Practical Application of Turn Lane Design Criteria in Developing Suburban & Urban Corridors

Presented by
Gilmer D. Gaston, P.E., PTOE

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When are Turn Lanes Needed (Required)

• Access Management Manual
  • Right Turn Deceleration Lanes (Table 2-3) are needed:
    • Speed > 45 mph & Right Turn Volume > 50 vph
    • Speed <= 45 mph & Right Turn Volume > 60 vph
    • Other factors
      • Crash experience
      • Heavy peak flow
      • Large truck volumes
      • Limited sight distance

• Left Turn Deceleration Lanes (Table 2-3) are needed under All conditions
Right Turn Lane Design

1. Storage Length
2. Taper Length
3. Deceleration Length
4. Lane Width
Storage Length, Right Turn

• Traffic Projections – round to “tens” or more.
• Queue Length estimated:
  • HCM Software (HCS)
  • SYNCHRO
  • VISSIM

• Minimum storage length for a single right turn lane is 30 feet per Roadway Design Manual. For trucks, use appropriate vehicle length.
Right Turn Lane Design Criteria: Storage

- Or estimated by:

\[ L = \left( \frac{V}{N} \right)(2)(S) \]

**Where:**
- \( L \): Storage length, feet
- \( V \): Turning volume per hour, vph
- \( N \): Number of cycles if signalized or 30 if unsignalized
- 2: Factor for storage of all vehicles. (1.8 may be acceptable on collector streets)
- \( S \): Queue storage length per vehicle, feet, typically 25 feet for automobiles, adjust per % of Trucks using table to right

<table>
<thead>
<tr>
<th>% of Trucks</th>
<th>S (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5</td>
<td>25</td>
</tr>
<tr>
<td>5-9</td>
<td>30</td>
</tr>
<tr>
<td>10-14</td>
<td>35</td>
</tr>
<tr>
<td>15-19</td>
<td>40</td>
</tr>
</tbody>
</table>
Right Turn Lane Design Criteria: Taper Length

- Taper length can be shortened with no detrimental effects, but should not be lengthened.

- Straight line taper or an equivalent distance set of reverse curves on curbed roadways.

- Dual lane taper lengths are 100 feet for < 40 mph and 150 feet for higher speeds per RDM, Table 3-4.

<table>
<thead>
<tr>
<th>Speed (MPH)</th>
<th>Single Lane Taper Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 to 40</td>
<td>50 ft.</td>
</tr>
<tr>
<td>45 to 55</td>
<td>100 ft.</td>
</tr>
<tr>
<td>&gt;= 60</td>
<td>150 ft.</td>
</tr>
</tbody>
</table>
Right Turn Lane Design Criteria: Deceleration Length

• Moderate deceleration occurs in the through lane, creating speed differential.

• Ideal speed differential in through lane is 10 MPH; however, frequently 15 MPH and 20 MPH are acceptable. Values are included in RDM.

<table>
<thead>
<tr>
<th>Speed (MPH)</th>
<th>Speed Differential</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 MPH</td>
</tr>
<tr>
<td>30</td>
<td>160 ft</td>
</tr>
<tr>
<td>35</td>
<td>215 ft</td>
</tr>
<tr>
<td>40</td>
<td>275 ft</td>
</tr>
<tr>
<td>45</td>
<td>345 ft</td>
</tr>
<tr>
<td>50</td>
<td>425 ft</td>
</tr>
<tr>
<td>55</td>
<td>510 ft</td>
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Roadway Design Manual, Tables 3-3 and 3-3A
Right Turn Lane Design Criteria: Deceleration Length

- **AASHTO Green Book (2011) deceleration rates.**
  - While moving laterally into turn lane = 5.8 fps²
  - When in turn lane = 6.5 fps²
  - Emergency braking = 14.8 fps² to 11.2 fps²

- **Per Stover & Koepke, Transportation & Land Development, ITE, observed deceleration rates for drivers braking to a stop (Fig 5-19, p. 5-41)**
  - 85th percentile deceleration rate = 6.7 fps²
  - 50th percentile deceleration rate = 9.2 fps²
### Turn Lane Design Criteria: Lane Width

<table>
<thead>
<tr>
<th>Speed (mph)</th>
<th>Minimum Lane Width (ft)*</th>
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<tbody>
<tr>
<td>&lt;= 30</td>
<td>10</td>
</tr>
<tr>
<td>35 - 40</td>
<td>11</td>
</tr>
<tr>
<td>&gt;= 45</td>
<td>12</td>
</tr>
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</table>

*Roadway Design Manual, Table 3-1 for Urban Streets allows for 9 ft. wide speed change lanes on Local streets with design speed of 30 mph.

