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The Case against Cycle Paths

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Abstract

Well-designed cycle paths[1] can be safe and pleasant for cycling.

Having said that, many existing cycle paths in New Zealand fall far short of the required design "best practice", and potentially put cyclists at risk. Simply put, a good cycle path has no driveways crossing it unless there is ample unimpeded visibility between driveway users and the path. In practice, this means that a cycle path must be separated from the boundary (from where driveways emerge) by at least 7 m. Where a cycle path is close to the boundary, cyclists are unable to stop in time to avoid hitting (or being hit by) a car emerging from a driveway.

This paper explains the engineering principles behind safe cycle path design in relation to driveways. The advantages and disadvantages of cycle paths are explored, in terms that both lay readers and professional traffic engineers will find compelling. The large space requirements for safety are not widely understood. This finding has significant implications for New Zealand as a new era dawns for the construction of cycling facilities. Road controlling authorities across the country are responding to a number of recent cycle-friendly policy initiatives from central government by promoting cycling strategies and cycling facilities. This paper is a timely reminder of the need to ensure that new facilities are built to suitable standards so that cyclists' safety is not compromised in the rush to improve conditions for cyclists.

About the Author Andrew Macbeth (BE, MEng, MIPENZ, Registered Engineer) has been active as a cycle facility designer, cycling policy planner, cycling research engineer and cycling advocate in New Zealand and Canada for 30 years.

[1] Cycle **paths** are paths separated from the road and designed for use by cyclists. They are usually also available to pedestrians. Cycle **lanes** are quite different – they are lanes specifically for cyclists on roads adjacent to general traffic lanes and are typically separated from motor vehicles by a painted white line. Cycle paths are off-road facilities; cycle lanes are on-road.

1 Outlining the Case

Cycle paths are charged with being potentially dangerous to cyclists.

There has been significant movement in New Zealand over recent years to support cycling by various levels of government. Transfund New Zealand, Transit New Zealand, the Land Transport Safety Authority (LTSA) and the Ministry of Transport are all engaged in useful projects at a national level. Similarly, many regional, district and city councils have begun implementing cycling strategies and specific cycling projects such as the construction of cycle paths and cycle lanes, often with financial support from Transfund.

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Many existing cycle paths in New Zealand fall far short of the required design “best practice”, and potentially put cyclists at risk. Simply put, a good cycle path has no driveways crossing it unless there is ample unimpeded visibility between driveway users and the path. In practice, this means that a cycle path must be separated from the boundary (from where driveways emerge) by at least 7 m. Where a cycle path is close to the boundary, cyclists are unable to stop in time to avoid hitting (or being hit by) a car emerging from a driveway. A well designed cycle path with no intersecting driveways is illustrated in Figure 1.

Figure 1: Cycle paths with no intersecting driveways are pleasant and safe for cycling.

It is also important to realise, however, that on-road cycling facilities (such as cycle lanes or wide shoulders) are not always appropriate. When traffic speeds and volumes are high, off-road cycle paths (preferably on both sides of the road) may be the best solution. But good engineering design practice, including the treatment of driveways, is fundamental to achieving safe and well-used facilities.

Nevertheless, both off-road and on-road solutions may be advantageous in many circumstances, giving cyclists of different abilities the choice to travel more slowly and with more comfort on off-road paths or more quickly on cycle lanes or wide shoulders on roads.

This paper explains the engineering principles behind safe cycle path design in relation to driveways. The large space requirements for safety are not widely understood. This finding has significant implications for New Zealand as a new era dawns for the construction of cycling facilities. Road controlling authorities across the country are responding to a number of recent cycle-friendly policy initiatives from central government by promoting cycling strategies and cycling facilities. This paper attempts to provide relevant information to help ensure that new facilities are built to suitable standards so that cyclists' safety is not compromised in the rush to improve conditions for cyclists.

