THE EFFECTIVENESS OF
TWO-WAY STREET CALMING PINCH-POINTS

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ABSTRACT

Research investigated the effect of roadway widths for street narrowings or "pinch-points" in Christchurch, with a particular focus on speed and yielding behaviour.

A 6m wide 2-way pinch-point was found to be not effective in slowing most private vehicles down. Drivers travelled at a similar speed whether they were crossing the pinch-point by themselves or with opposing traffic approaching.

Approximately 40% of drivers reduced their vehicle speed when negotiating a 5m wide 2-way pinch-point. Around 20% of drivers avoided traversing with oncoming traffic and opted to wait until it was clear before proceeding. Male drivers also tended to travel faster through the narrowing when compared to female drivers.

For a 4.5m wide 1-way pinch-point where motor vehicles and cyclists approached them simultaneously, one of them gave way and waited nearly 60% of the time. Around 35% of the time cyclists and motorists shared the narrowing and 8% of the cyclists (mostly younger children) avoided the narrowing, using a bypass instead.

It is recommended that further research be conducted:

1. at more sites with different road widths and environment;
2. with heavy vehicle movements on these pinch-points;
3. to understand whether a longer pinch-point will alter driver behaviour.

1. INTRODUCTION

The principle of a traffic calming pinch-point is to reduce vehicle operating speeds and this in turn is anticipated to improve road safety. Each year, the Christchurch City council has upgraded roads in the urban district to improve the function and safety for the local residents. However, there is limited information available on the effectiveness of 2-way street calming devices. As such, this allows room for the discretion of road designers to determine the appropriate roadway width for 2-way pinch-points. For the most part, the 2-way pinch-points in Christchurch City generally provide a narrowing of around 6m wide carriageways. Some pinch-points have been constructed to narrower widths to manage cyclists and motor vehicles usage.

2. OBJECTIVES

The objectives of this research were:

- To investigate road users' behaviour at 2-way street calming devices.
- To assess the level of effectiveness of roadway width narrowing that achieves a desirable outcome for a 2-way street calming device.
- To investigate cyclists' usage of the street calming devices when other motorised vehicles are sharing the space at the narrowing.

This research was undertaken as part of a Master of Engineering in Transportation (MET) research project (Chai 2011).

3. LITERATURE REVIEW

3.1 Pinch-point (Slow Point)

Austroads (2004) defines a pinch-point or 'slow point' or 'chicane' as *"a series of kerb extensions on alternating sides of a street, that narrow and deflect the trafficable roadway – can be angled and can include a central median island or line-marking"*. A slow point is commonly installed on both one-way or two-way trafficable roadway (shown in Figure 1).

