Treating bicycle and pedestrian collisions at roundabouts

The following table provides a brief overview of the treatments and their appropriateness on certain routes.

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

Grade Separation

'Hovenring' in the Netherlands (Hovenring © *ipv Delft: Helibeeld.nl*)[1]

Brief description	
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.	
Potential locations	• 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 with high operating speeds where at-grade cycling and/or pedestrian treatments do not deliver the best level of service.
Considerations	• 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. • 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. • 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. • Whether the design of the infrastructure leads to the creation of an environment that is 'unsafe' or 'unwelcoming' for pedestrians or other users.
Supporting treatments	• Shared, separated and segregated paths
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 and/or pedestrians may continue 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 • Austroads Guide to Road Design Part 6A Section 3 (2009)

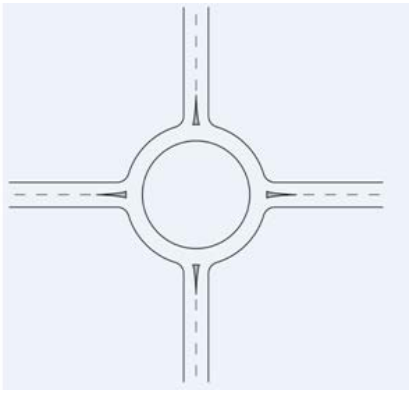
[1] Image Source: www.ipvdelft.com

Annular roundabouts - separated bicycle / pedestrian path

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

Brief description	
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 navigate 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.	
Potential locations	• 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 and arterial road roundabouts.
Considerations	• 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) • 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. • Provision of signage and pavement markings to direct cyclists on, off and along the off-road path.
Supporting treatments	• Shared, separated or segregated paths • Raised platforms/ approach deflection/ pedestrian refuges • Static signage
Pros	• Provides an alternate and safer route for cyclists and pedestrians by providing a separate off-road path for cyclists and 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’– 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 • Austroads Guide to Traffic Management Part 6 (2013) • Austroads Research Report AP-R461-14 (2014)

Radial roundabouts



Typical radial roundabout design

Brief description	
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[2].	
Potential locations	• 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.
Considerations	• 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. • Provision of crossing facilities for pedestrians. • Sufficient swept path for heavy vehicles to safely navigate the roundabout (where applicable).
Supporting treatments	• Lane sharing (sharrows) • Raised platforms • Static signage • Bicycle activated warning signs • Kerb extensions (narrowing of roadway)/raised pedestrian crossings/pedestrian refuges
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.
Further reading	• Patterson, F. (2010), “Cycling and roundabouts: An Australian perspective”, Road & Transport Research Vol 19 No 2 June 2010

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

C-roundabouts

Canning Street / Pigdon Street, Carlton North

Brief description

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.

Potential locations	• 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.
Considerations	• 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 pedestrian crossing facilities
Supporting treatments	• Approach deflection • Raised platforms • Signage • Raised pedestrian crossings • Pedestrian refuges
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. • 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 it difficult to cross the roundabout.
Further reading	• Queensland Department of Transport and Main Roads Technical Note 136 (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)

Splitter kerbs

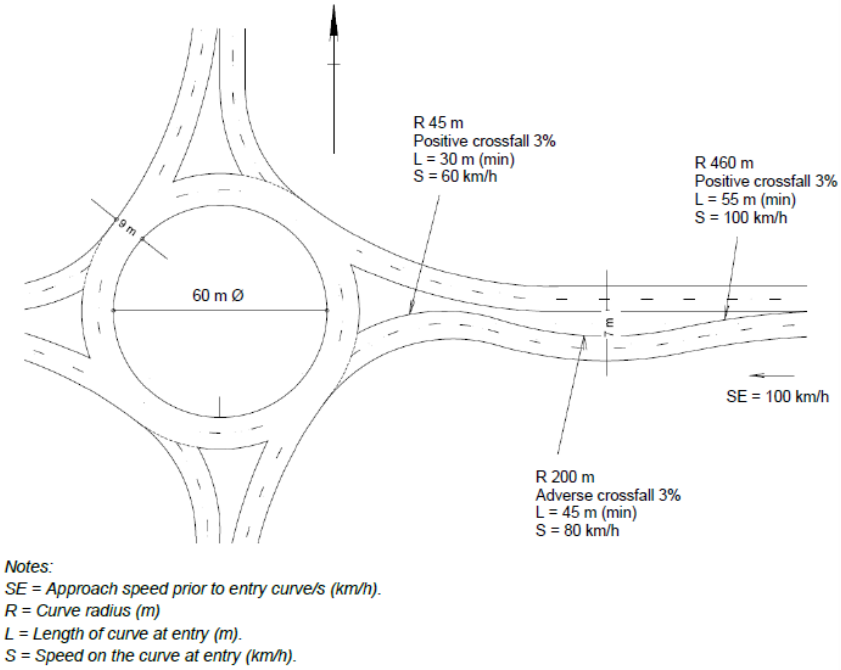
Splitter kerbs at Laver Drive and Easthill Drive roundabout Robina, Queensland. Image Source: Google Maps

Brief description

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 and cyclists.

Potential locations	• Roundabouts with a high volume of cyclists turning left. • At entries and exits of roundabouts.
Considerations	• There is sufficient approach sight distance. • 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. • 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 1.8m between kerb faces.
Supporting treatments	• Approach deflection • Raised platforms • Static signage • Bicycle activated warning signs • Raised pedestrian crossings • Pedestrians refuges
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)

Approach deflection



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).

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

Brief description

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 and in particular cyclists where the severity of crashes will be reduced.

