INJURY REDUCTION MEASURES IN AREAS HAZARDOUS TO PEDESTRIANS

STAGE 1: COUNTERMEASURE OPTIONS

by

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Abstract:
Victorians have enjoyed substantial reductions in the annual numbers of pedestrians killed after 1989. However, despite these excellent gains, the overall problem remains a serious community concern with nearly 80 persons killed and over 700 persons seriously injured in 1999. A large part of the savings appears due to a general downward trend in Victoria’s overall road toll after 1989. Pedestrians appeared to have benefited significantly from measures targeted at drivers, such as the introduction of speed cameras and a boost in random breath testing, both of which occurred in 1990. However, pedestrian crashes in high activity/commercial centres still represent a long-standing problem for which few effective solutions have been found. This report addresses the problem of high concentrations of pedestrian casualty crashes in strip shopping centres along Melbourne’s arterial roads. It is suggested that innovative and comprehensive approaches are needed to moderate excessive vehicle speeds to uniformly lower levels in environments where there is high pedestrian activity. An examination of some philosophies and practices in Denmark and The Netherlands was also undertaken. The report concludes with a discussion of the possible application of these philosophies and practices to the Victorian setting as a means of accelerating improvements in pedestrian safety.

Key Words:
Accident, Injury, Pedestrian, Traffic Engineering, Countermeasure, Speeding, Cost-benefit, Speed Limit, Road Environment.

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EXECUTIVE SUMMARY

Victorians have enjoyed substantial reductions in the annual numbers of pedestrians killed after 1989. A large part of the savings appears due to a general downward trend in the overall Victorian road toll which occurred after 1989. Pedestrians benefited significantly from measures targeted at drivers, such as the introduction of speed cameras and a boost in random breath testing, both of which occurred in 1990. Despite these excellent gains, pedestrian safety remains a serious community concern with nearly 80 persons killed and some 740 persons seriously injured in 1999.

This project addresses the problem of high concentrations of pedestrian casualty crashes along Melbourne’s arterial roads, either through strip shopping environments of where certain types of land use generate high levels of pedestrian activity. In these common urban situations, opportunities to reduce vehicle or pedestrian volumes, or to reduce road widths, are usually quite limited. Similarly, it is not practicable along many of these arterial roads to provide wide medians on order to reduce pedestrian exposure to crash risk and to simplify the road crossing task. Furthermore, many road and traffic engineering pedestrian crash countermeasures have been considered impractical because they conflict with other transport and commercial objectives.

The two remaining alternatives are, firstly, to control pedestrians so that they are separated from vehicles, either in time or space, and secondly, to moderate vehicle speeds. For many years, measures to separate pedestrians and vehicles have been widely used. For example, traffic signals are used to provide time-separation between pedestrians and vehicles. Other attempts to provide spatial separation include pedestrian bridges or underpasses, or pedestrian precincts above or below street level. These traditional countermeasures, however, have not shown the intended effect of an overall reduction in casualty crashes and have proved to be unsuccessful in terms of assuring safe passage for pedestrians. In other words, we have been unable to design and operate such systems in a manner that safely provides for pedestrians on a consistent basis.

The second alternative is to develop ways of achieving more moderate vehicle speeds in high pedestrian environments. Indeed, past research has identified vehicle speeds excessive for the conditions as a key factor in both the incidence and severity of pedestrian crashes. This project aimed to initially develop practical, new approaches to improving pedestrian safety by moderating vehicle speeds in locations known to be hazardous to pedestrians.

This report draws on the philosophies and practices of two European countries, namely Denmark and the Netherlands, both of which are known for their innovative and enlightened approaches to pedestrian safety and amenity. In the Netherlands, the consistent and systematic application of three key safety principles is vital to achieving sustainable pedestrian safety. These are:

i) functional use of the road network, by preventing unintended use of roads,

ii) homogeneous use, by preventing large differences in vehicle speed, mass and direction of movement, and

iii) predictable use, thereby avoiding uncertainty among road users.
With sustainability as a fundamental platform, the three following practices have been adopted:

i) reducing traffic volumes,

ii) reducing road widths, and

iii) reducing vehicle speeds.

The Danish also support strategies which emphasise both sustainability and safety. In Copenhagen, traffic signals are used on a metropolitan scale to moderate and regulate traffic volumes. Measures such as moderating vehicle speeds, reducing road widths, constructing kerb extensions, medians and separators are increasingly favoured. Furthermore, texture and colour of pavement is used to guide traffic and to convey a strong sense of human activity in areas used by pedestrians.

Promising opportunities for adopting Dutch or Danish philosophies are discussed in terms of their applicability to Victoria. Reducing traffic volumes along roads hazardous to pedestrians will decrease pedestrian exposure to crash risk, especially where roads are situated in busy, complex traffic environments. Reductions in road widths can potentially benefit pedestrians. Practices such as widening footpaths, protecting parking lanes and providing fewer traffic lanes result in more uniform traffic flow, reduced vehicle speeds, and reduced exposure for pedestrians on the roadway.

Treatment priorities for Victoria with the potential to moderate vehicle speeds without seriously affecting arterial road travel times were identified in this project. These treatment types are summarised in terms of the ability to meet three main criteria, namely to reduce complexity of the pedestrian crossing task, comprehensively treat a route to improve pedestrian safety, and be compatible with a shopping centre environment. Three options for moderating vehicle speed were highlighted for further evaluation. These were:

- 50 km/h Speed Zone – supported by enforcement and publicity,
- Gateway Treatments – such as road narrowing, changes in pavement texture, roundabouts,
- Street-Scape Improvements.

**SUMMARY**

To reduce pedestrian crash and injury risk, and innovative and more comprehensive approach is needed and that moderating excessive vehicle speeds to uniformly lower levels in environments where there is high pedestrian activity, offers an acceptable potentially cost-effective solution. Three options for moderating vehicle speeds without affecting travel times are proposed for evaluation.
1 INTRODUCTION

Victorians have enjoyed substantial reductions in the annual numbers of pedestrians killed after 1989. A large part of the savings appears due to a general downward trend which occurred in Victoria’s road toll after 1989, and that pedestrians benefited significantly from measures targeted at drivers, such as the introduction of speed cameras and a boost in random breath testing, both of which occurred in 1990. Despite these excellent gains, pedestrian safety remains a serious community concern with nearly 80 persons killed and some 740 persons seriously injured in 1999.

Pedestrian crash and injury risk is a function of many factors, with vehicle speeds, pedestrian and vehicle volumes, road width and road cross-section each playing a primary role. Modification to these risk factors can lead to substantial and sustainable reductions in pedestrian crash and injury risk.

