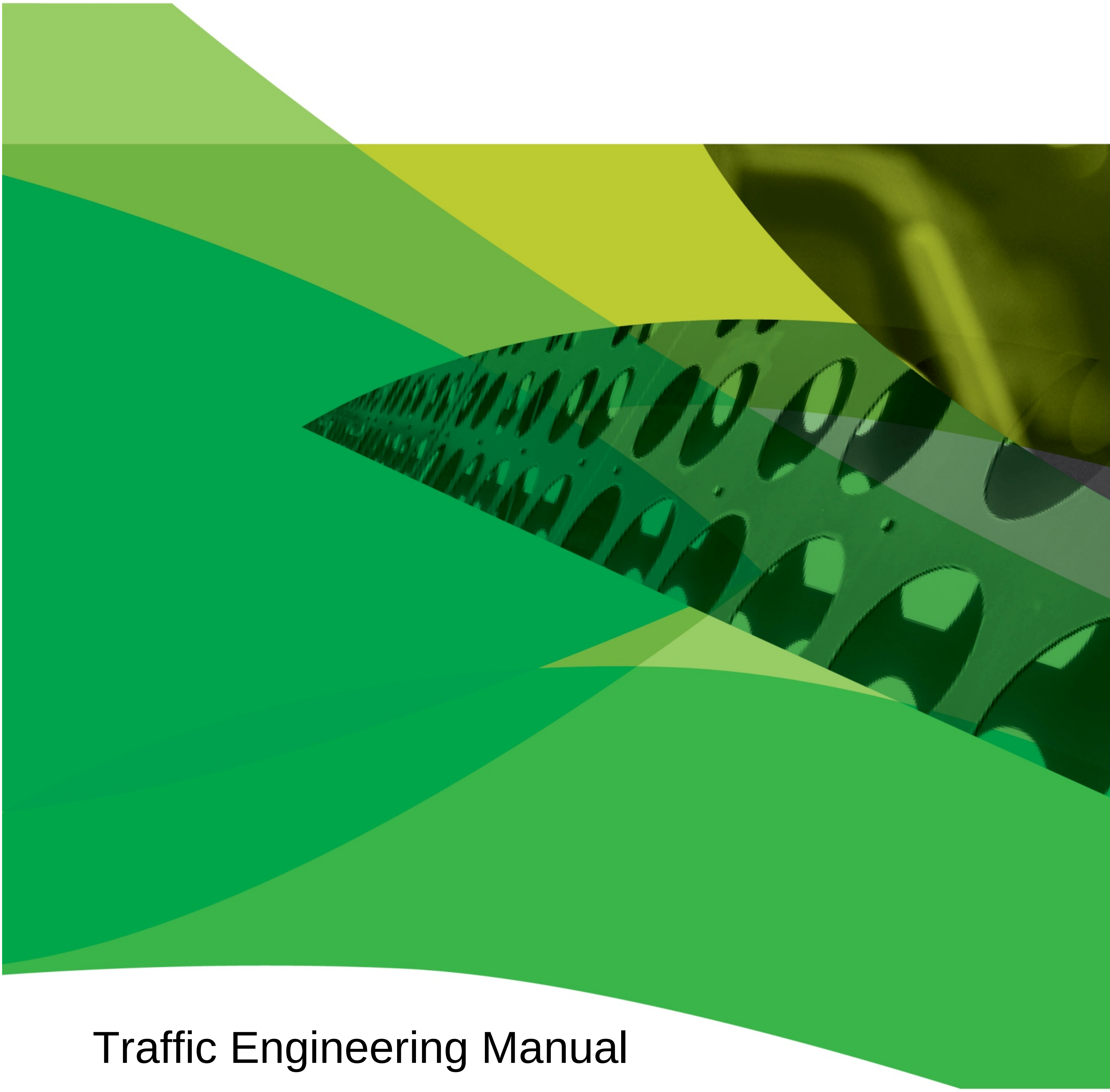

Traffic Engineering Manual

Volume 3 – Additional Network Standards & Guidelines

Guidance on Bicycle and Pedestrian Treatments at Roundabouts

Edition 1, December 2016

vicroads.vic.gov.au

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1. Introduction

Roundabouts are commonly perceived by cyclists and pedestrians as one of the most hazardous forms of intersection control on the road network. The predominant cyclist crash pattern at roundabouts is an entering vehicle colliding with a circulating cyclist. At roundabouts, 80% of crashes involving cyclists are due to motorists failing to correctly judge the cyclist's speed and having a lack of awareness of the cyclist's presence. Refer to Appendix A for statistics on cyclist casualties at roundabouts.

By definition, multi-lane roundabouts are designed to cater for large volumes of vehicular traffic by having more than one lane circulating the central island, while a single-lane roundabout consists of only one circulating lane. A roundabout's efficiency and safety are based on road users' judgment and, importantly, the design of the roundabout itself.

Figure 1: Example of a local road roundabout in inner Melbourne

Pedestrians are another group of roads users that need to be catered for at roundabouts. The design of conventional roundabouts poses a number of issues for crossing pedestrian, including:

- long crossing distances which increase exposure time
- high vehicle approach and departure speed (where the risk of high-speed injury increases)
- potential collisions with bicycles and motor vehicles
- difficulties in judging who is going to turn off the roundabout depending on signalling discipline of drivers

To mitigate the above issues faced by pedestrians, physical treatments, such as reducing the crossing distance, may be required as a measure to enhance the level of pedestrian safety.

In addition, where there is a medium to high level of interaction between cyclists and pedestrians, such as along off-road paths, measures may need to be implemented to separate cyclists and pedestrians to ensure that the risk of collision between pedestrians and cyclists is mitigated.

The guidance provided in this document aims to address the issues surrounding the movement of pedestrians and cyclists at a roundabout. The table below summarises the relationship between the speed environment and whether the movement of pedestrians and cyclists is across or through the roundabout.

Speed environment	Pedestrian and cyclist movement at the roundabout
Low speed environments	Pedestrians: Cross the roundabout at grade Cyclists: Go through the roundabout at grade (on the road shared with motor vehicles)
Intermediate speed environments	Pedestrians: Cross the roundabout at grade Cyclists: Cross the roundabout at grade (using separated off-road facility)
High speed environments	Pedestrians: Cross above or below the roundabout Cyclists: Cross above or below the roundabout

This report aims to provide guidance on the possible treatments that can be applied to improve the safety of cyclists and pedestrians at new and existing roundabouts. All treatments (and supporting treatments) in this document are to be considered and assessed, with the rational and evaluation for the recommended treatment(s) documented.

The treatments are classified as follows:

- **Elimination treatments** – these treatments virtually eliminate the risk of collision between motor vehicles and cyclists / pedestrians within a roundabout.
- **Reduction treatments** – these treatments reduce the risk of collision between motor vehicles and cyclists / pedestrians within a roundabout.
- **Supporting treatments** – these treatments enhance the safety benefits already provided by the 'elimination' and 'reduction' treatments. Multiple 'supporting' treatments may be used to improve cyclist and pedestrian safety on the approach and through the roundabout.

VicRoads Movement & Place Framework and SmartRoads

The Movement and Place framework supports integrated transport and land use decision making by considering the variety of roles that roads and streets play. Many of Victoria's roads cater for high volumes of "movement" by various modes of transport, while others are quiet local streets. Streets and roads are also "places" such as shopping and leisure destinations, local neighbourhoods or tourist routes, and contribute to Victoria's liveability and character.

The primary objective of SmartRoads is to improve the long term operational management of arterial roads across Victoria by providing priority to modes of transport, on certain roads, and at particular times of the day. SmartRoads recognises the increasing importance of public transport, walking and cycling as transport modes. Under SmartRoads, certain roads or areas have been classified as bicycle priority routes or pedestrian priority areas where there is a focus on providing facilities that promote and prioritise cycling and pedestrian movements.

Each treatment in this document will make reference to SmartRoads. This document will be updated further as the Movement and Place framework develops.

Safe System Approach

The Safe System approach to road safety is the key concept in Victoria's strategy to reduce fatalities and serious injuries from road crashes. The Safe System approach is built on the premise that people make mistakes which can lead to crashes and that there is a limit to the human body's tolerance to crash forces. Accordingly, the road transport system needs to be designed and managed to cater for human failure.

By applying the Safe System philosophy, the long term vision is to eliminate fatal and serious injuries arising from crashes. The achievement of a Safe System is a shared responsibility and it requires four interconnected cornerstones of safe travel to be working effectively together – safer people, safer vehicles, safer roads and safer speeds.

To create a Safe System, it is important to influence how people and vehicles can safely access the road system. Greater emphasis and effort needs to be placed on developing and maintaining more forgiving roads and roadsides, so both the likelihood of a crash occurring and the severity of crashes when they do occur are reduced.

In the event of a crash, pedestrians and cyclists are more vulnerable than vehicle occupants because they have little or no protection. Well designed and maintained paths will help in the safety of pedestrians and cyclists and also encourage more walking and cycling as the best way to stay healthy and get around.

VicRoads' key role is to help provide Victorians with safe and easy connections to the people and places that matter most to them. As part of the VicRoads' aim to achieve ongoing reductions in the number and severity of road crashes and the resultant cost of road trauma, several treatments have been developed to help improve the safety of pedestrians and cyclists. This document aims to eliminate and reduce the risk of collision between motor vehicles and cyclists/pedestrians within a roundabout.

Each treatment in this document will make reference to the Safe System approach.

Crash Reduction Factors

For the crash reduction factors for the various treatments listed in this document, practitioners should refer to the latest available research. At the time of publication, the following documents may be useful in providing guidance for these factors:

- Austroads Technical Report AP-T151/10 Road Safety Engineering Risk Assessment Part 6: Crash Reduction Factors(2010)
- Austroads Research Report AP-R422-12: Effectiveness of Road Safety Engineering Treatments (2012)

It should be noted that other research may be available and practitioners may use this information where appropriate.

2. Summary of treatments

Table 1 below provides a brief overview of the treatments and their use in certain road environments.

For full details regarding a treatment's effectiveness and appropriateness in certain road environments, please refer to the detailed section for each treatment.

Table 1: Overview of treatments and their use on certain routes

	Treatments to eliminate bicycle and pedestrian collisions at roundabouts	**Treatments to reduce bicycle and pedestrian collisions at roundabouts**				
Road Use Classification **(including SmartRoads Road Use Hierarchy categories)**	Grade separation	Annular roundabouts	Radial roundabouts	Bicycle Streets	C-roundabouts	Splitter kerbs
Preferred traffic route	🟢	🟢	🔴	🔴	🟡	🔴
Tram priority route	🟢	🟢	🟡	🔴	🟡	🟡
Bus priority route	🟢	🟢	🔴	🔴	🟡	🟡
Pedestrian priority area (or network)	🟢	🟢	🟢	🟢	🟡	🟡
Bicycle priority route	🟢	🟢	🟡	🟡	🟡	🟢
Traffic route	🟢	🟢	🔴	🔴	🟡	🔴
Freight route	🟢	🟢	🔴	🔴	🟡	🔴
Collector road (without specific traffic priority)	🔴	🟢	🟢	🟡	🟡	🟢
Local road (without specific traffic priority)	🔴	🟢	🟢	🟢	🟡	🟢

KEY:

🟢 Appropriate   🟡 May be appropriate   🔴 Unlikely to be appropriate

3. Elimination treatments

3.1 Grade separation

Grade separation is a junction design which allows cyclists and pedestrians to cross above (overpass) or below (underpass) the intersection. By separating the interaction between cyclists / pedestrians and motorists, all conflict points are effectively eliminated.

The key features of this treatment include:

- Virtually eliminating all conflicts between motorists, pedestrians and cyclists.
- Motorised and un-motorised modes are not interrupted by one another, allowing free flow through the roundabout.
- Accommodating speed differentials and safe travel at hidden approaches.
- Underpasses can utilise the central island to connect to multiple paths from the different roundabout approach legs.

Potential locations for grade separation:

- At roundabouts within pedestrian priority areas or on bicycle priority routes intersecting with preferred traffic routes as defined in the VicRoads SmartRoads strategy.
- Areas with high volumes of pedestrians and/or cyclists.
- Across major roads (e.g. preferred traffic routes under the VicRoads SmartRoads strategy) with high operating speeds where at-grade cycling and/or pedestrian treatments do not deliver the best level of service.
- At roundabouts on public transport priority routes where at-grade cycling and/or pedestrian treatments do not deliver the best level of service.

Where such a treatment is to be considered, the following should be taken into account:

- The geometry of the overpass/underpass will appropriately cater for the expected volume of cyclists and pedestrians.
- The impact on travel times for users of the grade separated facility which may not be favourable for pedestrians where the walking distance is perceived to be significantly greater than the at-grade distance.
- Where the volume of pedestrians and/or cyclists is large or there is the potential for conflicts between the two modes (due to high differential speeds), consideration should be made for a separate path for cyclists and pedestrians along the overpass/underpass - refer to the main 'supporting treatments' section (Section 5) for further details.
- To encourage pedestrians and cyclists to use the facility and prevent them crossing at grade, fencing on the approaches to the grade separation facility may be required.
- The connection between the overpass/underpass and the on-road bicycle lane (where applicable), including the potential conflicts with pedestrians once cyclists are off the road.
- The land acquisition that may be required in order to build the structure – including provision of land for ramps and other supporting bridge or tunnel structures.
- Provision of Disability Discrimination Act (DDA) compliant infrastructure – refer to Australian Standards AS 1428.4 series. This includes providing ramps that are accessible by all users.
- Whether the design of the infrastructure leads to the creation of an environment that is 'unsafe' or 'unwelcoming' for pedestrians or other users. To overcome this, several measures can be implemented:
    - Provision of lighting - refer to VicRoads TCG 006 and AS/NZS 1158.5: Lighting for road and public places – Tunnels and underpasses (2014).
    - Graffiti prevention measures.
- The design of overpasses should consider the following:
    - The visual impact on the surrounding environment.

  - Provision of side barriers to prevent rock throwing or falls.
  - The clear width of walkway should be 1.8 m minimum for pedestrians[1].
  - Vertical clearance over roadways shall be 5.5 m minimum with no adjacent bridges and 6.0 minimum on designated high clearance routes.[2]
  - The clear width of bicycle paths on the carriageway should be 2.0 m minimum, 3.0 m minimum on separated bicycle path and two-way shared path.[3]
  - Appropriate lighting - refer to AS/NZS 1158 series
- The design of underpasses should consider the following:
  - Provision for drainage
  - Security and vandalism issues
  - Underpasses should be constructed with a maximum change in level of 3.5 m[4]
  - Appropriate lighting - refer to Section 4 of AS/NZS 1158.5:2014
- On-going maintenance costs.

Supporting treatments

Listed below are supporting treatments that can be used with this primary treatment. For full details on each supporting treatment (including appropriate locations and other considerations), refer to the main 'supporting treatments' section (Section 5).

Shared, separated and segregated paths

Adopting a separate or segregated path for cyclists and pedestrians should be considered in the following situations:

- Where the volume of pedestrians and/or cyclists is large or there is the potential for conflicts between the two modes, there may be a need to separate the path between cyclists and pedestrians along the overpass/underpass, and at other associated locations where pedestrians and cyclists are adjacent to one another.
- Limited sight distance between cyclists and pedestrians.
- Where the differential speeds between cyclists and pedestrians are high.

Design concepts

Grade separation has been used at a number of roundabouts in Europe, at locations where traffic speeds are high and there is a large volume of cyclists.

