Recent developments in geometric road design practices

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Agenda

- Identify two conferences attended by the Department of Transport and Main Roads staff
- Outline papers presented by the department’s staff
- Discuss major learnings from the conferences
- Workshop session on particular learnings.
Conferences attended
Conferences attended

• 5th International Symposium on Highway Geometric Design (ISHGD)

• 95th Annual Transportation Research Board (TRB) Meeting.
ISHGD

• Exclusively about the field of roadway geometric design
• ISHGD held every five years

• 5th ISHGD
  - Held in Vancouver, Canada
  - June 2015
  - Around 300 attendees from 38 countries
  - 142 papers presented.
Annual TRB meetings

• Promote innovation and progress in all transportation modes through research
• Roadway geometric design is but one field among many
• Holds annual meetings in Washington D.C., United States of America (USA)

• 95th Annual TRB meeting
  - Held in January 2016
  - Around 14,000 attendees
  - About 5000 presentations delivered.
Purpose of attendance

Objectives of attendance

To gain international recognition (and acceptance) of technology developed by the department through presentation of papers

To discuss local issues and concerns with other practitioners from around the world

To keep up to date with world’s best practice in the field of roadway geometric design
Papers delivered by the Department of Transport and Main Roads
Papers presented

Australian Country Report
• Presentation by Owen Arndt and Ricky Cox

Development of a new Time-Gap Based Intersection Sight Distance Model for Heavy Vehicles
• David Cole, Ricky Cox and Owen Arndt

Development of warrants for Unsignalized Intersection Turn Treatments
• Owen Arndt, Dan Sullivan and David Gough

Facing up to the beed for Road Design Guidelines for Brownfield Sites
• Owen Arndt, Ricky Cox, Les Louis and Rod Troutbeck
Major learnings
Performance based geometric design

- The American Association of State Highway and Transportation Officials (AASHTO) ‘A Policy on Geometric Design of Highways and Streets’ (green book) is:
  - Applicable for new road design
  - Rural centric
  - Lacks basis in science and is conservative in the selection of design values.
Performance based geometric design (cont.)

- Only 5% of federal USA funds in 2013 were spent on new road construction
- There is a move from ‘compliance with a code’ to a ‘performance based design’ process, especially for retrofits to existing roads
  - Flexibility in design
  - 3R design process
  - Designing for very low volume roads
  - Highway Safety Manual
  - Value engineering.
Performance based geometric design (cont.)

- One of the measures of performance based design is the substantive or measured safety performance.
- The USA is working on a second edition of the Highway Safety Manual.
  - Some established relationships in the 1st edition are not very robust.
- If a lot of design exceptions are having to be justified, then the design criteria must not be suitable in the first place.
Performance based geometric design (cont.)

Discussion

- The department has been moving in this direction for some time for example:
  - Developing Extended Design Domain
  - Applying the Design Exception process
  - Introducing the Design Guidelines for Road Design on Brownfield Sites.

Recommendations

- The Road Design Section to review the National Co-operative Highway Research Program (NCHRP) report 785 for potential processes that can be adopted
- Pursue the scope of Extended Design Domain to include other parameters where relevant.
Safe Systems

- Designing, constructing and maintaining a road system so that forces on the human body generated in crashes are generally less than those resulting in fatal or debilitating injury.
Safe Systems approach

Australian Transport Council (2006) reported that the chances of surviving a crash decrease markedly above certain speeds, depending on the type of crash:

- Pedestrian struck by vehicle 20 – 30 km/h
- Motorcyclist struck by vehicle (or falling off) 20 – 30 km/h
- Side impact vehicle striking a pole or tree 30 to 40 km/h
- Side impact vehicle to vehicle crash 50 km/h
- Head-on vehicle to vehicle crash 70 km/h

10% of crashes involving the above relative speeds will result in a death
**Safe Systems / Vision Zero**

<table>
<thead>
<tr>
<th>Safe Systems</th>
<th>Vision Zero</th>
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</thead>
<tbody>
<tr>
<td>• Traffic speeds lowered to critical limits to prevent injuries (location / context specific)</td>
<td>• A goal of zero deaths and severe injuries, with interim achievable goals</td>
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• Are being more widely adopted / debated by worldwide road authorities
  - Including the United Kingdom, which has one of the safest road networks in the world.
Safe Systems / Vision Zero (cont.)

Sweden is recognised as the leader in Vision Zero.

There was a lot of discussion within the Swedish Transportation Authority before Vision Zero was presented to the politicians for adoption.

There was much conflict within the Swedish Transportation Authority to get Vision Zero adopted (and there still is).
The outcome of most studies to date show that the driver is the critical reason for the majority of crashes. This is now being questioned. Several papers indicate that the shortcomings are in the transportation system and that the transportation system designers are responsible for the safety of the system.
Safe Systems / Vision Zero (cont.)