This project addresses the problem of high concentrations of pedestrian casualty crashes along Melbourne’s arterial roads, either through strip shopping environments or where certain types of land use generate high levels of pedestrian activity. In these common urban situations, opportunities to reduce vehicle or pedestrian volumes, or to reduce road widths, are usually quite limited. Similarly, it is not practicable along many of these arterial roads to provide wide medians in order to reduce pedestrian exposure to crash risk and to simplify complex road crossing tasks. We are, therefore, left with two main alternatives for reducing the risks of death or serious injury to pedestrians.

The first of these alternatives involves controlling pedestrians so that they are separated from vehicles, either in time or space. For example, while traffic signals have been widely used, for many years, to provide time-separation between pedestrians and vehicles, we have been unable design and operate such systems in a manner that safely provides for pedestrians on a consistent basis. Crash records suggest that approximately 20-30% of Melbourne’s reported pedestrian casualty crashes occur at traffic signals or pedestrian crossings (Corben and Diamantopoulou, 1996). Many more pedestrian crashes occur in the near vicinity of these frequently encountered traffic control devices. Attempts to provide spatial separation between pedestrians and vehicles through infrastructure development, such as pedestrian bridges or underpasses, or pedestrian precincts above or below street level, have proven to be similarly unsuccessful in terms of assuring safe passage for pedestrians. Many pedestrians find such facilities inconvenient and/or lacking in personal security and choose not to use them. In other instances, they have been too costly to provide, other than in a few special cases.

The remaining alternative is to develop ways of achieving more moderate vehicle speeds. The nature of the relationship between vehicle speeds and the risk of fatal injury to pedestrians is both powerful and well understood. A compelling case for moderating vehicle speeds in high pedestrian activity areas is illustrated in Figure 1.1. It shows that the risk of death to a pedestrian struck at 30 km/h is around 10%, at 40 km/h about 20%, while for a pedestrian struck at 50 km/h it rises steeply to about 80%. At a 60 km/h and above collision speed, the risk of death to a pedestrian is 100%.
There are, of course, safety benefits from more moderate speeds for all road users. The risks of death or long term injury are substantially reduced by small reductions in speed, with society’s vulnerable groups, especially the young and the elderly, likely to benefit most.

1.1 PROJECT BACKGROUND

Pedestrian crashes in high activity/commercial centres represent a long standing problem for which few effective solutions have been found. While progress with the overall pedestrian crash problem has been promising since 1990, reductions in recent years appear to have been due to the general decline in fatal and serious injury crashes throughout Victoria, rather than because of programs targeted specifically at pedestrians. For example, drink-driving initiatives and the speed camera program have resulted in an overall reduction of crashes in all road user groups. Hazardous pedestrian environments thus require a concerted and innovative approach to uncover better solutions for pedestrians.

Corben and Diamantopoulou (1996) investigated arterial road locations with high concentrations of pedestrian casualty crashes and identified vehicle speeds excessive for the conditions as a key factor in both the incidence and severity of pedestrian crashes. In addition, the critical role of excessive speeds in pedestrian crash outcomes was illustrated by Mclean, Anderson, Farmer, Lee & Brooks (1994). They showed that for small reductions in travel speed from 60 to 55 km/h, there would be a
reduction in the incidence of pedestrian fatalities of approximately 30%. Furthermore, black spot program evaluations have shown that traditional countermeasures used to treat pedestrian black spots have not shown the intended effect of an overall reduction in casualty crashes (Corben, Newstead, Diamantopoulou & Cameron, 1996; Newstead, Corben & Diamantopoulou, 1997). Duarte and Corben (1998) investigated the effectiveness of pedestrian facilities used as black spot treatments and found that traditional treatment types such as pedestrian operated signals have had limited success in reducing the frequency and severity of pedestrian crashes. They concluded that proper and comprehensive initiatives to target pedestrian crash problems are required at pedestrian black lengths, and that “spot” treatments to address the crash problem occurring along a route are often insufficient.

This strongly suggests that to reduce pedestrian crash and injury risk, an innovative and more comprehensive approach is needed and that moderating excessive vehicle speeds to uniformly lower levels in environments where there is high pedestrian activity, offers an acceptable potentially cost-effective solution. Further, it is desirable that arterial road travel times not be seriously affected.

This project aimed initially to develop practical, new approaches to improving pedestrian safety by moderating vehicle speeds in locations known to be hazardous to pedestrians. The specific area targeted was strip shopping centres located along arterial roads. As a second stage in the project, the effectiveness of measures implemented in a demonstration project will be evaluated, and the method and results of Stage 2 presented in a subsequent report. Perceptual countermeasures, variable traffic signal operational strategies, variable speed limits during high risk times, modifications to reduce conflict and/or to be more consistent with surrounding land use, are examples of possible approaches to achieving safer environments for pedestrians.

1.2 OBJECTIVES

The specific objectives of this study were to:

1) reduce serious pedestrian crashes, through the development of practical new approaches to moderating vehicle speeds, thereby improving pedestrian safety in locations shown to be hazardous to pedestrians;

2) evaluate the effectiveness of recommended measures, so that the most cost-effective measures may be introduced at hazardous locations in Victoria's urban areas.

This report briefly outlines the pedestrian safety problem in Victoria. In the following chapter, some potential countermeasures are described for use in strip shopping centres. Chapter 3 describes some Dutch and Danish philosophies and practices for improving pedestrian safety. Chapter 4 discusses a wide range of potential countermeasures identified from the relevant literature and their potential use in Victoria. Last, Chapter 5 draws together the findings and presents the advantages and disadvantages of these initiatives.
2 THE PEDESTRIAN SAFETY PROBLEM IN VICTORIA

This section briefly describes the Victorian pedestrian crash situation. It quantifies the size, recent trends and the nature of the crash problem, including the main crash circumstances and contributing factors to crash occurrence along arterial routes in Melbourne.

There has been a growing awareness of the vulnerability of pedestrians in the last decade. The National Road Safety Strategy document published by the Australian Federal Office of Road Safety (1992) identified pedestrians as a group especially vulnerable to injuries sustained in road crashes. This need was further reiterated in the State of Victoria by the Victorian Road Safety Strategy ‘Safety First’ published by VicRoads, the Transport Accident Commission and Victoria Police. This document emphasised the need to improve pedestrian safety and stressed the importance of programs aimed at reducing the extent and severity of injuries to all aged pedestrians (VicRoads, 1995). This document further identified a number of high priorities including the identification of high-risk locations and the introduction of design features and engineering treatments to make roads safer for pedestrians.

As illustrated in Figure 2.1, pedestrian fatalities in Victoria averaged 144 per annum during the seven-year period between 1983 and 1989. In 1990 there was a dramatic drop to 93 fatalities per year. This new level, which steadily decreased during 1991 to 1994, represents a 43% reduction in pedestrian fatalities between the periods 1983 to 1989 and 1990 to 1994. However the number of fatalities increased again in 1995 to 84 pedestrian deaths, representing a 31% increase on the previous year. The increasing trend has not continued, however. Since 1996 the number of pedestrian fatalities has fallen to under 80 deaths, with 76 deaths in 1996 and 1999.