Overpasses such as the 'Hovenring' in the Netherlands (see Figure 2) allow cyclists to travel over the road, while motorists travel below the structure at ground level. Unlike other treatments, grade separation is among the most expensive. The construction cost of the 'Hovenring' was € 6.3 million Euros (approximately $7.6 million AUD) (not including the land acquisition and relocation of utilities costs).

An example of an underpass at a roundabout is at Oxenford in Queensland, as shown in Figure 3.

Figures 4 , 5 and 6 show a 'compact underpass' concept design that can be used at urban and rural roundabouts (note a shared path has been shown in the figures – refer to the main 'supporting treatments' section (Section 5) for other types of paths).

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[1] Clause 9.10 of AS5100.1-2004 Bridge Design Part 1: Scope and general principles

[2] Clause 9.11 of AS5100.1-2004 Bridge Design Part 1: Scope and general principles

[3] Clause 9.13 of AS5100.1-2004 Bridge Design Part 1: Scope and general principles

[4] Section 4.4.1 of Austroads Guide to Road Design Part 4C Interchanges

Figure 2: 'Hovenring' in the Netherlands (Image source: 'Hovenring' © ipv Delft: Helibeeld.nl)[5]

[5]Image source www.ipvdelft.com

Figure 3: Tamborine-Oxenford and Regatta Avenue, Oxenford, Queensland Australia. Image source: Google Maps

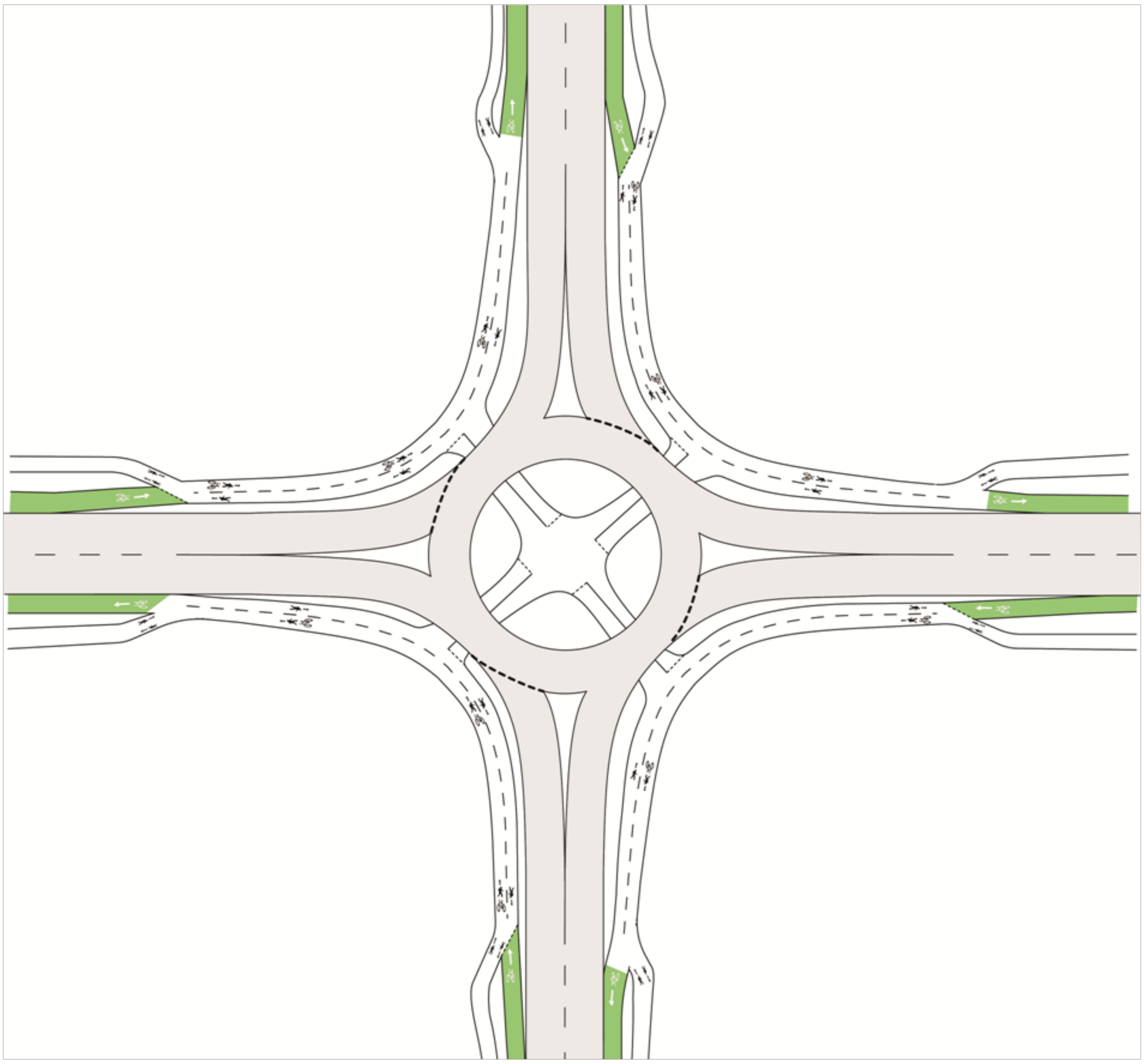

Figure 4: Compact underpass at an urban roundabout (plan view)

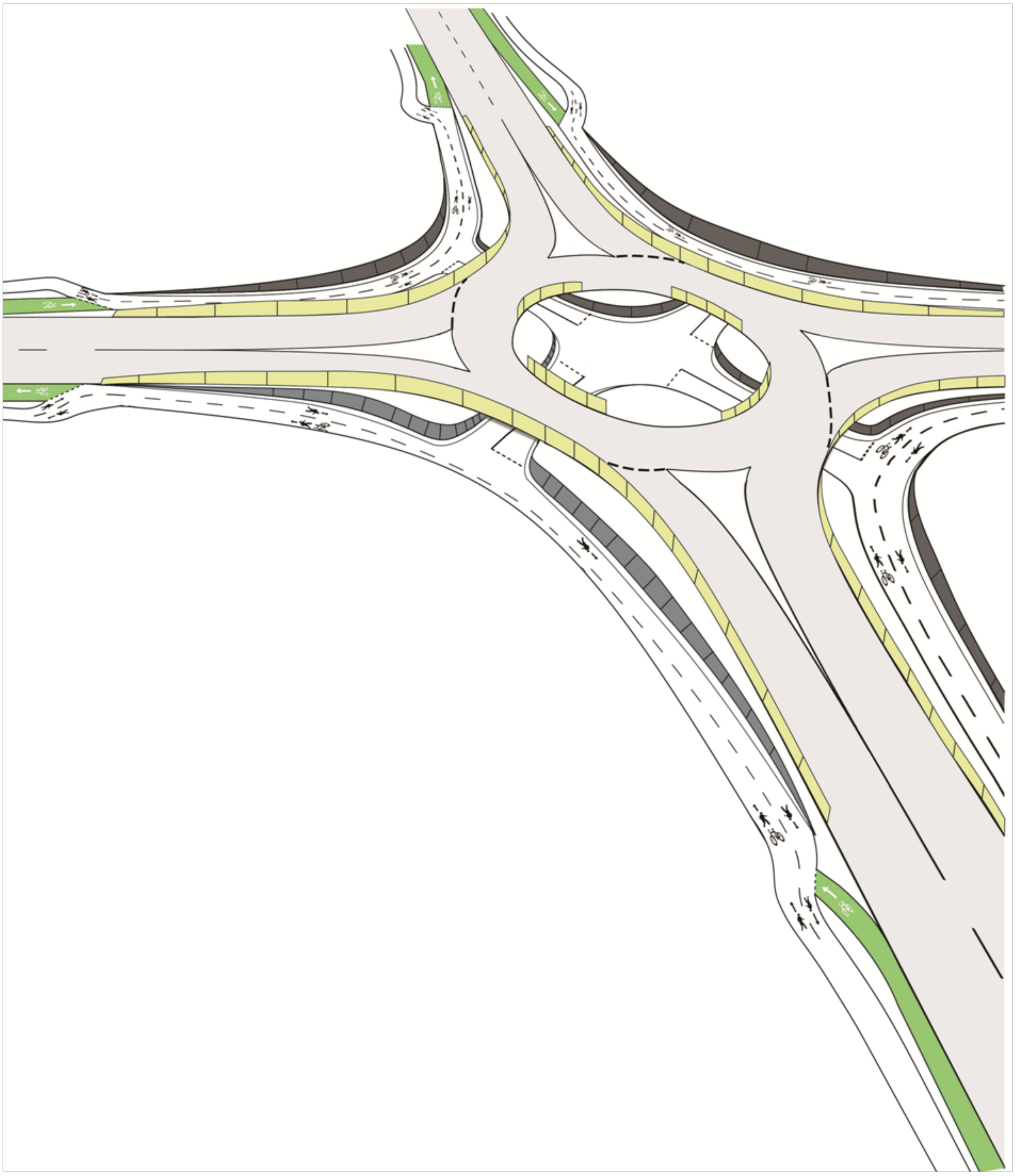

Figure 5: Compact underpass at an urban roundabout (3D view)

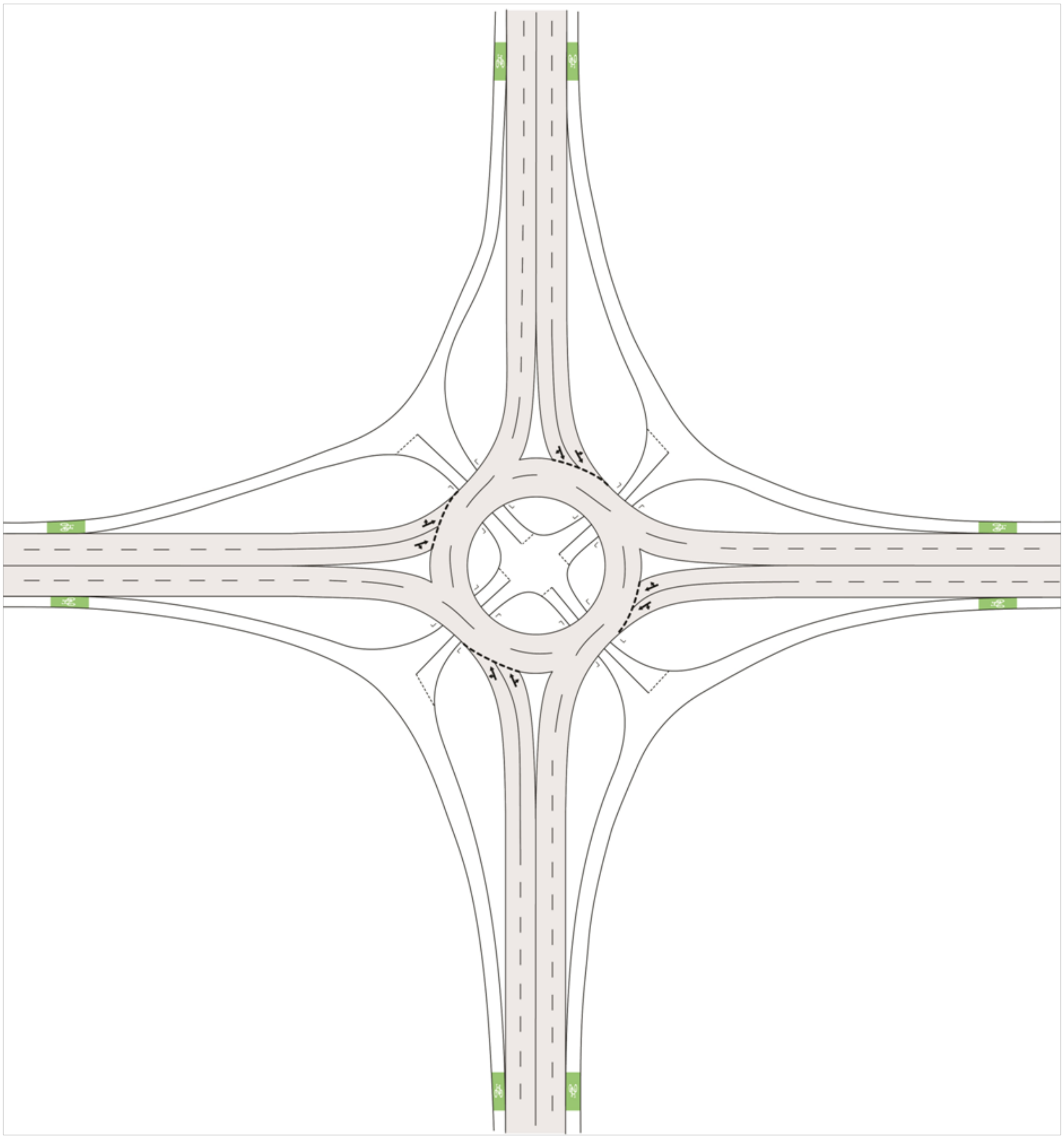

Figure 6: Compact underpass at a rural roundabout

The transition between an on-road bicycle lane and the off-road path should be clearly marked in order to allow bicycles to smoothly transfer on to the path, as shown in Figure 7. Where the bicycle path crosses the footpath, measures may need to be taken to highlight who has right of way at the 'crossing point'.

Figure 7: High speed ramp on Fitzgerald Road, Laverton North

Summary

This particular treatment has the following pros and cons:

Pros

- Cyclists and pedestrians are fully separated from other transport modes – no conflicts with vehicles at road level.
- Cyclists and pedestrians can cross the roundabout at any time without being delayed by other vehicle modes.
- The treatment can become a landmark for the local area through a prominent design.

Cons

- Potential high cost in provision of infrastructure (overpass or underpass).
- Potential increase in cyclist and pedestrian travel time, whereby cyclists may continue to ride through the roundabout.
- Poorly designed infrastructure may create an environment that is unwelcoming to cyclists and pedestrians or cause other safety issues (e.g. rock throwing).
- Potential high cost in the event of land acquisition.

Further reading

- Queensland Department of Transport and Main Roads Technical Note 136 "Providing for Cyclists at Roundabouts" (2015).
- Western Australia Department of Transport: 2014 Netherlands Cycling Study Tour Observations and Reflections Report.

- Austroads Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings (2013).
- Queensland Department of Transport and Main Roads, “Reduction of risk from objects thrown from overpass structures onto roads v1.2”.
- Austroads Guide to Road Design Part 4: Intersections and Crossings – General (2009).
- Pedestrian planning and design guide (2004): Section 15.4 (Land Transport New Zealand).
- Lighting: VicRoads TCG 006, AS/NZS 1158.3.1 (2005), AS/NZS 1158.5 (2014).
- Austroads Guide to Road Design Part 6A Section 3 (2009).
- Stairways – AS 1657.
- Disability Discrimination Act (DDA): AS 1428.4 series.
- Dimensions for pedestrian bridges – AS 5100.

4. Reduction treatments

4.1 Annular roundabout - separated bicycle / pedestrian path

In this treatment, a separated pedestrian and bicycle path is provided at the roundabout whereby cyclists / pedestrians can utilise this off-road facility, avoiding the need to ride or cross through the roundabout. It involves cyclists / pedestrians being placed on separated paths that begin prior to the roundabout and then on to a circular path around the roundabout. In terms of cyclists, this treatment can also be described as a separate ‘bicycle roundabout’ provided on the outside of the ‘vehicular roundabout’.