- A representative of the Swedish Transportation Administration Authority presented the following on road safety.

<table>
<thead>
<tr>
<th>Traditional approach</th>
<th>Vision Zero</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causes – human factors</td>
<td>Humans make mistakes</td>
</tr>
<tr>
<td>People don’t want safety</td>
<td>Responsibility for safety is with the system designer</td>
</tr>
<tr>
<td>Optimum number of road crashes</td>
<td>People want safety</td>
</tr>
<tr>
<td></td>
<td>Eliminate fatalities and serious injuries</td>
</tr>
</tbody>
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A USA paper reports that:

- A number of USA cities are passing policies calling for the elimination of traffic related fatalities over the next decade.
- The USA should take the same direction on Vision Zero as has been adopted in Australia.
- A tool has been developed to help cities identify strategies to adopt Vision Zero.
Much of our geometric road infrastructure is based on:  

1. Precedence

Road network largely designed for slower vehicles and slower speeds

Community and industry requirements for reduced delays by allowing more capable vehicles and higher speeds
Much of our geometric road infrastructure is based on:

2. Design standards (for new and upgraded roads)

World’s best practice / latest research and experience, which has seen safety improved over time

To optimise design factors, particularly cost and safety
Much of our geometric road infrastructure is based on:

3. What is considered acceptable to the community

In terms of the balance of capacity, delays, safety, environment, cost and so on.
Safe Systems / Vision Zero – Discussion (cont.)

To achieve a major step toward Safe Systems / Vision Zero in the short term (around 10 years), one of the following needs to occur:

- Much more funding is required to build much safer roads
- A combination of more funding and lower speed limits
- A mass reduction in speed limits to achieve safe system limits
There is an effort by some to increase speed limits, including within the USA and within Australia.

There has been a significant lack of collaboration between advocates of Safe Systems / Vision Zero and the road design fraternity, in Australia and the USA.

A network of fully autonomous vehicles in the future will likely not require much of the road infrastructure needed now to achieve Safe Systems / Vision Zero.
Safe Systems / Vision Zero – Recommendations

Engineering and Technology Branch continues the project to coordinate the department’s action plan to address Safe Systems / Vision Zero

- In coordination with others, including the Land Transport and Safety Branch
- Include strategy for communicating the message to politicians and the general public.
The Austroads Road Safety Task Force collaborate much more heavily with the Austroads Road Design Task Force.
Alternative intersection designs

- The Federal Highway Administration (FHWA) of the USA has produced four new informational guides, each for an alternative intersection design.
- Generally, alternative intersection designs are claimed to have both improved traffic operations (for example, capacity) and improved safety.
Alternative intersection designs (cont.)

Displaced Left Turn (DLT)

(Source: Jenior & Bugg (2015) 'FHWA Alternative Intersection Informational Guides')
Alternative intersection designs (cont.)

Median U-Turn (MUT)

Indirect left turns are made by first turning right and then making a U-turn in the wide median.

No direct left turns at main intersection.

(Source: Jenior & Bugg (2015) ‘FHWA Alternative Intersection Informational Guides’)

Alternative intersection designs (cont.)

Restricted Crossing U-Turn (RCUT)

(Source: Jenior & Bugg (2015) 'FHWA Alternative Intersection Informational Guides')
Diverging Diamond Interchange (DDI)

- Up to 24 installed in the USA
- Has lower right-of-way requirements, lower roadway area and enhanced bicycle lane designs.
Diverging Diamond Interchanges (DDIs)

• Two papers investigated capacity / delay considerations at DDIs:
  - Treatments to reduce the queue on exit ramps.
  - Field data showed different results to the Highway Capacity Manual (HCM).

(Source: Shannon et al (2016) 'Impact of Off-Ramp Geometric Treatments at Diverging Diamond Interchanges on Queue Spillback)
Alternative intersection designs (cont.)

Discussion

• Alternative intersections designs are being considered for use at various locations in Queensland and Australia, especially the Diverging Diamond Interchange.

Recommendations

• The Road Design Section to review the FHWA Informational Guides and review the content for application within Queensland.
• Consider trialling the alternative intersection designs as a Pilot Projects.
Roundabout design in Germany

- Single lane radial roundabouts are used in urban and rural areas.
- Trucks up to 24 m long, with steering on the rear units, use these roundabouts.
- On smaller urban roundabouts, 50 mm high encroachment areas are used in the central island which do not produce complaints by truck or bus operators.