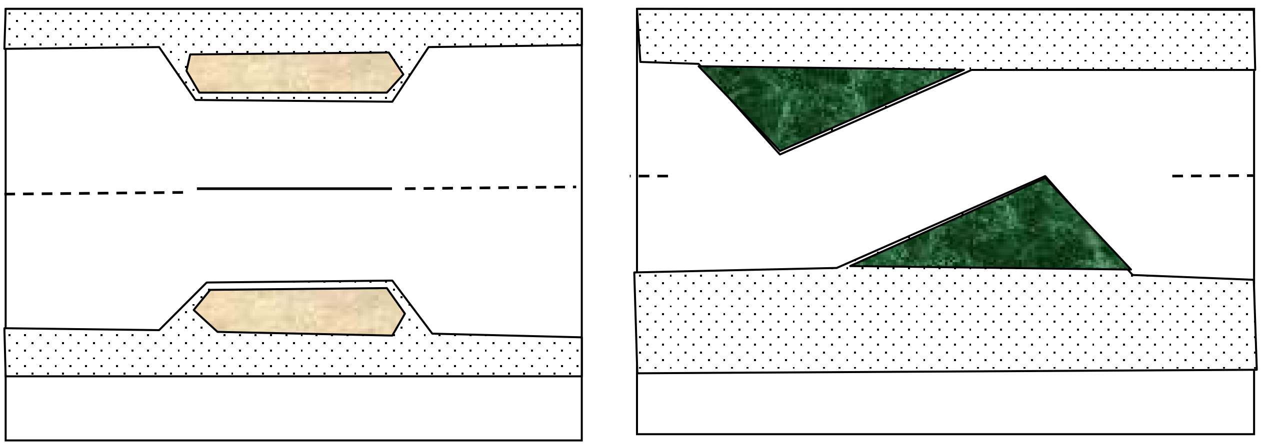

Figure 1: Typical 2-way Pinch-Point and 1-way Chicane

Some research has found that 'slow points' for single-lane and double-lane treatments will reduce the vehicle operating speed by around 20km/h on urban streets (Minnema, 2006). The accident frequency also shared a similar reduction, by up to 54%, in terms of the 'before and after' treatment. However, the single-lane slow point device may increase the risk to cyclists, if cyclists were to be overtaken by motorists within the narrowing area (Minnema, 2006).

Bus operators and representatives of the emergency services usually prefer narrowings and build-outs to traffic calming by vertical deflection (e.g. humps and platforms), particularly on strategic access routes (IHT/CSS, 2005).

Austroads (2008) provides various standards on suitable roadway width for the different road hierarchies. However, this standard does not consider two-way pinch-points as effective in slowing vehicles down. In the Christchurch City Plan (CCC, 1995), it is expected that a pinch-point device should not be over 60m in length and that there is at least 60m separation between corresponding devices further along the treated street. However, there is no current guideline on the carriageway width suitable for the type of road to be treated. The most relevant road design guideline for the City, which touches on the roadway width reduction at traffic management devices, is the Christchurch Infrastructure Design Standard [CIDS] (CCC, 2007). Part 8 of CIDS indicates that both car and bicycle could share a wide kerbside lane with a minimum width of 3.7m. However, no specific guideline has been provided for the roadway widths of 2-way vehicular traffic.

Having reviewed the various transport standards, including the most recent subdivision infrastructure standard NZS:4404 (Standards NZ 2010), it is found that most of the standards address the 1-way pinch-point device, while Austroads (2008) has indicated that 2-way pinch-points will not be effective in slowing vehicles down to achieve the intended effects. As such, this research aims to provide useful information for road designers to consider when 2-way pinch-points are used in their street calming devices.

4. STUDY METHOD

4.1 Sites Selection

In this research, it was intended to identify the road user behaviours of at least two different types of pinch-points that involved motor vehicles and cyclist movements. For the most part, reconstructed two-way roads in Christchurch City generally provide narrowings of around 6m wide carriageways. However, some of the two-way narrowing designs have been further reduced to around 4.5m to 5m in widths, such as such Banks Avenue and Draper St. Some of these street-calming treatments were later found to be overly narrowed and, due to the residents' complaints, have been amended to a wider width (e.g. Aynsley Terrace, which was designed to be 4.8m wide but has now been constructed to 5.4m in width). In some cases these devices are located close to schools, malls and high-density residential suburban districts. As such, this study included 4.5m, 5m and 6m-wide pinch-points and the selected sites are as follows:

Mansfield Ave

Mansfield Ave, a local street, provided a 6m-wide pinch-point. The geometry of this pinch-point is shown in Figure 2.

Figure 2: Mansfield Ave pinch-point

Draper Street

Draper Street, another local street, provided a 5m-wide pinch-point. This pinch-point design is shown in Figure 3.

Figure 3: Draper Street pinch-point

Banks Ave

Banks Ave was selected to test cyclists' usage. This pinch-point is 4.5m wide and the geometry of this pinch-point with a chicane is shown in Figure 4. There were no give-way signs on either approach; however limit lines were marked on both sides of the pinch-point.

Figure 4: Banks Ave pinch-point

4.2 Data Collection

One hundred and fifty travel-time samples were collected from vehicles at the pinch-points, fifty of which were collected for free-flowing (unopposed) vehicles passing the pinch-points. The travel times of these unopposed vehicles were used to compare with the 2-way (opposed) movement of vehicles to determine if there were any changes in the drivers' behaviour. At Banks Ave, one hundred samples were also collected for cyclists' behaviour at the pinch-point.

