Estimation of Capacity of Inter Urban Expressway

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Do not give up, the beginning is always the hardest.
Introduction

A sample of around 50 major National Highway corridors in India shows that the general length of constructed & upcoming intercity corridors shows peak distance range of 50km, 150km & 250-500km (Sandeep, Dr. Sewaram, International journal of Earth Sciences)

Increasing trend of urbanization
Mega cities
Phenomenal growth

RESULT:
Congestion
Reduction in travel time
NEED FOR FASTER ROADS (Expressways)
Aim & Objective

- **Aim**
  - To calculate the capacity of the Inter-Urban Expressway in Indian driving conditions.

- **Objectives**
  - To analyze traffic flow data collected on urban Expressways varying in roadway and traffic conditions.
  - To study the effect of influencing parameters like lane width, traffic composition, and number of Lanes on capacity of Expressway under mixed traffic conditions.
  - To estimate adjustment factors for each parameter analyzed in the present study.
  - To evolve a systematic procedure to determine capacity of a Expressway road under mixed traffic conditions.
Scope

The scope of the study is to calculate the capacity of ‘Basic Expressway section’ of NH 8 Expressway Section. It will also include studying the impact of change in various segments.

Limitation

One expressway considered
The expressway systems and Ramps are not considered in it.
24 hrs. duration surveys not conducted due to time and human resource

Scope and Limitation
Theoretical Approach

Now Presentation as per methodology... 1
\[ q = k \cdot v \]

Where:
- \( q \) = Flow (vehicles/hour)
- \( v \) = Speed (kilometers/hour)
- \( k \) = Density (vehicles/kilometer)

- Relationship in between Flow, Speed and Density
- Equation used to calculate flow from speed density relationships given by various researchers.

Speed, Flow and Density Relationship
<table>
<thead>
<tr>
<th>Model</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green shield’s</td>
<td>$v = \frac{1}{1-K_Kj}$</td>
</tr>
<tr>
<td>Green Berg</td>
<td>$v = \gamma_m \log \left( \frac{k_j}{k} \right)$</td>
</tr>
<tr>
<td>Underwood</td>
<td>$v = \nu_f e^{-\left( \frac{k_j}{k} \right)}$</td>
</tr>
<tr>
<td>Northwest</td>
<td>$v = \nu_r e^{-\left( \frac{k_j}{k} \right)^2}$</td>
</tr>
<tr>
<td>Drew</td>
<td>$v = \nu_f \left[ 1 - \left( \frac{k_j}{k} \right)^{\frac{1}{2}} \right]$</td>
</tr>
<tr>
<td>Drake</td>
<td>$v = \nu_f \left( \frac{V}{\theta_0} \right)^{1/\gamma}$</td>
</tr>
<tr>
<td>Pipes Munjal</td>
<td>$v = \nu_f \left( 1 - \left( \frac{k_j}{k} \right)^m \right)$</td>
</tr>
<tr>
<td>Old BPR Model</td>
<td>$\bar{q} = \nu_0 \left( 1 + \alpha \left( \frac{V}{\bar{V}} \right) \right)$</td>
</tr>
<tr>
<td>Old HCM</td>
<td>$c = c_{H}\left( t_{ae}^{1/2} \right)$</td>
</tr>
<tr>
<td>MoRTH</td>
<td>$FFS = BFFS - f_LW - f_{L_C} - f_{N} - f_{D}$</td>
</tr>
</tbody>
</table>

Almost all researchers have relationship between Speed and flow

Q. IS SPEED-FLOW CURVE IS BEST FITTED FOR FLOW-DENSITY AND SPEED-DENSITY TOO???

HCM methods are conventional for US Roads

MoRTH method is similar to HCM method.

Deterministic Model
Field Studies

Now Presentation as per methodology... 2
(a) NH 8 Delhi Gurgaon Expressway, (b) Section of more than 3 km chosen for the test stretch (c) blow up of the section showing the 1000m section (d) google image showing the surrounding landuse and footover bridge for the video marking.

Site Selection
Video 1: (free flow speed) Morning 7-8 AM – for free mean speed of the vehicle and vehicle count is less than 400 PCU/ Hr.

Video 2: (Normal) Evening 6:30 – 7:30 PM – for capturing evening inter-urban peak traffic.

Video 3: (Night) Night 12:30 AM – 1:30 AM – for capturing heavy vehicles traffic.

Video 4: (Before Peak) Afternoon 1:30 – 2:30 PM to capture shallow traffic.

Video 5: (Normal 2) Morning 8:00 – 9:00 AM for traffic before peak hour.

