Pedestrian Safety in Strip Shopping Centres

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1. Abstract

Strip Shopping Centres generally develop over time along major traffic routes and have high levels of pedestrian and parking activity associated with them. The complex and dynamic interaction between this traffic and land use activity often results in high crash rates along the Centre's length, with a relatively high incidence of pedestrian crashes.

The presence of strip shopping centres on arterial or major roads also tends to have an impact on the performance of the strategic road network. Considerations of road safety and the interaction between pedestrians and vehicles is important at a strategic level and the solutions may have broad impacts.

A comparative study was undertaken by the author in 2004 on three strip shopping centre sites that provided an overview of the inter-connections between traffic flow, pedestrian activity, land use, parking and crash rates. This paper builds on the findings of this study, and includes the impacts of varying the speed limit on road safety, with emphasis on pedestrian safety. Over time, the speed limit of one of the subject sites has varied from 60 km/h to 50 km/h, and more recently 40 km/h. Other infrastructure improvements have been undertaken that have impacted on traffic flow and road safety.

The paper concludes that pedestrian safety in high activity areas such as strip shopping centres is a continuing issue that must be dealt with carefully and appropriately.

2. Introduction

Strip Shopping Centres form part of the fabric of urban infrastructure and are commonplace throughout Australia and overseas. They can loosely be described as an attached row of stores or service outlets managed as a coherent retail entity, with most parking usually located on-street in front of the stores. Open canopies may connect the storefronts, but a strip shopping centre may not have enclosed walkways linking the stores. A strip shopping centre may be configured in a straight line, or have an "L" or "U" shape along a road corridor.

These centres are usually located on busy roads and have high levels of activity associated with the adjacent land uses. The main street through a strip shopping centre serves an important traffic carrying function as well as providing pedestrian access to the frontages and on-street parking supply. The complex and dynamic interaction between through traffic and land use activity often results in high crash rates along the Centre's length.

This paper presents the findings of detailed crash analysis of three strip shopping centres that front onto a common main road corridor conducted in 2004. Careful evaluation of crash rates with traffic data, parking patterns, pedestrian flows and adjacent land use was conducted at these sites and critically compared.

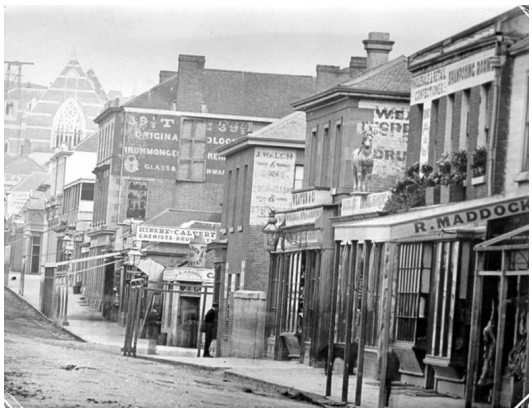
Various infrastructure modifications have been undertaken since this time at each of the three test sites. This paper focuses on the changes that have taken place in the North Hobart site during the past three years, and the impacts on traffic flow, crash rates and pedestrian activity as a result.

3. Evolution of Modern Strip Shopping Centres

Strip Shopping Centres generally develop over time along traffic routes for various reasons. Often these centres were developed prior to the widespread increased use of the private motor vehicle. This is illustrated in Figure 1.1, showing the shopping precinct of North Hobart in Elizabeth Street, where shops have developed along a major tram route (being a horse and cart track prior to this) in the early 1900's and progressively developed into a major shopping precinct.

Trams eventually gave way to the high demands of the motor vehicle, and Elizabeth Street has now become a major urban arterial road. Like many urban road corridors, the function of Elizabeth Street has evolved over time to cater for large numbers of vehicle movements. This massive increase in vehicular traffic could not have been foreseen in the early days of development of the road corridor.

