Designing and Testing Bollards To Protect Pedestrians

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Outline

- Introduction
  - Current pedestrian injury rates
  - Interface Analysis Design – Survivability
  - Example poor interface designs
- Example IAD bollard systems
- Revision of AS/NZS 3845
- Conclusions and Recommendations
Introduction

Around 700,000 road crashes in Australia in 2011
1300 fatalities and 35,000 serious injuries (BITRE, 2012)

Pedestrian fatalities 14%
- 2010 = 170 deaths
- 2011 = 185 deaths
- 2012 = 174 deaths

Fatality downward trend has stalled.

Serious Injury (2008-2009 data only available for all Australia)
Pedestrian serious injury 7% (≈ 2500 serious injuries)
Australian pedestrian fatalities since 2000
(BITRE annual fatality reports, 2009 & 2013)

Introduction

Default 50 km/h introduced

Pedestrian Deaths

Year

What is a survivable impact?  
20 km/h?
What is a survivable crash?

**Safe System Approach**

*Make crashes survivable – intrinsic safety*

What is a survivable crash?

**Safe System Approach**

*Make crashes survivable – intrinsic safety*

![Graph showing the relationship between collision speed and fatality risk.](image-url)
What is a survivable crash?

**Safe System Approach**

Make crashes survivable – *intrinsic safety*

What is a survivable crash?

Safe System Approach

Make crashes survivable – intrinsic safety

Australia’s default limit 50km/h is high!

Collision speed km/h

Fatality risk %

What is a survivable crash?
Speed from skid equation

\[ V^2 = 2aD \]

- \( V = \text{vehicle velocity} \)
- \( a = \text{acceleration} \)
- \( D = \text{length of skid} \)
Speed from skid equation

\[ V^2 = 2aD \]

\[ V = \text{vehicle velocity} \]

\[ a = \text{acceleration} = g = 9.81 \text{ m/sec}^2 \]

\[ D = h = \text{distance fallen} \]
Speed from skid equation

\[ V^2 = 2gh \]

\( V = \text{vehicle velocity} \)

\( a = \text{acceleration} = g = 9.81 \text{ m/sec}^2 \)

\( D = h = \text{distance fallen} \)
What is a survivable impact?

\[ V^2 = 2gh \]

- \( V \) = vehicle velocity
- \( h \) = height above ground
- \( g \) = gravity acceleration
  - \( g = 9.81 \text{ m/sec}^2 \)
What is a survivable impact?

30 km/h \equiv\text{ falling off a house roof.}\quad(10\% \text{ risk of death})

40 km/h \equiv\text{ falling from window of a 2 story house } \quad(35\% \text{ risk of death})

50 km/h \equiv\text{ falling from window of a 3 story building } \quad(80\% \text{ risk of death})

60 km/h \equiv\text{ falling from roof of a 3 story house } \quad(93\% \text{ risk of death})
You can determine the future of your European cities!
We want to have real traffic safety and a better quality of life.
So, we are asking for an EU-wide speed limit of 30 km/h (20 mph) in villages and cities. Register to vote with us – support our European Citizen's Initiative (ECI).

Sign Online!
Bad interface designs to protect pedestrians
Bad interface designs to protect pedestrians & cyclists
Preferable interface designs to protect pedestrians
Preferable interface designs to protect pedestrians
Crash Testing Requirements

Testing requirement to separate cosmetic bollards vs crashworthy bollards to protect both the pedestrian and the vehicle occupants

**TABLE 7.3 (a)**

**TEST MATRIX FOR BOLLARDS USED AS A SAFETY BARRIER**

<table>
<thead>
<tr>
<th>Test Level</th>
<th>Feature</th>
<th>Test designation</th>
<th>Impact conditions</th>
<th>Evaluation Criteria (see Table 5.1 of NCHRP 350)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bollard</td>
<td>1-100</td>
<td>Vehicle: 1500A</td>
<td>Nominal Speed (km/h): 50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bollard Array: 1-102</td>
<td>820C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1-103</td>
<td>2000P</td>
</tr>
<tr>
<td>2</td>
<td>Bollard</td>
<td>2-100</td>
<td>Vehicle: 1500A</td>
<td>Nominal Speed (km/h): 70</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bollard Array: 2-102</td>
<td>820C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2-103</td>
<td>2000P</td>
</tr>
</tbody>
</table>

(a) See Figure 3.5 of NCHRP 350.
Crash Testing Requirements

Acceptable performance may be:

• redirection, controlled penetration, or controlled stopping of the vehicle at acceptable non-injurious deceleration rates;

• the vehicle should not penetrate, under-ride, or override the bollard although controlled lateral deflection of the bollard is acceptable to a limit;

• detached elements, fragments or other debris from the bollard should not:
  o penetrate or show potential for penetrating the occupant compartment;
  o present an undue hazard to other road users, in particular to pedestrians;
  o block the driver’s vision or otherwise cause the driver to lose control of the vehicle;

• the vehicle should remain upright during and after collision although moderate roll, pitching and yawing are acceptable.
Conclusions & Recommendations

- Interface Analysis and Design for Crashworthy Bollards
  - Energy dissipating bollards offer a practical protective interface between vehicles and pedestrians principle for lower speed roads
  - Prevent ingress of an errant vehicle into a protected area by providing positive passive protection for shopping strips, outside dining areas, bus stops.
  - Bollards should be crash tested (either as barricades/gating so that they don’t injure occupants if they are not crashworthy or as passive crashworthy systems)
  - Bollards need to be marked whether they are barricades or crashworthy systems (and to what level)
Questions?

Together we can save lives.