4.3 Control Vehicle Method

For the 6m and 5m wide pinch-points, a control vehicle was used to act as an opposing vehicle to identify the effect on the travel-time of the observed vehicles. The study area is shown in Figure 5. An observer was parked down the road and recorded travel times between two fixed points.

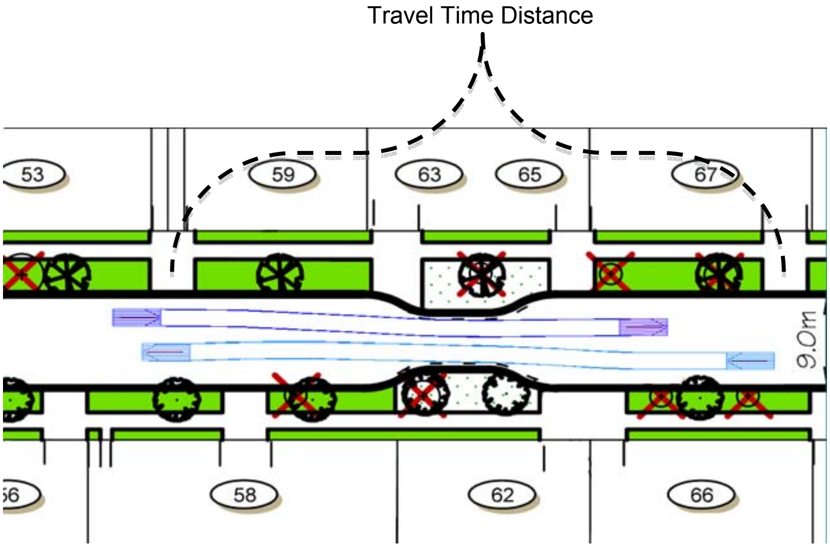

Figure 5: Two-way vehicle movements at the pinch-point

The control vehicle used in this research was a Mitsubishi Pajero (i.e. 4m in length, 1.7m in width and 1.8m in height). It was stationed at an appropriate distance from the pinch-point before initiating the approach. This distance took account of the length for the control vehicle to accelerate to a reasonable approach speed that is natural when viewed by the opposing drivers and riders. The objective of the appropriate approaching distance is to avoid the control vehicle appearing aggressive to the observed drivers.

For the 4.5m wide pinch-point, the cyclists' usage of the street calming device were recorded when other drivers were approaching the pinch-point, therefore a control vehicle was not used for this survey. Motor vehicles travelling in the same direction as the cyclists and opposing the cyclists were both observed at the pinch-point.

5. RESULTS

5.1 Comparison of Mansfield Ave and Draper Street

A summary of the mean travel times and their associated statistical analysis between the unopposed and opposed movements at the Mansfield Ave and Draper Street sites is shown in Table 1.

Table 1: Mean Travel Times for Unopposed and Opposed Pinch-point Movements

Site and Roadway Width	Mean Travel Time (and sample sizes)		Drivers Stopped & Waited	t-Test	t-Test Critical (p = 0.05)	Variance		F-Test (p = 0.05)
	Unopposed	Opposed			2-tail	Unopposed	Opposed	
Mansfield Ave (6m)	7.03s n_1 = 53	6.79s n_2 = 100	1%	t = 1.134 p=0.260 (df=151) (H_0 = 0)	1.986	1.787	1.248	*F(1.432)<Fcrit(1.472)* p(2-tail)=0.126 (df = 52,99) (No Sig)
Draper St	6.23s	9.36s	13%	t = -9.58	1.980	0.566	9.937	*F(17.370)>Fcrit(1.493)*

(5m)	n_1 = 58	n_2 = 102		*p*=0.000 (df=158) ($H_0 \neq 0$)				*p*(2-tail)=0.000 (df = 57,101) (Sig)

5.2 Mansfield Ave

At the 6m wide Mansfield Ave pinch-point, the mean travel times between the unopposed (*Mean = 7.04s, SD = 1.34s*) and opposed (*Mean = 6.79s, SD = 1.12s*) movements were very similar at around 7 seconds. The F-test comparison of the two variances yielded no significant differences ($F(52,99) = 1.432$, $p = 0.126$). The t-test comparison of the two mean travel times (i.e. at equal variance) has shown that there were no significant differences in travel time between the unopposed and opposed movements ($t(98) = 1.134$, $p = 0.26$). That means, the null hypothesis cannot be rejected; there were no significant differences between the two mean travel times of the 1-way unopposed and 2-way opposed movements.