Figure 1 Development of Elizabeth Street Transport Corridor



1870

1900

1940

1960

This evolutionary method of forming a major arterial road is very different to the manner that modern high traffic carrying roads are constructed. Highways and freeways are designed to carry large volumes of traffic in a safe and efficient manner – one of the benefits of these roads is that they have restricted

property access, little side friction and minimal (if any) pedestrian movements. Many urban arterial roads do not have the ability to modify access or activity from the adjacent land uses, and hence have a large array of conflicts associated with them.

Interestingly, the high traffic volumes and high associated activity in strip shopping centres appear to be dependent on each other in the sense that shops rely on passing trade of the main street, and the Centre itself provides a convenient shopping area for passing traffic. The conflict between the through traffic and Centre activity is not easily separated.

4. North Hobart Strip Shopping Centre

North Hobart is a commercial/ retail area well known for its diverse range of restaurants take away shops and cafes. The area studied for this paper is Elizabeth Street between Federal Street and Tasma Street. Numerous small boutique retail shops and medium sized supermarket/ retail shops are located within the site. The site is approximately 1.2 kilometres north from Hobart GPO. Elizabeth Street continues to the northwest into the suburb of New Town and southwest into Hobart central business district.

Numerous side streets connect with Elizabeth Street in the form of t-junctions that connect with urban residential and commercial areas of North Hobart, West Hobart and Mount Stuart. Typical views of this section of Elizabeth Street are shown in Figure 2.

Figure 2 North Hobart Strip Shopping Centre

5. Findings of 2004 Study

In order to obtain appropriate crash trends from varied forms of shopping strips in an urban environment, it would be necessary to investigate many sites with different characteristics such as type of road, number of lanes, configuration of parking, etc. It was determined to limit the study size to only consider three sites that were reasonably similar in their traffic function, land-use patterns and layout so that any crash trend similarities could be adequately determined. Three sites were selected on the basis that they could be studied in sufficient detail within the time and resource constraints of the study.

The three sites selected were all in the Greater Hobart area, and are assumed to be reasonably typical of strip shopping centres in urban environments. All three sites were contained along the same road corridor north of the central business district of the City of Hobart. The selected sites were as follows:

» North Hobart – Elizabeth Street between Federal Street and Burnett Street;

» Moonah – Main Road between Amy Street and Florence Street; and

» Glenorchy – Main Road between Elwick Road and Chapel Street.

Whilst the overall findings from these three sites is of interest, this paper focuses on the recent developments in the North Hobart site.

5.1 Geometric Comparisons of Sites

The three sites vary in their overall length, number of intersections, intersection configurations, road widths, geometry and land use function. It is important to recognise that these distinguishing features of each site may all have influences on various crash trends.

Table 1 provides a comparison of various geometric and intersection information for each site.

Table 1 Site Characteristics

	North Hobart	Moonah	Glenorchy
Road length	535 metres	840 metres	715 metres
Number of intersections	8	5	7
No. signalised intersections	2	2	5
No. T-junctions	5	3	2
No. 4-way give way junctions	1	0	0
Number of road links	7	4	6
Number of signalised mid-block pedestrian crossings	1	0	1
Average daily traffic volume (2004 volumes)	19,000 vehicles per day	21,500 vehicles per day	10,500 vehicles per day
85%ile speed (2004 measurements)	45 km/h	52 km/h	41 km/h

From Table 1, it is interesting to note that the North Hobart site has the shortest length of the three sites, but has the highest number of intersections along its length. The North Hobart site comprises of several

closely spaced T-junctions, or staggered T-junctions. In contrast to the North Hobart site, Moonah has the longest overall length and lowest number of intersections along this length compared to the other two sites.

The Moonah site carries both the highest traffic volume and the higher 85%ile traffic speed. The Glenorchy site carries the lowest traffic volume of the three sites and also has the lowest 85%ile traffic speed.

5.2 Overall Crash Findings

Six years of crash data for each site was obtained from the Department of Infrastructure, Energy and Resources (DIER), between the beginning of 1998 to the end of 2003. A total of 427 crashes were recorded along the main streets of the three strip shopping centres during that time. The overall crash types for each site is shown in Table 2.

