1ST INTERNATIONAL ROADSIDE SAFETY CONFERENCE
SAFER ROADS, SAVING LIVES, SAVING MONEY

Sponsored by
TRB Standing Committee on Roadside Safety Design (AFB20)

Co-Sponsored by
Transportation Pooled Fund Program Project No. TPF-5(329), including US State Departments of Transportation for Kentucky, Minnesota, Nebraska, Ohio, Washington, and West Virginia
1ST INTERNATIONAL ROADSIDE SAFETY CONFERENCE
SAFER ROADS, SAVING LIVES, SAVING MONEY

TECHNICAL SESSION 7A: HIGH PERFORMANCE, INNOVATIVE, AND AESTHETIC BARRIERS

Moderator: Michael Drezenes, International Road Federation, Chicago, Illinois

Compliance Crash Testing of the CA ST-70 Side Mounted Bridge Rail
Vue Her, California Department of Transportation, Sacramento, California

Development of MASH TL-5 Steel Median Safety Barrier
Richard Clausius, ArcelorMittal Global R&D, East Chicago, Indiana

Development of a MASH TL-4 Roller Barrier
Frederick Mauer, Gregory Industries, Canton, Ohio

*Implementing MASH High-Tension, Three-Cable Guide Rail (HT3CGR) System in Ontario
Mark Ayton, Ontario Ministry of Transportation, Ontario, Canada (*Invited Presentation)
Development of a MASH TL-4 Roller Barrier

1st International Roadside Safety Conference
San Francisco

Presentation by Rick Mauer – Gregory Industries
Overview

- This roller barrier was the first test level 4 (TL4) barrier in the world to achieve MASH criteria.
- The Occupant and Vehicle Risk Factor Criteria were all met within MASH’s Preferred Categories
- It’s shock absorbing nature converts some of the impact energy to rotational energy thereby decreasing speed impact whilst redirecting vehicle back into its lane.
- The absorptive capacity of the roller barriers aids in the reduction of driver & passenger fatalities
- Has a lower frequency repair and maintenance when compared to traditional barriers.
- Visually stands out, thus by its presence alone deters vehicle from impacting the barrier.
- Life cycle costs are less than existing barrier systems.
System Components

- Steel Line Posts
- Intermediate Posts
- Post Sleeve
- Shock Absorbing Roller
- Stopper Board
- Top & Bottom Rail
- Top & Bottom Rail Sleeve
System Components – Line & Intermediate Posts

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Line Posts</td>
<td>140mm diameter x 4.5 mm thickness CHS sections, 2200 mm long.</td>
</tr>
<tr>
<td>Intermediate Line Posts</td>
<td>140mm diameter x 4.5 mm thickness CHS sections, 780 mm long.</td>
</tr>
<tr>
<td>Inner Post</td>
<td>127 mm diameter x 4.3 mm thick CHS sections, 1000 mm long.</td>
</tr>
<tr>
<td>Post Sleeve</td>
<td>34mm diameter x 4.0 mm thick x 125mm long</td>
</tr>
</tbody>
</table>
Roller Barrier - System Components – Safety Roller
System Components – Stopper Boards
System Components – Top and Bottom Rails
System Components – Rail Sleeves / Splice
System Components
The Crushive strength & resilience of the Safety Roller
The Safety Roller Thermal Testing

<table>
<thead>
<tr>
<th>Report NO. :</th>
<th>TAS - 34802</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Name :</td>
<td>Safety E.V.A Roller</td>
</tr>
</tbody>
</table>

Test Method < KS M 6518 : 2006 >

< Low Temperature Resistance Test((-70±2) °C, 10 h) Before Sample >

< Low Temperature Resistance Test((-70±2) °C, 10 h) After Sample >
The Safety Roller accelerated age testing

Report NO.: TAS - 34803
Sample Name: Safety E.V.A Roller

Test Method < KS M 6518 : 2006 >

< Aging Test((80±1) °C, 10 h) Before Sample >

< Aging Test((80±1) °C, 10 h) After Sample >
The Safety Roller makes the difference
Maximum Roadway Curvature

Safety Roller (GS-G506-TL4)-Installation scene

- Main Post: 0.139.8 x 2200L
- Sub Post: 0.139.8 x 780L

LOCAL ROAD
ZONE MOTEWAY 7

D2-1a: 3331L (Hole: 666.7 mm)
D2-1b: 2564L (Hole: 666.7 mm)
D2-2a: 3154L (Hole: 631.4 mm)
D2-2b: 2522L (Hole: 631.4 mm)

CUTTING RAIL SECTION

R = 6313
R = 6073

R = 6313
R = 6073
International Accreditations.