Potential locations	• Roundabouts on high-speed roads, commonly with approach speed over 60 km/h • Roundabouts on rural roads where drivers may be less alert when they travel for long distances and long periods of time
Considerations	• 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 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: o An appropriate entry path radius on the single entry curve o The curve should be long enough in higher speed areas (≥ 80km/h) • Approach treatments to be applied to minimise single vehicle crashes on approach deflection to the roundabout with operating speeds ≥ 80km/h: o Successive reverse curves o A raised median or splitter island and a kerb along the left side of the approach o Rumble strips o Appropriate speed limit signs
Pros	• Limits the angle formed between entering and circulating vehicle paths and minimises the relative 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 the Austroads Guide to Road Design Part 4B: Roundabouts (2015) • Austroads Guide to Traffic Management Part 6 (2013)

Raised platform on approach to the roundabout – speed cushions

Speed cushions

Brief description
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 however there are concrete and asphalt variations.

Potential locations	• 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.
Considerations	• 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.
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)

Raised platform on approach to the roundabout – fully raised platforms

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

Brief description

The approach to the roundabout may be raised for a certain distance as a way to reduce operating speeds at the roundabout. There are two main types:

- Flat top road humps (less than 6 m in length)
- Raised platform (greater than 6 m in length)

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 is also intended to slow down motorists and cyclists travelling across the pedestrian crossing.

Potential locations	• 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. • On bicycle priority routes as defined in the VicRoads SmartRoads strategy.
Considerations	• 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.
Pros	• Raises the prominence of cyclists 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

Lane sharing at roundabouts (sharrows)

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

Brief description

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.

Potential locations	• 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.
Considerations	• 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. • Signs may be required to highlight to all road users that bicycles are allowed to ride in the centre of the lane. • Cyclist confidence and safety in sharing the lane with general traffic.
Supporting treatments	• Approach deflection • Raised platforms • Static signage • Raised pedestrian crossings • Pedestrians refuges
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	• 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. • 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) • 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)

Transverse lines on approach to the roundabout

Raised: Maltravers Road, Ivanhoe

Flush: Old Warrandyte Road, Donvale. Image source: Google Maps

Brief description

The approach to the roundabout may have transverse lines, that extend across the traffic lanes as a way to reduce operating speeds at the roundabout. There are two main types:

- Raised – rumble strips provide an audible and tactile sensation to drivers.
- Flush – visual indication to motorists of a change in road environment ahead.

Potential locations	• 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.
Considerations	• 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.
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 motorist thus reducing its effectiveness.
Further reading	• Austroads Guide to Traffic Management Part 8: Local Area Traffic Management (2016)

Static Warning and Regulatory Signs

G9-57 Watch for bicycles sign

W6-1 Pedestrian warning sign

W6-7 Bicycle warning sign

Brief description	
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.	
Potential locations	• Where the presence of cyclists or pedestrians is unexpected. • To supporting pavement or lane markings. • To supporting new treatments that motorists may not be familiar with. • At pedestrian crossings with a high volume of crossing pedestrians. • To warn of vertical deflection measures.
Considerations	• 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.
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)

Bicycle Activated Warning Signs

McDonald St, Mordialloc Source: ARRB Group[3]

Brief description
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.

Potential locations	• 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.
Considerations	• 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. • Using 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.
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)

[3] 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

Metering of roundabouts

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

Brief description

Where traffic flows in one approach (or a number of approaches) is larger than the other legs, this can result in difficulties for pedestrians crossing a particular leg of a roundabout or cause issues for cyclists navigating through the roundabout. 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) 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, but can 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.

Potential locations	• 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.
Considerations	• The use of purpose built signals. • Whether pedestrian and/or bicycle operated signals be part of the metering signals. • Advance warning signals should be considered where sight restrictions exist.
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 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)

Shared, separated and segregated paths

Example of separated pedestrian and cyclist path

Brief description

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.

Potential locations	• Where there is sufficient land to implement a shared, separated and segregated paths. • 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, and at other associated locations where pedestrians and cyclists are adjacent to one another.
Considerations	• 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 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. • Signage to highlight to users where they should walk or ride. • Whether the bicycle aspect of the separated path be designed as a two-way facility or one-way facility.
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

Pedestrian crossing facilities – Pedestrian refuge

Local road roundabout with pedestrian refuge in Richmond. Image source: Google Maps

Brief description

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.

Potential locations	• Local and collector roundabouts • Where the approach road is already divided
Considerations	• Sufficient width in the pedestrian refuge to cater for the number of crossing pedestrians as well 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).
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.

Pedestrian crossing facilities – Kerb extensions

Local road roundabout with kerb extensions in Richmond. Image source: Google Maps

Brief description

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.

Potential locations	• 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 motorists is to be reduced. • Where off-road paths (including shared paths) cross at a roundabout
Considerations	• 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 • 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 measure 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. • A narrowed roadway may restrict passage of large vehicles and buses.
Pros	• Reduces the distance that pedestrians have to cross. • Improve 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 (2009) • Street lighting – refer to AS/NZS 1158.3.1 – 2005 and AS/NZS 1158.4 – 2009 (Section 10.1)

Pedestrian crossing facilities –pedestrian crossings

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

Brief description	
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).	
Potential locations	• 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.
Considerations	• Location of the actual crossing at the roundabout. • Whether flashing yellow signals are required to enhance the presence of the crossing to motorists (refer to Clause 6 of AS 1742.10). • Under the road rules, bicycles are not permitted to use a zebra 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
Pros	• Improves accessibility for pedestrians, especially disabled pedestrians. • 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.
Further reading	• Austroads Guide to Traffic Management Part 4 Section 8.2.3 (2016) • Australian Standards AS 1742.10 (2009)