This design virtually eliminates all on-road bicycle left turn conflict points; however cyclists are still subjected to a possible conflict with motor vehicles when the off-road path crosses the road and pedestrians are still required to cross multiple traffic lanes. In addition, there is a potential for conflict between pedestrians and cyclists on the off-road path.

Potential locations for segregating bicycles and pedestrians at roundabouts include:

- Multi-lane roundabouts.
- Along roads which have been classified as bicycle priority routes under the VicRoads SmartRoads strategy.
- Single-lane roundabouts with high cyclist crash history.
- Locations where cyclists have difficulty in making a right turn.
- Local road roundabouts.
- Arterial road roundabouts.
- Roundabouts with a high volume of motor vehicles (including on preferred traffic and public transport routes) making cyclist navigation difficult.

Where such a treatment is to be considered, the following should be taken into account:

- Avoid obstructing landscaping that impairs the visibility between the road and off-road path.
- Where the volume of pedestrians and/or cyclists is substantial or there is the potential for conflicts between the two modes (including due to high differential speeds), consideration should be made for a separate path for cyclists and pedestrians - refer to the main ‘supporting treatments’ section (Section 5) for further details.
- Reduce operating speed and/or speed limit.
- Whether pedestrians and cyclists are to be given priority when crossing the road legs.
- Where segregation or separation is not desired, the need for a wider shared path to reduce potential conflicts between pedestrians and cyclists.
- The off-road path alignment should be as direct as possible, assuring sufficient distance and visibility for cyclists to react to incoming motorists or pedestrians.
- Provision of signage and pavement markings to direct cyclists on, off and along the off-road path.

- Provision of a raised platform on the approach and departure legs to slow down motorists – this may assist cyclists / pedestrians to judge vehicle speeds and to enhance motorists' awareness of cyclists / pedestrians at the roundabout.
- Physical treatments to raise the prominence of crossing pedestrians – such as raised crossing platforms. Other traffic calming measures may be required to assist in reducing the road's operating speed thus reducing the risk of injury to pedestrians.
- Signs to warn motorists of crossing pedestrians and cyclists at the road crossing points.
- Provision of ground markings and lane markings on the road and shared, segregated or separated path (e.g. painting the bicycle path green to indicate its use by bicycles).
- Holding rails on the sides of the splitter islands to allow cyclists to stay upright when waiting to cross the road legs.

The separated bicycle path at roundabouts has been effectively applied within the Netherlands with a study showing that roundabouts with a separated circulating bicycle path (without cyclist priority at crossings, i.e. cyclists have to give way to vehicles at road crossings) was 87% safer compared to an unsignalised intersection. The same study also showed that by giving cyclists priority at the roundabout, the level of safety increased only by 11% compared to an unsignalised intersection - almost 8 times less than the non-priority roundabout[6].

Supporting treatments

Listed below are supporting treatments that can be used with this primary treatment. For full details on each supporting treatment (including appropriate locations and other considerations), refer to the main 'supporting treatments' section (Section 5).

Supporting treatments that may be used with this primary treatment include:

Shared, separated or segregated paths

Adopting a separate or segregated path for cyclists and pedestrians should be considered in the following situations:

- Where the volume of pedestrians and/or cyclists is large or there is the potential for conflicts between the two modes, there may be a need to separate or segregate the path between cyclists and pedestrians along the annular path, and at other associated locations where pedestrians and cyclists are adjacent to one another.
- Limited sight distance between cyclists and pedestrians.
- Where the differential speeds between cyclists and pedestrians are high.

Pedestrian related treatments

For pedestrians, the following supporting treatments can be used:

- Raised pedestrian crossings
- Controlled pedestrian crossings (e.g. zebra crossings) (considerations need to be made to whether pedestrians/cyclists are to have priority of crossing over vehicles or vehicles are to have priority of crossing over pedestrians/cyclists).
- Pedestrian refuges.

Other treatments

Other treatments include:

- Approach deflection
- Raised platforms
- Static signage

[6] Ir. A. Dijkstra (2005). Are roundabouts with separate cycle tracks also safe for cyclists?

Design concepts

Figures 8, 9, 10 and 11 show various examples of segregated and separated bicycle paths at roundabouts. Explanation and discussion are provided under each set of figures.

Figure 8: Fairbairn Avenue and Creswell Street, Campbell, ACT. Image source: Google Maps

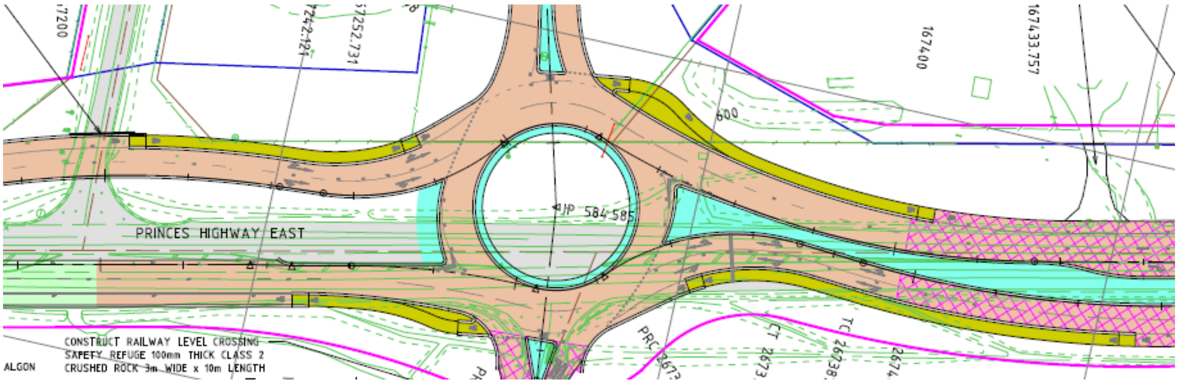

Figure 9: Princes Highway East, Traralgon – the segregated bicycle path is shown in yellow.

Figures 8 and 9 show roundabouts with a transition from an on-road bicycle lane to an off-road bicycle path. As can been seen, these particular treatments are fairly compact and may not require land acquisition outside of the road reserve. However, the conflict between pedestrians and cyclists needs to be carefully considered in these designs and further monitoring and evaluation will be required to ensure cyclist conflicts with other modes are reduced or mitigated.

These treatments may be considered for use on low to high speed roads and on both local and arterial roads.

Figure 10: Assen, Netherlands. Image source: Google Maps

Figure 11: Eindhovenseweg and Anconalaan intersection, Netherlands. Image source: Google Maps

Figures 10 and 11 show examples of segregated bicycle/pedestrian paths in the Netherlands. These circulating bicycle paths have greater separation from the circulating road with a separate pedestrian path provided.

These treatments may be considered for use on low to high speed roads and on both local and arterial roads.

Summary

Pros

- Provides an alternate and safer route for cyclists / pedestrians by providing a separate off-road path for cyclists / pedestrians at the roundabout.
- Reduces the number of conflicts points with motor vehicles, including where cyclists make a right turn and the conflict with left turning motorists.

Cons

- Where the off-road bicycle path cannot be built within the road reserve, it may require land acquisition.
- Cyclists are made to take an off-road ‘detour’ instead of riding directly through the roundabout – cyclists may not use this off-road path due to the possible additional travel time.
- Where the path crosses a road leg, cyclists/pedestrians may not have priority at the crossing resulting in potential delays.
- Conflicts between cyclists and pedestrians where there is no segregation or separation between the two modes.

Further reading

- Austroads Guide to Road Design Part 4B: Roundabouts (2015) Clause 5.3.5– design details for bicycle paths at roundabouts.
- Austroads Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings (2013).
- Cycling Aspects of the Austroads Guide Section 5.5.5 (2014) - further details on paths around roundabouts.
- Austroads Guide to Road Design Part 6A (2009).
- Austroads Research Report AP-R461-14 - assessment of the effectiveness of on-road bicycle lanes at roundabouts in Australia and New Zealand.
- SWOV Report R-2004-14 “Are roundabouts with separate cycle tracks also safe for cyclists?”

4.2 Radial roundabouts

At radial roundabouts, the entries from the approach legs are aligned towards the centre of the roundabout with no significant deflection to the left as with tangential roundabouts. The intention is to reduce vehicle speeds before drivers enter the roundabout, as the lack of a large entry deflection requires vehicles either to slow down or come to a complete stop. The entries and exits are generally of a narrower width which aids in the slowing down of vehicles[7].

Radial roundabouts are common on local roads in the Netherlands and on local roads in inner Melbourne.

The lower speeds reduce the severity of cyclist crashes and also benefits pedestrians who are crossing the roundabout.

Potential locations for radial roundabouts include:

- Single lane roundabouts on local or collector roads or where the approach operating speed is less than 60 km/h.
- Local roads where there is a need to reduce the operating speed.
- Roundabouts that have sight distance issues and it is desirable that approaching vehicles either slow down or come to a complete stop before entering the roundabout.
- Where cyclist segregation is not practicable.
- Roads with narrow widths.

Where such a treatment is to be considered, the following should be taken into account:

- Reducing the operating speed of the road before the roundabout, whether through the use of traffic calming measures (e.g. raised platforms) or reduced speed limits.
- Due to the lack of a large deflection, the design of the roundabout should be prominent enough to ensure drivers recognise the intersection as a roundabout.

[7] Patterson, F. (2010), “Cycling and roundabouts: An Australian perspective”, Road & Transport Research Volume 19 No. 2 June 2010

- Physical treatments to raise the prominence of crossing pedestrians – such as raised crossing platforms and/or kerb extensions. Other traffic calming measures can assist in reducing the road's operating speed thus reducing the risk of injury to pedestrians.
- Mixing cyclists and motorists may lead to conflict due to the differential speed making this treatment more appropriate on low-speed roads.
- Sufficient swept path (or mountable central island for large vehicles) for heavy vehicles to safely navigate the roundabout or providing alternative routes for heavy vehicles (where applicable).

Supporting treatments

Listed below are supporting treatments that can be used with this primary treatment. For full details on each supporting treatment (including appropriate locations and other considerations), refer to the main 'supporting treatments' section (Section 5).

Supporting treatments that may be used with this primary treatment include:

- Lane sharing (sharrows)
- Raised platforms
- Static signage
- Bicycle activated warning signs

For pedestrians, the following supporting treatments can be used:

- Kerb extensions (narrowing of roadway)
- Raised pedestrian crossings (e.g. zebra crossings)
- Pedestrian refuges

Design concepts

Figure 12 compares a radial roundabout to a tangential roundabout. The radial roundabout has non-flared entries and exist. The tangential roundabout has flared entries and exists.

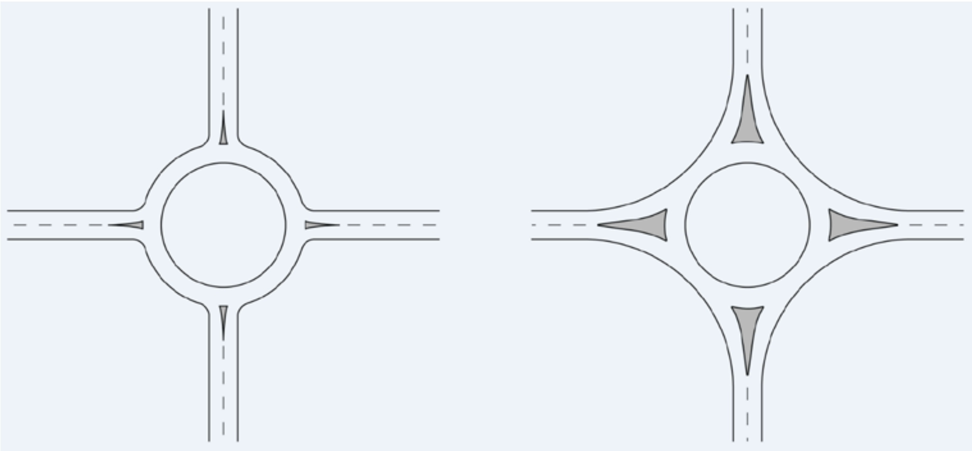

Figure 12: Radial roundabout design (left) and tangential roundabout design (right)

Summary

This treatment has the following pros and cons:

Pros

- Lower speed environment significantly increases the chances of cyclists surviving a crash and reduces the injury risk for pedestrians.
- Narrower lanes mean that the crossing width for pedestrians is reduced.
- Potentially low-cost retrofit.
- Compact, potentially no need for additional land acquisition.

Cons

- Although a radial roundabout has the ability to slow down motorists, there is still the possibility of a collision between a vehicle and cyclist or pedestrian, especially on the approach to the roundabout.
- Mixing with cars may be confronting for cyclists who are inexperienced or lacking confidence.
- Narrow lanes may impact heavy vehicle access.

4.3 C-roundabouts

A C-roundabout is a modified roundabout design that consists of a central island of an irregular geometry which increases the deflection through the roundabout and coupled with narrow entry lanes (2.7 m width). The C-roundabout design aims to slow motorists' speeds to that of a cyclist (approximately 30km/h). The lower speeds also benefit pedestrians who are crossing the roundabout.

The C-Roundabout design was first implemented in New Zealand in 2006.The design of the C-roundabout allows two cars to travel alongside with a clearance of 0.5 m. The roundabout also has a mountable area allowing larger vehicles to turn safely or to straddle on the approach.

Potential locations for C-roundabouts include:

- Along roads which have been classified as bicycle priority routes under the VicRoads SmartRoads Strategy.
- On new and existing single-lane and multi-lane roundabouts where separation of cyclists away from the roundabout may not be possible.
- Locations where there is a high crash history and separation of cyclists away from the roundabout may not be possible.
- Local road roundabouts.
- Arterial road roundabouts.
- Roundabouts with a high volume of motor vehicles (including on preferred traffic and public transport routes) making cyclist navigation difficult.

Where such a supporting treatment is to be considered, the following should be taken into account:

- Sufficient swept path for heavy vehicles to safely navigate the roundabout (including the use of concrete aprons to ensure the central island is mountable). In addition, signage may be required to assist heavy vehicles to navigate the roundabout.
- Installation of supporting treatments to reduce vehicle approach speeds.
- Provision of crossing facilities for pedestrians – physical treatments should be considered to improve pedestrian safety.

The aim of the C-roundabout design was to create a lower-speed environment to improve the safety of cyclists. By having the 85th percentile through speed as 30km/h, the fatality risk for a cyclist in a collision significantly decreases to 10%[8]. For pedestrians, the fatality risk also drops to 10%[8].

Figure ***13*** shows design examples of tangential roundabout C-roundabout. The C-roundabout design increases the deflection of the roundabout and reduces vehicle speeds through the roundabout. In this case, the speed differential between vehicles and cyclists/pedestrians can be reduced. Therefore, improved safety for pedestrians, cyclists and motorists is achieved, particularly in terms of the severity of crashes. The conversion of an uncongested roundabout to a C-roundabout has very little impact on vehicle average delay[9].

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[8] Wramborg, P. (2005), "A New Approach to a Safe and Sustainable Road Structure and Street Design for

Urban Areas", Paper presented at Road Safety on Four Continents Conference, Warsaw Poland.