Table 2 Crash Types

CRASH TYPE	NORTH HOBART	MOONAH	GLENORCHY	TOTAL
Rear end	40	41	46	127
Angle	39	30	26	95
Parked vehicle	23	24	19	66
Side Swipe (same direction)	20	13	27	60
Hit pedestrian	18	12	25	55
Head on	2	1	1	4
Side swipe (opposite direction)	1	2	1	4
Roll on road	1	2	1	4
Roadside furniture	0	3	1	4
Leave road	1	0	0	1
Object on road	0	1	0	1
Total	145	129	147	427

There were five prominent crash types at the selected sites. These crash types were significant in terms of their consistently high frequency of occurrence at each site. These crash types ranked in order of most to least frequent were: rear end, angle, parked vehicle, side-swipe (same direction) and hit pedestrian. The remaining crash types were significantly less frequent. Pedestrian and side-swipe crashes ranked higher than parked vehicle crashes for the Glenorchy site.

The crash rates per year and per million vehicle-kilometres travelled is provided in Table 3.

Table 3 Standardised Crash Rates

Site	Total Crashes (Jan 1998 to Dec 2004)	Average Crashes per Year	Million Crashes per Vehicle Kilometres Travelled
North Hobart	147	24.5	6.7
Moonah	129	21.5	3.3
Glenorchy	145	24.2	9.3

It can be seen that all sites have very similar crash rates per year, but the Moonah site had a much lower crash rate per million vehicle-kilometres travelled and the Glenorchy site had the highest crash rate per million vehicle-kilometres travelled.

5.3 Overview of Findings of Three Sites

The three strip shopping centres selected, whilst being on a common road corridor, had distinct differences in terms of traffic flows, pedestrian activity and land use. These sites appeared to be a good representation of urban strip shopping centres on main two-lane, two-way urban arterial roads.

Conflicts between through traffic and activity associated with the selected strip shopping centres were readily observed between through traffic, parking movements and pedestrian activity. The reduction of vehicle speeds and capacity are the most easily identified impacts of these conflicts. The conflicts also appeared to be strongly represented within the road safety performance of the sites.

The types of crashes occurring within strip shopping centres can give some indication of the conflicts present along the main road corridor. These conflicts arise due to associated land use and generated pedestrian and parking activity. There were five significant crash types at the selected sites. These were: rear end, angle, parked vehicle, side swipe (same direction) and hit pedestrian.

A strong correlation between hourly traffic volumes and total crash rates was noted at the sites. In all cases, the pattern of crashes closely followed the hourly traffic volume distribution for each site. The Glenorchy site however had the highest number of crashes of the sites, but had nearly half the traffic volume. This suggests that traffic volumes alone do not dictate crash rates at these sites. It appeared that whilst traffic volumes are linked, factors such as pedestrian movements and parking activity play a much more significant role in crash trends.

Pedestrian crashes generally had high associated severities and accounted for a significant proportion of all injury crashes across the sites. This highlights the vulnerability of these road users.

From the findings of the three selected strip shopping centres, it is clear that there are strong road safety issues associated with strip shopping centres. The combination of high traffic volumes and high activity within the centres is strongly represented in the crash histories. It is equally apparent that strip shopping centre activity impacts on traffic flow and the strategic function of the roads that pass through them. With these issues in mind, how can prioritisation of these conflicts be effectively achieved?

The 2004 study concluded that issues of road safety must take priority over road capacity and efficiency. It is not usually possible to remove either the through traffic or the associated land use activity – these two functions are too closely interconnected to be separated. It was also noted that removing unnecessary through traffic may not yield overall road safety improvements, particularly for pedestrians.

This is highlighted in the findings of the Glenorchy site, which had the lowest through traffic volume of the three sites, but the highest crash rate in terms of absolute crashes and standardised crashes by exposure.

Much work has been done to manage conflicts by well-known traffic calming and traffic management techniques. If road safety performance is to be enhanced further in these sorts of roads, further work must be done to reduce the risks associated with the conflicts, or reduce the consequences of collisions.