2 Evidence

2.1 Introduction

Cyclists, like motorists, need to be able to avoid running into obstacles in their path. For example, good cycling technique has cyclists on urban roads riding wide past parked cars, to avoid the "door prize". To be wide alongside parked cars means that cyclists are often riding well out from the kerb even when there are no parked cars.

For cyclists on cycle paths, potential hazards are usually not parked cars, but obstacles alongside or on the path. Well-established traffic engineering techniques exist from routine road design so that designers can ensure that bends on cycle paths are not too tight. They can design facilities so that trees, poles or other fixed objects are not too close to paths and that paths are wide enough for cyclists to pass each other and other path users (such as pedestrians) safely.

These techniques and design principles are documented in the New Zealand Supplement to Austroads Guide to Traffic Engineering Practice Part 14: Bicycles[2] and other documents.

One condition, however, which appears to have not been identified previously is the geometric relationship necessary between a cycle path and an intersecting driveway to ensure safety for cyclists. Cars can emerge from driveways to present unavoidable hazards to cyclists when driveways are hidden from the view of approaching cyclists by hedges or fences.

This condition is unlike other intersection situations, in that roads are much wider than driveways and have extra space at their intersections, often with sight lines across the corners reserved in the road allowance to maintain "inter-visibility" between approaching vehicles.

Most people agree that cyclists should not be permitted to ride on footpaths in urban areas. This position can be supported out of concern for pedestrians, but it is also well understood that cyclists on footpaths face significant risk at driveways. Footpaths in urban areas are typically 1.5 m from road boundaries or less, giving cyclists and motorists emerging from driveways very little time to react to prevent collisions. Because pedestrians on footpaths travel much more slowly than cyclists, they are able to perceive, react to and stop for emerging motor vehicles at driveways, and the spacing requirements for footpaths are not an issue.

[2] The New Zealand Supplement to Austroads Guide to Traffic Engineering Practice Part !4: Bicycles is under development by MWH New Zealand Ltd on behalf of Transit New Zealand. A consultation draft was released publicly by Transit in July 2003 as the New Zealand Cycling Design Guide.

Cyclists will be unable to detect motor vehicles emerging from concealed driveways in sufficient time to prevent collisions unless there is a certain amount of clear space between cycle paths and the adjacent road boundary from which driveways emerge. This paper calculates this safe spacing conservatively as 7 m.

2.2 Assumptions

A number of assumptions are made in the following calculations:

1. Car drivers emerging from driveways do not notice cyclists approaching on cycle paths. Thus the onus for preventing collisions falls on the cyclists. This assumption is necessary because:

   - motorists are likely to assume that cyclists will not be present because cyclist numbers are often very low;

   - motorists tend to look to their right for approaching vehicles, not to the left; and hence may not notice cyclists approaching from their left on a two-way cycle path; and

   - at night or during rain, cyclists are often hard to see.

   Accordingly, the appropriate design philosophy is to assume that car drivers will not stop prior to a cycle path while emerging from a driveway and before entering a road.

2. Motorists emerging from concealed driveways drive to the road edge and stop to wait for a gap in road traffic before joining the traffic stream. The motor vehicle will block the cycle path (typically located 1 or 2 metres from the road edge) while the driver is waiting to join the road traffic. This is the period of risk to cyclists.

3. The average speed of an emerging motor vehicle from the time it leaves the property boundary to the time it stops at the road edge is 5 km/h.

4. Any driveways may become concealed driveways even if they are not concealed at the time the design is done, as property owners usually have the right to plant hedges and build fences on their properties on most roads where cycle paths are contemplated.

5. New driveways may be built in the future at any point alongside the facility unless vehicular access to the road from abutting property is limited by regulations or bylaws.

6. The design speed for cyclists is 30 km/h. (This is recommended in Austroads Part 14 Bicycles[3]. In the Netherlands, a design speed of 25 to 30 km/h is recommended[4] for cycle paths.).