For crashes involving serious pedestrians injuries (see Figure 2.2), the corresponding drop in 1990 was substantial, though less dramatic at 26%, but has continued to fall in the following four years, resulting in a 33% drop from 1989 to 1994. However, after 1994 serious pedestrian injuries again increased, until a marked fall occurred in 1997. This number increased slightly in 1998 but fell again in 1999.

Using 1992 reported fatal and serious injury data and corresponding social cost estimates, annual social costs of Victorian pedestrian fatal and serious injury crashes were estimated to exceed $150m (Corben & Diamantopoulou, 1996). This estimate excludes social costs of crashes not requiring hospital admission.
2.1 CONTRIBUTING FACTORS TO PEDESTRIAN CRASHES

Studies of pedestrian crashes in Victoria showed the main predisposing factors to be alcohol, age and the road environment. Struik, Alexander, Cave, Flemming, Lyttle and Stone (1988) reviewed many pedestrian safety studies, reporting similar findings to Corben and Diamantopoulou (1996) who investigated six hazardous Melbourne arterial road lengths and found the following factors contributed to crashes in high activity centres:
1. **Pedestrian Crossing Demand** – the nature of pedestrian crossing demand in strip shopping centres is, by definition, linearly distributed. Land use development results in pedestrians choosing to cross at almost any location throughout a centre and infrequently provides a clear focus for crossing movements. Pedestrian signals and crossings are only partly effective in attracting pedestrian use.

2. **Pedestrian Compliance with Traffic Signals** – a significant proportion of pedestrian crashes appear to be due to the failure by pedestrians to comply with traffic signals. In many cases, drivers are assigned the major share of available time and road space. Pedestrians experience long cycle times, short walk times and may take two cycles to cross divided roads. Consequently, they tend to cross at high risk places (e.g., near but not at signals) and at high-risk times (i.e., against red signals).

3. **Pedestrian Interaction with Public Transport** – pedestrian crashes are often associated with public transport, especially trams, with pedestrians exposed to serious risks crossing busy arterials to board departing trams or buses. This situation is exacerbated where traffic signals unduly delay pedestrians.

4. **Pedestrian Age** – both young and older pedestrians encounter difficulty in complex traffic situations where experience and the ability to make reliable judgements and decisions are vital. Impaired sight and/or hearing, reduced agility, and greater frailty make older pedestrians particularly vulnerable in strip shopping centres where low speed reversing/manoeuvring of vehicles is both risky and common.

5. **Pedestrian Intoxication** – alcohol plays an important role in pedestrian crash occurrence and, clearly, is influenced by the nature of land use and associated road features. An investigation of alcohol-related pedestrian crashes in metropolitan Melbourne (Corben, Diamantopoulou, Mullan and Mainka, 1996) found these crashes clustered in the immediate vicinity of hotels along arterial roads, occurred predominantly at night and often involved pedestrians with very high BAC readings (e.g., >0.250).

6. **Traffic Speed** – McLean et al. (1994) found that “small differences in travelling speed can result in large differences in impact speed because braking distance is proportional to the square of the initial speed.” Further, for a reduction in vehicle travel speed from 60 to 55 km/h, a reduction in the incidence of pedestrian fatalities of around 30% is predicted. Even though many drivers travel within normal arterial road speed limits in strip shopping centres, lower speeds have the potential to reduce pedestrian injury risk over their length, without adversely affecting travel times.

7. **Pedestrians Crossing Between Queuing Vehicles** – rather than be delayed by using traffic signals, pedestrians tend to cross on the approaches to red traffic signals, often between queuing vehicles. In these high-risk situations, pedestrians may be obscured from the view of drivers (and vice versa) as they safely traverse one lane of stationary vehicles, only to be struck by a moving vehicle in an adjacent lane.
8. **Road Widths and Complexity** – wider roads and complex traffic environments heighten pedestrian crash risk, especially for young, older and alcohol-affected pedestrians.

9. **On-street Parking** – about one-sixth of pedestrian casualty crashes involve pedestrians emerging from in front of parked/stationary vehicles. While on-street parking interferes with sight lines between drivers and pedestrians, its intrinsic value to commercial centres makes it difficult to modify or remove.

10. **Conflicting Objectives in Commercial Environments** – commercial, public transport and traffic-related objectives, often conflict with efforts to improve pedestrian safety in commercial environments.

Despite past efforts to reduce the number and severity of pedestrian crashes in high crash frequency locations, they have not been particularly effective (Newstead et al., 1997), and are often frustrated by conflicting commercial land use and traffic flow objectives. It seems, however, that a balanced approach could address a sizeable portion of the urban pedestrian crash problem.

### 2.2 POTENTIAL COUNTERMEASURES

The project aimed initially to develop practical, new approaches aimed at moderating vehicle speeds, thereby improving pedestrian safety in locations shown to be hazardous to pedestrians. The specific type of environment targeted was the strip shopping centres located on arterial roads. Measures which would have minimal adverse effect on vehicle travel times were favoured.

Many road and traffic engineering pedestrian crash countermeasures for high activity centres have been considered impractical because they conflict with other transport and commercial objectives. Therefore, more innovative and flexible approaches to the pedestrian safety problem must be developed. Priority issues for countermeasure development in such environments have been described by Corben and Diamantopoulou (1997) and are noted below.

#### 2.2.1 Vulnerable Pedestrian Groups

The abilities and shortcomings of young, older and intoxicated pedestrians must be explicitly recognised in treating known pedestrian crash problems and providing safe conditions as part of new projects. Treatments should aim to simplify the traffic environment by reducing road widths, providing medians to stage crossing movements, and by reducing delays and simplifying traffic signals. High-standard street lighting helps drivers to avoid intoxicated pedestrians.

#### 2.2.2 Pedestrian Locational Preferences to Cross

To reduce delay and inconvenience, pedestrians cross at almost any location within a strip shopping environment. Pedestrian facilities at spot locations assist, but when combined with linear treatments, such as medians, pedestrian needs can be better met.
2.2.3 Public Transport Services

Safer arrangements are needed for road-based public transport users, especially of trams. With reduced delays at traffic signals, passengers can avoid undue risks crossing to “catch” the service. Also, tram safety zones should direct pedestrians to safe crossing points.

2.2.4 Crossing Width and Complexity

Reductions in complexity and crossing width assist pedestrians, especially young, older and intoxicated pedestrians. Narrower roads also tend to reduce vehicle speeds.