6. Elizabeth Street Recent Developments

Since the 2004 comparative study, several developments have occurred in North Hobart. These include:

» Reduction of the speed limit from 60 km/h to 50-km/h to 40-km/h;

» Installation of a roundabout at Elizabeth Street/ Newdegate Street/ Strahan Street; and

» Progressive upgrade of streetscape.

These modifications have been analysed at a network level to determine overall changes to road safety performance of the strip shopping centre.

6.1 Roundabout Installation

Hobart City Council installed a roundabout on Sunday 13th July 2003 at the intersection of Elizabeth Street / Newdegate Street / Strahan Street in the North Hobart strip shopping centre. The roundabout was an unusual configuration, with a small diameter mountable island, and was situated in such a way as to "combine" a set of offset 'T' intersections. The roundabout was installed to improve access to Newdegate and Strahan Streets, as well as to provide U-turn opportunities for parking circulation, and to reduce vehicle speeds.

Council designed the roundabout with consideration of pedestrian movements across all approaches. Median refuge islands were installed on all approaches and much work was done to determine the effects on pedestrians from a safety, mobility and perception point of view.

6.1.1 Roundabout Impacts on Traffic Flow

The high traffic volumes on Elizabeth Street during peak times mean that the introduction of the roundabout creates a reasonable level of queuing and delays on the Elizabeth Street approaches. Council undertook some queuing and general traffic flow observations with the following results:

» Lengthy queues were often observed on the Elizabeth Street approaches to the roundabout during the morning and afternoon peak hours, with negligible queuing on the side roads;

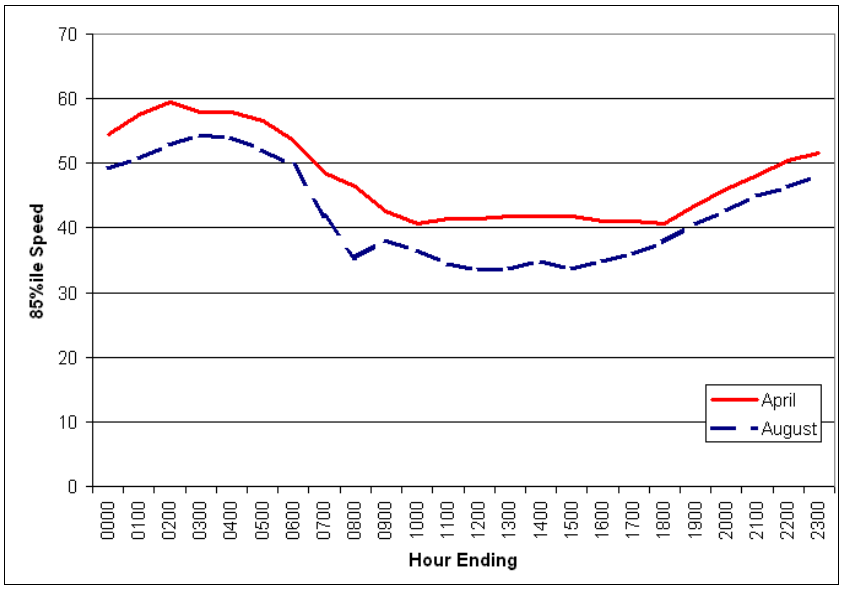
» Traffic was noticeably 'calmed' by the presence of the roundabout;

» A slightly higher volume of city-bound traffic utilised Newdegate Street to avoid congestion in Elizabeth Street; and

» A slight increase of pedestrians was observed crossing Elizabeth Street in the vicinity of the roundabout.

Traffic data was collected using pneumatic tube counters for one full week prior to and one week following the installation of the roundabout. The location was approximately 50 metres north of the roundabout. The 85%ile speeds for each hour before and after the roundabout's installation are shown in Figure 3.

Figure 3 Roundabout 85%ile speeds before and after installation



It can be seen from Figure 3 that there is a noticeable decrease in the 85%ile speeds before and after the roundabout's installation. Generally, the 85%ile speeds decreased from around 40km/h during business hours to around 35km/h, and similarly from 50-60km/h to 50-55km/h outside business hours.