7. The time taken for a cyclist to identify a potential hazard of a car emerging from a driveway and to start applying the brakes is three seconds. This is known as the "perception and reaction" time. On an off-road cycle path, designers should expect cyclists to be paying only casual attention to potential driveway hazards. The principle of an off-road path is to provide a safe, conflict-free cycling environment, thus allowing cyclists to enjoy the scenery or the company of friends or family. Accordingly, a perception and reaction time of 3 s is considered to be a reasonable assumption.

2.3 Traffic Engineering Calculations

Austroads Part 14 (page 75) recommends a "safe stopping sight distance" of 35 m for cyclists travelling at 30 km/h on level ground. Safe stopping sight distance is the distance required for a cyclist to perceive a hazard, react to (start applying the brakes) and stop their cycle.

[3] Guide to Traffic Engineering Practice Part 14 Bicycles, Austroads 1999 page 70
[4] Sign Up for the Bike: Design Manual for a Cycle Friendly Infrastructure, CROW (Netherlands), 1993 page 26

This is confirmed by the author's first-hand experience, where field tests found that a cycle could be stopped on a dry road from 30 km/h in a space of 8 m by braking hard. Assuming constant deceleration, the cycle speed changes from 30 km/h (8.33 m/s) to 0 km/h over a distance of 8 m, giving a braking time of 8/(8.33/2) or 1.9 s.

In addition, during the perception and reaction time of 3 seconds (the time to start applying the brakes), a cycle travelling at 30 km/h (8.33 m/s) would travel 3 x 8.33 or 25 m. Thus the total distance travelled during perception, reaction and braking time is 33 m (consistent with the Austroads figure of 35 m) and the total time for this to occur is 3 s + 1.9 s or 4.9 s.

During the 4.9 s that a cyclist is travelling 33 m and coming to a complete stop to avoid an emerging car, the car is assumed to be travelling at an average of 5 km/h or 1.39 m/s. In 4.9 s, the car would travel 4.9 m/s x 1.39 m or 6.8 m.

Thus if the cycle path is any closer to the road boundary than 7 m, then the motor vehicle is likely to be stopped across the cycle path, resulting in the cyclist crashing into the side of the stopped car. The clear space requirement is illustrated in Figure 2.

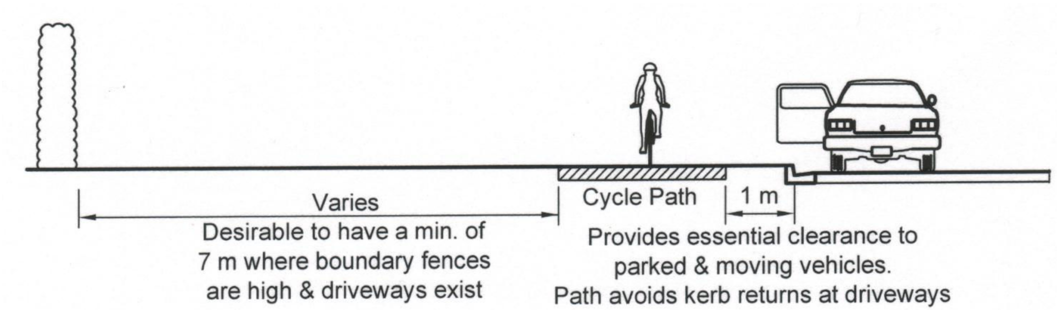

Figure 2: The desirable minimum spacing between boundary and cycle path is 7 m

If the path is not on level ground, greater clear space is required because cyclists will be likely to be travelling faster and a design speed higher than 30 km/h should be used.

Appendix A documents the calculations in this paper, including a sensitivity analysis of some of the assumptions used.

