So You Want to Build a Cross Section

Concepts, Principles, and Practices

Balancing a Multimodal Design:
A new challenge for designers

2013–2014 MnDOT
Context Sensitive Solutions

Webinar

February 18, 2014
Online participants are encouraged to engage in and add to the discussion.

Submit comments and questions any time by clicking the upper left gold box on your screen – this will take you to the chat page: www.cts.umn.edu/contextsensitive/workshops/crosssection/

Sign in to your Chatroll account, or sign in using your Facebook or Twitter account. We have asked pre-registrants to create a chat log in ahead of time. It simple to create an account.
The cost of speed in towns and cities

Source: UK Department of Transport
IN TERMS OF MONEY
WE HAVE NO MONEY.
Agenda

- Overview Complete Street Design Process
- Rural Main Streets
- Constrained Urban Streets
Complete Street Design Process

- Iterative Process
- Major Challenges
  - Community
  - Traffic Analysis
  - Target Operating Speed
  - Allocation of Space
  - Intersections
Key Principles

- Think “type of community” – not “type of roadway” – give community values and needs a high priority
Key Principles

- Think “outside in” rather than “inside out”
- Allocate space first to most vulnerable users
Components of Pedestrian Realm
Design Element Spotlight

Bicycle Lanes
### Table 4-1: Bikeway Design Selection for Urban (Curb and Gutter) Cross Section – English Units

<table>
<thead>
<tr>
<th>Motor Vehicle ADT (2 Lane)</th>
<th>&lt;500</th>
<th>500-1,000</th>
<th>1,000-2,000</th>
<th>2,000-5,000</th>
<th>5,000-10,000</th>
<th>&gt;10,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Vehicle ADT (4 Lane)</td>
<td>N/A</td>
<td>N/A</td>
<td>2,000-4,000</td>
<td>4,000-10,000</td>
<td>10,000-20,000</td>
<td>&gt;20,000</td>
</tr>
<tr>
<td>Motor Vehicle Speed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 mph</td>
<td>SL</td>
<td>WOL</td>
<td>WOL</td>
<td>WOL</td>
<td>BL = 5 ft</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>30 mph</td>
<td>SL with sign</td>
<td>WOL</td>
<td>BL = 5 ft</td>
<td>BL = 5 ft</td>
<td>BL = 6 ft</td>
<td>BL = 6 ft</td>
</tr>
<tr>
<td>35 - 40 mph</td>
<td>WOL</td>
<td>BL = 5 ft</td>
<td>BL = 5 ft</td>
<td>BL = 6 ft</td>
<td>BL = 6 ft</td>
<td>BL = 6 ft</td>
</tr>
<tr>
<td>45 mph and greater</td>
<td>BL = 5 ft</td>
<td>BL = 5 ft</td>
<td>BL = 6 ft</td>
<td>BL = 6 ft</td>
<td>BL = 6 ft or PS = 8 ft</td>
<td>SUP or PS = 10 ft</td>
</tr>
</tbody>
</table>

BL = Bicycle Lane, SL = Shared Lane, WOL = Wide Outside Lane, SUP = Shared-Use Path, PS = Paved Shoulder

### Table 4-2: Bikeway Design Selection for Rural (Shoulder and Ditch) Cross Section – English Units

<table>
<thead>
<tr>
<th>Motor Vehicle ADT (2 Lane)</th>
<th>&lt;500</th>
<th>500-1,000</th>
<th>1,000-2,000</th>
<th>2,000-5,000</th>
<th>5,000-10,000</th>
<th>&gt;10,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Vehicle ADT (4 Lane)</td>
<td>N/A</td>
<td>N/A</td>
<td>2,000-4,000</td>
<td>4,000-10,000</td>
<td>10,000-20,000</td>
<td>&gt;20,000</td>
</tr>
<tr>
<td>Motor Vehicle Speed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 mph</td>
<td>PS = 4 ft* or SL</td>
<td>PS = 4 ft* or SL</td>
<td>PS = 4 ft* or WOL</td>
<td>PS = 4 ft*</td>
<td>PS = 4 ft*</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>30 mph</td>
<td>PS = 4 ft* or SL</td>
<td>PS = 4 ft* or SL</td>
<td>PS = 4 ft* or WOL</td>
<td>PS = 4 ft*</td>
<td>PS = 6 ft</td>
<td>PS = 6 ft</td>
</tr>
<tr>
<td>35 - 40 mph</td>
<td>PS = 4 ft* or SL</td>
<td>PS = 4 ft* or WOL</td>
<td>PS = 6 ft</td>
<td>PS = 6 ft</td>
<td>PS = 6 ft</td>
<td>PS = 8 ft</td>
</tr>
<tr>
<td>45 mph and greater</td>
<td>PS = 4 ft*</td>
<td>PS = 4 ft*</td>
<td>PS = 6 ft</td>
<td>PS = 6 ft</td>
<td>PS = 8 ft</td>
<td>SUP or PS = 10 ft</td>
</tr>
</tbody>
</table>

