

Title: Pedestrian Risk Management during Urban Construction projects

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Abstract:

Pedestrian risk management during urban construction projects within densely populated areas can be very complex. This paper outlines key issues for pedestrian risk management based on casual observations made during the course of several years experience working in this field.

Understanding how to quantify and mitigate risks to pedestrian safety is an important part of construction traffic management. Unfortunately, current guidelines and standards typically are more applicable to smaller scale construction activities and suburban roads. Limited information on how to manage and assess risks to pedestrians in urban areas is available. Further research, more in depth reporting of pedestrian crash statistics and development of industry accepted risk exposure models would assist practitioners in estimating pedestrian related risks and therefore increase safety at worksites.

During major infrastructure projects, stakeholder objectives, design and contractual constraints may also impose constraints which compete with pedestrian safety. These include the minimisation of land resumption, maintaining traffic capacity, delay minimisation (limiting speed reduction), and providing vehicular and pedestrian access to properties throughout construction. The Gold Coast Rapid Transit project in Queensland is used to provide examples of pedestrian risk management issues that occur in such environments.

This paper does not aim to promote or encourage the use of specific pedestrian management solutions. Rather, it hopes to encourage further research into pedestrian risk management at urban worksites.

Keywords

Pedestrians, Construction, Traffic Management, Risk Management

Pedestrian Safety and Risk Management during Urban Construction Projects

Introduction

This paper summarises issues relating to pedestrian risk management in urban construction projects within densely populated areas. The issues raised are based on casual observations made during the course of several years experience working in this field and a limited review of available literature. The author hopes this paper will inspire additional research and development of guidelines to assist practitioners in the field of construction traffic management.

As urban infrastructure in Australia ages and our major metropolitan cities grow, upgrades and improvements will be required to provide new or improved roads, public transport and other public infrastructure. These projects are frequently located adjacent to major arterial and sub-arterial road corridors, in densely populated areas with a high volume of pedestrian traffic. The Gold Coast Rapid Transit project in Queensland is used to provide examples of pedestrian risk management issues that occur in such environments.

Pedestrian Risks Traffic and Risk Management Standards

Undertaking road and public transport construction activities in urban environments requires the safe provision of temporary footpath diversions and relocation of pedestrian crossing facilities. It also requires undertaking construction activities in proximity to existing footpaths and traffic, creating additional risks to pedestrians. Assessing these risks and providing acceptable solutions that mitigate risks is an important part of traffic management for major construction projects.

The relevant legislation and requirements for traffic management at construction worksites vary between states. In Queensland, it is a legislated requirement to apply a risk management process in accordance with the Department of Main Roads' Manual of Uniform Traffic Control Devices (MUTCD) Part 3 (Workplace Health and Safety Act 2011). Like most road authorities in Queensland, the Department of Main Roads MUTCD is based on Australian Standard 1742.3 but also provides additional details and regional context.

A review of these and other states worksite traffic management manuals finds that pedestrian management information is very limited and does not acknowledge the different risks associated with the volume of pedestrians, road environments and surrounding land uses. No guidance is provided on how to assess the risk exposure to pedestrians from traffic and construction. For example, the main requirement for management of pedestrians provided in AS1742.3 is as follows:

