Evaluating the Effects of I-35W Bridge Collapse on Road-Users in the Twin Cities Metropolitan Region

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On August 1st, 2007, the I-35W Bridge over the Mississippi River in Minneapolis tragically collapsed.

The bridge features:

- Four lanes each direction
- 140,000 vehicles on an average day
- Proximity to downtown Minneapolis, University of Minnesota, and the junction with I-94
Background

- Initial evaluation by Minnesota Department of Transportation (Mn/DOT)
  - Only two detour routes available
  - 90,000 road-users take the I-694 route while 50,000 take TH-280
  - Economic loss to road users would total $400,000 per day.
Background

- Evaluative study by University of Minnesota
  - A quick evaluation five days after the tragedy
  - A “back-of-envelope” analysis based on a simplified travel demand model
  - An estimated economic loss of $71,000 to $220,000 a day
  - Results are used by Mn/DOT to value the payment to contractors for early completion of a replacement bridge
Outline

• Simplified Travel Demand Model
• Calibration
• Scenarios for evaluation
• Results
• Conclusion
Travel Demand Models

- Classic four-step travel demand models developed by University of Minnesota’s Networks, Economics, and Urban Systems (Nexus) Research Group in 2006 for Twin-Cities Region based on following simplifications:
  - Not distinction between trip purposes
  - One vehicular mode (no separate freight model)
  - Calibration again traffic counts only from freeways

- One model run is limited to one hour, enabling quick evaluation of the effect of bridge collapse under various scenarios
Travel Demand Models

- Four-step travel demand models developed by UMN Nexus Research Group in 2006 for Twin-Cities Region:
  - Linear trip generation/attraction models
  - Doubly constrained trip distribution models
  - Stochastic User Equilibrium (SUE) traffic assignment

- Simplifications:
  - Not distinction between trip purposes
  - One vehicular mode (no separate freight model)
  - Calibration again traffic counts only from freeways

- One model run is limited to one hour, which enables quick evaluation of the effect of bridge collapse with reasonable accuracy.
Calibration

• Procedure of calibration:
  - Randomly picked 10% of the full set of 1,000 detector stations in the region.
  - Matched 63 out of the selected stations with the planning network.
  - Morning peak hour counts were produced using the average of loop detector data from 7:00 a.m. to 9:00 a.m. on Monday, Wednesday and Friday in the last full week of July 2007.
  - Distribution model friction factor was adjusted to minimize the difference between model estimates and actual counts on selected set of links.
The final calibrated model has:

- A friction factor of 0.14/min
- An overall 0.71 percent error between the forecasts and the real counts
- The R-Squared, estimated by regressing forecast peak hour volumes on real counts for selected set of links, of 0.91
- The root mean square error (RMSE), defined by the formula below, of 33.6%.
## Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Time</th>
<th>Trip Table after Aug 1st</th>
<th>Planning Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (Base)</td>
<td>Before bridge collapse</td>
<td>N.A.</td>
<td>Complete network</td>
</tr>
<tr>
<td>1</td>
<td>After bridge collapse</td>
<td>Variable</td>
<td>Crippled network</td>
</tr>
<tr>
<td>2</td>
<td>After bridge collapse</td>
<td>Fixed</td>
<td>Crippled network</td>
</tr>
<tr>
<td>3</td>
<td>After bridge collapse</td>
<td>Variable</td>
<td>Crippled network with upgrades</td>
</tr>
<tr>
<td>4</td>
<td>After bridge collapse</td>
<td>Fixed</td>
<td>Crippled network with upgrades</td>
</tr>
</tbody>
</table>

- A fixed trip table indicates people did not change the number of trips, or destinations in response to bridge failure, while a variable trip table allowed destinations of all trips to vary.
- The crippled network is created by removing the two I-35W bridge links from the base-scenario network, while ignoring Mn/DOT's efforts on infrastructure upgrades.
- Infrastructure upgrades include a series of traffic restoration projects implemented by August 2007, such as widening the north and south ramps of TH280 to two lanes, and adding a lane in each direction of I-94 between TH280 and I-35W.
Evaluation

• Vehicle Kilometer Travel (VKT) and Vehicle Hour Travel (VHT)
  - A peak hour to daily factor of 0.08 is estimated using the average peak hour and daily traffic counts from 2005 detector data.

• Economic loss
  - A composite value of time of $14.19 is used by assuming 80% auto and 20% truck.