2.2.5 Vehicle Speeds

Higher vehicle speeds increase crash and injury risk for pedestrians. As previously mentioned, Mclean et al. (1994) found that small changes in travel speed can have a dramatic effect on pedestrian crash and injury risk, suggesting that an innovative approach is needed to moderate vehicle speeds to uniformly lower levels in pedestrian environments.

2.2.6 Pedestrian Level-of-Service

If traffic signals are designed and operated to improve the level-of-service to pedestrians, higher levels of compliance, and a consequent increase in safety, can be expected.

Having considered these priorities, especially the potential benefits of more moderate vehicle speeds, a number of criteria were developed to help in the assessment of candidate approaches or treatments. The potential for candidate measures to have the desired effect should take explicit account of the following criteria:

- reduction in pedestrian crashes;
- encouragement of greater awareness and safer behaviour among all road users, especially pedestrians;
- capacity to comprehensively address pedestrian injury risk along a given route;
- moderation in vehicle speeds;
- reduction in road width to be crossed by pedestrians;
- reduction in complexity of crossing movements;
- acceptable impact on vehicle travel times, including public transport operations;
- compatibility with shopping centre environment;
- highly cost-effective, innovative approach.
3 SOME OVERSEAS PHILOSOPHIES AND PRACTICES

This section describes some philosophies and practices of two European countries, specifically Denmark and the Netherlands, both of which are known for their innovative and enlightened approaches to pedestrian safety and amenity. This description, together with background on Victoria’s pedestrian safety problem, enables consideration of the possible application of these philosophies and practices in Victoria and elsewhere in Australia. Insights into the Dutch and Danish approaches were gained during site visits and discussions with staff of the Dutch Institute for Road Safety Research (SWOV), the Federation of European Pedestrian Associations (FEPA), the Danish Road Directorate, two municipalities in Copenhagen, and from reports and related information obtained as a result.

3.1 THE NETHERLANDS

The Netherlands is a relatively small country with a high population density. Because usable land area is highly constrained, future development recognises that there is a finite limit to the number of vehicles that can ultimately be accommodated. In essence, the Dutch philosophy is not to provide more road space than is needed, especially if this is at the expense of other activities, such as residential or shopping amenity.

The Dutch Pedestrian Association, VBV, (Jansen-Marsman, undated) estimates that, with the rapid expansion in motorised traffic activity since the 1940s and 1950s, some 30-35 times more enforcement resources are needed per kilometre of road currently, compared to fifty years ago. Notwithstanding the more automated and improved enforcement techniques now available, such enforcement levels are unlikely to be feasible or sustainable. Therefore, physical improvements, which operate continuously and require less human resources than enforcement, and are likely therefore to be more cost-effective, are likely to provide better solutions for the future.

In response to the rapid motorisation of Western Europe, VBV was formed some 45 years ago. The Association’s goals were to help pedestrians move safely in the street and to make cities and villages livable for residents and residential activities (Jansen-Marsman, undated). The Association, concerned that pedestrians have traditionally been of only secondary interest in planning, designing and operating road traffic systems (e.g., the first traffic signals did not include pedestrian displays), believes a more balanced approach is needed. In areas such as strip shopping centres, where conflict between traffic and activity functions is high, pedestrian and driver behaviour should, and can, be changed by creating the right atmosphere, and by embracing the activity function and down-playing the traffic function.

In 1996, the Dutch Government launched a new national road safety policy entitled “Towards Safer Roads” (Transport Research Centre (AVV), 1996). The policy, while acknowledging the success of traditional approaches which target high risk groups, notes that safety returns are diminishing and safety targets set for 2010 will not be met without new and innovative policies. “Towards Safer Roads” was inspired by the
Dutch not wanting the next generation to inherit a road system that causes thousands of deaths and injuries each year, nor to “respond with hindsight to the results of thoughtlessness, lack of expertise or simply afford the issue inadequate policy priority”. The new policy recommends “a more structural and preventative approach” based on the concept of sustainable road safety, with “man as the reference standard” and the traffic system being adapted to the limitations of human capacity, through proper road design, improved vehicle features, and by educating, informing and controlling road users.

The consistent and systematic application of the following three key safety principles is noted in the policy as being vital to achieving sustainable safety and to reducing implicit injury risk in advance:

i. **functional use** of the road network, by preventing unintended use of roads;

ii. **homogeneous use**, by preventing large differences in vehicle speed, mass and direction of movement;

iii. **predictable use**, thereby avoiding uncertainty among road users.

### 3.2 Denmark

In Denmark, the private car, cycling and walking modes account for similar shares of all travel. While the philosophies and principles used by the Danes for improving pedestrian safety are very similar to those expressed by Dutch experts, they do not appear to have been so comprehensively documented. As with the Dutch philosophies on pedestrian safety and amenity, the Danish practice recognises that densely populated countries cannot sustain unconstrained growth in motorised traffic. Hence, politicians have supported strategies which emphasise both sustainability and safety.

From discussions with Danish experts at both national and city levels, and from site visits and observations of pedestrian and driver behaviour, it was found that:

- traffic signals are used on a metropolitan-scale in Copenhagen to moderate and regulate traffic volumes entering the metropolitan area. The relatively unsophisticated signal system (i.e., basic traffic-actuated strategies), while offering some green-wave progression, delivers efficient traffic flow, automatic introduction of pedestrian phases and pedestrian delays rarely above 30 seconds;

- pedestrian safety programs are driven by analyses of national crash data, with special attention to high risk groups forming a significant portion of the problem;

- measures such as moderating vehicle speeds, reducing road widths (commonly to one lane/direction), and constructing kerb extensions, medians or narrow, slightly raised separators are increasingly favoured. Careful attention is also paid to pavement materials (texture and colour, especially) to guide traffic, be it...
vehicular, bicycle or pedestrian, and to convey a strong sense of human activity in areas used for shopping, business or other daily affairs.

The approaches described above are facilitated on a local or metropolitan scale, by constructing ring-roads or employing other traffic management strategies, supported by traffic signal phasing and signing, to reduce the volumes of traffic in safety-sensitive areas (e.g., shopping centres). By regulating traffic volumes to sustainable levels, rather than simply meeting the prevailing traffic demand, it has become feasible for roads to operate both safely for vulnerable road users (pedestrians and bicyclists), and efficiently for other traffic, with just one traffic lane in each direction (Hvad Sker Der I, KGS. Lyngby, 1996).

The City of Copenhagen has implemented an extensive pedestrianisation project along a network of its major shopping streets in the central area and along less significant connecting routes. Delivery vehicles are permitted, at walking speeds, during nominated hours but no private vehicles may use these streets. This approach virtually eliminates pedestrian crash risk and greatly enhances the shopping environment. Other plans for improving pedestrian safety concentrate on treating a length of arterial road passing through a variety of land uses, including strip shopping. Both the crash problem and pedestrian crossing demand are linearly distributed. The treatment plans incorporate more moderate speeds (~50 km/h), reduced road widths with a single-lane in each direction, and central refuges for pedestrians.