Roundabout design in Germany

- Although conventional two-lane roundabouts are not used, turbo-roundabouts are.
- The raised lane dividers adopted in the Netherlands are not used. Although some drivers tend to cut lanes, this does not seem to be a problem.
- A slightly wider single lane roundabout is also used where drivers stagger their vehicles (capacity increased by 50%).
Roundabout design in Germany

There are various geometric forms of Turbo Roundabouts.


BASIC  EGG  KNEE

There are various geometric forms of Turbo Roundabouts.
Roundabout design

Discussion

• The international uptake of turbo-roundabouts is increasing

• Australian road authorities have a concern about the raised lane dividers being a hazard to motorcyclists

• The Dutch, though also initially concerned, have not found this to be a problem.

Recommendation

• Consider trialling Radial and Turbo Roundabouts as Pilot Projects.
Swedish Practice – 2+1 roadways

- Have an average traffic volume of 8000 vehicles per day
- Are usually only retrofitted to existing roads with 12 m – 13 m carriageway width
- Have reduced sight distance around barriers which has not appeared to be a safety problem, although the issue is still being debated
- Disadvantages are the crash barrier repair costs and increased rutting. There is a trend to use box beam barriers instead of wire rope.

2+1 roadways

Discussion

• The international uptake of 2+1 roadways is increasing.
• The retrofitting of 2+1 lanes in Queensland is unlikely to be justified because virtually all of the two-lane, two-way road network does not have sufficient width.

Recommendations

• For each project, Transport and Main Roads’ Districts determine whether wire rope barriers provide the lowest whole-of-life costs, given the trend to move towards box beam guardrail in Sweden.
Swedish Practice – Two-lane, two-way rural roads

• In Sweden, three treatments are being rolled out on two-lane, two-way roads with:
  - Speed limits greater than or equal to 80 km/h
  - Traffic volumes between 1000 and 5000 vehicles per day
  - Formation width insufficient for a 2+1 cross section.

These are:

• Rumble centrelines
• Rumble median with overtaking lanes
• Median barriers with overtaking lanes.
Swedish Practice – Two-lane, two-way rural roads (cont.)

• Rumble centrelines
  - 4000 km
  - Reduction of 10 – 15% in fatal and serious injury single vehicle crashes.

• Rumble median with overtaking lanes
  - Overtaking lanes spaced 4 – 10 km apart
  - No overtaking on the 1+1 sections
  - Roadside barriers on the outside of sharper curves
  - Reduction of fatality and severe injury crashes by 30 – 40%.
Swedish Practice – Two-lane, two-way rural roads (cont.)

- Median barriers with overtaking lanes.
  - With a median barrier in lieu of the rumble median, the range in crash reduction is 60 – 70%.

Two-lane, two-way rural roads

Discussion

• Significant lengths of the department’s major highways have speeds >80 km/h, AADTs in the range 1000 – 5000 vehicles/day.
• Our current practice of installing Wide Centreline Treatments and overtaking lanes at regular intervals is consistent with the Swedish practice.

Recommendations

• Continue to consider the cost effectiveness of adding centreline barriers to two-lane, two-way rural road projects.
Number of lanes on connector ramps

- A German paper indicated:
  - Current “RAA Guide” requires two lanes when length > 500 m
    - even though only one lane required for traffic
  - Studied 80+ connectors
    - Safety performance
    - Driving lines
    - Operating speeds versus design speeds.
  - No worthwhile safety or operational benefit from extra lane.

(Source: Austroads Guide to Traffic Management, Part 6)
Number of lanes on connector ramps (cont.)

Discussion

• Austroads has volume and length criteria for number of lanes.
• There have been absurd cases proposed due to rigid application.

Recommendations

• Review Austroads length criterion.
Number of lanes on connector ramps (cont.)
Conclusion
Conclusion

Key Learnings

• There is pressure in the USA to adopt a greater level of performance based standards, especially for retrofits.
• Safe systems / vision zero are being more widely adopted / debated by worldwide road authorities.
• Alternative intersection and roundabout designs are becoming popular.
• Swedish practice for rural road cross section widths is reasonably consistent with the department’s.
• There is support for reviewing the number of lanes on connector ramps.
Workshop session

• **Performance Based Standards**
  - What current geometric standards do you consider are performance based? What are the performance measures?
  - Have you ever used crash modification factors to achieve a safety outcome? If so, provide example/s.

• **Safe Systems**
  - Have you ever considered this concept in road design? If so, explain how.
  - As road designers, have you any suggestions of how we can practically improve road safety through Safe Systems concepts in say the next 10 years?

• **Alternative Intersection Designs**
  - Have you ever designed an alternative intersection? If so, provide an example.
  - Are there any barriers to the implementation of alternative intersection designs?
Thank you