Throughout the survey, only one driver (female) stopped and waited for the approaching vehicle (i.e. control vehicle) to exit the pinch-point before traversing the narrowing. This equates to only 1% of the opposed sample (100) not attempting the 2-way opposing movement at this pinch-point. In other words, 99% of the time the 6m wide pinch-point was not slowing drivers down even when they encountered opposing traffic at the narrowing.

5.3 Draper Street

For the 5m wide Draper Street pinch-point, the mean travel times between the unopposed (*Mean = 6.23s, SD = 0.75s*) and opposed (*Mean = 9.36s, SD = 3.15s*) movements were rather different. The mean travel times for unopposed and opposed movements were around 6 seconds and 9 seconds respectively. The F-test comparison of the two variances yielded significant differences ($F(57,101) = 0.057$, $p < 0.001$). The t-test comparison of the two mean travel times (i.e. at unequal variance) has shown that there were significant differences in travel time between the unopposed and the opposed movements, ($t(100) = -9.582$, $p < 0.001$). That means the null hypothesis can be rejected in this case. The negative t-value indicated that the mean travel time of the unopposed 1-way movement was less than the opposed 2-way traffic movements.

It was also noted that the travel times of the unopposed 1-way movements (n=58) ranged between 4.4 seconds to 7.7 seconds to complete the drive through the study area. For the 2-way opposed traffic movements (n=102), it was considered that any vehicle travelling longer than say 8 seconds (i.e. outside the range of the 1-way movement) would be the result of interruption caused by the opposing vehicle (i.e. the controlled vehicle). Based on this criterion, the survey identified:

1. 43 drivers (42%) did not slow down for the opposing vehicle,
2. 38 drivers (37%) slowed down for the opposing vehicle;
3. 21 drivers (21%) stopped and waited.

In terms of the performance of the 2-way opposing movement of traffic at the narrowing, the interruption of traffic for the 5m wide pinch-point is shown in Figure 6.

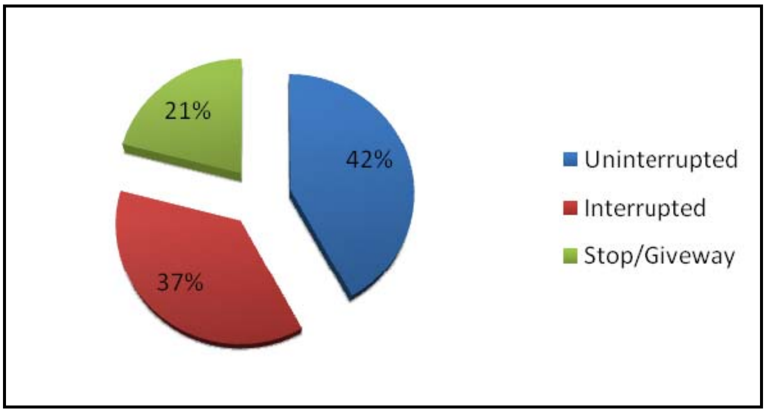

Figure 6: Two-way usage of Draper Street Pinch-point

5.4 Behaviour of Male and Female Drivers

At the 5m wide Draper Street pinch-point when no opposing traffic was present this research found that the 29 male drivers (51% of the sample) observed tended to travel through the narrowing faster than the 28 female drivers (49% of the sample). However, the opposite was found at the 6m wide Mansfield Ave pinch-point. There it was observed that the 16 female drivers (30% of the sample) recorded in the survey travelled through the narrowing faster than the 37 male drivers (70% of the sample) when no opposing traffic was present, albeit only slightly.