[9] Jurisich I, Asmus D, Campbell D, Dunn R (2012) Evaluation of C-roundabout- an improved multi-lane roundabout design for cyclists

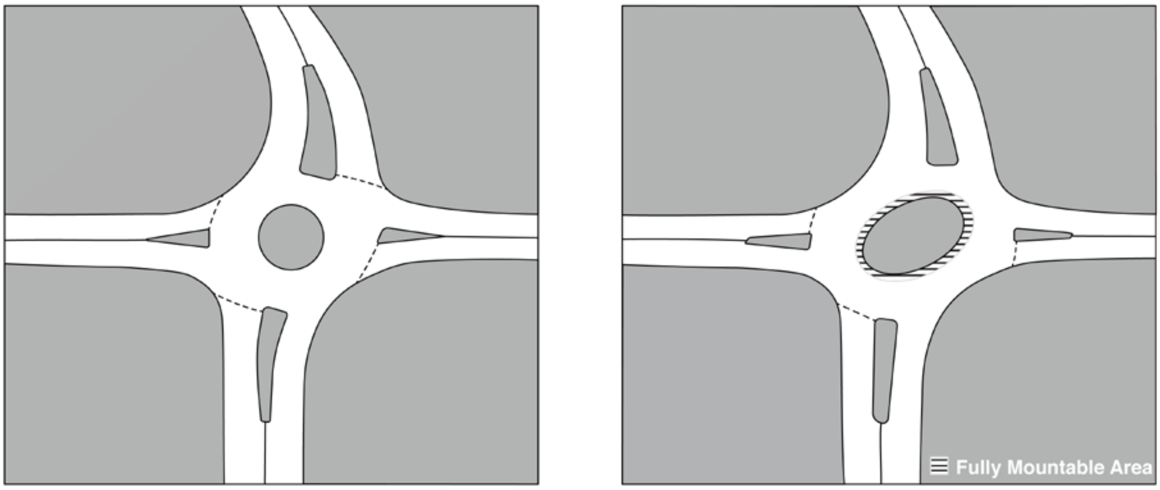


***Figure** 13: Tangential roundabout (left) and C-roundabout (right)*

Supporting treatments

Listed below are supporting treatments that can be used with this primary treatment. For full details on each supporting treatment (including appropriate locations and other considerations), refer to the main 'supporting treatments' section (Section 5).

Supporting treatments that may be used with this primary treatment include:

- Approach deflection
- Raised platforms
- Static signage
- Bicycle activated warning signs

For pedestrians, the following supporting treatments can be used:

- Raised pedestrian crossings
- Pedestrian refuges

Design concepts

Figure 14 below shows the typical path of vehicles before and after the reconstruction of roundabout at Palomino Drive and Sturges Road in New Zealand.

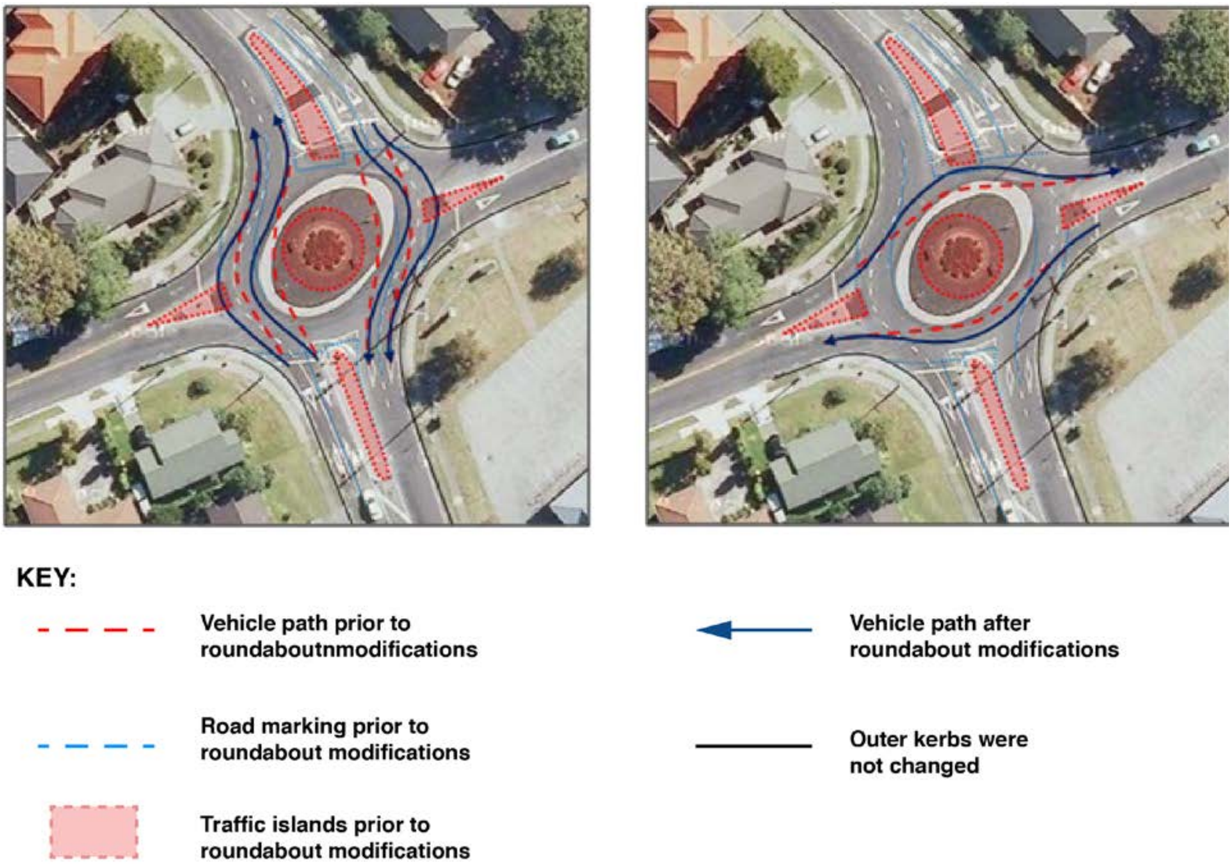


Figure 14: Typical path of vehicles before and after Palomino Drive / Sturges Road reconstruction [9]

Where this treatment has been implemented:

- Canning Street/Pigdon Street, Carlton North (refer to Figure 15 and Figure 16).
- Palomino Drive/Sturges Road, Auckland, New Zealand.
- Seymour Road/Parrs Cross Road, Auckland, New Zealand.
- Waimumu Road/Triangle Road, Auckland, New Zealand.

Figure 15: Canning Street / Pigdon Street, Carlton North

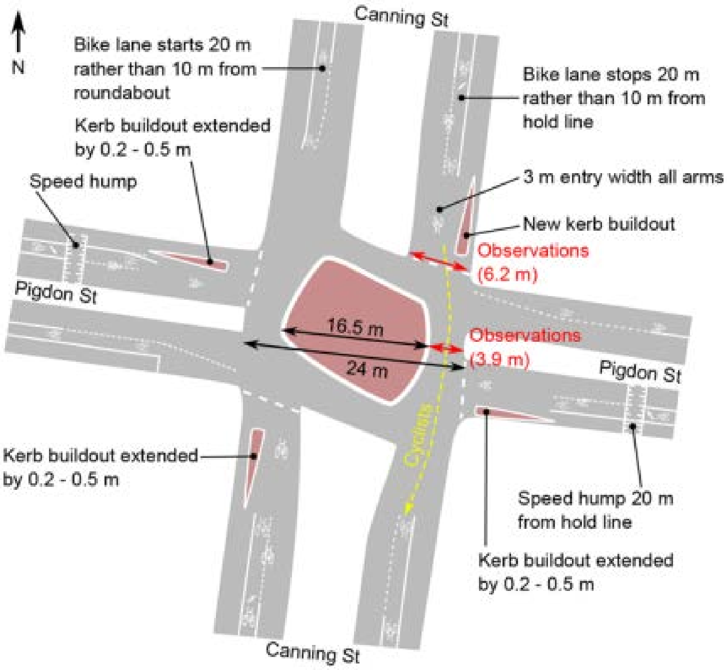


***Figure 16: Canning Street / Pigdon Street, Carlton North*[10]**

Summary

C-roundabouts have the following pros and cons:

Pros

- Lower speed environment significantly increases the chances of cyclists / pedestrians surviving a crash.
- Reduced lane widths result in a reduced crossing width for pedestrians.
- Potentially low-cost retrofit.
- Compact, potentially no need for additional land acquisition.
- The irregular geometry of a C-roundabout has had little impact on the capacity of multi-lane roundabouts

Cons

- Narrow lanes may impact heavy vehicle access.
- The narrow lanes may increase the potential for sideswipe collisions through the roundabout.
- Conflict issues still remain between cyclists and motorists in the roundabout as cyclists are still required to share the roundabout with motorists, including the conflict where a cyclist turns right through the roundabout.
- Without supporting treatments, pedestrians may find this type of roundabout difficult to cross.

Further reading

- Queensland Department of Transport and Main Roads Technical Note 136 “Providing for Cyclists at Roundabouts” (2015).
- NZ Transport Agency research report 510 “Evaluation of the C-roundabout – an improved multi-lane roundabout design for cyclists” (2012).
- Jurishich I, Asmus, D, Campbell D, Dunn D “Reducing Speed: The C-Roundabout” (2011).
- Austroads Guide to Road Design 4B: Roundabouts (2015).

[10] Austroads Assessment of the Effectiveness of On-road Bicycle Lanes at Roundabouts in Australia and New Zealand (page 39)

4.4 Splitter kerbs

Splitter kerbs are raised platforms that provide separation between bicycles (in a bicycle lane) and motorists on the approach to a roundabout. The island can also increase the deflection of the approach, requiring motorists to slow down on their approach to the roundabout. On the roundabout departure, this treatment can also be installed once again to provide physical separation between motorists (especially motorists who have turned into the leg) and cyclists and also to increase the prominence of bicycles in the bicycle lane or in situations where cyclists are merging back into the traffic lane.

Splitter kerb design may also benefit from being connected to a bicycle lane.

The splitter kerb can also act as a refuge island for pedestrians who are crossing the road, however a sufficient width is required to reduce pedestrian exposure to passing vehicles and appropriate gaps for disabled pedestrians to cross.

Potential locations for splitter kerbs:

- Roundabouts with a high volume of cyclists turning left.
- At entries and exits of roundabouts.

Where such a treatment is to be considered, the following should be taken into account:

- There is sufficient approach sight distance.
- There is adequate signage delineating the splitter kerb.
- Sufficient width in the refuge island to cater for the number of crossing pedestrians as well as to reduce the exposure of pedestrians to passing vehicles (a ‘buffer zone’).
- Sufficient design clearances to accommodate pedestrians with mobility aids.
- Significant conflict issues still remain between cyclists and motorists in the roundabout as cyclists are still required to share the roundabout with motorists, including the conflict where a cyclist turns right through the roundabout.
- Pavement/lane markings (e.g. contrast colour pavement).
- Ensuring that on-street parking does not interfere with the visibility of the splitter kerb or general visibility of cyclists.
- The bicycle lane should be at least 1.8 m between kerb faces.

Supporting treatments

Listed below are supporting treatments that can be used with this primary treatment. For full details on each supporting treatment (including appropriate locations and other considerations), refer to the main ‘supporting treatments’ section (Section 5).

Supporting treatments that may be used with this primary treatment include:

- Approach deflection
- Raised platforms
- Static signage
- Bicycle activated warning signs

For pedestrians, the following supporting treatments can be used:

- Raised pedestrian crossings, including across the segregated bicycle lane
- Pedestrians refuges

Design concepts

According to Clause 9.2.2 of AS 1742.10-2009, the desirable width of a refuge island used by pedestrians is not less than 3 m when there are high pedestrian or cyclist volumes or disabled persons. In other cases, not less than 2 m is acceptable.

Figure 17 shows an example of splitter kerbs used at a roundabout.

Figure 17: Splitter kerbs at Laver Drive and Easthill Drive roundabout in Robina, Queensland. Image Source: Google Maps

Summary

This particular treatment has the following pros and cons:

Pros

- Provides physical separation between cyclists and motorists approaching the roundabout.
- A pedestrian refuge can be provided in the splitter kerb for a staged crossing.
- Protects cyclists from encroachment by left turning vehicles on the approach to the roundabout and by vehicles on the departure of the roundabout.
- Motorists turning left have more room to react to cyclists on their left.

Cons

- The splitter kerb may not be able to cater for a high volume of cyclists, which may result in congestion on the approach to the roundabout. This can deter cyclists from using the segregated lane.
- Significant conflict issues still remain between cyclists and motorists in the roundabout as cyclists are still required to share the roundabout with motorists, including the conflict where a cyclist turns right through the roundabout.
- Without treatments such as wide pedestrian refuges, pedestrians may find this type of roundabout difficult to cross.

Further reading

- Austroads Guide to Road Design Part 4B: Roundabouts (2015).

- Austroads Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings (2013).
- Queensland Department of Transport and Main Roads Technical Note 136 “Providing for Cyclists at Roundabouts” (2015).
- Austroads Research Report AP-R461-14 “Assessment of the Effectiveness of On-Road Bicycle Lanes at Roundabouts in Australia and New Zealand” (2014).

5. Supporting treatments

5.1 Approach deflection

An approach deflection to a roundabout, whether through the use of an entry curve or a series of reverse curves, can be an important geometric design to control the operating speed of vehicles approaching the roundabout. A lower relative speed will bring safety benefits to all road users including cyclists and pedestrians where the severity of crashes will be reduced.

This supporting treatment may be used for all types of tangential roundabouts especially where there is a presence of vulnerable road users.