2.4 Sensitivity to Assumptions

If different assumptions to those outlined above are made, the clear space requirement varies according to the table below:

Assumptions	**Clear space requirement**
As outlined above (30 km/h cycle design speed; 3 s cyclist perception and reaction time; 5 km/h average approach speed for emerging car)	7 m
20 km/h cycle design speed	6 m
10 km/h cycle design speed	5 m
2.0 s perception and reaction time; 30 km/h cycle design speed	5 m
10 km/h average speed for emerging car; 30 km/h cycle design speed	14 m

It can be seen that this calculation is very sensitive to the assumed speed of approaching cars (emerging from driveways). It is suggested that the assumption of 5 km/h average speed for a motor vehicle exiting a driveway is conservative. In many semi-rural situations, driveways are often quite long, and motorists driving out to the road, knowing that the road is still some considerable distance from the boundary fence, will often be travelling at nearer 10 km/h than 5 km/h. As can be seen from the table, this means that the path needs to be located at least 14 m from the boundary to allow a cyclist time to stop prior to colliding with the car.

2.5 Other Factors

This case is built on safety grounds, but there are equally compelling other reasons for convicting cycle paths.

- Cycle paths tend to be constructed to lower standards than roads, so the ride quality is lower than on roads. Consequently cycle paths tend to be bumpy, and the surface often deteriorates more rapidly than on a comparable road.

- Gravel, litter and broken glass often accumulate on cycle paths, which are seldom swept. The edges of roads (where cyclists ride), while not usually free of debris, are usually cleaner than off-road paths.

- Wider road shoulders or cycle lanes are cheaper to build than cycle paths.

- Wider road shoulders or cycle lanes provide general safety benefits to other traffic, giving motor vehicle drivers more recovery space if they stray out of their lane or if they need to avoid hazards on the road ahead.

- Cycle paths have no priority over side roads, so cyclists on these facilities must give way to vehicles on all intersecting roads.

- Cycle paths tend to be less well illuminated than on-road cycling facilities, introducing potential night-time hazards.

2.6 Prior Cases

Tennyson Street in Christchurch has been re-constructed with an off-road cycle path on each side, and a narrower carriageway. The project is illustrated in Figure 3.

Figure 3: Tennyson Street in Christchurch – cycle path too close to driveways

The clear space between property boundaries and the cycle path is about 3 m. Using similar calculations to those above, this gives an effective design speed for cyclists using the facility of less than 10 km/h. Cyclists wishing to travel faster than this should be encouraged to use the road, except that the road is now too narrow to safely accommodate cyclists. Cyclists are now worse off than before this expensive project, designed to improve conditions for cyclists, was installed.

The greatest potential use of cycle paths appears to be in rural or semi-rural situations, however. Many road controlling authorities (including Transit and territorial authorities) are concerned about cyclist safety on rural fringe roads with typically 70 km/h speed limits or higher. They are increasingly favouring off-road cycle paths (on just one side of the road) in the mistaken belief that this is the safest, most cost-effective way forward to provide for cyclists.

3 Summing Up

A case can be made for requiring cycle paths to be located 14 m from road boundaries where driveways exist (or may exist in the future). However, even if the more achievable clear space of 7 m is used, this will result in cycle paths generally not being provided. The amount of space allocated to clear space is likely to be considered uneconomic given the generally small numbers of cyclists found on most roads, or anticipated in future.

If 7 m is assigned to clear space, plus a nominal path width of 2.0 m and a clear space of 1.0 m between the path and the road, some 10 m is required between the property boundary and the road edge. If this kind of facility is provided on one side of the road with an 8 m carriageway (typical of rural or semi-rural areas), plus a nominal 6 m berm on the other side of the road, a road reserve of 24 m is needed. Most roads in New Zealand have a road reserve of about 20 m. If a cycle path is provided on both sides of the road, they should be designed with a 7 m clear space on each side of the road, requiring a total road reserve of 28 m. It the carriageway is wider than 8 m, then a wider road allowance will be needed.

For these reasons, it is unlikely that cycle paths will be built to adequate standards in New Zealand. If, however, cycle lanes or wide shoulders are provided, these can be built on a 12 m carriageway for a rural two-lane road (2.5 m cycle lanes or shoulders plus two general traffic lanes of 3.5 m). At speed limits of less than 100 km/h, less width is needed.