* See discussion in Section 4-3.1 regarding rumble strips on 4-foot shoulders.
PS = Paved Shoulder, SL = Shared Lane, SUP = Shared-Use Path, WOL = Wide Outside Lane
Rural highway shoulder

MnDOT Bikeway Facility Design Manual
Rural highway shoulder

MnDOT Bikeway Facility Design Manual
Classical bicycle lanes

MnDOT Bikeway Facility Design Manual
Wide outside lane treatment

MnDOT Bikeway Facility Design Manual
Shared lane

MnDOT Bikeway Facility Design Manual
Shared lane marking (aka sharrow)
Key Principles

- Think “slow” – not “fast” – select the lowest reasonable targeted operating speed
Key Principles

- Think differently about traffic impacts
  - Corridor travel time/delay not time/delay at individual intersection
  - Number of hours of congestion not minutes during the peak hour
  - Mid-day not peak hour
Design Element Spotlight

Traffic
# 2 miles of Urban Arterial
ADT = 10,000
36 Access Points

<table>
<thead>
<tr>
<th></th>
<th>Crashes</th>
<th>Upper Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Lane Undivided</td>
<td>5.7</td>
<td>32,600</td>
</tr>
<tr>
<td>3 Lane, Two Way Turn Lane</td>
<td>5.5</td>
<td>32,900</td>
</tr>
<tr>
<td>4 Lane, Undivided</td>
<td>6.5</td>
<td>40,100</td>
</tr>
<tr>
<td>4 Lane Divided</td>
<td>3.5</td>
<td>66,000</td>
</tr>
<tr>
<td>5 Lane, Two Way Turn Lane</td>
<td>9.9</td>
<td>53,800</td>
</tr>
</tbody>
</table>
2 miles of Urban Arterial
ADT = 32,600
36 Access Points

<table>
<thead>
<tr>
<th></th>
<th>Crashes</th>
<th>Upper Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Lane Undivided</td>
<td>26.5</td>
<td>32,600</td>
</tr>
<tr>
<td>3 Lane, Two Way Turn Lane</td>
<td>23.8</td>
<td>32,900</td>
</tr>
<tr>
<td>4 Lane, Undivided</td>
<td>27.4</td>
<td>40,100</td>
</tr>
<tr>
<td>4 Lane Divided</td>
<td>14.2</td>
<td>66,000</td>
</tr>
<tr>
<td>5 Lane, Two Way Turn Lane</td>
<td>34.7</td>
<td>53,800</td>
</tr>
</tbody>
</table>
Minnesota Crash Rates

Note: Only for Trunk Highway Segments
“Rural” Refers to a non-municipal area and cities with a population less than 5,000.
## Minnesota Crash Rates

<table>
<thead>
<tr>
<th>Five Years of Crash Data (2007–2011)</th>
<th>All Crashes</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crash Rate</td>
<td>Sever. Rate</td>
<td>Fatal Rate</td>
<td>F+A Rate</td>
</tr>
<tr>
<td>Urban 2–lane : ADT∈[0,1500)</td>
<td>1.71</td>
<td>2.86</td>
<td>3.08</td>
<td>9.23</td>
</tr>
<tr>
<td>Urban 2–lane : ADT∈[1500,5000)</td>
<td>1.43</td>
<td>2.03</td>
<td>0.76</td>
<td>2.57</td>
</tr>
<tr>
<td>Urban 2–lane : ADT∈[5000,8000)</td>
<td>2.00</td>
<td>2.82</td>
<td>0.47</td>
<td>3.36</td>
</tr>
<tr>
<td>Urban 2–lane : ADT∈[8000,∞)</td>
<td>2.05</td>
<td>2.92</td>
<td>0.65</td>
<td>2.64</td>
</tr>
<tr>
<td>Urban 4–lane Undivided</td>
<td>3.86</td>
<td>5.23</td>
<td>0.59</td>
<td>4.75</td>
</tr>
<tr>
<td>Urban 4–lane Divided</td>
<td>2.81</td>
<td>3.83</td>
<td>0.57</td>
<td>2.70</td>
</tr>
<tr>
<td>3–lane Undivided</td>
<td>2.10</td>
<td>2.95</td>
<td>0.63</td>
<td><strong>2.38</strong></td>
</tr>
<tr>
<td>5–lane Undivided</td>
<td>3.06</td>
<td>4.24</td>
<td>0.57</td>
<td>2.65</td>
</tr>
</tbody>
</table>
Level of Service vs. Traffic Volume
(From HCM ex. 16-14)
Level of Service vs. Traffic Volume
(From HCM ex. 16-14)