MASH is judged by three criteria:

- Structural Adequacy
- Occupant Risk
- Vehicle Trajectory Post Impact

Accreditations:

- MASH TL3/TL4 Federal Highways NHCRP 350
- AustRoads & VicRoads accreditation
- Tested to EN 1317
- Tested to Korean SB 4/5
MASH 4-10 Testing
MASH 4-10 Test Summary

- Test Article: KII Global Australia PTY LTD Safety Roller Barrier System
- Total Length: 60 m
- Key Element - Barrier
  - Description: Roller Barrier with bus rail and steel line post
  - Length: 60.6 metre LGN
  - Rail Height: 970 mm
  - Post Spacing: 967 mm nominal
- Test Vehicle:
  - Designation: 1100C
  - Manufacturer: 2005 Kia Rio
  - Dimensions (WxLxH): 4225 x 1685 x 1420 mm
  - Curb Weight: 1065 kg
  - Test Inertial weight: 1082 kg
  - Gross Static weight: 1157 kg
- Impact Conditions
  - Speed: 97.5 kph
  - Angle: 25°
  - Impact Point: 1.0 m upstream of line post 22
- Exit Conditions
  - Exit Speed: 97.6 kph
  - Exit Angle: 14.2°
- Post Impact Vehicle Behaviour
  - Vehicle Stability: Good
  - Vehicle Snagging: None
  - Vehicle Picketing: None
  - Occupant Impact Velocity
    - Longitudinal: 0.2 m/s at 0.0807 sec
    - Lateral (optional): 8.9 m/s at 0.0807 sec
  - Occupant Ride Down Deceleration
    - x-direction: 0.6 g (0.0076-0.0176 seconds)
    - y-direction: 7.0 g (0.0966-0.0998 seconds)
    - z-direction: 7.8 m/s at 0.0836 seconds
    - PID (optional): 7.9 g (0.0836-0.0933 seconds)
- Test Article Damage: Low
- Test Article Deflections
  - Dynamic: 0.135 m
  - Permanent: 0.060 m
  - Elastic: 0.135 m
- Vehicle Damage - Exterior
  - VDS: 11-LFG-0
  - CDC: 11-P22
  - Max. Deformation: 95 mm
MASH 4-11 Testing
MASH 4-11 Test Summary

**TEST ARTICLE**
KSH Global Australia PTY LTD Safety Roller
Barrier System
60 m

**KEY ELEMENTS – BARRIER**
Description: Roller Barrier with box rail and steel line posts
Length: 60.0 metre LON
Rail Height: 970 mm
Post Spacing: 667 mm nominal

**TEST VEHICLE**
Designation: 2270P
Make/Model: 2005 Dodge Ram 1500 Quad Cab
Dimensions (lwh): 5720 x 2050 x 1930 mm
Curb Weight: 2260 kg
Test Inerital weight: 2282 kg
Gross Static weight: 2282 kg

**IMPACT CONDITIONS**
Speed: 98.4 kph
Angle: 25°
Impact Point: 0.7 m upstream of line post 22

**EXIT CONDITIONS**
Exit Speed: est. 48.3 kph
Exit Angle: 21°

**POST IMPACT VEHICLE BEHAVIOUR**
Vehicle Stability: Good
Vehicle Stopping Distance: 26.5 metres

**VEHICLE SNAPPING**
None

**VEHICLE PENETRATION**
None

**OCCUPANT IMPACT VELOCITY**
Longitudinal: 0.1 m/s at 0.1309 sec
Lateral (optional): 5.9 m/s at 0.1309 sec

**OCCUPANT RIDEDOWN DECELERATION**
x-direction: 1.1 g [0.1566 - 0.1706 m]
y-direction: 9.7 g [0.1477 - 0.1577 m]
THIV (optional): 5.6 m/s at 0.1378 sec
PIID (optional): 9.7 g [0.1477 - 0.1577 m]