Not only are on-road solutions safer, they have a range of other advantages. Cycle paths are appropriate in parks and alongside a range of linear facilities such as rivers, shorelines and railway lines. But in general, on-road solutions such as cycle lanes or wide sealed shoulders are generally preferable.

4 Verdict

Cycle paths are guilty as charged.

They may be appropriate in parks, or alongside motorways, railway lines or rivers, but in general they should not be used alongside roads. Generally there is inadequate road reserve to provide the clearances necessary for cycle paths to operate safely. Cyclists will be safer on properly designed road shoulders or cycle lanes. If cycle paths are built at lower standards than recommended here, they pose significant risks for cyclists and offer a poor level of service, because they can only be used safely at very low speeds.

In addition, cycle paths exhibit a range of other disadvantages over on-road cycle facilities. Amongst other things they are generally more expensive to construct, more likely to accumulate litter and broken glass, offer a rougher riding surface and have no priority over side roads.

Appendix A: Calculations

Lateral Clearance Requirements for Cycle Paths	Case 1	Case 2	Case 3	Case 4	Case 5	Units
	Differences between cases are explained below					
Design speed for cycle (see Austroads Part 14 page 70)	**30**	**20**	**10**	30	30	km/h
=	8.33	5.56	2.78	8.33	8.33	m/s
Assumed (constant) speed for car emerging from concealed driveway and then stopping over cycle path waiting to enter road	**5**	5	5	5	**10**	km/h
=	1.39	1.39	1.39	1.39	2.78	m/s
Assume car stops at carriageway to assess traffic						
Assumed perception and reaction time	**3**	3	3	**2**	3	s
Distance travelled during perception and reaction	25.0	16.7	8.3	16.7	25.0	m
Braking distance (based on field testing)	8	3.5	1	8	8	m
Total stopping sight distance	33.0	20.2	9.3	24.7	33.0	m
Stopping Sight Distance for cycle (from Austroads Part 14 page 75) - not used in these calculations but corroborate figures in line above	35	20	7	35	35	m
Time spent braking	1.92	1.26	0.72	1.92	1.92	s
Time for cyclist to travel SSD	4.92	4.26	3.72	3.92	4.92	s
Distance travelled by car while cycle approaches (assuming speed as in Line 6)	6.8	5.9	5.2	5.4	13.7	m
This is the **space required between property boundary and edge of cycle path** for a cyclist to be able to stop if he or she chooses to do so.	**7**	**6**	**5**	**5**	**14**	**m**
Conclusion: Cycle paths on flat ground should be at least 7 m away from property boundaries (and more if the cycle path is on a gradient).						
Further Comments:						
This clear space requirement is even more important when a cycle path exists on only one side of a road, as motorists emerging from a driveway would typically only look right, in the direction of approaching motor vehicles on their side of the road. Cyclists approaching from the left would thus be vulnerable and need to be able to react in time to prevent colliding with an emerging motor vehicle.						
The designer must assume that any driveways may become concealed driveways even if they are not concealed at the time the design is done, as property owners have the right to plant hedges and build fences on their properties.						
The designer must also assume that new driveways may be built in the future at any point alongside the facility unless the road is a limited access road.						
It is also assumed that car drivers do not see cyclists approaching on cycle paths and thus the onus for preventing a collision falls on the cyclists. This assumption is necessary because motorists are likely to assume that cyclists will not be present as cyclist numbers are often very low. In addition, cyclists may be cycling in the "wrong" direction on a two-way cycle path and motorists tend to look to their right for approaching vehicles, not to the left. At night, even well illuminated cyclists are hard to see.						

Assumptions for each case	Case 1	Case 2	Case 3	Case 4	Case 5	Units
Cycle design speed	30	20	10	30	30	km/h
Average speed of car emerging from driveway	5	5	5	5	10	km/h
Perception and reaction time	3	3	3	2	3	s