It was also observed that on average, the female drivers would tend not to exceed the posted speed on the road, travelling at around 47km/h at both pinch-points. Whereas for male drivers, it was observed that they were travelling below posted speed (around 46km/h) at the wider Mansfield Ave pinch-point and slightly over the legal speed (around 52km/h) at the Draper Street narrowing. It was unclear as to why male drivers have travelled slower at the wider pinch-point of Mansfield Ave and much faster at the narrower Draper Street's pinch-point when no opposing traffic was present. Nonetheless, it should be noted that the sample sizes of these comparisons were less than 30 observations per gender, therefore more data is required to further establish these behavioural trends. Figure 7 summarises the mean and 85^{th} percentile speeds of both male and female drivers at Mansfield Ave and Draper Street.

Of the group of opposed drivers on Draper Street who stopped and gave-way to the approaching vehicle (i.e. control vehicle) before traversing through the narrowing, it was observed that 30% of all the female drivers (11 of the 36 females drivers) and 15% of all the male drivers (i.e. 10 out of the 66 male drivers) were in this group. Again, the numbers are too small to draw any firm conclusions.

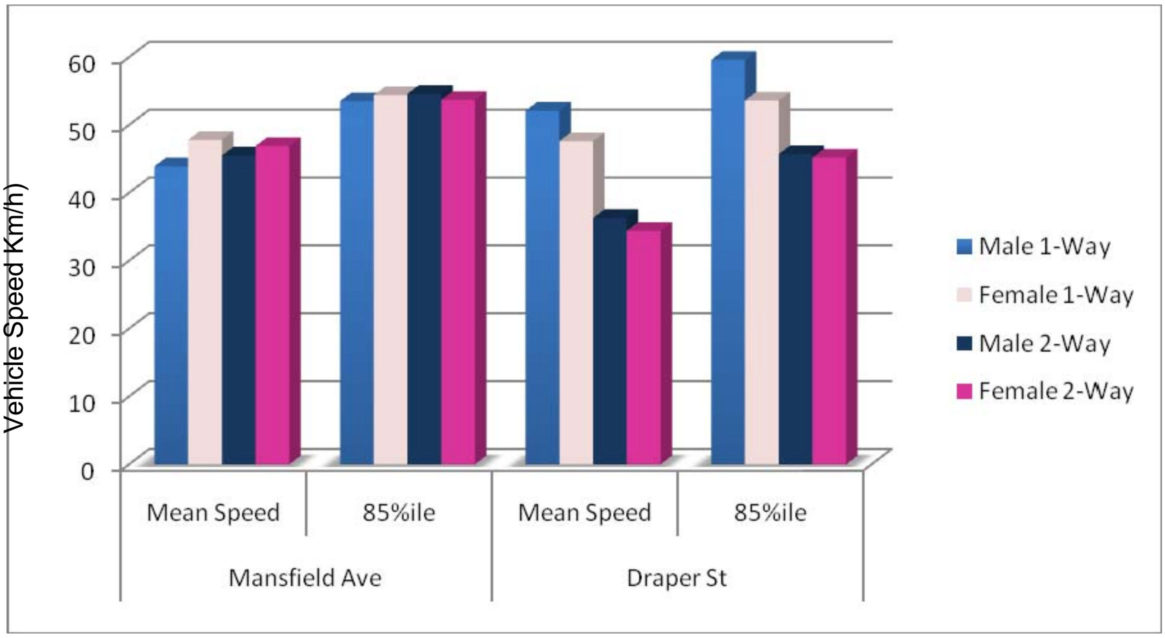

Figure 7: Travelling Speeds of Male and Female Drivers at Pinch-points

5.5 Banks Avenue

It was observed that the travel speed at this pinch-point was relatively low (around 20km/h) and the street calming device provided good sight distance for traffic on either approach, therefore both cyclists and drivers could clearly identify each other before entering the road space at the narrowing. Altogether, there were 100 observations collected at Banks Ave. Figure 8 summarises the level of usage between cyclists and drivers on the 4.5m wide Banks Ave pinch-point.