Average Daily Traffic (ADT)

Number of Lanes and Speed Limits

- Two Lane Street - 30 MPH
- Four Lane Street - 30 MPH
- Six Lane Street - 30 MPH

LOS E
LOS D
LOS C
Key Principles

- Start with smallest number of lanes – reducing width by a single lane can free up space for other modes

- Think “minimums” not “desirables” – start with the smallest dimensions
We Over-Build Way Too Often

Crosswalk 120'

14' 14' 6' 14' 12' 12' 12' 14'
Designing a “main street”

- Low Speed (45 mph or less) vs. High Speed
- Major Challenges
  - Community
  - Traffic Analysis
  - Target Operating Speed
  - Allocation of Space
  - Intersections
Where is the Most Design Flexibility?

- **Vehicle Design Considerations**
  - Lower Speeds are appropriate
  - Number of Lanes
  - Lane width
  - Change in cross section elements along corridor

- **Allocation of space**
  - Sidewalks
  - Parking
  - Bicycles
Downtown Cosmos
Old TH4 Roadway
Design Element Spotlight
Shoulder / Parking Lane Width
<table>
<thead>
<tr>
<th>HIGHWAY TYPE</th>
<th>MINIMUM WIDTH (FEET) (^{(1)})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (or Left)</td>
</tr>
<tr>
<td></td>
<td>Usable</td>
</tr>
<tr>
<td>Arterials (Rural)</td>
<td>2 Lanes</td>
</tr>
<tr>
<td>ADT &lt; 400</td>
<td>4</td>
</tr>
<tr>
<td>ADT 400 - 1500</td>
<td>6</td>
</tr>
<tr>
<td>ADT 1500 - 2000</td>
<td>6</td>
</tr>
<tr>
<td>ADT &gt; 2000</td>
<td>8</td>
</tr>
<tr>
<td>Divided 4-lanes</td>
<td>4</td>
</tr>
<tr>
<td>Divided 6-lanes</td>
<td>8</td>
</tr>
</tbody>
</table>

MnDOT rural arterial shoulder widths

Technical Memo No. 12–12–TS–06
Rural two-lane: shoulder width safety effects

From AASHTO Highway Safety Manual
## Highway Safety Manual
### 2–Lane Rural Highway – Crashes/Year

<table>
<thead>
<tr>
<th>Lane Width</th>
<th>0'</th>
<th>1'</th>
<th>2'</th>
<th>4'</th>
<th>6'</th>
<th>8'</th>
</tr>
</thead>
<tbody>
<tr>
<td>9'</td>
<td>5.3</td>
<td>5.1</td>
<td>4.8</td>
<td>4.5</td>
<td>4.1</td>
<td>3.8</td>
</tr>
<tr>
<td>10'</td>
<td>4.8</td>
<td>4.6</td>
<td>4.4</td>
<td>4.1</td>
<td>3.8</td>
<td>3.5</td>
</tr>
<tr>
<td>11'</td>
<td>4.2</td>
<td>4.1</td>
<td>3.9</td>
<td>3.6</td>
<td>3.3</td>
<td>3.1</td>
</tr>
<tr>
<td>12'</td>
<td>4.1</td>
<td>3.9</td>
<td>3.8</td>
<td>3.5</td>
<td>3.2</td>
<td>3.0</td>
</tr>
</tbody>
</table>

*2 mile segment, ADT = 6,000 veh/day, paved shoulders, RHR =3, 5 access points/mile

