Multiobjective Optimization of Lane and Shoulder Widths at Rural Two-lane Highways

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MOTIVATION

- Wider lanes and shoulders generally help to reduce crashes.
- For 2-lane roads:
  - Total Roadway Width (TRW) = 2(Shoulder width + lane width)
- For fixed TRW, what fractions to lane width & shoulder width?
- Which is safer?
- Wider lanes with narrow shoulders? OR Narrow lanes with wide shoulders?

DATA DESCRIPTION

- Crash prediction models: 2006 INDOT study (Labi, 2006).
- Construction & maintenance cost data
  - Shoulder: Iowa State University 2001 study
  - Lane: Wisconsin and Washington DOT studies.

METHODOLOGY

- Examples of crash prediction models

\[
\text{Property damage only} = \exp[-4.66689 + 0.6706 \cdot \text{LN(LENGTH)} + 0.6259 \cdot \text{LN(AADT)}] - 0.6617 \cdot \text{LN(WL)} - 0.0119 \cdot \text{SW} - 0.0190 \cdot \text{FR} + 0.0163 \cdot \text{ARAD} + 0.1100 \cdot \text{AGRAD}]
\]
- Fatal-injury

\[
\exp[-6.6231 + 0.9237 \cdot \text{LN(LENGTH)} + 0.8526 \cdot \text{LN(AADT)}] - 0.0928 \cdot \text{LN(WL)} - 0.0321 \cdot \text{SW} - 0.0156 \cdot \text{FR} + 0.0262 \cdot \text{ARAD} + 0.0541 \cdot \text{AGRAD}]
\]

- Nonlinear optimization framework

Obj: Minimize

\[
T(LW, SW) = 2(w_{\text{agency}}(CC_1 \cdot LW + CC_2 \cdot SW)L + \frac{\text{MR}_1 \cdot LW + \text{MR}_2 \cdot SW)}{\text{MLW}}(LW, SW)) + w_{\text{user}}(\frac{\text{MR}_1 \cdot LW + \text{MR}_2 \cdot SW)}{\text{MLW}}(LW, SW)
\]

s.t.:

\[
2LW + 2SW = \text{TRW}; \quad LW \geq \text{MLW}
\]

RESULTS

- Optimal lane & shoulder widths across road functional classes for different TRWs (24 and 46 ft.)

CONCLUSIONS

- Study developed a framework for determining the optimal allocation of shoulder and lane widths on two-lane rural highways.
- For minor arterials and major collectors:
  - Optimal solutions (funnel diagrams) are similar.
  - For high user cost weights, the optimal solutions have zero shoulder width (lanes take up all TRW).
  - For low weights of the user cost, the optimum has a lane width of 10 ft., and the shoulder takes up the remaining TRW.
- For principal arterials
  - Optimal solution: lane width of 10 ft.; the rest of the TRW taken up by shoulder.
- Highway agencies can use the developed framework or decision support charts to determine the optimal lane and shoulder widths for a given highway functional class, total available roadway width, and other factors.

ACKNOWLEDGEMENTS & DISCLAIMER

- Steven Lavernz is acknowledged for initial work on this paper.
- The support of the JTRP program is greatly acknowledged, which made this study possible.
- This poster is based on a paper that has been accepted for publication in Transportmetrica Journal.