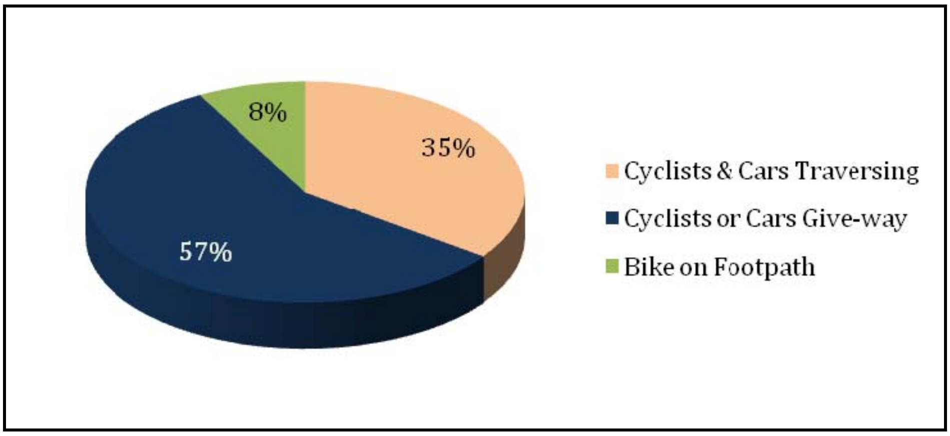

Figure 8: Drivers and Cyclists Usage at Banks Ave Pinch-point

In total it was observed that there were 35% of the road users (i.e. both cyclists and drivers) traversing or sharing the 4.5m wide pinch-point with other vehicles. It was observed that, due to the road environment (low vehicle operating speed and good sight lines) at the device, both drivers and cyclists could easily make the decision to abort entering the 20m long pinch-point with the opposing traffic if they had to. Therefore, the road users' decision to share the road space at the narrowing was considered a mutual one. It was also observed that 57% of the road users did not share the narrowing space and gave way, and 8% of the cyclists used the shared footpath bypass instead.

Of the 57% of the road-users who did not share the pinch-point (i.e. recorded not passing traffic at the narrowing), they involved 42 drivers and 15 cyclists who stopped and waited for the approaching traffic to pass before entering the pinch-point. The proportion of the give-way movements between the drivers and cyclists is shown in Figure 9.

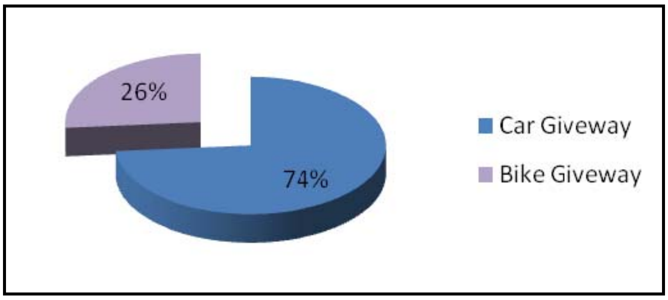

Figure 9: Road Users that Give Way

Overall, the Banks Ave pinch-point has restricted traffic movements (i.e. both motor vehicles and cyclists) at the device, especially during the peak cyclist traffic periods, which generally relate to school traffic. During these peak bicycle traffic periods the device will encourage drivers to slow down and give-way to cyclists. Based on observations, it is estimated that nearly 60% of the traffic (i.e. either motor vehicles or cyclists) gave way at the pinch-point, around 35% of the cyclists were comfortable in sharing the narrowing with motor vehicles and up to 10% of the cyclists avoided the narrowing.

5.6 Discussion of Findings

The effectiveness of the 2-way pinch-point is dependent on the carriageway width of the narrowing and also the opposing traffic volume on the road it serves. Given the lack of available guidance in the appropriate roadway width design for pinch-points,Table 2 provides a general guideline for road designers to consider. Some of this is based on the Christchurch City Council road design standard (CCC, 1995), which specifies the anticipated traffic volume for the various road hierarchy levels.