Video 6: (Peak Hr.) Morning 9:30 – 10:30 AM for peak hour traffic composition.

NH 8 Delhi Gurgaon Expressway
Primarily the Data is extracted under 3 Heads

- Volume
- Speed
- Density

Preliminary Data Analysis
LANE DEMARKATION
<table>
<thead>
<tr>
<th>Overall Average</th>
<th>Car (km/h)</th>
<th>2w (km/h)</th>
<th>Auto (km/h)</th>
<th>Bus (km/h)</th>
<th>Truck (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg</td>
<td>73.06</td>
<td>60.95</td>
<td>53.21</td>
<td>62.81</td>
<td>71.63</td>
</tr>
<tr>
<td>SD</td>
<td>24.19</td>
<td>21.57</td>
<td>10.07</td>
<td>18.85</td>
<td>17.38</td>
</tr>
<tr>
<td>Max Speed</td>
<td>131.10</td>
<td>115.64</td>
<td>76.39</td>
<td>126.92</td>
<td>118.44</td>
</tr>
<tr>
<td>95</td>
<td>111.16</td>
<td>96.72</td>
<td>70.20</td>
<td>89.09</td>
<td>100.77</td>
</tr>
<tr>
<td>85</td>
<td>99.08</td>
<td>81.40</td>
<td>64.85</td>
<td>79.69</td>
<td>91.16</td>
</tr>
<tr>
<td>50</td>
<td>72.31</td>
<td>63.30</td>
<td>52.81</td>
<td>64.17</td>
<td>72.17</td>
</tr>
<tr>
<td>15</td>
<td>50.70</td>
<td>40.53</td>
<td>43.10</td>
<td>42.18</td>
<td>56.19</td>
</tr>
<tr>
<td>Min Speed</td>
<td>28.01</td>
<td>11.98</td>
<td>27.19</td>
<td>15.73</td>
<td>29.18</td>
</tr>
</tbody>
</table>

Table showing various types of speed collected from the overall data for the stretch

**Speed**
Speed Analysis - Lane wise Mode wise
Speed Analysis - Lane wise Mode wise
Speed Analysis - Lane wise Mode wise

Etc and Many more Graphs has been Prepared Their maximum, 98th, 85th, 50th, 15th and minimum speeds mode wise lane wise compiled in table. Used as Speed decisions in Vissim Simulation Model.
<table>
<thead>
<tr>
<th></th>
<th>Volume LANE 1</th>
<th>Volume LANE 2</th>
<th>Volume LANE 3</th>
<th>Volume LANE 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FFS</strong></td>
<td>2160</td>
<td>1800</td>
<td>1020</td>
<td>900</td>
</tr>
<tr>
<td><strong>Normal</strong></td>
<td>2760</td>
<td>2820</td>
<td>2520</td>
<td>1680</td>
</tr>
<tr>
<td><strong>Night</strong></td>
<td>810</td>
<td>810</td>
<td>420</td>
<td>360</td>
</tr>
<tr>
<td><strong>Before Peak</strong></td>
<td>3480</td>
<td>2670</td>
<td>2730</td>
<td>1560</td>
</tr>
<tr>
<td><strong>Normal 2</strong></td>
<td>3450</td>
<td>3810</td>
<td>3300</td>
<td>1680</td>
</tr>
<tr>
<td><strong>Peak Hr.</strong></td>
<td>2880</td>
<td>3990</td>
<td>3930</td>
<td>3540</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Density LANE 1</th>
<th>Density LANE 2</th>
<th>Density LANE 3</th>
<th>Density LANE 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FFS</strong></td>
<td>32</td>
<td>24</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td><strong>Normal</strong></td>
<td>73</td>
<td>95</td>
<td>72</td>
<td>58</td>
</tr>
<tr>
<td><strong>Night</strong></td>
<td>200</td>
<td>418</td>
<td>340</td>
<td>633</td>
</tr>
<tr>
<td><strong>Before Peak</strong></td>
<td>47</td>
<td>54</td>
<td>76</td>
<td>33</td>
</tr>
<tr>
<td><strong>Normal 2</strong></td>
<td>78</td>
<td>70</td>
<td>56</td>
<td>60</td>
</tr>
<tr>
<td><strong>Peak Hr.</strong></td>
<td>126</td>
<td>164</td>
<td>140</td>
<td>185</td>
</tr>
</tbody>
</table>