Gravel shoulders will add 0% to 2% increase in crashes
<table>
<thead>
<tr>
<th>Arterials (Urban / Suburban)</th>
<th>2 Lanes</th>
<th>&gt; 45 mph</th>
<th>4+ Lanes</th>
<th>&gt; 45 mph</th>
<th>Divided (4 or more lanes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Lanes</td>
<td>≤ 45 mph</td>
<td>Without Parking</td>
<td>With Parking</td>
<td>Without Parking</td>
<td>Curb Reaction</td>
</tr>
<tr>
<td>2 Lanes</td>
<td>&gt; 45 mph</td>
<td>Without Parking</td>
<td>Without Parking</td>
<td>Without Parking</td>
<td>Curb Reaction</td>
</tr>
<tr>
<td>4+ Lanes</td>
<td>≤ 45 mph</td>
<td>Without Parking</td>
<td>With Parking</td>
<td>Without Parking</td>
<td>Curb Reaction</td>
</tr>
<tr>
<td>4+ Lanes</td>
<td>&gt; 45 mph</td>
<td>Without Parking</td>
<td>Without Parking</td>
<td>Without Parking</td>
<td>(See Above)</td>
</tr>
</tbody>
</table>

MnDOT urban arterial shoulder widths
Technical Memo No. 12–12–TS–06
### TABLE 4
**Standard Curb Reaction Dimensions**

<table>
<thead>
<tr>
<th>Design Speed</th>
<th>Curb Reaction Width for Indicated Curb Types (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B, V or vertical monolithic</td>
</tr>
<tr>
<td>≤ 45 mph</td>
<td>1-2</td>
</tr>
<tr>
<td>&gt; 45 mph</td>
<td>2-3</td>
</tr>
</tbody>
</table>

**Variable curb reaction widths**

Technical Memo No. 12-12-TS-06
<table>
<thead>
<tr>
<th>Arterials (Urban / Suburban)</th>
<th>2 Lanes</th>
<th>4 + Lanes</th>
<th>Divided (4 or more lanes)</th>
<th>Curb Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 45 mph</td>
<td>With Parking</td>
<td>With Parking</td>
<td>Curb Reaction</td>
<td>7 - 10</td>
</tr>
<tr>
<td>Without Parking</td>
<td>Without Parking</td>
<td>Without Parking</td>
<td>(See Above)</td>
<td></td>
</tr>
<tr>
<td>&gt; 45 mph</td>
<td>Without Parking</td>
<td>Without Parking</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

MnDOT urban arterial shoulder widths
Technical Memo No. 12-12-TS-06
12-foot parking lane
T.H. 60 (ADT 5,200)
An ocean of pavement

10-foot parking lane

Residential collector
7-foot width indicated by tape

10-foot parking lane

Residential collector
Let’s Design a Cross Section!

› Using the “STREETMIX” software!
New TH4 Driving Surface
Back In Angled Parking
Other Tools: Bump-Outs
Other Tools: Streetscaping
Constrained Urban Streets

- **Major Challenges**
  - Community Desires
  - Traffic Analysis – often high traffic volumes but high use by all modes
  - Target Operating Speed – needs to be slow
  - Allocation of Space – who gets the limited space available
  - Intersections – pedestrian crossing distances and times
Where is the Most Design Flexibility?

- Vehicle Design Considerations
  - Lower Speeds are appropriate
  - Smaller Design Vehicle is appropriate

- Allocation of space
  - Number of Lanes
  - Lane width
  - Parking (depends on adjacent land use)
  - Pedestrian and bicycle demand
    - *No two blocks are the same*
80’ Building Front to Building Front

- Transit Route
- Retail Stores
- Sidewalk Cafes
- Many Walkers
- Many Bicyclists
- On-Street Parking
- Near School for Seeing/Hearing Impaired
Design Element Spotlight

Lane Width
Rural two–lane: lane width effects on safety

From AASHTO Highway Safety Manual
<table>
<thead>
<tr>
<th>FUNCTIONAL CLASSIFICATION</th>
<th>DESIGN SPEEDS (mph)</th>
<th>LANE WIDTHS FOR SPECIFIED DESIGN ADT, feet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>under 400</td>
<td>400 to 1500</td>
</tr>
<tr>
<td>COLLECTOR</td>
<td>20-30</td>
<td>10 - 12 (1)</td>
</tr>
<tr>
<td></td>
<td>35-50</td>
<td>10 - 12 (1)</td>
</tr>
<tr>
<td></td>
<td>55+</td>
<td>11 - 12</td>
</tr>
<tr>
<td>ARTERIAL</td>
<td>40-45</td>
<td>11 - 12</td>
</tr>
<tr>
<td></td>
<td>50-55</td>
<td>11 - 12</td>
</tr>
<tr>
<td></td>
<td>60+</td>
<td>12 (2)</td>
</tr>
<tr>
<td>FREEWAY</td>
<td>50+</td>
<td>12</td>
</tr>
</tbody>
</table>

(1) 9 feet minimum for roads with a design speed of 40 mph or lower and with a design ADT less than 250

(2) On reconstruction projects, existing 11-foot lanes may be retained where the horizontal alignment is satisfactory and there is no crash pattern suggesting the need for widening

MnDOT standard lane widths – rural highways

Technical Memo No. 12-07-TS-02
“Traffic lanes on all freeways should be 12 feet wide. This is considered to be the ideal width for capacity and proper operations.”