Similar speed reductions were also noted along the length of Elizabeth Street through the Centre during business hours due to increased congestion generated by the roundabout.

6.1.2 Roundabout Impacts on Road Safety Performance

Four years of crash data was investigated before and after the roundabout's installation for the entire length of the North Hobart strip shopping centre site as analysed in the 2004 study. The results are shown in Table 4.

Table 4 Crash Comparison – Whole Site Before/ After Roundabout Installation

Total crashes 4 years before roundabout	**84**
Total crashes 4 years after roundabout	**87**

Severity	**Before**	**After**
Property Damage Only	52	75
First Aid Only	7	1
Minor Injury	20	6
Serious Injury	4	0
Not Known	1	5

Pedestrian Crashes	12	3

It can be seen from Table 4 that overall crash numbers have not changed significantly, with a slight increase from 84 to 87 crashes in the four years prior to the roundabout's installation and four years after the roundabout's installation. The incidence of injury crashes decreased after the roundabout's installation, as did the incidence of pedestrian crashes (reduced from 12 to 3 crashes over the four year timeframes).

On site observations suggested that the increased congestion created from the roundabout tended to provide greater road crossing opportunities for pedestrians, with traffic moving at a low speeds, or stop-start conditions, with clearly defined gaps in the flow.

Table 5 provides the results when looking at the crash impacts of the intersections directly effected by the roundabout.

Table 5 Crash Comparison – Newdegate & Strahan Sts Before/ After Roundabout Installation

Total crashes 4 years before roundabout	**10**
Total crashes 4 years after roundabout	**8**

Severity	**Before**	**After**
Property Damage Only	4	7
First Aid Only	1	0
Minor Injury	4	1
Serious Injury	0	0
Not Known	1	0

Pedestrian Crashes	2	0

It can be seen that there has been a slight reduction in total crashes in the four years before and after the roundabout's installation. It can also be seen that the incidence of crashes involving injury dropped substantially after the roundabout's construction. No pedestrian crashes have been reported at the roundabout since construction, compared to two in the four years prior.

6.1.3 Overview of Roundabout Findings

The roundabout had a significant effect of reducing vehicle speeds along Elizabeth Street. This speed reduction was noted along most of the length of Elizabeth Street during peak periods when high traffic volumes approached saturation for the intersection.

It is most likely that the decrease in vehicle speeds coupled with defined breaks in traffic flow and improved pedestrian crossing facilities was responsible for the identified road safety performance improvements.

In the context of this site, the overall road safety improvements were measured at a network level at the cost of through traffic efficiency.

6.2 Speed Limit Reductions

The posted speed limit of the North Hobart site has been reduced twice since 2002. Prior to May 2002, the speed limit through the North Hobart site was 60 km/h.

6.2.1 General Urban Speed Limit

The Tasmanian Government introduced 50-km/h General Urban Speed Limit on 1st May 2002. The General Urban Speed Limit (GUSL) was reduced from 60 to 50-km/h.

Whilst much of the Elizabeth Street/ New Town Road/ Main Road corridor retained a speed limit of 60-km/h (to maintain a collector road function), the high activity areas such as the North Hobart shopping centre were reduced to 50-km/h.

Four years of crash data were collected before and after the installation of the 50-km/h speed limit (8 years total crash data). The results in Table 6 provide the crash data summary, and indicates that the reduction of the speed limit for this site did not appear to provide any significant road safety improvements. A slight reduction of total crashes was noted, however it is possible that this reduction could be attributed to general fluctuations in annual crash rates over time.

Table 6 50-km/h GUSL Crash Summary

Total crashes before (4 years)	**104**
Total crashes after (4 years)	**99**

Severity	**Before**	**After**
Property Damage Only	77	71
First Aid	4	5
Minor	17	15
Serious	2	3
Not Known	3	5

Pedestrian Crashes	11	10

This result most likely due to the prevailing vehicle speeds being less than 50km/h during typical business hours when most activity (in terms of pedestrians and parking activity) is at a peak. The reduced speed limit therefore has little effect on the actual free flow speeds in Elizabeth Street.

