How did we get here?
Reshaping Drop-offs

Typical of new PCC

Graphic Source: Zimmer and Ivey, Texas Transportation Institute
Reshaping Drop-offs

Typical of HMA overlay

Graphic Source: Zimmer and Ivey, Texas Transportation Institute
Reshaping Drop-offs

Graph showing the relationship between the longitudinal edge elevation change (inches) and the relative degree of safety. The graph includes three shapes: Shape A, Shape B, and Shape C. The graph indicates that typical of a 1:1 fillet results in a safe degree of safety.

Graphic Source: Zimmer and Ivey, Texas Transportation Institute
Safety Evaluation of the Safety Edge Treatment (2005-2011)
FHWA official study

- Rural two-lane with no paved shoulder
- Rural two-lane with less than 4’ paved shoulder
- Multi-lane with less than 4’ paved shoulder
Safety Impacts of Pavement Edge Drop-offs (2006)
(On rural paved roads with unpaved shoulders)

• Drop-off crashes were 17.7% of ROR crashes in Iowa, of those

<table>
<thead>
<tr>
<th>Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run-off-road right; cross centerline; run-off-road left</td>
<td>49.8%</td>
</tr>
<tr>
<td>Run-off-road right; lost control on shoulder</td>
<td>25.4%</td>
</tr>
<tr>
<td>Run-off-road right; cross centerline; sideswipe opposite direction</td>
<td>7.1%</td>
</tr>
<tr>
<td>Run-off-road right; return to road; run-off-road right</td>
<td>7.1%</td>
</tr>
<tr>
<td>Run-off-road right; cross centerline; head-on</td>
<td>4.4%</td>
</tr>
<tr>
<td>Run-off-road right; cross centerline; rolled in opposite lane</td>
<td>3.0%</td>
</tr>
<tr>
<td>Run-off-road right; sideswipe same direction</td>
<td>2.0%</td>
</tr>
<tr>
<td>Run-off-road right; run-off-road left; run-off-road right</td>
<td>0.5%</td>
</tr>
<tr>
<td>Run-off-road right; cross centerline; rear end</td>
<td>0.5%</td>
</tr>
<tr>
<td>Unknown</td>
<td>0.2%</td>
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</table>
Reshaping Drop-offs

Relative Degree of Safety

- Unsafe
- Questionable Safety
- Marginally Safe
- Reasonably Safe
- Safe

Longitudinal Edge Elevation Change (inches)

Example shapes:
- Shape A
- Shape B
- Shape C

Graphic Source: Zimmer and Ivey, Texas Transportation Institute
Iowa Adoption of Safety Edge
October 2010

Required on all primary highways unless:
• Roadway is an interchange ramp or loop
• Roadway or shoulder is curbed
• Paved shoulder width is 4’ or greater
Construction of Safety Edge

Similar to Conventional Paving

- Clip Shoulders
- Construct Pavement
- Pull Shoulders Flush
Construction of Safety Edge

Similar to Conventional Paving

- Clip Shoulders
- Construct Pavement
- Pull Shoulders Flush
Construction of Safety Edge
Construction of Safety Edge
Construction of Safety Edge

Similar to Conventional Paving

- Clip Shoulders
- Construct Pavement
- Pull Shoulders Flush
Costs of Safety Edge

- Shoe ~ $3000 one time
- Pavement Material ~ 1% to 7% increase
- Paving Process ~ no change once shoe placed
Benefits of Safety Edge

- **Crash Reduction Factor** of 5.7% in total crashes on rural two-lane highways
- Increased pavement edge durability
- Decreases drop-off potential of greater than 2” to assist shoulder maintenance efforts
- **Cost/Benefit ratios**
  - Two lane w/paved shoulders = 4 to 44
  - Two lane w/o paved shoulders = 4 to 63
  - Beneficial for roadway with 1000 ADT for CRF of 2%
Do we need median barriers?
Do we need median barriers?

- Increasing frequency of cross-median crashes
  - Higher traffic volumes and speeds
  - Greater risk-taking
  - Inattentive/distracted drivers
- A vehicle crossing the median today is more likely to impact another vehicle head-on
  - Often multiple fatalities/serious injuries
But why cable barriers?

Why not just build concrete barriers or steel beam guardrail in the median?
A note about crash tests

All barriers must pass a series of full-scale crash tests:

• Very controlled conditions
• Vehicles that are represent range of the current fleet (small car, pickup truck)
• Instrumented with tri-axial accelerometers and rate gyros
A note about crash tests

Simulate “worst practical conditions”:
  • 62 mph impact at 25° angle

Evaluated for:
  • Occupant risk (unbelted)
  • Structural adequacy
  • Post-impact vehicle behavior
Concrete Barrier
Steel Beam Guardrail
What is a cable barrier?