*RDM allows for 10 ft. wide speed change lane on 60 mph Local streets.*
Left Turn Lane Design Criteria: Components

1. **Storage** - Minimum length 100 feet
2. **Taper** – Same as Right Turn
3. **Deceleration** – Same as Right Turn
4. **Width** – Same as Right Turn

![Diagram of Left Turn Lane Design Criteria Components](Image)
Left Turn Lane Design Criteria: Storage Length

- **Macroscopic or Microscopic Analysis:**
  HCM Software (HCS), Synchro, VISSIM

- **100 feet is minimum for single lane.**

- **Storage length calculated by:**
  \[ L = \left( \frac{V}{N} \right)(2)(S) \]

*Where:*

- \( L \) = Storage Length, feet
- \( V \) = Turning Volume per hour, vph
- \( N \) = Number of Cycles if signalized or 30 if Unsignalized
- \( 2 \) = Factor for storage of all vehicles. (1.8 may be acceptable on collector streets)
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Obstructions to Providing Desirable Turn Lane Length

- **Drainage Features**
  - Culvert
  - Bridge
  - Basin
- **Trees**
- **Restricted Right-of-Way**
- **Property Line(s)**
- **Utilities**
  - Electrical Transmission Towers
  - Major Communication Hubs/Ducts
- **Railroad Crossings**
- **Adjacent Driveway or Intersection**
Obstructions to Providing Desirable Turn Lane Length

- Extreme Peak Period Turning Volume

Comment: Under congested operation vehicle speeds are typically lower & queued vehicles can extend beyond the storage area and into the deceleration portion of the turn lane.

While not desirable, it is relatively common in urban areas.
Key Point...

As the difference in vehicle speeds increase, crash rate increases.

What does that mean for Engineers & Designers?

- Adequate left-turn length is important but ANY length of turn lane is better than no turn lane.
Creative Turn Lane Designs – Sweeping Turns

- Not pedestrian friendly due to high speed turn.
- Fits the current context of this location and the frontage road.
**Turn Lane Design Trade Off**

Right turn lane extends the length of the adjacent property with existing driveways.

Vehicle on driveway may assume right-turning vehicle is turning at driveway and not at street.

Current decisions seem to be personal experience/opinion.

Options:
1) Use multiple short turn lanes.
2) Extend turn lane across multiple driveway.
Left Turn Lane Design Consideration

Sight Distance – Offset Left Turn Lanes

Negative Offset

Positive Offset
Offset Design for Sight Obstruction

**Problem:** Westbound (down) lanes approximately 4 feet higher than the eastbound lanes. Sight obstruction due to geometrics and terrain versus opposing vehicle.

Crest vertical curve located east of driveway, compounding left-turn ingress sight distance.

**Solution** – Offset left-turn lane constructed, plus it allows for grade of left-turning traffic to match grade of westbound lanes, improving sight distance.
Key Point…

As the difference in vehicle speeds increase, so does the expected crash rate.

What does that mean?

- Adequate left-turn length is important but ANY length of turn lane is better than no turn lane.
Questions

Gilmer D. Gaston, P.E., PTOE
210.375.9000
210.316.0189
ggaston@pape-dawson.com
Total Length = Storage + Deceleration

<table>
<thead>
<tr>
<th>Speed (mph)</th>
<th>Minimum Left Turn Lane (ft)</th>
<th>Minimum Right Turn Lane (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>375</td>
<td>305</td>
</tr>
<tr>
<td>45</td>
<td>445</td>
<td>375</td>
</tr>
<tr>
<td>50</td>
<td>525</td>
<td>455</td>
</tr>
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