Potential locations for approach deflection include:

- Roundabouts on high-speed roads, commonly with approach speed over 60 km/h[11]
- Roundabouts on rural roads where drivers may be less alert when they travel for long distances and long periods of time

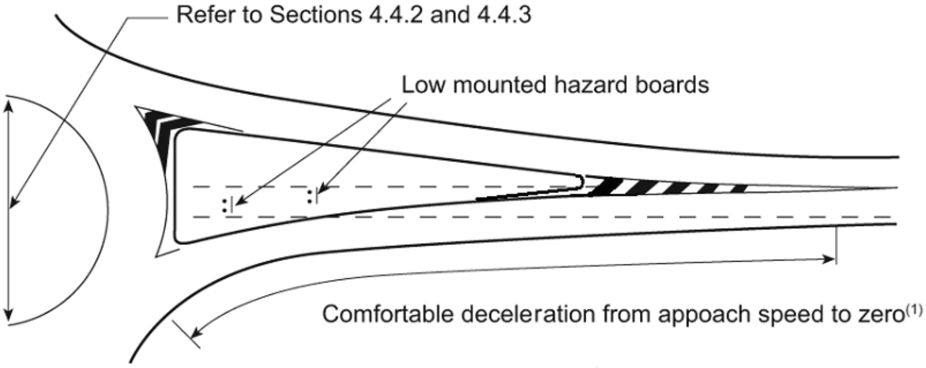
When implementing approach deflection to a roundabout, the following should be considered:

- The amount of deflection imposed on vehicles’ entry path is determined by the entry radius, the entry width, the circulatory roadway width and the central island geometry.
- The design of single entry curve approach should consider the following:
    - An appropriate entry path radius on the single entry curve [12]
    - The curve should be long enough in higher speed areas (≥ 80km/h)
    - The radius should be determined by the process in Austroads Guide to Road Design Part 4B
- Approach treatments to be applied to minimise single vehicle crashes on approach deflection to the roundabout with operating speeds ≥ 80km/h:
    - Successive reverse curves
    - A raised median or splitter island and a kerb along the left side of the approach to form physical restrictions to slow drivers
    - Rumble strips
    - Appropriate speed limit signs

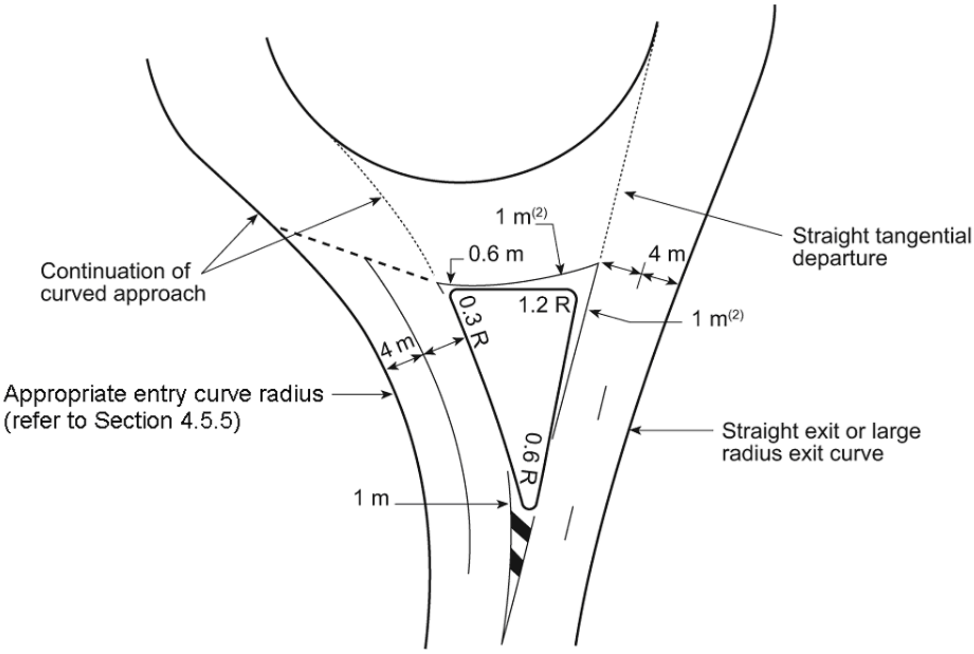
[11] Austroads Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings (2013)

[12] Austroads Guide to Road Design Part 4B: Roundabouts (2015)

Examples of typical approach and entries to a roundabout are shown in Figure 18. Figure 19 shows an example of a roundabout with reverse curves in a high speed rural environment.

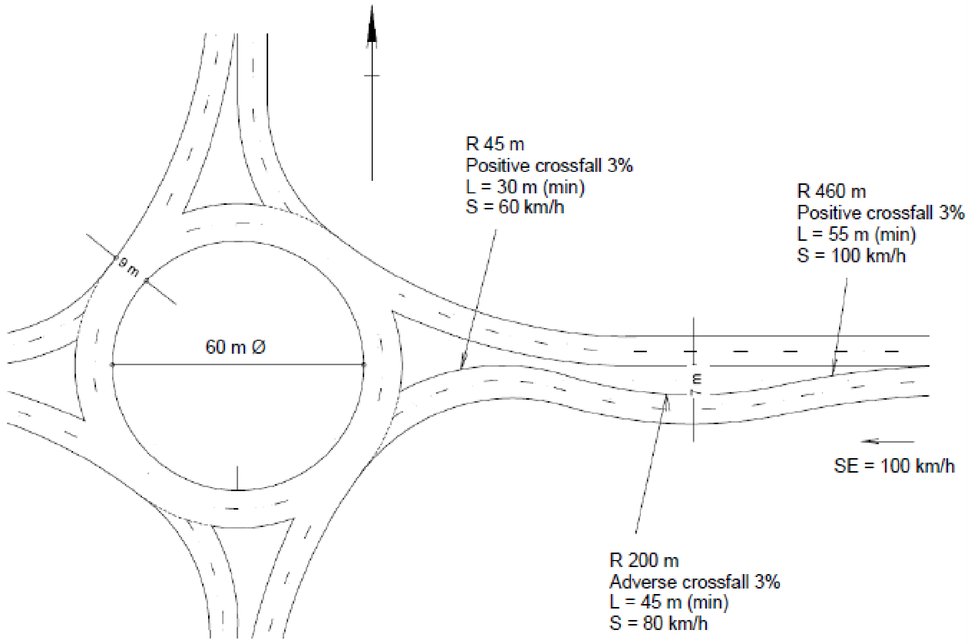


(a) Typical rural roundabout design (with high speed approach roads)



(b) Typical arterial urban roundabout

Figure 18: Typical roundabout entrances with a single entry curve approach. Source: Austroads



Notes:
SE = Approach speed prior to entry curve/s (km/h).
R = Curve radius (m)
L = Length of curve at entry (m).
S = Speed on the curve at entry (km/h).

Figure 19 Roundabout in a high speed rural environment – two reverse curves. Source: Austroads

Summary

This supporting treatment has the following pros and cons:

Pros

- Limits the angle formed between entering and circulating vehicle paths and minimises the differential speed between entering and circulating vehicles
- Reduces the entering speed of approaching vehicles
- Reduces the potential risk of fatality or serious injuries to pedestrians and cyclists

Cons

- A greater land area may be required and thus acquisition of land may be costly.
- Removal of parking in the vicinity of the approach deflection may be required.

Further reading

- Section 4.5 of Austroads Guide to Road Design Part 4B: Roundabouts (2015).
- Austroads Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings (2013).

5.2 Raised platform on approach to the roundabout

This treatment involves placing a raised platform on the approach to the roundabout. The intention is to reduce vehicle approach speeds, so that in the event of a collision between a cyclist or pedestrian and a motor vehicle, the vehicle operating speed is low (30 km/h or below) and the likelihood of cyclist or pedestrian serious injury is reduced. The design of the raised platform will need to slow vehicles to the desirable speed while also being traversable by heavy vehicles.

There are two main types of raised platforms for use on the approach to the roundabout:

- Speed cushion.
- Fully raised platforms (including flat top road humps).

5.2.1 Speed cushion

Speed cushions are a type of raised platform that are spaced in smaller sections across the road rather than occupying the entire roadway. The speed cushion is designed to be more favourable to cyclists, buses and larger vehicles.

Speed cushions are usually made of moulded rubber segments (see Figure 20) however there are concrete and asphalt variations.

Figure 20: Example of a speed cushion

Potential locations for speed cushions include:

- Where it is desirable to raise the profile of cyclists at the roundabout.
- Roundabouts where there is a significant presence of heavy vehicles which may have difficulty navigating across a fully raised platform or road hump that spans across the entire roadway.
- At roundabouts with a high history of crashes between vehicles and cyclists and/or pedestrians.
- On bicycle priority routes as defined in the VicRoads SmartRoads strategy.

Where such a treatment is to be considered, the following should be taken into account:

- Ensuring adequate lighting for driver awareness.
- Colour contrast to improve conspicuity of the cushions.
- Adequate signage and linemarking.
- The design of the raised platform should have the ability to slow down vehicles to an appropriate operating speed (which, in many situations, may be 30 km/h).
- Where raised platforms are to be used on high speed roads, there may be a need to reduce the speed limit to ensure the raised platform can be safely traversed.

Summary

This supporting treatment has the following pros and cons:

Pros

- Inexpensive retrofit and low maintenance.
- Reduces the speed of motor vehicles.
- Suited for mixed traffic.
- Can potentially improve gap acceptance at the roundabout.
- Designed to be more favourable to cyclists, buses and larger vehicles.

Cons

- Possible increase in noise before and after the cushion.
- Less effective in slowing down motorcyclists and heavy vehicles.

Further reading

- Austroads Guide to Traffic Management Part 8: Local Area Traffic Management (2016) – details on the design on speed cushions.

5.2.2 Fully raised platforms

The approach to the roundabout may be raised for a certain distance as a way to reduce operating speeds at the roundabout.

One type of raised platforms are flat top road humps. These road humps are a version of the speed hump where the top of the raised platform section is a flat surface instead of being entirely curved. The length of these humps are usually less than 6 metres and vehicles experience a definite rise and fall when traversing the platform.

An alternative type of raised platform is where the platform is of greater length (more than 6 m) and the platform extends to the holding line at the roundabout. This type of platform may be more desirable in locations where the vertical deflection (and changes in grade) is to be less severe than road humps.

Fully raised platforms with gradients of 1:15 to 1:20 are generally considered as cyclist friendly.

The pedestrian crossing at a roundabout may be placed on a raised platform as a way to elevate the prominence of pedestrians. The raised platform and marked pedestrian crossing are also intended to slow down motorists and cyclists travelling across the pedestrian crossing.

Potential locations for fully raised platforms include:

- Where it is desirable to raise the profile of cyclists at the roundabout.
- Where vehicle speeds before or through the roundabout are unacceptably high, however careful consideration is required when using raised platforms on high speed roads.
- Where the presence of crossing cyclists or pedestrians is unexpected.
- At roundabouts with a high history of crashes between vehicles and cyclists and/or pedestrians.
- On bicycle priority routes as defined in the VicRoads SmartRoads strategy.

Where such a treatment is to be considered, the following should be taken into account:

- The approach speed to the roundabout – vehicles should be able to cross the raised platform safely.
- The design of the raised platform needs to accommodate heavy vehicles (e.g. buses).
- Where crossing pedestrians do not have priority across the raised platform at the roundabout, the design of the crossing may need to highlight this.
- Although the raised platform has the ability to assist in slowing down vehicles, there is still the possibility of a collision (at speed) between a vehicle and cyclist.
- Appropriate drainage to reduce vehicle and pedestrian slip hazards.

Refer to Figures 21 and 22 for examples of raised platforms.

Figure 21: Flat top speed hump followed by sharrows on Pearson Street, Brunswick West. Image Source: Google Maps

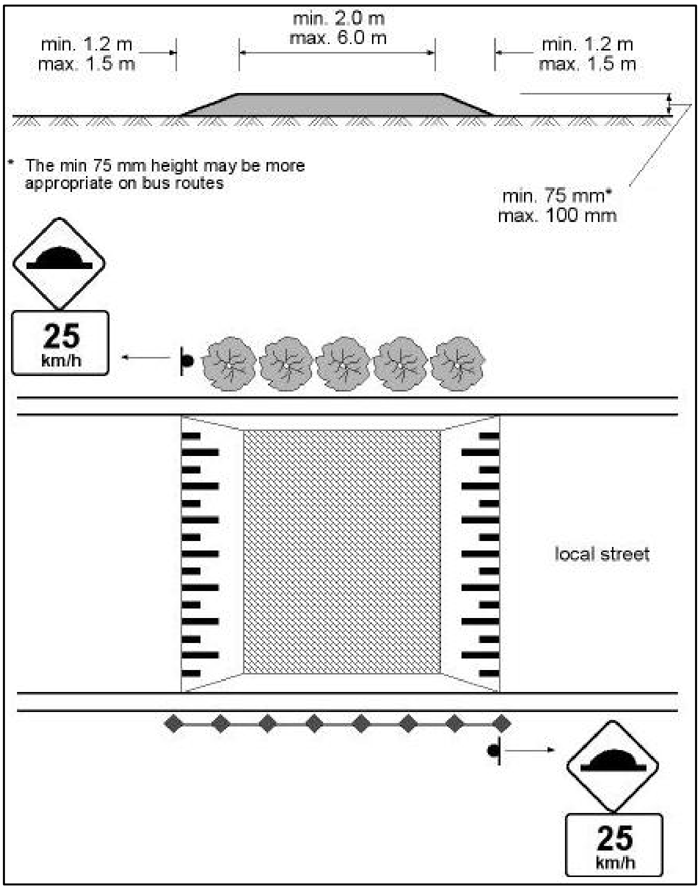


Figure 22: Typical dimensions of a flat top road hump. Source: Austroads[13]

[13] Austroads, 2008, "Guide to Traffic Management Part 8: Local Area Traffic Management" pp 79 Figure 7.7

Summary

This supporting treatment has the following pros and cons:

Pros

- Raises the prominence of cyclists and pedestrians and/or of the roundabout.
- May aid in the slowing down of vehicles before the roundabout and/or through the roundabout.
- Allows the installation of a raised pedestrian crossing whereby vehicle operating speeds before and through the crossing may be lower.

Cons

- May not be appropriate on high speed roads.
- Although the raised platform has the ability to assist in slowing down vehicles, there is still the possibility of a collision between a vehicle and a cyclist or pedestrian.

Further reading

- Austroads Guide to Traffic Management Part 8: Local Area Traffic Management (2016) – details on the design of flat top road humps and raised platforms.

5.3 Bicycle streets

Bicycle streets (Figure 23) are roads where bicycles are given priority over motor vehicles. Bicycle riders are encouraged to ride in the general traffic lane whereby other vehicles are expected to share the traffic lane with bicycle riders. For the application of lane sharing at individual roundabouts, refer to the 'lane sharing at roundabouts' treatment below.

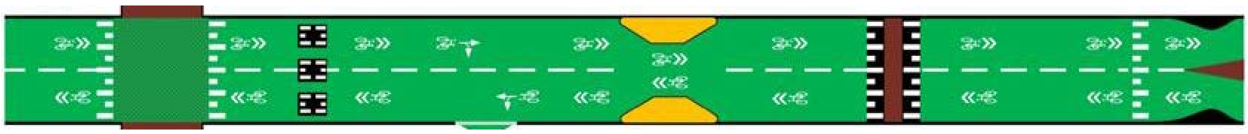


Figure 23: Example of a bicycle street

A bicycle street is most appropriate on undivided two lane roads where the operating speed is below 30 km/h and traffic volumes are low. The intention is to enhance the road environment to make cycling safer for all type of riders regardless of their level experience or confidence. Bicycle streets are to be clearly signed and line marked and may be used in combination with other treatments to provide a continuous safe riding environment.

The lower operating speed also reduces the risk of injuries for crossing pedestrians.

NOTE: VicRoads is currently investigating whether the Victorian Road Rules sufficiently allows cyclists to ride in the middle of the lane ('claiming the lane'). Some stakeholders perceive that there is a degree of ambiguity in the Road Rules regarding this issue. Practitioners wishing to use this treatment should seek legal advice to manage this risk.

Details on bicycle streets can be found in the VicRoads Guidance on Treating Bicycle Car Dooring Collisions document.

5.4 Lane sharing at roundabouts

Where lane sharing at roundabouts is to be used, this can be done through the use of sharrows. Sharrows are pavement markings consisting of a bicycle symbol and two chevron markings and may be used on the approach to a roundabout where a bicycle lane or similar facility terminates prior to the roundabout, and cyclists are required to merge into the main traffic lane. The intention of sharrows is to position cyclists into the centre of the traffic lane and to encourage them to mix with through traffic.

Figure 24 shows a typical application of sharrows at a single lane local road roundabout.

Figure 24: Example of sharrow pavement markings at a roundabout on Highett Street, Richmond

The objective of this treatment is to position cyclists in the most prominent position within the lane. This is sometimes referred to as “claiming the lane”.

NOTE: VicRoads is currently investigating whether the Victorian Road Rules sufficiently allows cyclists to ride in the middle of the lane (‘claiming the lane’). Some stakeholders perceive that there is a degree of ambiguity in the Road Rules regarding this issue. Practitioners wishing to use this treatment should seek legal advice to manage this risk.