There are few locations where fencing has been used to prevent or redirect pedestrian movements. Pedestrian fencing contradicts the philosophies of promoting and facilitating walking, and is, therefore, regarded as an undesirable means of achieving safe pedestrian conditions. Instead, greater freedom is provided to cross safely through narrower roads, with accompanying reduced traffic volumes and lower vehicle speeds.

### 3.3 APPLICABILITY TO VICTORIA

Section 3.3 discusses the applicability of Dutch and Danish philosophies and practices to advancing pedestrian safety in Victoria and elsewhere in Australia. Both countries embrace the philosophy of sustainable road safety - the Dutch through national policy. This commitment to sustainable road safety is evident in each country’s practice of regulating the volumes of traffic entering and circulating within major cities. Similar practices apply in other major cities of the world, including Singapore.

With sustainability as a fundamental platform, the Dutch consistently and systematically apply three key safety principles, namely:

- prevent unintended use of the infrastructure;
- prevent large differences in speed, direction and mass at moderate and high speeds;
- prevent uncertainty amongst road users.
Through these principles, it has become feasible, along many roads with high levels of pedestrian activity and/or crash risk, to adopt the following practices:

- **reducing traffic volumes** by constraining vehicle growth, promoting other transport modes, such as walking, cycling and public transport, and by promoting alternative routes, such as new ring roads around sensitive activity centres;

- **reducing road widths**, through widening of footpaths, providing medians and pedestrian refuges, bicycle separation and protected parking lanes;

- **reducing vehicle speeds** to 50 or 30 km/h, depending on road function.

Without the systematic application of the philosophies of sustainable road safety and the practice of reviewing functional use of the road network to prevent unintended use, many opportunities for improving safety may not be generated nor be credited with fitting within a structured and rational approach, based on prevention and sustainability. This report contends that a concerted and innovative approach is required if real and lasting gains are to be made to pedestrian safety in Victoria’s hazardous commercial environments. Promising opportunities for adopting Dutch or Danish philosophies and practices, as a means of accelerating improvements in pedestrian safety in Victoria are discussed in the following sections.

### 3.3.1 Reductions in Traffic Volume

Reducing traffic volumes along roads hazardous to pedestrians will decrease pedestrian exposure to crash risk, especially where roads are situated in busy, complex traffic environments. Opportunities to reduce traffic volumes will be created by comprehensively reviewing the functional use of the road network, having each road’s recorded pedestrian safety performance as a decision criterion.

Of special relevance to Melbourne are the opportunities presented by numerous recent or current major road projects. Extending the Eastern Freeway and constructing City Link and the Western Ring Road offer real possibilities to re-define the functional use of roads in affected transport corridors. Such a review would result in many existing arterial roads being reaffirmed as performing an essential flow function, while others categorised as fulfilling an access function. More appropriate designation of road function to a single, unambiguous use will lead to more rational and consistent decisions and generate new opportunities for enhancing pedestrian safety.

### 3.3.2 Reductions in Road Width

Where there are high levels of pedestrian crossing activity, both Dutch and Danish practice is to widen footpaths, protect parking lanes and provide fewer traffic lanes (bicycle lanes are also common). One moving lane and one parking lane per direction typify many busy roads. The Dutch experience has been that because intersections, typically those controlled by signals, form the critical capacity constraint along many urban arterials, traffic flow is more uniform along road segments with only one lane per direction and route travel times are unaffected. Potentially, there are important benefits for pedestrians to cross the road more safely. Only two lanes of traffic (i.e., one lane per direction) need be negotiated, and vehicle speeds tend to be lower, more uniform and hence more predictable (i.e., reduced variation in speeds). In such
conditions, both crash and injury risk for pedestrians could be expected to fall substantially.

Furthermore, vehicle flow is likely to become more predictable in terms of lateral positioning of vehicles and uniformity of speed. Footpath widening in busy areas becomes feasible and highly beneficial in such circumstances. Simpler crossing tasks are needed for pedestrians, especially young and older pedestrians, so that tasks are handled sequentially, rather than simultaneously, and that sequential task demands are separated in time by reasonable durations. Narrower roads are desirable in terms of reducing the complexity of crossing tasks - a single-lane in each direction allows more predictable selection of safe gaps by pedestrians and is claimed by practitioners to have similar capacity at uniform speeds of around 30 km/h as two lanes at faster or more variable speeds. This is largely because the capacity of mid-block locations is constrained by intersection signal capacity.

3.3.3 Reductions in Vehicle Speeds

A critical safety issue for pedestrians is vehicle speeds. The Dutch and Danish philosophies recognise serious injury risks for vehicle speeds of around 30 km/h, even to a pedestrian or cyclist, to be relatively low (Wegman and Elsenaar, 1997). The general urban speed limit in the Netherlands is 50 km/h with a shift occurring to 30 km/h. Higher zones of 70 km/h are possible by exception (i.e., no access to abutting development). Motorways are zoned at either 80 or 100 km/h and are fully access-controlled. Under this new arrangement, about 20% of urban roads (the more important arterials) would be zoned upwards to 50 km/h. Reducing vehicle speeds to 30 km/h has been found not to increase travel times.

As mentioned in relation to reductions in traffic volumes, a systematic review of the functional use of roads in Victoria, incorporating each road’s recorded pedestrian safety performance as a decision criterion, will help to bring to light roads where lower vehicles speeds would be highly beneficial to pedestrians but would not adversely affect vehicle travel times on roads performing a flow function.

3.4 SUMMARY

In summary, many pedestrian safety issues and challenges faced in the Netherlands and Denmark have close parallels in Victoria, especially Melbourne. Furthermore, it is likely that some of the philosophies and practices in use in these countries could be selectively applied throughout Victoria and, indeed, elsewhere in Australia, to substantially reduce pedestrian crash and injury risk. Furthermore, while this report has focused on the pedestrian crash problem in Melbourne, primarily because it is in Melbourne where pedestrian crashes occur most frequently and are most concentrated, the opportunities to implement the European approaches described here, may be even greater in Victoria’s provincial cities and rural towns, where competition with other traffic and commercial objectives is less intense.