**TEST ARTICLE DAMAGE**
Low

**TEST ARTICLE DEFLECTIONS**
Dynamic: 0.458 m
Permanent: 0.270 m
Working Width: 0.293 m

**VEHICLE DAMAGE - EXTERIOR**
VDS: 11-LFO-3
CDC: 11FLE2
Max. Deformation: 145 mm
MASH 4-12 Testing
MASH 4-12 Testing

KSI Global Australia PTY LTD Safety Roller Barrier System

- **Post Impact Vehicle Behaviour**
  - Vehicle Stability: Low
  - Vehicle Stopping Distance: 40 metres
  - Vehicle Snagging: None
  - Vehicle Pocketing: None
  - Occupant Impact Velocity
    - Longitudinal: 0.5 m/s at 0.2403 sec
    - Lateral (optional): 2.8 m/s at 0.2403 sec
  - Occupant Ride Down Deceleration
    - x-direction: 4.6 g (1.4551-1.4551 seconds)
    - y-direction: 4.3 g (0.3585-0.3585 seconds)
    - THV (optional): 2.5 m/s at 0.2500 seconds
    - PHT (optional): 4.5 g (0.3585-0.3585 seconds)
  - Test Article Damage: Mild
  - Test Article Deflections
    - Dynamic: 0.215 m
    - Permanent: 0.100 m
    - Working Width: 2.55 m
  - Vehicle Damage - Exterior
    - VDS: 11-LFG-0
    - CDC: 11FL-EE
    - Max. Deformation: 260 mm

- **Test Vehicle**
  - Designation: 10,000S
  - Make/Model: 2001 Mitsubishi Fuso Fighter
  - Dimensions (w/h): 7665 x 2040 x 3100 mm
  - Curb Weight: 3790 kg
  - Test Inertial Weight: 9060 kg
  - Gross Static Weight: 9990 kg

- **Impact Conditions**
  - Speed: 58.8 kph
  - Angle: 15°
  - Impact Point: 0.7 m upstream of line post 22

- **Exit Conditions**
  - Exit Speed: Estimated 8.0 kph
  - Exit Angle: 0.0°
The Barrier….. Installations

UNIVERSAL APPLICATIONS Median / centre lines between opposing traffic, managed lane separation, curved median strips, curved ramps, diverging points, curved downhill corners, hillside locations, school zones and danger & protection zones etc.

Current Installations | Pending Installations
---|---
Korea | USA
India |
Thailand | UAE
Australia | Taiwan
Singapore |
Malaysia |
Peru |
Argentina |
Sri Lanka |
KSI Korea have provided crash data from five key locations in Korea:

- 강릉시청: KANGNEUNG CITY HALL
- 전북도 김제시청: JEONLA BUKDO (KIMJE CITY HALL)
- 전라북도 청 도로공항과: JEONLA BUKDO (Road Airport department)
- 국토교통부: MOLIT (MINISTRY OF LAND, Infrastructure and Transport)
- 강릉시청: KANGNEUNG CITY HALL


<table>
<thead>
<tr>
<th>Measurements</th>
<th>Before KSI Barrier</th>
<th>After KSI Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Fatalities</td>
<td>3</td>
<td>Nil</td>
</tr>
<tr>
<td>Number of Serious Injuries</td>
<td>5</td>
<td>Nil</td>
</tr>
<tr>
<td>Number of Medical Treatment Required Injuries</td>
<td>3</td>
<td>Nil</td>
</tr>
<tr>
<td>Number of Minor Injuries</td>
<td>3</td>
<td>Nil</td>
</tr>
<tr>
<td>Number of Property Damage Only Incidents</td>
<td>6</td>
<td>Nil</td>
</tr>
<tr>
<td>Major Damage (Section replacement)</td>
<td>6</td>
<td>Nil</td>
</tr>
<tr>
<td>Minor Damage (Minor pole/ guard replacement)</td>
<td>3</td>
<td>Nil</td>
</tr>
<tr>
<td>Total Number of Collisions</td>
<td>9</td>
<td>Nil</td>
</tr>
</tbody>
</table>
In 18 months this ramp was repaired 6 times, yet it receives impacts almost every 10 to 15 days. (Fortunately, many of these accidents are minor and don’t rise to the level of requiring immediate repairs)
Victoria, Australia installation Dec 2016...
A minimum of 3 (visually confirmed) impacts in 115 days.