Potential locations for positioning cyclists into the centre of the traffic lane (use of sharrows) include:

- Single lane roundabouts on local or collector roads or where the approach speed limit is equal to or less than 60 km/h with operating speeds closer to the roundabout at less than 40 km/h.
- Roads with a low volume of through traffic.
- Where cyclist segregation is not practicable.
- Roads with a narrow width.

Where such a treatment is to be considered, the following should be taken into account:

- Reducing the operating speed on the approach and through the roundabout (to less than 40 km/h), whether through the use of:
  - Traffic calming measures to reduce the speed differential between cyclists and motorists, such as:
    - Increasing approach deflection.
    - Narrowing of lanes.
    - Larger circulating roundabout.
  - Reduced speed limits – refer to the VicRoads Speed Zoning Guidelines.
- Locating sharrow markings in prominent positions, to highlight to all road users that cyclists can claim the lane and ride in the centre of the lane (see design concepts).
- Signs may be required to highlight to all road users that bicycles are allowed to ride in the centre of the lane (see design concepts below).
- Community acceptance and understanding of lane sharing.

- Cyclist confidence and safety in sharing the lane with general traffic.
- This treatment is more appropriate on low-speed roads as mixing cyclists and motorists may lead to conflict if the differential speed is high.

CDM Research produced an evaluation of shared lane markings for cyclists in 2013. The work was prepared for VicRoads. The report describes the before and after characteristics at two sites on three Melbourne roads that have sharrow pavement markings.

The evaluation found that after sharrows were installed:

- There were significant changes in cyclist lateral tracking at four of the six sites. At two sites there was a significant reduction in the number of cyclists riding within the “dooring zone” (at the first site, 23% down to 4% and at the second site, 63% down to 40%).
- There was an increase at two sites in impatient or aggressive behaviour toward cyclists as a result of the sharrows.
- There was a significant difference between the average speed of cyclists and motorists. Motorists travelled on average 12-22 km/h faster than cyclists
- 54% of cyclists felt that sharrows made no difference to their safety, 40% felt that they made cycling a little safer and 6% felt that they made cycling a lot safer. No cyclists felt that the sharrows made them less safe.

The evaluation recommended that:

- Sharrows only be applied at existing sites.
- Sharrows should not be used where dedicated bicycle infrastructure can be provided instead.
- Sharrows should only be used where the traffic volumes and speeds are low enough that cyclists are safe to “share the lane”[14].

The importance of locating sharrows in a suitable road environment was highlighted in the evaluation of a bicycle infrastructure project at the Mountain Highway / Liverpool Road roundabout in The Basin[15]. At this roundabout, sharrows were installed on the Mountain Highway approaches to encourage cyclists to ride in the central lane position. Other works included:

- Kerbside bicycle lanes extending from around 90 m to 40 m behind the hold line on both Mountain Highway approach legs.
- Painted kerbside ‘blisters’ (painted shoulder, see Figure 25) on the approach and departure legs of Mountain Highway to encourage lower motorist speeds (through the narrowing of the traffic lane).
- Enlargement of the splitter islands on the Liverpool Road and Miller Road approaches to increase the deflection and create a greater sense of narrowing than the smaller islands and line marking that previously existed.

[14] CDM Research, 2013, “Evaluation of Shared Lane Markings for Cyclists”

[15] CDM Research, 2016, “Evaluation of Roundabout Improvements at Mountain Hwy / Liverpool Rd”

Figure 25: Painted shoulders ('Blisters') on the approach leg of Mountain Highway

The evaluation found that the treatment had not achieved its objective of encouraging cyclists to ride in the central lane position as between 53% (at the westbound hold line) and 76% (at the eastbound hold line) of riders chose to ride within the painted blister.

The main reasons for this were:

- The differential speed between motorists and cyclists on Mountain Highway was too high for cyclists to equitably share the lane.
- The traffic volume was deemed to be too high.
- The geometric changes to the roundabout were insufficient to significantly alter motorists' approach speeds from the Liverpool Road and Miller Road approaches (see Figure 27).
- Inconsistencies in the design – such as the introduction of a short bicycle lane upstream of the intersection (see Figure 26).

Given the findings, sharrows should only be installed at locations where the operating speeds of motorists are low and where other supporting treatments are provided. In this case, it will create an environment that is safe for cyclists to ride in the central lane position (see 'considerations' section above). An example concept design showing the appropriate placement of sharrows and other supporting treatments (including signs) can be found in the design concepts section.

Figure 26: Approach to roundabout on Mountain Highway

Figure 27: General view of Liverpool Road and Miller Road approaches

Supporting treatments

Listed below are supporting treatments that can be used with this primary treatment. For full details on each supporting treatment (including appropriate locations and other considerations), refer to the main 'supporting treatments' section (Section 5).

Supporting treatments that may be used with this primary treatment include:

- Approach deflection
- Raised platforms
- Static signage
- Bicycle activated warning signs

For pedestrians, the following supporting treatments can be used at intersections where sharrows are used:

- Kerb extensions (narrowing of roadway)
- Raised pedestrian crossings
- Pedestrians refuges

Design concepts

Figure 28 shows a schematic drawing example of sharrows before, at and after a roundabout.

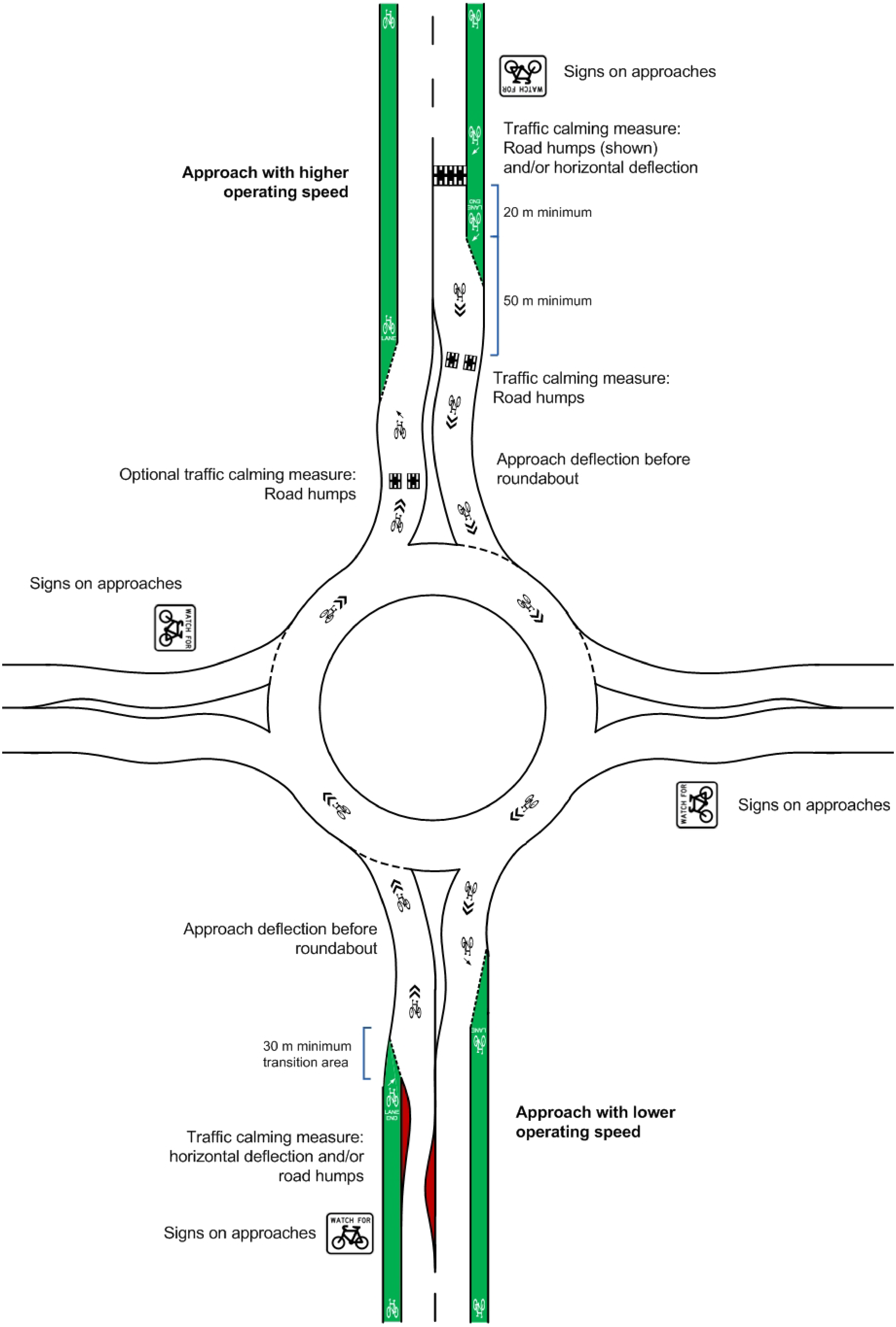


Figure 28: Schematic drawing example of sharrows at a roundabout

Summary

This treatment has the following pros and cons:

Pros

- The use of sharrows may assist in raising awareness of cyclists to motorists at roundabouts.
- Can be used to direct cyclists on a particular route.
- Provides reassurance to cyclists that they are on designated cycle routes in the absence of segregated cycle paths.
- Can assist in lateral positioning on the approach to a roundabout.
- Provides guidance for cyclists to “claim the lane” at the end of bicycle lanes.

Cons

- Treatment limited to low operating speed environments or locations where supporting treatments are effective in lowering approach operating speeds to below 40 km/h, at locations where cyclists are encouraged to claim the lane.
- Although sharrows have the ability to raise awareness of cyclists, there is still the possibility of a collision between a vehicle and cyclist.
- Motorists may become frustrated by cyclists blocking lanes and the perceived additional travel time.
- Mixing with cars may be confronting for cyclists who are inexperienced or lacking confidence.
- May lead to an increase in rear end crashes between cyclists and motor vehicles.

Further reading

- Austroads Guide to Traffic Management - Part 8: Local Area Traffic Management (2016)
- VicRoads Supplement to AS 1742.9:2000 (2015) – details on sharrows.
- Further information about the Western Australia “Bicycle Boulevards” can be found at: http://www.transport.wa.gov.au/activetransport/safe-active-streets-program.asp
- Austroads Technical Report “Cycling Infrastructure” Selected Case Studies (2014).
- Queensland Department of Transport and Main Roads Technical Note 136 “Providing for Cyclists at Roundabouts” (2015).
- Austroads Research Report AP-R461-14 Assessment of the Effectiveness of On-Road Bicycle Lanes at Roundabouts in Australia and New Zealand” (2014).

5.5 Transverse lines on approach to the roundabout

Transverse lines consist of intermittent pavement markings, which may be flush or raised, that extend across the traffic lanes. They are a common low cost treatment that is used to alert drivers that they are approaching a hazard or a potentially hazardous location at which they are required to reduce speed. They have typically been used on the approaches to high risk intersections and low speed curves.

Raised transverse lines (rumble strips) provide an audible and tactile sensation to drivers. It has been found that rumble strips can increase noise levels by up to 6 to 8 decibels, potentially making them less appealing for use in residential areas[16].

Provision may need to be made for cyclists to bypass raised transverse lines if they are likely to affect cyclists’ stability or comfort.

Potential locations for transverse lines include:

[16] Gupta, J. (1994). Development of criteria for design, placement and spacing of rumble strips. (Project No. 14465). Ohio Department of Transport.

- Where vehicle speeds before or through the roundabout are unacceptably high
- At roundabouts with a high history of crashes between vehicles and cyclists and/or pedestrians.
- Where the presence of crossing cyclists or pedestrians is unexpected.
- On bicycle priority routes as defined in the VicRoads SmartRoads strategy.

When implementing transverse lines, the following should be considered:

- The treatment generally involves marking the full width of the approach lane(s) in advance of the hazard. It is common practice to reduce the spacing between successive transverse lines in the direction of vehicle travel to create the impression that the closure speed is too fast so the driver is encouraged to respond. However, evenly spaced lines may also be used. Research on whether the former pattern is more effective is inconclusive.
- Care should be taken to ensure that transverse lines have adequate skid resistance which, as far as is practical, is similar to the surrounding road surface.
- Research into the effectiveness of rumble strips is generally inconclusive although some studies have shown reductions in speed of between 5 per cent and 12 per cent.
- Flush transverse lines have limited influence on travel speeds. Their benefit is largely confined to a visual indication to motorists of a change in road conditions ahead.

Examples of raised and flush transverse lines are shown in Figure 29 and Figure 30.

Figure 29: Raised transverse lines

Maltravers Road, Ivanhoe

Figure 30: Flush transverse lines

Old Warrandyte Road, Donvale. Image source: Google Maps

Summary

This supporting treatment has the following pros and cons:

Pros

- May be effective in reducing speeds if raised.
- Easy and inexpensive to install.

Cons

- Rumble strips can increase noise levels.
- Potential for objections from nearby residents.
- May be ignored by motorists thus reducing its effectiveness.

Further reading

- Austroads Guide to Traffic Management Part 8: Local Area Traffic Management (2016).

5.6 Static warning and regulatory Signs

Warning and regulatory signs convey simple symbols or words that are installed on the side of the road to provide information to all road users. They can also be used to regulate traffic movement or act as traffic calming devices. The primary use of these signs in the context of cyclist and pedestrian safety at roundabouts is to raise awareness of cyclists and pedestrians and to alert motorists of any upcoming traffic calming devices (such as raised platforms). In addition, regulatory signs may be used to inform road users of their legal requirements.

Signage should not be used as a standalone treatment but as a supplementary treatment to enhance the meaning and safety of other treatments.

Potential locations for signs include:

- Where the presence of cyclists or pedestrians is unexpected.
- To support pavement or lane markings.
- To support new treatments that motorists may not be familiar with.
- At pedestrian crossings with a high volume of pedestrians.
- To warn of vertical deflection measures.

When implementing signage, the following should be considered:

- The sign to be installed at a distance suitable for a vehicle to observe, read and comprehend the message before reaching the roundabout.
- A standard sign design should be used for the propose of consistency across the network.
- The correct sign type – e.g. whether the sign is of the warning type or regulatory type.
- The simplicity of the design – the message should be unambiguous.
- Appropriately sized for the road and/or speed environment.
- The location and frequency of where the signs should appear.

Examples of signs are shown in Figures 31, 32 and 33 . Further examples of signs and their usage can be found in Australian Standards AS 1742.2 - Traffic control devices for general use (2009) and AS 1742.9 - Bicycle facilities (2000) and the VicRoads Supplement to those two Australian Standards.

Figure 31: G9-57 watch for bicycles sign

Figure 32: W6-1 pedestrian warning sign

Figure 33: W6-7 bicycle warning sign

Summary

This supporting treatment has the following pros and cons:

Pros

- Alerts drivers to approaching hazards or change in road conditions.
- Signage with an unambiguous message may aid in highlighting the presence of cyclists or pedestrians to motorists.
- Inexpensive with low maintenance costs.
- May aid in the slowing down of vehicles through the roundabout.

Cons

- Although signs have the ability to raise awareness of cyclists and /or pedestrians, there is still the possibility of a collision between a vehicle and a cyclist or pedestrian.
- The sign may be missed by inattentive motorists.
- Additional signs may lead to sign clutter.

Further reading

- Australian Standards AS 1742.9 Manual of uniform traffic control devices - Bicycle facilities (2000).
- Australian Standards AS 1742.2 Manual of uniform traffic control devices - Traffic control devices for general use (2009).
- VicRoads Supplement to AS 1742.2 (2015).
- VicRoads Supplement to AS 1742.9 (2015).