Finally, and importantly, Danish and Dutch attitudes towards limiting the dominance of the motor vehicle in society are not as widely held in Australia, although the Brisbane City Council has been active in pedestrianising large parts of the city and promoting walking, cycling and public transport use (Brisbane City Council,
undated). Nevertheless, *sustainable* road safety is an appealing concept and, by definition, seeks a long term answer. Its ability to accelerate Victorian’s another step closer to reducing the enormous social burden of traffic crashes, especially where pedestrians are involved, should be carefully considered and, where appropriate, evaluated in practice.
4 DISCUSSION OF COUNTERMEASURE OPTIONS

This chapter discusses a wide range of potential countermeasures identified from the relevant literature. It provides the background to the summary in Chapter 5, where advantages and disadvantages of each countermeasure are presented.

4.1 COUNTERMEASURES FOR CONSIDERATION

As set out in Table 4.1, general countermeasures were identified from the existing literature and grouped under the headings of traffic control measures and physical measures. Each is discussed in detail in the following section.

Table 4.1: Grouping of countermeasure options

<table>
<thead>
<tr>
<th>1. Traffic Control Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC1 Speed zoning</td>
</tr>
<tr>
<td>TC2 Signs - static and dynamic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Physical Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicular space and speed-related</td>
</tr>
<tr>
<td>DC1 Gateway treatment</td>
</tr>
<tr>
<td>DC2 Different carriageway pavement</td>
</tr>
<tr>
<td>DC3 Rumble strips</td>
</tr>
<tr>
<td>DC4 Roundabouts</td>
</tr>
</tbody>
</table>

| Pedestrian and vehicular space-related |
| DC5 Carriageway/lane narrowing |
| DC6 Medians - narrow/wide |
4.2 TRAFFIC CONTROL MEASURES

4.2.1 Speed zoning (TC1)

Speed zoning changes could involve reducing speed limits from 60 km/h to 50km/h and should occur in conjunction with other measures. Figure 4.1 illustrates a 50 km/h speed limit and rumble bars on an arterial road in Melbourne.

![Figure 4.1: 50 km/h speed limit and rumble bars implemented along a Melbourne sub-arterial strip shopping centre](image)

The aim of changing the speed zone is to reduce vehicle speeds on the arterial road. Cameron (1992) reports that many western European countries (namely, Belgium, Denmark, Finland, France, Greece, Holland, Italy, Spain, Norway, Germany and Sweden) have set a consistent urban speed limit of 50 km/h, with 30 mph (48 km/h) being set in Great Britain. He further reported that there is evidence that the reduction in the general urban speed limit in Denmark from 60 km/h to 50km/h was accompanied by a reduction in accidents and injuries (especially fatalities) in urban areas. However, European experience in Denmark and Norway has shown that urban speeds cannot be managed by speed limits alone, and must be implemented in conjunction with other speed reduction measures.

The potential implementation of a 50 km/h speed zone along a length of arterial road through a strip shopping centre must also consider the issue of intersecting local roads being zoned (though not signed) as 60 km/h. To this effect, the implementation of appropriately designed advisory signs on the local roads, to advise of a lower arterial road limit, may be required to supplement the 50 km/h speed zone proposal. Figures 4.2 and 4.3 show examples of lower speed limits.
Figure 4.2: Danish example of a 40 km/h zone

Figure 4.3: US example of a 30 mph (48 km/h) zone
4.2.2 Signs (TC2)

Static Sign (TC2.1)

Static signs, e.g., “BEGIN SLOWING HERE” or “SLOW DOWN NOW” at the start of the shopping centre zone may be used to prompt motorists to reduce their speed at a specific location rather than a “Reduce Speed Ahead” sign which does not provide information on where to commence reducing speed (Figure 4.4).

In their experiments, Van Houten and Van Houten (1986) found clear reductions in the percentage of motorists travelling 10, 15 and 20 km/h over the posted 50 km/h speed limit with the introduction of a sign, “BEGIN SLOWING HERE”, located 86 m (in an 80 km/h zone) from the start of the first 50 km/h speed limit sign. A simulation of a static sign targeting vehicle speed is shown in Figure 4.4. These results suggest the importance of more specific road signs in influencing the behaviour of motorists. Furthermore, the 1988 speed zoning review of principles and practice in New South Wales recommended discontinuing the use of the “AHEAD” plate in conjunction with speed restriction signs, to indicate an eminent change of speed zone.

![Figure 4.4: Simulation of static sign targeting vehicle speeds (Melbourne strip shopping centre)](image)

Dynamic Sign (TC2.2)

In the transition zone approaching the core pedestrian area within a shopping centre, dynamic message signs may be used to selectively target drivers exceeding a desirable speed. Vehicle-activated, flashing, fibre-optic warning signs using radar, microwave or detector loop technology could be used to display messages such as, “TOO FAST” or “SLOW DOWN”, to offending drivers or riders.
Larsen, Salusjarvi, Sakshaug and Nilsson (1990) reported that a trial of a sign, which flashed if a driver was travelling too fast while approaching a bend, showed that it was effective in reducing vehicle speeds through the bend, especially in wet weather.

Philips and Maisey (1989, cited in Fildes & Lee, 1993), examined the benefits of public posting of speeding behaviour on an urban arterial in Perth, which had a history of speeding and an associated high accident rate. The proportion of drivers exceeding the speed limit by more than 20 km/h decreased significantly with the advent of the feedback posting, and the effect was still evident six months after the implementation of the sign. This result was obtained with only a minimal level of obtrusive police enforcement. Rogerson (1991) found, however, that while a trial installation of an electronic roadside sign in Victoria did result in fewer drivers exceeding the speed limit during its operating period, the effects quickly dissipated, thereby raising doubts about its cost-effectiveness.

Fildes and Lee (1993) noted that feedback mechanisms of general behaviour may not be sufficient to bring about change in an individual’s behaviour, as most motorists do not perceive themselves to be “average motorists”. Hence population or average information may have little effect on their subsequent behaviour. To this effect, it was noted that, perhaps, feedback of speed violations should be aimed specifically at individual indiscretions, by either in-vehicle displays or dynamic roadside displays showing local instances of excessive speeding immediately after they occur.

Hence, a dynamic feedback sign targeting speeding drivers may increase the credibility of the sign and result in a reduction of excessive speeds. While it is desirable to reduce the proportion of drivers exceeding the speed limit, it is also highly desirable to reduce pedestrian injury risk by reducing vehicle speeds overall, even for those drivers already travelling below the speed limit.

