters Considered in Determining the Length of a Crest Vertical Curve to Provide Sight Distance
Design of the Alignment

Crest Vertical Curves:

AASHTO recommends that the height of the driver's eye be taken as 3.5' and the object height be 2.0'. The equations now become:

<table>
<thead>
<tr>
<th>Metric</th>
<th>US Customary</th>
</tr>
</thead>
<tbody>
<tr>
<td>When ( S ) is less than ( L ),</td>
<td>When ( S ) is less than ( L ),</td>
</tr>
<tr>
<td>( L = \frac{AS^2}{658} )</td>
<td>( L = \frac{AS^2}{2158} ) (3.45)</td>
</tr>
<tr>
<td>When ( S ) is greater than ( L ),</td>
<td>When ( S ) is greater than ( L ),</td>
</tr>
<tr>
<td>( L = 2S + \frac{658}{A} )</td>
<td>( L = 2S - \frac{2158}{A} ) (3.46)</td>
</tr>
</tbody>
</table>

Design of the Alignment

Design of Crest Vertical Curves:

Exhibit 3-75. Design Controls for Crest Vertical Curves—Open Road Conditions