5.7 Bicycle activated warning signs

Bicycle activated warning signs are flashing electronic signs that aim to reduce the risk of conflict by raising awareness of the presence of cyclists on the road. Additionally, the sign aims to enforce the legitimacy of cyclists operating on the road. Unlike traditional static signs, the cyclist activated warning sign only lights up in the presence of cyclists and should be placed in areas of high crash risk.

Appropriate locations for bicycle activated warning signs include:

- Roundabouts where separated cycle paths cannot be implemented.
- Multi-lane roundabouts where other treatments cannot be applied.
- Roundabouts with mixed traffic on one or more legs.

Where such a dynamic sign is to be considered, the following should be taken into account:

- The electronic sign only warns motorists of cyclists – there is the probability that turning vehicles may miss the message.
- The cost of installation and maintenance.
- Use of solar power panel to power the sign - self-sustaining in the case of power failure.
- On-road detectors be located in prominent positions on the road to detect bicycles on the approach to the roundabout.

It is recommended this treatment be used at locations with a medium to high cycle volume. If the cycle volume is too high, the bicycle activated sign will continuously illuminate and may lose its effectiveness. Alternatively, if the cycle volume is too low then the treatment is not viable.

High costs are associated with installation and maintenance of bicycle activated warning signs. These signs can also be subject to technical faults and may be prone to vandalism. Additionally, the effectiveness of the signs may decline somewhat over time as regular road users become accustomed to its presence.

Figure 34 shows a typical bicycle activated warning sign.

Figure 34: McDonald Street, Mordialloc Source: ARRB Group[17]

Summary

This supporting treatment has the following pros and cons:

Pros

- Warns other road users of the presence of cyclists using the roundabout.
- Further legitimises the presence of cyclists on the road.
- May aid in the slowing down of vehicles through the roundabout.

Cons

- Although the electronic sign has the ability to raise awareness of cyclists, there is still the possibility of a collision between a vehicle and cyclist.
- In areas with a large cyclist volume, the sign can be activated for long periods of times, losing the impact value and potentially disrupting traffic flow.
- High installation and maintenance cost.

Further reading

- Queensland Department of Transport and Main Roads Technical Note 137 “Bicycle Activated Warning Signs” (2015).
- “Evaluation of a Cyclist Activated Warning Sign at the Black Rock Roundabout”, CDM research
- Queensland Department of Transport and Main Roads Technical Note 136 “Providing for Cyclists at Roundabouts” (2015).

[17] Cairney P, Beecroft A, Australian Road Research Board (ARRB), “Evaluation of the effectiveness of a bicycle activated warning sign at the intersection of Nepean Highway and McDonald Street, Mordialloc” pp 3 Figure 1.3

5.8 Metering of roundabouts

Where the traffic flow in one approach (or a number of approaches) of a roundabout is larger than the other legs, issues in relation to pedestrians crossing a particular leg and cyclists navigating through the roundabout can arise. Where this occurs and there is a need to balance or control the traffic flow, roundabout metering through the signalisation of the dominant approach leg(s) or the entire roundabout can be used.

Metering can also be used to give cyclists 'priority' movement through the roundabout, by holding traffic on an approach (usually the leg with the highest traffic volume). This can be achieved through bicycle sensors on a bicycle lane which activates the metering signals when a bicycle is detected.

Metering is generally employed on a part-time basis as in many cases heavy and unbalanced flows only occur during peak periods. However, this treatment can also be used outside of these times if deemed desirable to give bicycles preference at the roundabout.

Purpose built signals and pedestrian and/or bicycle operated signals are commonly used as part of the metering system.

Appropriate locations for metering in advance of roundabouts

- Where bicycles have difficulty in negotiating a roundabout due to heavy traffic flows
- Where pedestrians have difficulty in crossing a particular leg and a pedestrian crossing (zebra crossing) cannot be installed.
- Where the entry to a roundabout cannot function efficiently – causing excessive queuing and major delays on one or more legs of the roundabout

Where such a supporting treatment is to be considered, the following should be taken into account:

- The use of purpose built signals:
  - To be located at least 15 to 20 m in advance of the roundabout holding line.
  - Providing signs at the signals to inform drivers that the flow is metered.
- Whether pedestrian and/or bicycle operated signals be part of the metering signals, and if so:
  - Locate the crossing with sufficient distance from the holding line (to allow vehicles to store between the signals and holding line).
  - Locate the crossing with sufficient vehicle storage space from the exit.
  - The pedestrian crossing should be within pedestrian desire lines wherever possible and pedestrian fencing should be installed to guide pedestrians to the crossing.
- Provide appropriate signage to inform drivers the pedestrian signals are dependent on the metering and may change accordingly
- Advance warning signals should be considered where sight restrictions exist

A number of other supporting treatments may be used with metering:

- Raised platforms on the approach and departure of the roundabout.
- Raised crossing from pedestrians and cyclists
- Off-road paths

Figure 35: Metered roundabout approach at Governor Road and Boundary Road, Mordialloc. Image source: Google Maps

Summary

This supporting treatment has the following pros and cons:

Pros:

- Has the potential to reduce the amount of traffic in the circulating lane which would assist pedestrians and cyclists to cross the roundabout.
- Allows the installation of pedestrian and bicycle operated signals to assist pedestrians and cyclists to safely cross a leg or multiple legs of a roundabout.
- A cost-effective measure compared to fully-signalised intersection treatment.

Cons:

- Potential for high speed departures from the roundabout (if no other treatments are used in conjunction).
- Without the use of other supporting treatments, there may be a high speed differential between cyclists and motor vehicles through the roundabout.

Further reading

- Austroads Guide to Traffic Management Part 10 (2016).
- Austroads Guide to Traffic Management Part 6 (2013).

5.9 Shared, separated and segregated paths

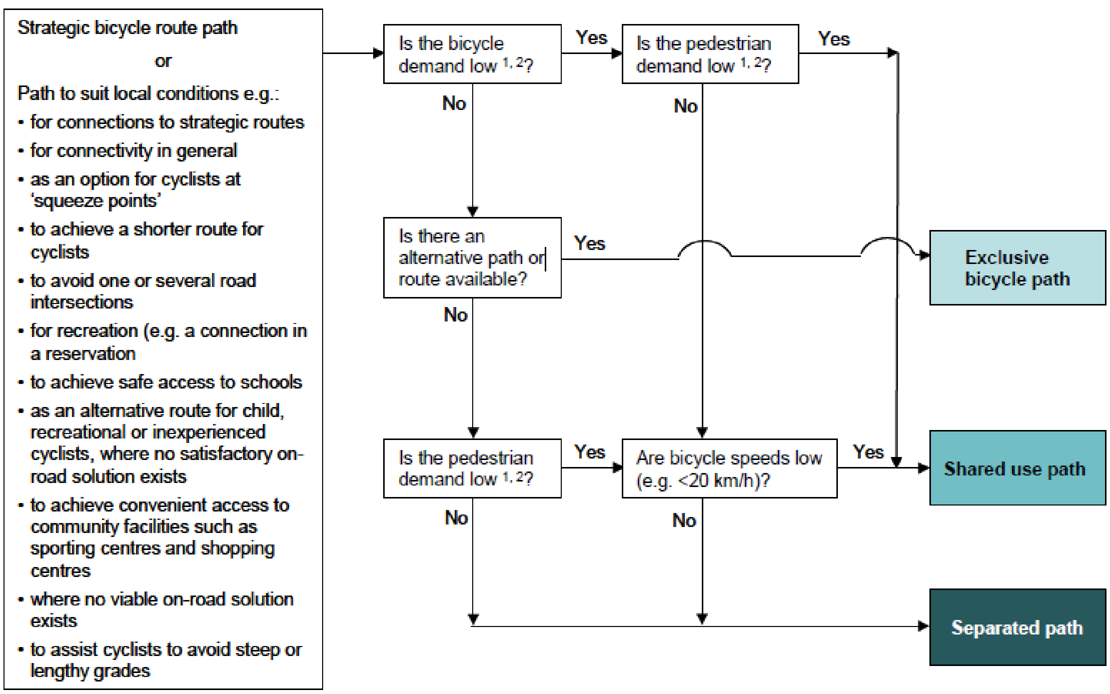
Where an off-road bicycle or pedestrian facility is to be provided, usually this involves the mixing of pedestrians and cyclists along the off-road path. There are three main types of paths that can be provided:

- Shared use path – a wide path where pedestrians and cyclists both use the same path.
- Segregated path – the pedestrian path is adjoining to the bicycle path, usually separated by linemarking or visually through the use of different colour pavements.
- Separated path – where the path for cyclists is physically separated from the path for pedestrians, e.g. by a barrier or median. The bicycle path component may also be known as an 'exclusive bicycle path'.

A separated path virtually eliminates the conflict between pedestrians and cyclists as they are physically separated. A segregated path also provides a level of separation; however as there is no physical separation, there is still a chance of a collision between a pedestrian and cyclist in the event they encroach onto each other's path.

Where there is a large differential speed between the two modes, there is an increased risk of injury to pedestrians in the event of a collision between a pedestrian and cyclist.

Section 7.3 of the Cycling Aspects to the Austroads Guide provides guidance regarding the types of paths that should be used. This decision making process is repeated below. Note that 'separated path' in the chart below also includes a segregated path. Practitioners should be aware there may be other issues, constraints and practices that will have a bearing on the decision-making process.



1 The level of demand can be assessed generally on the basis of the peak periods of a typical day as follows:

a. Low demand: Infrequent use of path (say less than 10 users per hour)

b. High demand: Regular use in both directions of travel (say more than 50 users per hour).

2 These path volumes are suggested in order to limit the incidence of conflict between users, and are significantly lower than the capacity of the principal path types.

Figure 36: Guide to the choice of path treatment for cyclists (source: Cycling Aspects to the Austroads Guide)

Further notes to Figure 36 above:

- Where the volume of pedestrians and/or cyclists is large (see Figure 36) or there is the potential for conflicts between the two modes, there may be a need to separate the path between cyclists and pedestrians, and at other associated locations where pedestrians and cyclists are adjacent to one another. It is recommended where there are more than 50 cyclists per hour that separated (or at the very least segregated) paths should be provided.
- There is a large number of commuter riders compared to recreational riders.
- Limited sight distance between cyclists and pedestrians.
- Where the differential speeds between cyclists and pedestrians is high.

Where separation is to be considered, the following should be taken into account:

- Whether full separation (separated path) is required, as opposed to a segregated path. This decision would be based on user volumes, sight distance along the corridor, crash history (if available) and land availability.
- Width of the path to adequately cater for the volume and types of bicycle riders (see 'design concepts').
- The design of the separated path should provide adequate separation between bicycles and pedestrians (median or barrier).
- The amount of land required for a segregated or separated path – these paths are wider than shared use paths.
- The cost of installation and maintenance.
- Signage to highlight to users where they should walk or ride.
- Whether the bicycle aspect of the separated path to be designed as a two-way facility or one-way facility.

Design concepts

Exclusive bicycle paths

For guidance on desirable widths and acceptable ranges of width for one-way exclusive bicycle paths, refer to the 'separated path requirement' guidance below.

Table 2 below shows dimensions when the exclusive bicycle path is in two-way operation.

Table 2: Exclusive bicycle path (two-way) widths[18]

	Path Width (m)	
	Local access path / minor path	**Major path**
Desirable width (minimum)	2.5	3.0
Minimum width – typical maximum	2.5[(1)]-3.0[(2)]	2.5[(1)]-4.5[(2)]

Notes for Table 2:

1. ***A lesser width should only to be adopted where cyclist volumes and operational speeds will remain low or there are space restrictions.***
2. ***A greater width may be required where the numbers of cyclists and pedestrians are very high or there is a high probability of conflict between users (e.g. people walking dogs, roller bladders and skaters etc.).***

[18] Section 7.5.4 of Cycling Aspects of the Austroads Guides (2014).

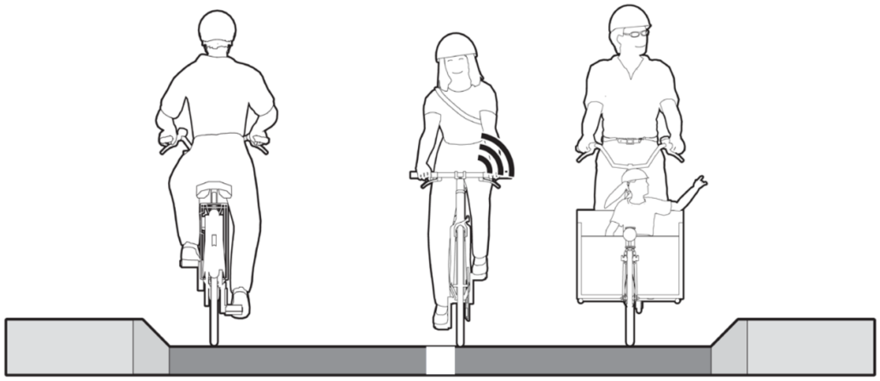


Figure 37: A desirable minimum width of 3.0 m allows passing movements to be comfortable undertaken (two-way path)[19]

Separated path requirement

The tables below show desirable widths and acceptable ranges of width for separated paths. A path width greater than the desirable width may be required to enhance user amenity of the path. It should be noted that these types of paths provide physical separation between pedestrians and cyclists.

Table 3 below can be used for one-way exclusive bicycle paths.

Table 3: Separated one-way path widths[20]

	Path width (m)		
	Bicycle path	Footpath	Physical separator between bicycle path and footpath
Desirable width (minimum)	1.5	1.5	1.0
Minimum width	1.2	1.2	0.5

Table 4: Separated two-way path widths[20]

	Path Width (m)		
	Bicycle path	Footpath	Physical separator between bicycle path and footpath
Desirable width (minimum)	2.5	1.5	1.0
Minimum width	2.0	1.2	0.5

[19] Image source: MassDOT Separated Bike Lane Planning & Design Guide, Chapter 3, Section 3.3.2 https://www.massdot.state.ma.us/highway/DoingBusinessWithUs/ManualsPublicationsForms/SeparatedBikeLanePlanningDesignGuide.aspx

[20] Section 7.5.4 of Cycling Aspects of the Austroads Guides (2014).

Figure 38: Example of separated pedestrian and cyclist path

Segregated path requirement

The tables below show desirable widths and acceptable ranges of width for segregated paths. A path width greater than the desirable width may be required to enhance user amenity of the path. It should be noted that these types of paths do not provide physical separation between pedestrians and cyclists.

Table 5: Segregated one-way path widths[21]

	Path width (m)	
	Bicycle path	**Footpath**
Desirable width (minimum)	1.5	1.5
Minimum width	1.2	1.2

Table 6: Segregated two-way path widths[21]

	Path Width (m)	
	Bicycle path	**Footpath**
Desirable width (minimum)	2.5	1.5
Minimum width	2.0	1.2

Shared use path requirements

The table below shows desirable widths and acceptable ranges of width for shared use paths. A path width greater than the desirable width may be required to enhance user amenity of the path.

[21] Section 7.5.4 of Cycling Aspects of the Austroads Guides (2014).