6.2.2 40km/h Shopping Zone

The speed limit was further reduced to 40km/h in the North Hobart site on 9 December 2005 as a road safety initiative. This is a fairly recent type of treatment in high activity areas such as strip shopping centres and central business districts with busy roads throughout Australia. Some other examples include Bridge Road in Richmond and Swanston Street in Victoria to name a few.

Crash data was analysed for an equal time either side of this date with results shown in Table 7.

Table 7 40-km/h "Shopping Zone" Crash Summary

Total crashes before (1.6 years)	**31**
Total crashes after (1.6 years)	**49**

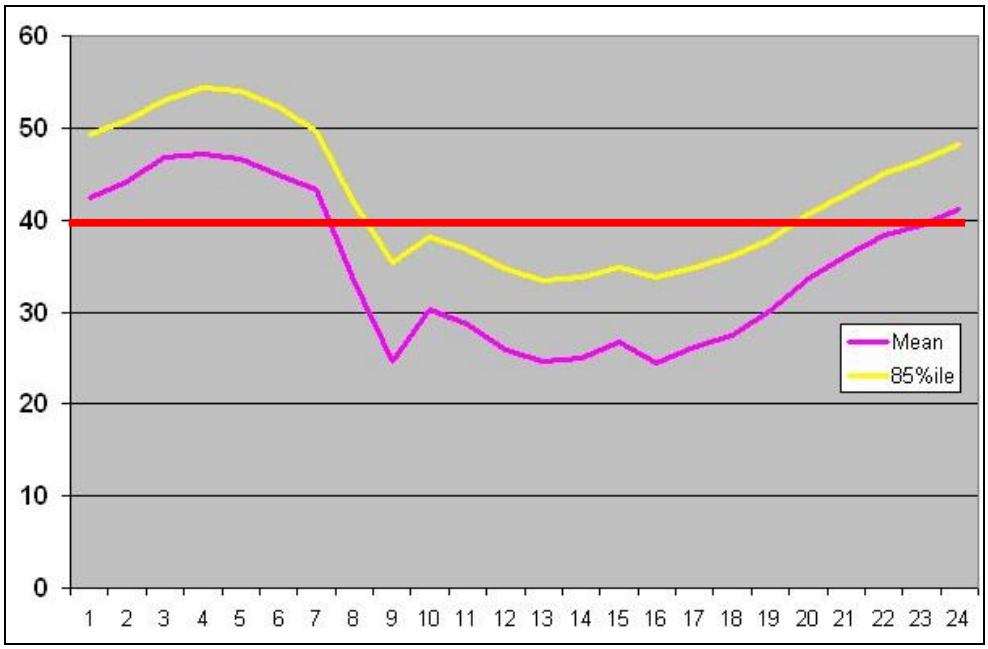
Severity	Before	After
Property Damage Only	22	40
First Aid	0	4
Minor	5	4
Serious	0	0
Not Known	4	1

Pedestrian Crashes	1	2

As with the analysis of the 50km/h installation, the impacts on prevailing speeds was not significant due to existing high traffic volumes and congestion effects reducing vehicle speeds to a level consistent with the posted speed limit. The crash trends indicate that no significant change occurred following the installation of the 40km/h zone. As with the 50km/h installation, the crash data indicates that the reduction of the speed limit for this site did not provide any significant road safety improvements, although the short period of data collection (being 1.6 years either side of the speed limit reduction) arguably does not provide enough data to draw any real conclusions from.

Figure 4 shows the comparison of the speed limit with the 85%ile and mean speeds in Elizabeth Street. It can be seen that the prevailing vehicle speeds are generally lower than the posted speed limit through general congestion effects. This means that the reduced speed limit simply reinforces the prevailing vehicle speeds, particularly during peak periods. It appears that the congestion effects play an important role in reducing vehicle speeds through this type of environment.