It should be noted that the study of the 6m wide pinch-point in this research only observed the light/private vehicles (i.e. approximately 1.8m wide & 5m in length), therefore it does not take into account longer and wider commercial or heavy goods (HGV) vehicles. If the road carries a reasonable level of heavy commercial vehicles, the road users' behaviour may be different.

On the other hand, it is also reasonable to conclude that a 5m pinch-point will not be suitable for roads that carry a high level of heavy commercial vehicle, which includes public transport (i.e. intended on collector roads), unless the intention is to discourage these types of vehicles on the road.

Table 2: The Effectiveness of Roadway Widths Design for Traffic Calming Pinch-points

Pinch-point Width	Road Hierarchy	Road Environment	Traffic Volume Range (VPD)	Effectiveness
4.5m (1-way)	Local Road (Urban)	Residential Streets School access	Less than 1000 vpd recommended	Based on this research, it is observed that this type of pinch-point will generally be operated as a 1-way movement for motor vehicle traffic. Only more confident cyclists are likely to traverse the narrowing with motor vehicles. Therefore, it is only recommended for street calming treatment on local roads with low-moderate bicycle traffic volumes.
5m (2-way)	Local Road (Urban)	For residential streets near business and community centres	Less than 2000 vpd recommended	The findings of this research indicate that during peak traffic periods this design is likely to discourage 'rat-runs' on the treated road. However, during the inter-peak period or when 2-way (opposing) traffic is not common, this design will not slow vehicle operating speeds.
6m (2-way)	Local Roads	Residential local roads that adjoin the commercial districts	Less than 6000 vpd recommended	It is found that this roadway width will not be effective in most residential suburban local roads for calming traffic. However, for roads with a high number of commercial vehicles and heavy goods vehicles 'rat-runs' through residential roads, it may be useful to discourage some of the through movement during the peak hours.

6. CONCLUSIONS

It was found that the 6m-wide pinch-point was not effective in significantly slowing down most private vehicles. The vehicles surveyed at this pinch-point did not slow down at the narrowing when opposing vehicles were approaching. On the other hand, the Draper Street 5m-wide pinch-point has shown that drivers will reduce their vehicle operating speeds and increase their travel times. In this case it was found that:

1. Around 40% of drivers did not slow down for the opposing vehicle,
2. Around 40% of drivers slowed down for the opposing vehicle;
3. Around 20% of the drivers stopped and waited.

In terms of what level of traffic volume is acceptable for this design, it is recommended that further research should be conducted to establish this.

The 4.5m wide pinch-point is in essence a 1-way movement for motorised vehicle traffic (i.e. non cyclist). It is found that this narrowing will encourage most of the drivers (approximately 60% to 70%) to give way to the approaching cyclists or cyclists who are already passing through the device, thus allowing the cyclists to have the right of way on the 1-way movement. Some drivers (around 35%) may treat it as 2-way movement with cyclists and, due to the low speed environment, some cyclists were observed to share the road space with the motor vehicles.

7. RECOMMENDATIONS

In terms of design practice for the roadway width design it is recommended that, for any future street calming project in a residential local street that involves 2-way pinch-points, the designer should consider using a 5m wide carriageway at the narrowing for a more effective treatment, as opposed to 6m.

For further research, it is recommended that:

- An assessment is made of the effectiveness the 5m and 6m wide pinch-points on the wider commercial vehicles and HGV movements.
- Further investigation should examine widths in between 5m and 6m (also widths slightly less than 5m), which will give some idea of when vehicles are likely to stop and wait.
- Consideration is given to the range of traffic volumes that would be effective to achieve the objectives of the 2-way pinch-point device without causing it to become a safety issue for the road users.
- It should be determined whether the length of the pinch-point changes the behaviour of road users.
- It should also be investigated whether the night-time driving environment changes the behaviour of road users
- Other roads with similar roadway widths should be investigated to see if they also share the results and findings of this research. In particular, the behaviour of drivers observed at Banks Ave should be considered elsewhere, to see whether the drivers are more likely to give-way to cyclists at the narrow road space of the pinch-point.

8. ACKNOWLEDGEMENT

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