Capacity and LOS

CIVL 3161

Capacity

• The capacity of a facility is the maximum hourly rate at which persons or vehicles reasonably can be expected to traverse a point or a uniform section of a lane or roadway during a given time period under prevailing roadway, traffic, and control conditions. (HCM 2000)

Level of Service

• A quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience (HCM 2000).
• Rating scale A-F indicate best to worst operation
Factors Influencing LOS

• Volume
• Lane width
• Lateral obstructions
• Traffic composition
• Grade
• Speed

Measures of Effectiveness for LOS

<table>
<thead>
<tr>
<th>Type of Flow</th>
<th>Type of Facility</th>
<th>Measure of Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uninterrupted</td>
<td>Freeways (Basic, Weaving, Ramp)</td>
<td>Density (pc/mlj/mi)</td>
</tr>
<tr>
<td></td>
<td>Multilane Highway</td>
<td>Density (pc/mlj/mi)</td>
</tr>
<tr>
<td></td>
<td>Two-Lane Highway</td>
<td>Avg. Travel Speed (mph); % time spent following</td>
</tr>
<tr>
<td>Interrupted</td>
<td>Signalized Intersections</td>
<td>Control Delay (s/veh)</td>
</tr>
<tr>
<td></td>
<td>Unsignalized Intersections</td>
<td>Control Delay (s/veh)</td>
</tr>
<tr>
<td></td>
<td>Urban Streets</td>
<td>Average Travel Speed (mph)</td>
</tr>
</tbody>
</table>
Basic Freeway Segment Characteristics

Ideal conditions for maximum service flow rate:
- Minimum interchange spacing 2 miles
- Only passenger cars
- Lane widths ≥ 12 feet
- Lateral obstructions ≥ 6 ft from roadway edge
- Level terrain (grades < 2%)
- Drivers typical of weekday (regular) traffic
- 10 or more lanes in urban areas **removed in HCM2010

Operational Analysis

Flow Rate:

\[ v_p = \frac{V}{PHF \times N \times f_{lw} \times f_p} \]

Where:
- \( v_p \) = 15-minute passenger-car equivalent flow rate (pc/h/ln)
- \( V \) = hourly volume in the given direction of flow (vph)
- \( PHF \) = peak-hour factor
- \( N \) = number of lanes in the given direction of flow
- \( f_{lw} \) = an adjustment factor for th presence of "heavy" vehicles
- \( f_p \) = an adjustment factor to account for the fact that all drivers of the facility may not be commuters or regular users.

*Basis for analysis is peak 15 min flow rate.
Heavy Vehicle Effects:

\[ f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)} \]

- \( P_T, P_R \) = proportion of trucks and buses, and RV’s
- \( E_T, E_R \) = PCEs for trucks and buses, and RV’s

Analysis is based on general extended freeway segment:
- Level - heavy vehicles maintain same speed as p/c’s (grade <2%).
- Rolling - HV’s travel at speeds lower than p/c’s.
- Mountainous - HV’s operate at reduced speed for significant distances.

When conditions are very severe, we will instead base on grade and length of grade.
- Restrictions for use: No grade > 5% for longer than 1/2-mi.
- No grade > 3% for longer than 1/3-mi.

Operational Analysis

**DETERMINING LOS**

The first step in determining LOS of a basic freeway segment is to define and segment the freeway facility as appropriate. Second, on the basis of estimated or field-measured FFS, an appropriate speed-flow curve of the same shape as the typical curves (Exhibit 23-3) is constructed. The basis of the flow into, \( v_a \), and the constructed speed-flow curve, an average passenger-car speed is read on the y-axis of Exhibit 23-3. The next step is to calculate density using Equation 23-4.

\[ \rho = \frac{v_a}{S} \]

where
- \( \rho \) = density (p/c/ft.),
- \( v_a \) = flow rate (p/c/h), and
- \( S \) = average passenger-car speed (mph).

LOS of the basic freeway segment is then determined by comparing the calculated density with the density ranges in Exhibit 23-2.
3/19/12

Figure 14.2   Base Speed-Flow Curves for Freeways (Source: Basic Freeway Segments, Draft Chapter 11, NCHRP Project 3-92, Production of the 2010 Highway Capacity Manual, Kittelson and Associates, Portland OR, 2009, Exhibit 11-6, p. 11-8.)

Figure 14.4   Graphic Solution for Speed on a Basic Freeway Segment
Determining Capacity

Capacity = $MSF \times PHF \times N \times f_{HV} \times f_p$

* this is total capacity - maximum service flow rates can also be determined to remain in a specific level of service using $MSF_i$.

Design Analysis

$N_i = \frac{DDHV}{MSF \times PHF \times f_{HV} \times f_p}$

Where:
$N_i$ = number of lanes required (in one direction) to provide LOS "i"
$DDHV$ = directional design hour volume, veh/h
Example

Given:
Four-lane freeway (2 in each direction)
Lane width = 11 ft
Right-side lateral clearance = 2 ft
Commuter traffic (regular users)
Peak-hour, peak-direction demand volume = 2,000 veh/h
5% trucks, 0% RVs
PHF = 0.92
TRD = 4 ramps/mile
Rolling terrain
Find: LOS

Example

Given:
Older 4-lane freeway
11 ft lanes
Directional peak hour volume = 2100 vph
PHF = 0.95
6% trucks
TRD = 2.0/mi
Level terrain
Obstructions 2 ft from edge of traveled way at both roadside and median.

Find:
a. Average speed for prevailing conditions.
b. LOS
c. The amount of additional traffic that the facility can accommodate in the peak hour before reaching capacity.