Figure 4 Speed Limit and Prevailing Speed Comparison



6.3 Footpath Upgrades

Provision of improved pedestrian infrastructure has been installed in the North Hobart shopping strip over the last ten years or more. This includes new paving, new kerb ramps, improved street lighting, etc.

Whilst it is difficult to quantify road safety impacts arising from these changes, the improved amenity of the site for pedestrians may increase the Centre's attractiveness for patrons.

7. Conclusions

Conflicts between through traffic and activity associated with the strip shopping centres can be readily observed between the interactions of through traffic, parking movements and pedestrian activity. The reduction of vehicle speeds and capacity are the most easily identified impacts of these conflicts. The conflicts also appear to be strongly represented within the road safety performance of the sites. Standardised crash rates in strip shopping centres appear to be much higher than for higher order traffic carrying roads as well as local streets.

The types of crashes occurring within strip shopping centres can give some indication of the conflicts present along the main road corridor. These conflicts arise due to associated land use and generated pedestrian and parking activity. There were five significant crash types at the selected sites. These were: rear end, angle, parked vehicle, side-swipe (same direction) and hit pedestrian.

A strong correlation between hourly traffic volumes and total crash rates was noted at the three sites studied in 2004. In all cases, the pattern of crashes closely follows the hourly traffic distribution for each site. The Glenorchy site however had the highest number of crashes of the sites, but had nearly half the traffic volume. This indicates that traffic volumes alone do not dictate crash rates at these sites. It appears that whilst traffic volumes are linked, factors such as pedestrian movements and parking activity play a much more significant role in crash trends.

Pedestrian crashes generally had high associated severities and accounted for a significant proportion of all injury crashes across the sites. This highlights the vulnerability of these road users and provided a focus for this paper.

The North Hobart strip shopping centre has had a number of infrastructure modifications in recent times including general footpath improvements, the installation of a roundabout, and two reductions of the posted speed limit. These changes have been reviewed in terms of traffic flow and road safety performance.

The installation of the roundabout appeared to have the greatest impact on both traffic flow and road safety performance. As a result of the roundabout's installation, vehicle speeds reduced along the Elizabeth Street corridor, congestion increased and the number of crashes and crash severities decreased. Importantly, there was also an observed reduction of reported pedestrian related crashes throughout the Centre after the roundabout's installation. On site observations indicated that the increased congestion created from the roundabout tends to provide greater road crossing opportunities for pedestrians, with traffic moving at a low speeds, or stop-start conditions, with clearly defined gaps in the flow.

The installation of reduced speed limits through the North Hobart strip shopping centre did not appear to generate any significant road safety improvements. At first glance, this result appears to be contrary to many recent studies conducted on reduced urban speed limits, but it should be noted that actual vehicle speeds are generally at or below the current speed limit of 40 km/h during business hours. The installation of the reduced speed limits therefore provides a message to motorists that prevailing vehicle speeds are similar to the legal limit. It is also considered that more data would be required to accurately quantify any road safety performance as the 40-km/h speed limit was only installed 18 months prior to the preparation of this paper.

From the findings of the 2004 study and analysis of further developments in the North Hobart site, it is clear that there are strong road safety issues associated with strip shopping centres. The combination of high traffic volumes and high activity within the centres is strongly represented in the crash histories. Strip shopping centres also have a high incidence of pedestrian crashes associated with them. It is equally apparent that strip shopping centre activity impacts on traffic flow and the strategic function of the roads that pass through them.

It is therefore considered that to improve pedestrian safety in strip shopping centres, a combination of physical modifications to reduce vehicle speeds and provide defined gaps for pedestrians to cross, and improved pedestrian crossing facilities (such as central median islands, kerb ramps, reduced crossing distances, and the like) are most effective.

Whilst this study did not find any significant road safety benefits from the reduction of the speed limit through the site, it is still considered that this type of treatment is highly beneficial. Such changes reinforce to motorists that the area high pedestrian activity, and assists in reducing high end speeds during times when traffic flow permits (ie. during non-peak times). This type of treatment may have more measurable road safety impacts on corridors with a lower traffic volume and less constrained traffic flow.

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