**Average Volume and Density per Lane**
Lane Utilization
Putting Data Collected from Site in Theoretical Model

{ Crossing of methodology Heads...}
Green Shield Model

\[ V = \nu_f \left( 1 - \frac{K}{K_j} \right) \]

\[ Q = K \times \nu_f \left( 1 - \frac{K}{K_j} \right) \]
Greenberg Model

\[ V = v_m \log \frac{k_j}{k} \]
Greenberg Model
Underwood Model

\[ v = v_f e^{-\left(\frac{k}{k_0}\right)} \]
Underwood Model
Northwest Model

\[ V = v_f e^{-\frac{1}{2} \left( \frac{k}{k_0} \right)^2} \]

*Modified v$_f$ of the Lane
Northwest Model
Drew’s Model

\[ v = v_f \left[ 1 - \left( \frac{k}{k_j} \right)^{n + \frac{1}{2}} \right] \]
Drew’s Model
Drake Model

\[ V = \nu_f e^{\frac{1}{2}\frac{k}{k_f}} \]
Drake Model
Pipes Munjal Model

\[ v = v_f \left(1 - \left(\frac{k}{k_j}\right)^n\right) \]
Pipes Munjal Model
SPA modified BPR equation

\[ V = \frac{V_f}{1 + \alpha \cdot \left(\frac{V}{C}\right)^\beta} \]
SPA modified BPR equation
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
<th>Lane 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green shield's</td>
<td>Moderately fitting</td>
<td>Best Fitting</td>
<td>Best fitting at low concentration but not in higher concentration</td>
<td>Moderately fitting</td>
</tr>
<tr>
<td>Greenberg</td>
<td>Behaves well in congested conditions but not satisfied at low concentration</td>
<td>Moderately fitting for higher concentration</td>
<td>Moderate fit in Higher Concentration but not in lower concentration</td>
<td>Moderate fitting at higher concentration and not fitting at lower concentration</td>
</tr>
<tr>
<td>Underwood</td>
<td>Presents good fit but behaves differently at high or low concentration</td>
<td>Moderately fitting for higher Flow\</td>
<td>Moderately fitting</td>
<td>Poor fitting for higher flows but moderate fitting for lower flows</td>
</tr>
<tr>
<td>Northwestern</td>
<td>Best Fitting</td>
<td>Best Fitting at lower flows but moderately fitting at higher flows</td>
<td>Moderately fitting at low and high volume but overall weak fitting.</td>
<td>Weak fitting at all volumes and not fitting at lower concentration</td>
</tr>
<tr>
<td>Drew</td>
<td>Best fitting</td>
<td>Good Fitting</td>
<td>Moderate fitting</td>
<td>Moderate fitting at low volume and higher concentration</td>
</tr>
<tr>
<td>Drake's</td>
<td>Not fitting</td>
<td>Not Fitting</td>
<td>Not Fitting</td>
<td>Not Fitting</td>
</tr>
<tr>
<td>Pipes-Munjal</td>
<td>Moderately fitting</td>
<td>Moderate fitting at low volume but least fitting at higher volumes</td>
<td>Moderately fitting at high density</td>
<td>Low fitting at high concentration</td>
</tr>
<tr>
<td>Modified BPR</td>
<td>Best fitting</td>
<td>Best Fitting</td>
<td>Best Fitting at low Flows and Moderate fitting at high density</td>
<td>Moderate Fitting at low density and bad fit at higher density</td>
</tr>
</tbody>
</table>

**Results from the various Models**
Simulation Approach

{ Now Presentation as per methodology... 2 }
Data Collected
- Geometric Data
- Peak hour composition
- Peak hour flow
- Spot Speed Data (Vehicle wise)
- Normalized Speed for all types of vehicles
- Speed decisions for each lane
- Lateral Distance between vehicles

Simulation and Results
Normal Traffic
Peak Hour
Peak Hour
1. Different Behaviors obtained at Different Lanes
2. Theoretical graphs are best fitted to estimate capacity up to lane 1 and 2 and sometimes up to Lane 3.
3. Lane 4 is showing less fitting behavior in the study and also showing the less capacity
4. It may be examined that if we convert the 4th lane into NMT-Cycle Expressway what is going to be the benefit to Motorised as well as Non-Motorised Traffic.
5. Psychological speed reduction in the extreme lanes are observed
6. Effect of Heavy vehicles is observed from the above graph generated from the vissim
7. Effect of composition is also observed from the various simulation plots.
8. Best fitted Model is Modified BPR Model.

Conclusions
Multiple Curve Fittings May Give better results
To explore the possibility of fitting of Multiple Curve
To research the expressways with service Road and without service road which can be used for planning and design of cross section.
To study the effect of converting the 4th lane into NMT-Cycle Expressway.

Future Research
Thanking you