• Accessibility measures
  - Number of jobs reachable within a duration
  - Gravity-type measures

• Benefit-cost analysis
### Results

<table>
<thead>
<tr>
<th></th>
<th>Scenario 0</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>+1.432 (0.35%)</td>
<td>+1.442 (1.09%)</td>
<td></td>
<td>1.441 (1.00%)</td>
</tr>
<tr>
<td>Daily VHT (10^6 veh.hrs)</td>
<td>1.427</td>
<td>1.432 (0.35%)</td>
<td>1.442 (1.09%)</td>
<td>1.431 (0.31%)</td>
<td>1.441 (1.00%)</td>
</tr>
<tr>
<td>Daily VKT (10^6 veh.kms)</td>
<td>86.53</td>
<td>86.27 (-0.31%)</td>
<td>86.58 (0.05%)</td>
<td>86.27 (-0.30%)</td>
<td>86.58 (0.06%)</td>
</tr>
<tr>
<td>Daily Economic loss ($)</td>
<td>N.A.</td>
<td>71,466</td>
<td>220,198</td>
<td>62,408</td>
<td>203,409</td>
</tr>
<tr>
<td>Aver trip length (kms)</td>
<td>18.82</td>
<td>18.76 (-0.31%)</td>
<td>18.83 (0.05%)</td>
<td>18.76 (-0.30%)</td>
<td>18.83 (0.06%)</td>
</tr>
<tr>
<td>Aver trip time (mins)</td>
<td>18.61</td>
<td>18.68 (0.35%)</td>
<td>18.82 (1.09%)</td>
<td>18.67 (0.31%)</td>
<td>18.8 (1.00%)</td>
</tr>
<tr>
<td>jobs reached in 10 mins</td>
<td>110,072</td>
<td>108,036 (-1.85%)</td>
<td>107,692 (-2.16%)</td>
<td>108,255 (-1.65%)</td>
<td>107,931 (-1.95%)</td>
</tr>
<tr>
<td>jobs reached in 20 mins</td>
<td>557,514</td>
<td>545,791 (-2.10%)</td>
<td>543,669 (-2.48%)</td>
<td>546,751 (-1.93%)</td>
<td>545,230 (-2.20%)</td>
</tr>
<tr>
<td>jobs reached in 30 mins</td>
<td>1,105,462</td>
<td>1,089,406 (-1.45%)</td>
<td>1,087,226 (-1.65%)</td>
<td>1,090,994 (-1.31%)</td>
<td>1,089,424 (-1.45%)</td>
</tr>
<tr>
<td>Accessiblity to jobs</td>
<td>3.23E+11</td>
<td>3.17E+11 (-1.70%)</td>
<td>3.17E+11 (-2.00%)</td>
<td>3.18E+11 (-1.58%)</td>
<td>3.17E+11 (-1.83%)</td>
</tr>
<tr>
<td>Accessiblity to workers</td>
<td>3.30E+11</td>
<td>3.25E+11 (-1.55%)</td>
<td>3.24E+11 (-1.79%)</td>
<td>3.25E+11 (-1.41%)</td>
<td>3.25E+11 (-1.60%)</td>
</tr>
<tr>
<td>Aug 2007, % off average</td>
<td>N.A.</td>
<td>0.52%</td>
<td>1.57%</td>
<td>0.61%</td>
<td>1.66%</td>
</tr>
<tr>
<td>Aug 2007, RMSE oct</td>
<td>N.A.</td>
<td>37.98%</td>
<td>38.35%</td>
<td>38.03%</td>
<td>38.44%</td>
</tr>
<tr>
<td>Oct 2007, % off average</td>
<td>N.A.</td>
<td>-5.81%</td>
<td>-4.82%</td>
<td>-5.73%</td>
<td>-4.74%</td>
</tr>
<tr>
<td>Oct 2007, RMSE oct</td>
<td>N.A.</td>
<td>32.18%</td>
<td>32.00%</td>
<td>32.17%</td>
<td>32.01%</td>
</tr>
</tbody>
</table>
Findings

- It is estimated that the economic loss incurred by the I-35W bridge collapse on road users is between $71,000 and $220,000 a day, depending on how flexible people are switching their destinations.

- According to household survey, home-based work trips accounts for 34.3% of all AM peak trips in the Twin Cities. In this sense, an assumption of 1/3 fixed trips, or an economic loss of $120,000 may be closer to reality.
Findings

- Reduced travel delay due to major upgrades saves $9,500 to $17,500 a day;
- The estimated benefit-cost ratio ranges from 2.0 to 9.0, given that:
  - The total budget of restoration projects included in this analysis amounts to no more than $2.4 million
  - It is scheduled the replacement I-35W bridge would not open until December 24th, 2008, or 511 days after bridge collapse (noted that the new bridge in fact opened on September 18th, 2008 with $25 million early complete bonuses given to contractors)
Conclusions

• This analysis could be treated as a “back of the envelope” calculation in order to capture the magnitudes of the economic impact of the bridge closure.

• The use of a simplified, scaled-down travel demand model enabled us to carry out the analysis quickly and accurately.

• While more accurate results could be obtained with a longer examination time period, this analysis could see contributions in transportation planning under situations such as emergency relief and comprehensive design.
Thank you!

Questions?