4.3 PHYSICAL MEASURES

4.3.1 Vehicular Space and Speed Related

Gateway treatment (DC1)

A gateway treatment can be used to make motorists aware of a change in the road environment, to mark the extremities of a strip shopping centre, and create an image of the shopping centre (Westerman, Black, Brindle, Lukovich & Sheffield, 1993). Gateways can be located at either end of a shopping centre zone or the core zone, and by their design should bring about the perception of passing through a constricted “gateway” opening. Some examples of gateway treatments are given in Figures 4.5 to 4.8. Fildes and Lee (1993) reported that there are safety benefits, particularly in urban settings, to be gained from clearly informing drivers of the transition from one environment to another (e.g., rural to urban). A visual gate can be created through the various combinations of a portal/arch or canopy, tree canopy, sign-board, flagpole arrangement, special lighting etc.
Figure 4.5: Gateway treatment - canopy (Melbourne)

Figure 4.6: Gateway treatment - sails (Wellington, New Zealand)
Pavement treatments can be used in the core zone area of the shopping centre where pedestrian densities and vehicle volumes are high, to increase skid resistance for vehicles, to reduce vehicle speeds and to make both drivers and pedestrians aware of...
the potential conflict area (Figures 4.9 and 4.10). Schnull and Lange (1990) reported that changes of the road surface to rougher materials in entrance areas led to a distinct speed reduction, especially of excessively high speeds.

*Figure 4.9: Contrasting pavement - cobblestone (Denmark)*

*Figure 4.10: Contrasting pavement, reduced carriageway width (Denmark)*
**Rumble pad or rumble strips (DC3)**

Rumble strips or pads can have a marked influence on driving, through visual perceptual modification and it is argued that this type of treatment can act to reduce vehicle speed because of their “alerting influences” on the driver (Fildes, Godley, Triggs & Jarvis, 1997). Figures 4.11 and 4.12 show examples of rumble pads and bars in Melbourne.

*Figure 4.11: Rumble pad using bluestone located before a strip shopping centre (Melbourne)*

*Figure 4.12: Rumble bars located on a straight road section (Melbourne)*
Fildes et al., (1997) conducted a study which aimed to examine the effectiveness of transverse line treatments at reducing travel speeds (refer Figure 4.12). They found that transverse lines appear to have a positive effect on speed, often commencing 2 or 3 seconds before the lines are actually reached. Furthermore, the combined rumble (auditory and vibration) and visual effects, are likely to have a larger effect than a visual effect alone. However the study found that the effect of the transverse lines is less in the approach to straight road hazards (e.g., intersections) than it is for curves. It should be noted that this study only evaluated approaches to stop signs and roundabouts on straight sections. Therefore no data are available on the effects of this treatment on curved sections of road.

Gupta (1994) also examined the effectiveness of rumble strips in the US and concluded that they are effective in reducing mean speeds by up to 6.5 km/h at the first rumble strip pad. They also found that subsequent pads had less of an effect on the mean speed and recommended that rumble strips be placed prior to the location of intended effect. However, Gupta (1994) also found that rumble strips create an increase in noise level of 6 - 8 decibels. This change in noise level can vary due to various factors such as speed, vehicle types, pavement surface conditions and tyre tread and, as such, may be undesirable close to residential areas.

**Roundabouts (DC4)**

Roundabouts can be used as a gateway treatment as well as an effective speed management tool. Appropriately designed roundabouts have a permanent speed reducing effect and are an effective means of breaking-up long lengths of road that otherwise might encourage speeding. Roundabouts can achieve this without causing undue delays (Figure 4.13). Newstead et al (1997) reported dramatic reductions in casualty crash frequency and costs at black spot intersections where roundabouts have been constructed.

Herrsted (1992, cited in Fildes & Lee, 1993), reported that the effectiveness of roundabouts on vehicle speeds is mediated by the extent to which drivers are forced into a roundabout manoeuvre. Schnull and Lange (1990), Lynam (1987) and Davies (1988, cited in Fildes & Lee, 1993) also found roundabouts were successful at keeping vehicle speeds down and breaking-up the perceived “straightness” of the road.
4.3.2 Pedestrian and Vehicular Space Related

Street-scape Improvements (DC5)

By creating a street-scape that clearly signifies that changed conditions will be encountered, drivers can be encouraged to travel at speeds more compatible with the conditions. Street-scapes that reduce carriageway widths and convey a more confined feeling for drivers are more likely to produce lower vehicle speeds.

Carriageway/lane narrowing

Schnull and Lange (1990) reported that the narrowing of the carriageway had a speed reducing effect, in a study which evaluated the effects of such measures on vehicle speed on through-roads in 12 villages in Germany. An example of carriageway narrowing is provided in Figure 4.14.

Similarly, Fildes, Leening and Corrigan (1989, cited in Fildes & Lee, 1993) found that road width had a strong influence on speed perception. It was reported that there was also evidence of speed and crash reduction benefits from reduced travel lane widths, dependent on lane widths and class of road. Minimum lane widths of 3.0m or less were reported to be necessary to induce sufficient perceptual effect to ensure free speed reductions on the road. However, on arterial roads considered in this project, the minimum lane width for consideration would have to be 3.0 m, if provision is made for large commercial vehicles to use them.
Tree planting and kerb out-stands

Tree planting within kerb out-stands, in the footpath or median (Figure 4.15) have the potential to enhance the street-scape, make significant contributions to the objectives of environmental adaptation, and, with enclosed tree canopies, provide a sense of containment and encourage reduced speed (Westerman et al., 1993).
However, particular attention should be paid to power and tram lines, type and location of trees, and impact on roadside safety, visibility, and sight distance.

**Medians - narrow/wide (DC6)**

Medians assist pedestrians to cross a road by breaking a potentially complex task into two simpler tasks that can be dealt with sequentially. This is particularly beneficial for older pedestrians who experience difficulty crossing complex two-way roads. A median strip provides both a safe area for pedestrians to pause and allows pedestrians to cross busy roads in two stages (Oxley, Fildes, Ihsen, Charlton & Day, 1997). This can be achieved by delineating an area of the road where pedestrians are separated from vehicular traffic. They can be raised or flush with the pavement. Figures 4.16 to 4.19 show a range of median treatments.

In a study of mid-block sections of arterial road in Adelaide, Scriven (1986) showed that raised wide medians (about 2.9m wide) resulted in the lowest annual rate of pedestrian crashes, followed by a flush 1.8m wide painted median and a narrow, 1.2m wide raised median. Moreover, in a later study, Claessen and Jones (1994) found that where a narrow (1.8m wide) painted median was replaced by a wide, raised median, the rate of pedestrian crashes fell by 23 per cent. This would suggest that the provision of a more substantial median is safer for pedestrians, probably due to the more effective separation it provides between vehicles and pedestrians. However, it is not clear from this finding whether crash reductions were due to the increased width of the median, the raised nature or the combination of these two features.

![Figure 4.16: Narrow raised median treatment (Melbourne)](image-url)
Figure 4.17: Wide flush median - contrasting aggregate (Melbourne)

Figure 4.18: Traffic island used to create a median and narrow the carriageway (Germany)
Figure 4.19: Environmentally adapted through road (Germany)
5 SUMMARY OF PROPOSED TREATMENTS

This final chapter draws together key elements of earlier chapters, setting out the main treatment options for moderating vehicle speeds in areas which are hazardous to pedestrians. To assist in prioritising the identified options, criteria were proposed and used to arrive at a smaller set of measures, which can then form the basis for a trial. As mentioned earlier in the report, it is intended that one or more measures be implemented at a suitable location in Melbourne, or possibly in a provincial city of Victoria, and rigorously evaluated to guide the direction of future practice in this area of pedestrian safety. The results of these evaluations will be the subject of a separate report.