“Desirably the through lanes on arterial streets should also be 12 feet wide. However, the stringent controls of right-of-way and existing development may make use of 11-foot lanes necessary.”
“Any width less than 11 feet is considered unsatisfactory for arterial highways.”
"[Urban arterial] Lane widths may vary from 10 ft to 12 ft. The 10–ft widths are used in highly restricted areas having little or no truck traffic. The 11–ft lanes are used quite extensively for urban arterial street designs. The 12–ft lane widths are most desirable and are generally used on all higher speed, free–flowing, principal arterials."
“Under interrupted-flow operating conditions at low speeds up through 40 mph narrower lane widths are normally adequate and have some advantages.”

“Reduced lane widths allow greater numbers of lanes in restricted right-of-way and allow better pedestrian cross movements because of reduced distance.”
Relationship of Lane Width to Safety for Urban and Suburban Arterials

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Word Count: 5,594 + 9 tables = 8,144
“...no general indication that the use of lanes narrower than 12 ft on urban and suburban arterials increases crash frequencies.”

“The lane width effects in the analysis conducted were generally either not statistically significant or indicated that narrow lanes were associated with lower rather than higher crash frequencies.”
“Lane widths may vary from 10 to 12 ft. Lane widths of 10 ft may be used in more constrained areas where truck and bus volumes are relatively low and speeds are less than 35 mph. Lane widths of 11 ft are used quite extensively for urban arterial street designs. The 12-ft lane widths are desirable, where practical, on high speed, free-flowing, principal arterials.”
### MnDOT standard lane widths – urban streets

Technical Memo No. 12-07-TS-02

<table>
<thead>
<tr>
<th>FUNCTIONAL CLASSIFICATION</th>
<th>LANE WIDTHS FOR SPECIFIED DESIGN SPEED RANGES, feet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LOW SPEED ($&lt; 50$ mph)</td>
</tr>
<tr>
<td>COLLECTOR</td>
<td>10 - 11 $^{(1)}$ $(^{(2)})$</td>
</tr>
<tr>
<td>MINOR ARTERIAL</td>
<td>10 - 12 $^{(2)}$</td>
</tr>
<tr>
<td>PRINCIPAL ARTERIAL</td>
<td>11 - 12</td>
</tr>
<tr>
<td>FREEWAY</td>
<td>N/A</td>
</tr>
</tbody>
</table>

$^{(1)}$ 12 feet may be considered in industrial areas

$^{(2)}$ 11 feet minimum on four-lane undivided facilities
“...changes including lane width reduction...did not have any adverse safety impacts.”

“No adverse safety impacts were observed in the use of 11 foot lane widths. No operational impacts were reported.”
“Literature suggests that 10-foot lanes provide no significant operational or safety impacts in suburban or urban arterials. No findings or observations in this research dispute these claims.”
U.S. 10 – Staples
Let’s Design a Cross Section!

› Using the “STREETMIX” software!
Other Tools: Medians

- Planted median
- Right-in/right-outs
- Parking lanes
- Pedestrian crossings
Other Tools:

- Bump-outs
- Bicycle parking
- Pedestrian lighting
- Landscaping
- Streetscaping
Other Tools:

- Parallel Bike Boulevards
- Pedestrian Crossings
- Sidewalks/Bike Lanes Across Major Barriers
Re–Cap of Key Principles

- Design for Type of Community
- Design Outside–In
- Address Vulnerable Users First
  - Pedestrians, Transit Users, Bicyclists, Disabled
  - Pedestrian Crossing Times
  - Conflict Points
- Consider All Day/Corridor Traffic (not just peak period, single intersection LOS)
- Use Slower Speeds
- Use Fewer/Narrower Lanes
Final chat page check-in
Thank you

**Upcoming Training Opportunities:**

Advanced Flexibility in Design Workshop  
April 22 – April 24, 2014

Complete Streets Workshop  
May 14 – May 15, 2014

For more information visit:  
www.cts.umn.edu/contextsensitive/workshops/