- 3-4 tensioned steel cables
- Anchored to ground at ends
- Held at varying heights by weak steel posts
- Posts bend or break on impact
- Cables “grab on” to vehicle
- Cables deflect backwards and do most of the work
Cable Barriers Aren’t New

• Used in Iowa since mid-1920s
• Various types/number of cables over the years
• Low-tension design used since 1960s
Cable Barriers Aren’t New

- Iowa’s first high-tension installation in 2003
- Only high-tension designs have been used in the median to separate traffic
What makes a *high-tension* cable barrier?

- Each cable tensioned to 5,000-8,000 pounds
  - Extra tension reduces deflection under impact
  - Cables maintain heights even with multiple posts knocked down
- Posts set in concrete sleeves
  - Damaged posts easily removed and replaced
Cable Barrier Crash Test
Benefits of Median Cable Barriers

• Less snow drift
• Ease of maintenance
• Crash performance
  – Works from either side
  – Less severe crashes
  – Effective on sloped ground
  – Capable of handling multiple impacts
Benefits of Median Cable Barriers

• Low installation cost
  – Cable Barrier:
    $9 per foot
  – Steel Beam Guardrail:
    $18 per foot
  – Concrete Barrier:
    $100 per foot
Benefits of Median Cable Barriers

• Not designed or tested to capture large trucks, however…
Drawbacks of Median Cable Barriers

- Nuisance hits
- Crashes at end anchors
- Cables down = no protection
- Multiple systems to inventory
- Affects other operations
  - Snow plowing
  - Speed enforcement
  - First Responders
Drawbacks of Median Cable Barriers

• Public perception
  – “No safe place to go”
  – “Too close to the road”
  – “Causes too much damage”
  – “Rubber band”
  – “Cheese slicer”
Where to place in the median?

• Vehicle capture highly dependent upon height of bumper at barrier interface
  – Bumper too low: vehicle goes under barrier
  – Bumper too high: vehicle goes over barrier

• Bumper heights vary as a vehicle crosses the median
  – High near the sides
  – Low near the middle
Effect of Median Shape
Cables near Center of Median
Cables on near Side of Median
Cables on far Side of Median
Design Typical in Iowa

To provide the best chance of capturing a wide range of vehicles, we re-shape the median when installing cable barriers.
## Crash Performance

### All Crashes

<table>
<thead>
<tr>
<th></th>
<th>2 Years Before</th>
<th>2 Years After</th>
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</thead>
<tbody>
<tr>
<td>All Crashes</td>
<td>1471</td>
<td>1891</td>
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<tr>
<td>Fatal Crashes</td>
<td>18</td>
<td>14</td>
</tr>
<tr>
<td>Major Injury Crashes</td>
<td>54</td>
<td>40</td>
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<tr>
<td>Fatalities</td>
<td>26</td>
<td>14</td>
</tr>
<tr>
<td>Major Injuries</td>
<td>74</td>
<td>47</td>
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</tbody>
</table>
## Crash Performance

### Cross-Median Crashes

<table>
<thead>
<tr>
<th>Category</th>
<th>2 Years Before</th>
<th>2 Years After</th>
<th>Percentage Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Crashes</td>
<td>36</td>
<td>9</td>
<td><strong>-75%</strong></td>
</tr>
<tr>
<td>Fatal Crashes</td>
<td>7</td>
<td>1</td>
<td><strong>-93%</strong></td>
</tr>
<tr>
<td>Major Injury Crashes</td>
<td>5</td>
<td>0</td>
<td><strong>-87%</strong></td>
</tr>
<tr>
<td>Fatalities</td>
<td>15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Major Injuries</td>
<td>8</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Future Developments

• Non-proprietary Midwest Cable System
  – Midwest states pooled fund (11 states)
  – Led by University of Nebraska
  – 4-cable design, new post shape
  – For use ANYWHERE in a 6:1 V-ditch
  – Requires passing 8 different crash tests
Midwest Cable System

• Completed tests have revealed issues
  – Interaction of vehicle with slope
  – Cable penetration into occupant compartment
  – Impacts directly into a post
  – Closer post spacing = tripping potential
Interaction with Slope
Windshield Penetration
Impacts directly at a post
Close post spacing
Midwest Cable System

• But solutions found:
  – Optimization of cable attachments
    • Strong in X-axis (horizontal pulling)
    • Weak in Y-axis (vertical lifting)
    • Quick release of top cable from posts
  – Reduction in cable tension
  – Limit on close post spacing (for now)
Attachment Strength
Limit on post spacing
Questions?