Left Turn Bay Design

CIVL 4162/6162
Single Left Turn Lane

Diagram of a single left turn lane with labels for storage, deceleration, taper, and total length. The lane includes a separator and has a median width.
Overflow and Blockage

Overflow

Blockage

Through Vehicle

Left-Turn Vehicle
# Available Methods

<table>
<thead>
<tr>
<th>Existing Methods by Categories</th>
<th>Reference</th>
<th>Major Results</th>
</tr>
</thead>
</table>
| **Rule of Thumb Methods**     | • TxDOT Roadway Design Manual  
• NCHRP Report 279  
• NCHRP Report 348 | • Equations (4) & (5) |
| **Analytical-Based Methods**  | • Basha (1992)  
• Gard (2001) | • Equations (8) and (9)  
• Table 9 |
| Unsignalized Intersections     | • Lertworawanich et al. (2003) | • Table 10 |
| Regression based               | • NDOR Roadway Design Manual (2005) | • Equations (13) to (15)  
• Table 11 |
| Queuing theory based           | • Oppenlander et al (1989) | • Equations (16) to (18)  
• Table 12 |
| Vehicle arrivals in a given interval | • Kikuchi et al. (1993) | • Tables 13 and 13 |
| Signalized Intersections       | • Kikuchi et al. (2004) | • Table 14 |
| Queuing theory based           | • Oppenlander et al. (1994, 1996, 1999 and 2002)  
• Lakkundi et al. (2004) | • Tables 15 and 16  
• Figures 7 and 8 |
| DTMC based                     |           |               |
| Vehicle arrivals in the red phase |       |               |
Rule of Thumb Method

\[ L = K (V/N_C) S \text{ for signalized intersection} \]

and

\[ L = K \left[ V/(3600/I) \right] S \text{ for unsignalized intersection} \tag{3} \]

where:

- \( L \) = storage length (ft)
- \( V \) = left-turn flow rate during the peak hour (vph)
- \( K \) = a constant to reflect random arrival of vehicles (usually 2)
- \( N_C \) = number of cycles per hour (for signalized intersection)
- \( I \) = average vehicle waiting interval in seconds (for unsignalized intersection)
- \( S \) = average queue storage length per vehicle (average distance, front bumper-to-bumper of a car in queue)
Queuing Based Method: Signalized

\[ n = \frac{\log P_n - \log (1-\lambda/\mu)}{\log (\lambda/\mu)} \]  \hspace{1cm} (16)

where:

\( n \) = number of vehicles in the queue  
\( P_n \) = probability of \( n \) vehicles in the queue  
\( \lambda \) = arrival rate, equivalent passenger cars per second (pcps)  
\( \mu \) = service rate, equivalent passenger cars per second (pcps)

and, \( \lambda \) and \( \mu \) can be estimated by following Equations:

\[ \lambda = 1.1 \times \frac{V}{3600} \]  \hspace{1cm} (17)

\[ \mu = S \times \frac{(G/C)}{3600} \]  \hspace{1cm} (18)

where:

“1.1” = adjustment factor for the equivalence of left-turn vehicles with a separate phase  
\( V \) = left-turn volume, equivalent passenger cars per hour (pcph)  
\( S \) = lane saturation flow, equivalent passenger cars per hour of green (pcphg)  
\( G/C \) = ratio of green time to cycle length (cycle split) for the turning-lane phase
Regression Based Method-Unsignalized

• Since queuing is not prevalent

\[ Q = f_2(D, G) \]

and

\[ G = f_1(V) \]

where:

\( Q \) = maximum left-turn lane length, in vehicles
\( D \) = left-turn volume, in vehicles per interval
\( G \) = total acceptable gap times in opposing traffic in a specific interval, sec
\( V \) = opposing traffic volume, in vehicle per interval

The functions \( f_1 \) and \( f_2 \) were derived by regression analysis and the general forms of these two equations were given in Equation (7).

\[ G = f_1(V) = \alpha^G V^{g^G} \]