Table 7: Shared path widths[22]

	Path Width (m)		
	Local Access path	**Commuter path**	**Recreational path ([1])**
Desirable width (minimum)	2.5	3.0	3.5
Minimum width – typical maximum	2.5[(2)]-3.0[(3)]	2.5[(2)]-4.5[(3)]	3.0[(2)]-4.0[(3)]

Notes for Table 7:

1. ***A recreational path consists of cyclists which are, for the large majority, not commuter or sports riders.***
2. ***A lesser width should only be adopted where cyclist volumes and operational speeds will remain low or there are space restrictions.***
3. ***A greater width may be required where the numbers of cyclists and pedestrians are very high or there is a high probability of conflict between users (e.g. people walking dogs, roller bladders and skaters etc.).***

Summary

This supporting treatment has the following pros and cons:

Pros:

- A separated path virtually eliminates the conflict between pedestrians and cyclists as they are physically separated.
- A segregated path also provides a level of separation; however as there is no physical separation, there is still a chance of a collision between a pedestrian and cyclist in the event a cyclist encroaches onto the pedestrian path.

Cons:

- Where there is a large differential speed between the two modes, there is an increased risk of injury to pedestrians in the event of a collision between a pedestrian and cyclist.

Further reading

- Austroads Guide to Road Design Part 6A Sections 3.4 and 3.5 (2009) – design details on shared use and separated paths.
- Cycling Aspects of the Austroads Guide Sections 7.1 to 7.10 (2014) – further details on the provision of shared use and separated paths.
- VicRoads Design Guidance for Strategic Cycling Corridors.

5.10 Pedestrian crossing facilities

Supporting treatments to enhance the safety of crossing pedestrians at roundabouts include the following treatments.

Pedestrian Facility Selection Tool

Austroads has developed the Pedestrian Facility Selection Tool which assists in selecting the most appropriate type of pedestrian crossing based on walkability, safety and economic outcomes.

The online tool assesses the viability of different types of pedestrian crossing facilities according to the physical and operational parameters of a site and its safety performance.

[22] Section 7.5.4 of Cycling Aspects of the Austroads Guides (2014).

For each feasible option, the tool then evaluates pedestrian and vehicle delay, safe sight distances, pedestrian level of service and, using default economic parameters developed for each Australian jurisdiction and New Zealand, calculates a benefit cost ratio.

The tool can be found via: http://www.austroads.com.au/road-operations/network-operations/pedestrian-facility-selection-tool.

5.10.1 Pedestrian refuges

Pedestrian refuges can be provided at roundabouts to allow pedestrians to make staged crossings across a leg of the roundabout. By reducing the amount of time pedestrians spend on the road, this reduces the potential for collisions with vehicles.

For roads that are already divided on the approach to the roundabout, the physical median generally becomes a pedestrian refuge for crossing pedestrians. For undivided roads, a splitter island can be created on the approach which acts as both a pedestrian refuge and approach deflection.

Benefits of pedestrian refuges include:

- Improves accessibility for pedestrians and cyclists.
- Users cross one direction of traffic at a time making gap selection easier.

Appropriate locations for pedestrian refuges include:

- Local and collector roundabouts
- Where the approach road is already divided

Where such a supporting treatment is to be considered, the following should be taken into account:

- Sufficient width in the pedestrian refuge to cater for the number of crossing pedestrians as well as to reduce the exposure of pedestrians to passing vehicles
- The cost of installation and maintenance.
- Where the roadway needs to be widen to accommodate a pedestrian refuge, this may require land acquisition (although in many cases, this additional land is in the road reserve).

Design concepts

An example of a pedestrian refuge (in a splitter island) is shown below.

Figure 39: Local road roundabout with pedestrian refuge (note: DDA components are not shown in the image). Image source: Google Maps

Summary

This supporting treatment has the following pros and cons:

Pros

- Improves accessibility for pedestrians and cyclists.
- Users cross one direction of traffic at a time making gap selection easier.

Cons

- Land acquisition may be required to accommodate the refuge.
- A pedestrian refuge that is not of adequate size will lead to conflict between crossing pedestrians and cyclists.
- Insufficient space on the pedestrian refuge may result in safety concerns and inconvenience for pedestrians with prams, wheelchairs or pets.

Further reading

- Austroads Guide to Road Design Part 4 Section 8.2.2 (2009) – design details on the use of pedestrian refuges.
- Austroads Guide to Traffic Management Part 6 Section 4.4.3 (2009) - details on the use of pedestrian refuges.

5.10.2 Kerb extensions

Kerb extensions involve the narrowing of a traffic lane or carriageway on the approach to and on the departure from a roundabout. This narrowing is generally achieved through physical means, such as extending the kerb or nature strip into the traffic lane.

The narrower road space encourages motorists to reduce their speed when approaching or leaving the roundabout and as such reduces the likelihood of injury in the event of a collision.

Benefits of kerb extensions include:

- Shorten the crossing distance for pedestrians.
- Improve the inter-visibility between pedestrians and motorists.
- Discourages illegal parking in the vicinity of the roundabout.

Appropriate locations for kerb extensions include:

- Collector roads, local streets and in strip shopping centres where there is high pedestrian demand.
- Locations where kerbside parking occurs.
- Where approach and departure speeds are deemed too high and pedestrians have difficulty in judging when it is safe to cross.
- Locations where differential speed between cyclists and motorist is to be reduced.

Where off-road paths (including shared paths) cross at a roundabout.Where such a supporting treatment is to be considered, the following should be taken into account:

- An edge line should be painted on the approach and departure side of the kerb extension to delineate the narrowed roadway.
- Where there is a kerbside parking lane on the approach or departure side, matching the width of the kerb extension to the width of the parking lane (typically 2.3 - 2.5 m)[23] to add emphasis to the kerb extension.

[23] Western Australia Department of Transport: Planning and Designing for Pedestrians: Guidelines Section 9.3.5 Kerb Extensions (or Nibs)

- Reducing the crossing distance between the extensions to an amount that reduces the exposure of crossing pedestrians/cyclists.
- Kerb extensions can be used in combination with traffic calming measures such as refuges, zebra crossings and raised platforms.
- To achieve a minimum safe sight distance between approaching motorists and crossing pedestrians/cyclists where there is parking on the approach, a kerb extension typical 6 m to 10 m in length is required[23].
- A narrowed roadway may restrict passage of large vehicles and buses.

Design concepts

An example of a kerb extension is shown below.

Figure 40: Kerb extensions at a roundabout in Richmond (note: DDA components are not shown in the image). Image source: Google Maps

Summary

This supporting treatment has the following pros and cons:

Pros

- Reduces the distance that pedestrians have to cross.
- Improves the visibility between pedestrians and motorists.
- May reduce the travel speed of incoming vehicles through the narrowing of the road.

Cons

- A narrowed roadway may restrict passage of buses and large vehicles.

Further reading

- Western Australia Department of Transport: Planning and Designing for Pedestrians: Guidelines – 9. Pedestrian Crossing Facilities.
- Section 8.2.2 and Commentary 6 of Austroads Guide to Road Design Part 4: Intersections and crossings (2009).
- Street lighting – refer to AS/NZS 1158.3.1 – 2005 and AS/NZS 1158.4 – 2009 (Section 10.1).

5.10.3 Pedestrian crossings

Consideration may be given to providing priority crossings (zebra crossings) for pedestrians where there is a desire to give pedestrian priority over vehicles. To enhance the presence of crossing pedestrians, crossings may be placed on raised platforms (known as a wombat crossing).

There are factors practitioners should take in consideration when these facilities are to be provided, which are outline below.

For the provision of raised pedestrian crossing points (uncontrolled), refer to Section 5.2.2 of this document.

Appropriate locations for raised pedestrian crossings include:

- High pedestrian volumes.
- A high proportion of young, elderly or infirm pedestrians.
- Pedestrians experiencing particular difficulty in crossing and being excessively delayed.
- Generally only suitable for single-lane roundabouts in low-speed environments - not recommended for multi-lane approaches to roundabouts.

Where such a supporting treatment is to be considered, the following should be taken into account:

- Location of the actual crossing at the roundabout – refer to the discussion in 'Design concepts'.
- Whether flashing yellow signals are required to enhance the presence of the crossing to motorists (refer to Clause 6 of AS 1742.10).
- Under road rule 248(1) of the Victorian Road Safety Road Rules 2009, bicycles are not permitted to use a pedestrian crossing without dismounting.
- Depending on how close the crossing is to the roundabout, drivers who have just departed from the circulating lane may not have enough time to react to the crossing.
- Sufficient lighting of the crossing.
- Costs associated with installation of the crossing, including lighting and infrastructure.

Design concepts

For details on the geometric, pavement marking and signage, refer to Australian Standards AS 1742.10.

Location of the pedestrian crossing

The pedestrian crossing may be located at one of two key positions. There are factors that need to be considered with these locations:

- Setback from the roundabout (holding line / entrance to the departure) to allow storage of a single vehicle (usually one car length – typically 5 m).
- At the holding line (no storage space).

Setback from roundabout

The pedestrian crossing is located at a distance away from the holding line (usually one car length – typically 5 m) to allow a vehicle to store in between the holding line and the pedestrian crossing. In addition, this allows motorists departing the roundabout further time to perceive and react to pedestrians on the crossing and drivers can wait while not blocking the circulating lane of the roundabout.

This layout is generally preferred for most roundabouts, especially on roads that are of collector status or higher and have an appreciable amount of vehicular traffic. Also, this layout should be considered where the operation of the roundabout would be negatively affected by vehicles waiting in the circulating lane. However, the distance between the crossing and roundabout should not be too great, as the further the crossing is from the roundabout, the greater the chance that pedestrians will avoid using the crossing (as it may be too far from the desired crossing line).

Example of a pedestrian crossing setback from the roundabout is shown in Figure 41.

Figure 41: Pedestrian crossing at Sir John Monash Drive / Queens Avenue, Caulfield, with a setback to store vehicles between the crossing and roundabout.

At the holding line

In this layout, the pedestrian crossing is provided adjacent to the holding line, generally in the direct desired crossing line of pedestrians. There is no storage area for vehicles before or after the crossing which may result in vehicles waiting to enter the roundabout storing across the crossing and vehicles waiting to exit storing in the circulating lane. This layout is generally not suitable where the delay caused by vehicles waiting in the circulating lane is a safety issue or is deemed undesirable (e.g. delays to buses).

The geometry of the roundabout needs to be taken into account to ensure adequate sight distance between exiting vehicles and crossing pedestrians.

Examples of a pedestrian crossing at a roundabout holding line are shown in Figures 42 and 43.

Figure 42: Raised pedestrian crossing at the roundabout holding line - Asling Street and Martin Street, Brighton. Note the pedestrian crossing signs have been angled to face circulate traffic. Image source: Google Maps

Figure 43: Pedestrian crossing at Sir John Monash Drive / Queens Avenue, Caulfield

Summary

This supporting treatment has the following pros and cons:

Pros

- Improves accessibility for pedestrians, especially pedestrians with mobility aids.
- Provides priority for crossing pedestrians.
- Enhances the visibility of the location where pedestrians are crossing.

Cons

- Cyclists have to dismount in order to use the zebra crossing.
- Depending on how close the crossing is to the roundabout, drivers who have just departed from the circulating lane may not have enough time to react to the crossing.
- Crossings located at the holding line may have vehicles stored across the crossing.

Further reading

- Australian Standards AS 1742.10 (2009).
- Austroads Guide to Traffic Management Part 4 Section 8.2.3 (2016).

6. Appendix A

Statistics – Cyclist crashes at roundabouts

Figure 44 below shows cyclist crashes between 2003 and 2013.

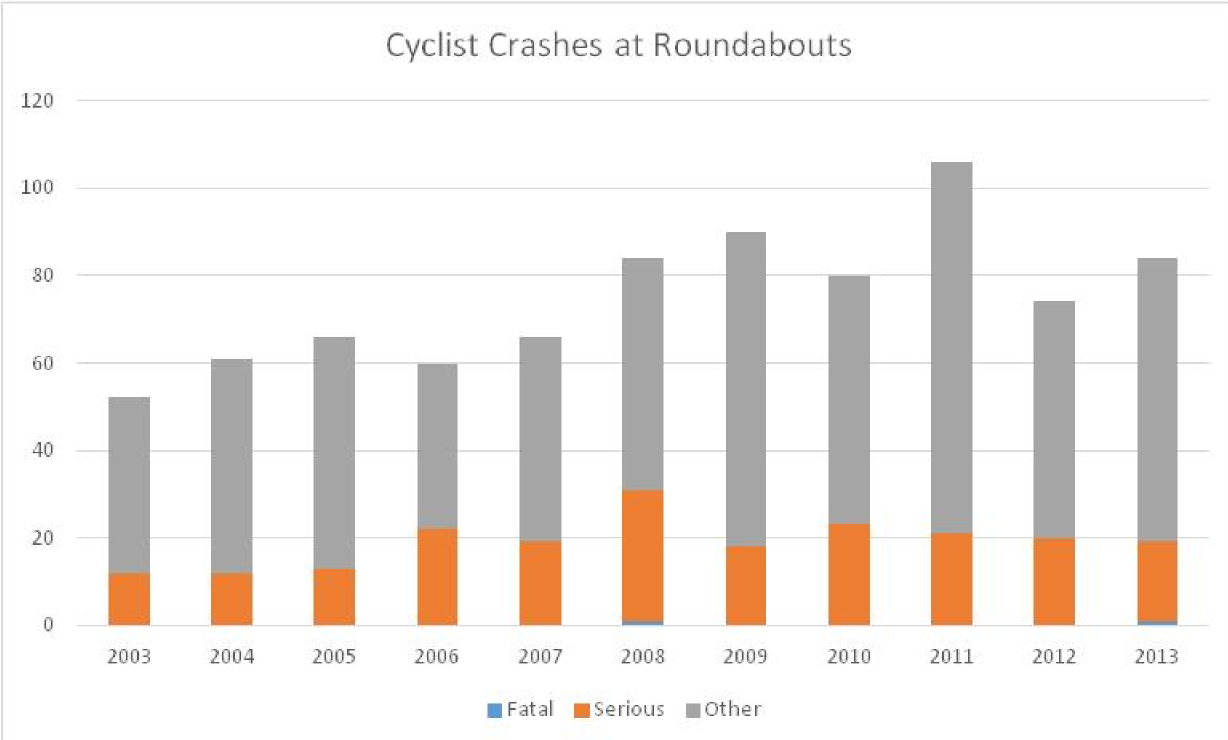


Figure 44: Cyclist crashes at roundabouts between 2003 and 2013[24]

[24] VicRoads CrashStats data – 2003 to 2013

The top Victorian locations for cyclist crashes (2003 – 2013) are listed in Table 8 below.

Table 8: Top crash roundabout locations in Victoria (2003 – 2013)[1]

Ranking	Intersection		Suburb	Total (2003-2013)	Serious	Other
1	Canning Street	Pigdon Street	Carlton North	18	3	15
2	Balcombe Road	Beach Road	Beaumaris	16	8	8
3	Haymarket Roundabout		Melbourne CBD	10	1	9
4	St Kilda Street	Bent Avenue	Brighton	8	2	4
5	Dorcas Street	Moray Street	South Melbourne	7	1	4
6[25]	St Georges Road	Merri Parade	Preston	7	2	5
7	Nepean Highway	Beach Road	Beaumaris	7	3	4
8	Bent Avenue	Murphy Street	Brighton	6	3	3
9	Todd Road	Cook Street	Port Melbourne	6	2	3
10	Leveson Street	Queensbury Street	North Melbourne	6	0	4

[25] This intersection is no longer a roundabout – it has been converted to a signalised intersection.

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