5.1 OVERSEAS PRACTICES

Overseas experience indicates that a comprehensive package of treatments is required to successfully target and moderate vehicle speeds, in order to reduce the frequency and severity of pedestrian crashes. The “Environmentally Adapted Through Roads” study, trialed in three towns in Denmark, involved the treatment of the main road passing through each town. Herrstedt (1992) reported speed reductions in the order of 10 km/h (for speed limits of 40 and 50 km/h) resulting from the combined effects of pre-warning signs and rumble strips, speed signs, gateway treatments, changes in road surfaces, staggerings created by lateral and central islands, roundabouts, trees and hedges and lighting elements placed at gateways. Significant reductions in crashes have also been reported (Kjemtrup & Herrstedt, 1992). Reductions of 78% in the number of seriously injured pedestrians as a result of environmental adaptation have been reported in Denmark (Engel & Thomsen, 1992). These researchers also reported that no crash migration had been observed.

As indicated in Section 3.4, many of the pedestrian safety issues and challenges faced in the Netherlands and Denmark are similar to those in Victoria, especially Melbourne, and some of the philosophies and practices in use in these countries could be selectively applied here. The opportunities may be even greater in Victoria’s provincial cities and rural towns, where competition with other traffic and commercial objectives is less intense.

While Danish and Dutch attitudes towards limiting the dominance of the motor vehicle in society are not as widely held in Australia, the concept of sustainable road safety is, nevertheless, a compelling vision for the future.

5.2 TREATMENT PRIORITIES

This project has identified a range of treatment types with the potential to moderate vehicle speeds, thus reducing pedestrian crash or injury risk, without seriously affecting arterial road travel times. Table 5.1 summarises these treatment types, along with the perceived ability of each type of measure to meet three main criteria, namely to:
• reduce complexity of the pedestrian crossing task;
• comprehensively treat a route to improve pedestrian safety;
• be compatible with shopping centre environments.

Table 5.1 also notes main advantages and disadvantages, and a cost range for each measure, to assist in the selection of a final package of treatments. As noted earlier, the performance of treatment types chosen for trial will be evaluated and the results reported in a subsequent stage of this study.

Based on an assessment of the information contained in Table 5.1 and, in consultation with members of the Project Advisory Committee established for this study, an evaluation of one or more of the following three options for moderating vehicle speeds in areas known to be hazardous to pedestrians, was endorsed in principle:

i. 50 km/h Speed Zone (TC1) - supported by enforcement and publicity

ii. Gateway Treatments - such as road narrowing, changes in pavement texture, roundabouts, etc., (DC1, DC4)

iii. Street-scape Improvements (DC5)

The next stage of the project involves the identification of locations which would be suitable for the trial of one or more of these measures. Identification of candidate locations will be carried out in consultation with VicRoads and Local Government, and will include consideration of pedestrian crash histories, the physical features of the route, and vehicle and pedestrian volumes along the route.
### Table 5.1: Summary of possible treatments to moderate vehicle speeds

<table>
<thead>
<tr>
<th>TREATMENT TO MODERATE VEHICLE SPEEDS</th>
<th>MAIN CRITERIA (Refer Table Below)</th>
<th>ADVANTAGES / DISADVANTAGES</th>
<th>COST RANGE (Refer Table Below)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 km/h Speed Zone (TC1)</td>
<td>✓ ✓ ✓</td>
<td>• more effective if supported by other measures, such as publicity, enforcement and appropriate physical changes</td>
<td>L</td>
</tr>
<tr>
<td>Static Signs (TC2.1)</td>
<td></td>
<td>• static signs may have short term benefits which diminish over time</td>
<td>L</td>
</tr>
<tr>
<td>Dynamic Signs (TC2.2)</td>
<td>✓</td>
<td>• dynamic signs may better target high-risk drivers</td>
<td>L</td>
</tr>
<tr>
<td>Rumble strips or pads (DC3)</td>
<td>✓</td>
<td>• probable increase in noise level of traffic</td>
<td>L</td>
</tr>
<tr>
<td>Medians (DC6)</td>
<td>✓ ✓ ✓</td>
<td>• dependant on available road width and presence of trams</td>
<td>M</td>
</tr>
</tbody>
</table>
| Gateway (DC1)                        | ✓                                | • potential to improve amenity, but may be costly  
• parking losses may be minimal if measures located at extremities of shopping strip | M - H                           |
| Different carriageway pavement (DC2) | ✓ ✓                             | • high costs  
• may increase traffic noise level, dependent on pavement type used | M - H                           |
| Streetscape (DC5)                    | ✓ ✓ ✓                            | • footpath widening reduces road capacity  
• tree planting limited by power and tram lines, as well as roadside safety considerations | M - H                           |
| Roundabouts (DC4)                    | ✓                                | • high costs in some circumstances  
• multi-lane roundabouts may compromise pedestrian safety, but less so if used as gateway treatments | H                              |

<table>
<thead>
<tr>
<th>No</th>
<th>Main Criteria Description</th>
<th>Cost Code</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Reduce complexity of crossing task</td>
<td>L</td>
<td>up to $15,000</td>
</tr>
<tr>
<td>II</td>
<td>Comprehensive treatment of route</td>
<td>M</td>
<td>$15,000 to $50,000</td>
</tr>
<tr>
<td>III</td>
<td>Compatible with shopping centre environment</td>
<td>M - H</td>
<td>$30,000 to $75,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>H</td>
<td>greater than $50,000</td>
</tr>
</tbody>
</table>
5.3 EVALUATION

The specific objectives of this study are to:

i  reduce serious pedestrian crashes, through the development of practical new approaches to moderating vehicle speeds, thereby improving pedestrian safety in locations shown to be hazardous to pedestrians;

ii  evaluate the effectiveness of recommended measures, so that the most cost-effective measures may be introduced at hazardous locations in Victoria's urban areas.

Two alternative approaches to evaluating treatments will be considered. One approach involves implementing and evaluating different treatment combinations, while the other entails implementing and evaluating individual treatments, one at a time, before evaluating them in combination. A decision on this matter will be taken as part of Stage 2 of this study, when one or more trial locations will be chosen and measures designed and implemented in cooperation with VicRoads and Local Government.

The evaluation will be in the form of a before-after comparison of speed profiles and vehicle travel times, following the implementation of speed moderating treatment(s).
REFERENCES


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