No need to replace or repair.................
A minimum of 3 (visually confirmed) impacts in 115 days.

*Tire tracks clearly show re-direction occurring following a barrier impact.*
*Note: the lack of damage to the barrier.*
A minimum of 3 (visually confirmed) impacts in 115 days.

*Nick in the reflective tape*
Benefit cost ratio (BCR) takes into account the amount of monetary gain realized by performing a project versus the amount it costs to execute the project. The higher the ratio the better the investment. Ratios greater than 1 are better than the alternative.
## Cost Benefit: 5 years – W-Beam Install & Repair Cost

**Location:** High St Laverton Victoria

**W-beam & Installation**

<table>
<thead>
<tr>
<th>Year</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4 hits x $2,520</td>
<td>4 hits x $3,720</td>
<td>9 hits x $2,520</td>
<td>9 hits x $3,720</td>
</tr>
<tr>
<td>1</td>
<td>4 hits x $2,520</td>
<td>4 hits x $3,720</td>
<td>9 hits x $2,520</td>
<td>9 hits x $3,720</td>
</tr>
<tr>
<td>2</td>
<td>4 hits x $2,520</td>
<td>4 hits x $3,720</td>
<td>9 hits x $2,520</td>
<td>9 hits x $3,720</td>
</tr>
<tr>
<td>3</td>
<td>4 hits x $2,520</td>
<td>4 hits x $3,720</td>
<td>9 hits x $2,520</td>
<td>9 hits x $3,720</td>
</tr>
<tr>
<td>4</td>
<td>4 hits x $2,520</td>
<td>4 hits x $3,720</td>
<td>9 hits x $2,520</td>
<td>9 hits x $3,720</td>
</tr>
<tr>
<td>5</td>
<td>4 hits x $2,520</td>
<td>4 hits x $3,720</td>
<td>9 hits x $2,520</td>
<td>9 hits x $3,720</td>
</tr>
</tbody>
</table>

**Assumptions**

- **Based on Vic Roads**
- **Incl Traffic Mgt** $1,200
- **3 hits in 115 days extrapolated.**
- **Incl Traffic Mgt. 3 hits in 115 Days extrapolated**

**Total**

$7,800

**Apply Discount rate**

3%
## Cost Benefit: 5 years - Roller Barrier Install & Maint. Costs

**Location:** High St Laverton, Victoria

- **SRB:** $620/ per m, 60m = $37,200
- **Installation:** $160/m x 60 m, 1 Day = $9,600
- **Total Installation Cost:** $46,800

### Costs - To install Roller Barrier and Maintenance

<table>
<thead>
<tr>
<th>Year</th>
<th>Initial cost</th>
<th>Maint *</th>
<th>Total Cost</th>
<th>Present Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$46,800</td>
<td></td>
<td>$46,800</td>
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<td>$1,000</td>
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<td>$1,000</td>
<td>$952</td>
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<tr>
<td>3</td>
<td>0</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$929</td>
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<tr>
<td>4</td>
<td>0</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$906</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$884</td>
</tr>
</tbody>
</table>

**Total PV of Costs over 5 yr.**

- **$51,800**  
- **$51,446**

*Assuming maintenance x 2 per year @ $500 each time based on data 115 days.*
## Cost Benefit: 5 years. Roller Barrier VS W-Beam Cost

### Benefit - Previous Maintenance Cost with W Beam VS Roller Barrier

<table>
<thead>
<tr>
<th>Year</th>
<th>Scenario 1 Benefit</th>
<th>Present Benefit</th>
<th>Scenario 2 Benefit</th>
<th>Present Benefit</th>
<th>Scenario 3 Benefit</th>
<th>Present Benefit</th>
<th>Scenario 4 Benefit</th>
<th>Present Benefit</th>
</tr>
</thead>
<tbody>
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<td>0</td>
<td>$7,800</td>
<td>$7,800</td>
<td>$7,800</td>
<td>$7,800</td>
<td>$7,800</td>
<td>$7,800</td>
<td>$7,800</td>
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<tr>
<td>1</td>
<td>$10,080</td>
<td>$9,834</td>
<td>$14,880</td>
<td>$14,517</td>
<td>$22,680</td>
<td>$22,127</td>
<td>$33,480</td>
<td>$32,663</td>
</tr>
<tr>
<td>2</td>
<td>$10,080</td>
<td>$9,594</td>
<td>$14,880</td>
<td>$14,163</td>
<td>$22,680</td>
<td>$21,587</td>
<td>$33,480</td>
<td>$31,867</td>
</tr>
<tr>
<td>3</td>
<td>$10,080</td>
<td>$9,360</td>
<td>$14,880</td>
<td>$13,818</td>
<td>$22,680</td>
<td>$21,061</td>
<td>$33,480</td>
<td>$31,090</td>
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<tr>
<td>4</td>
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<td>$9,132</td>
<td>$14,880</td>
<td>$13,481</td>
<td>$22,680</td>
<td>$20,547</td>
<td>$33,480</td>
<td>$30,331</td>
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<td>$10,080</td>
<td>$8,909</td>
<td>$14,880</td>
<td>$13,152</td>
<td>$22,680</td>
<td>$20,046</td>
<td>$33,480</td>
<td>$29,591</td>
</tr>
</tbody>
</table>

**PV of Benefit W-Beam**
- Scenario 1: $58,200
- Scenario 2: $54,630
- Scenario 3: $76,930
- Scenario 4: $131,167

**PV of Benefit Roller Barrier**
- Scenario 1: $51,800
- Scenario 2: $51,446
- Scenario 3: $51,446
- Scenario 4: $51,446

**BCR Value**
- Scenario 1: 1.06
- Scenario 2: 1.50
- Scenario 3: 2.20
- Scenario 4: 3.18

**Assumptions**
- Based on Vic Roads
- Incl Traffic Mgt.
- 3 hits in 115 days
- Extrapolated
- $1,200 extrapolated
- Incl Traffic Mgt.
- 3 hits in 115 Days
- Extrapolated
## Cost Benefit: 10 years. Roller Barrier vs W-beam Costs

### Benefit - Previous Maintenance Cost with W Beam vs Roller Barrier

<table>
<thead>
<tr>
<th>Year</th>
<th>Scenario 1 Benefit</th>
<th>Scenario 1 Present Benefit</th>
<th>Scenario 2 Benefit</th>
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<td>$17,718</td>
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<td>$26,155</td>
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</tbody>
</table>

**PV of Benefit of W-Beam**

- $108,600
- $96,021
- $156,600
- $138,031
- $234,600
- $206,297
- $342,600
- $300,819

**PV of Benefit of Roller Barrier**

- $56,800
- $55,552
- $56,800
- $55,552
- $56,800
- $55,552
- $56,800
- $55,552

**BCR Value**

- 1.73
- 2.48
- 3.71
- 5.42

### Assumptions

- Based on Vic Roads Incl Traffic Mgt. 3 hits in 115 days $1,200 extrapolated.
- W-Beam email.
- Incl Traffic Mgt. 3 hits in 115 Days extrapolated.
In conclusion……..

- The development of the Roller Barrier has provided the motoring public a safe and cost beneficial MASH TL4 Barrier.
- The Barrier has been shown to lower maintenance & repair/replacement costs.
- By it’s presence alone the Barrier appears to be deterring and reducing the frequency of impacts.
- The Safety Roller technology has proven to reduce accident severity over standard steel barriers.
Thank You!

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