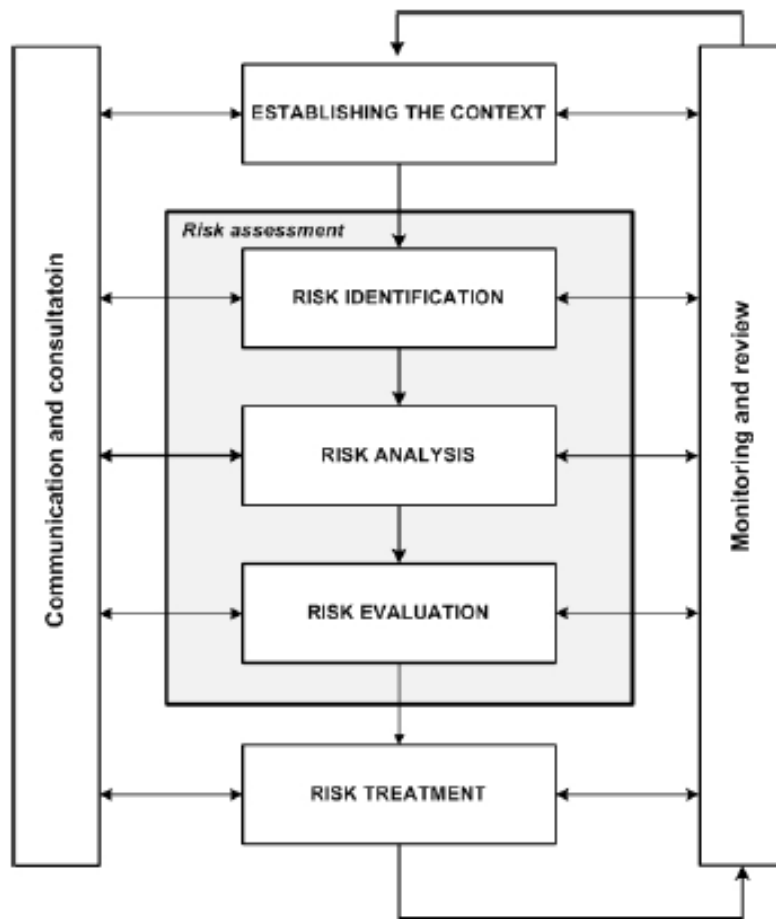
“Where there is a demand for use of the detour by pedestrians, cyclists or wheelchairs, facilities such as footpaths, cycle tracks and sealed shoulders as appropriate to the demand and the safety requirements should be provided.”

The Queensland MUTCD Part 3 provides slightly more guidance which can be summarized as follows:

- Where pedestrian traffic has been diverted onto an existing roadway the pedestrian path shall be separated from vehicular traffic. A mesh fence may be used provided that:
 - the clearance to the delineated edge of the traffic lane is at least 1.2 m and the speed limit is 60 km/h or less; or
 - the clearance to the delineated edge of the traffic lane is less than 1.2 m and the speed limit is 40 km/h or less.
 - Where traffic speeds are more than 10 km/h above the top end of these ranges a road safety barrier system shall be provided.
- Crossings shall be located as near as practicable to established pedestrian routes, and shall have the same level of function as the crossings they replace, including provisions for the people with a vision impairment.

While beyond the scope of this paper, both documents appear to be inconsistent with the Safe System approach adopted in the National Road Safety Strategy 2011 – 2020 with regard to the survivable impact speeds for pedestrians.

Austrroads has recently published several reports relating to best practices and standardisation of traffic management at a national level (Austrroads 2012). That report recommends a risk management process shown in Figure 1 and a risk identification matrix identified at Figure 2. Consideration of risks to pedestrians and cyclists is outlined as a key consideration.



Source: ISO:31000: 2009

Figure 1 – Risk Management Process Overview

		Likelihood			
		Very likely	Likely	Unlikely	Very unlikely
Consequence	Fatal	Very high	Very high	Very high	High
	Serious injury	Very high	Very high	High	Medium
	Minor injury	Very high	High	Medium	Low
	PDO/first aid only	High	Medium	Low	Low

Risk	Suggested treatment approach
Very high	Must be corrected.
High	Should be corrected or the risk significantly reduced, even if the treatment costs are high.
Medium	Should be corrected or the risk significantly reduced, if the treatment cost is moderate, but not high.
Low	Should be corrected or the risk reduced, if the treatment cost is low.

Source: AP-R403-12

Figure 2 – Risk Assessment Matrix

Understanding Pedestrian Risks

A key limitation of applying this risk management framework to pedestrians is that without detailed guidance or methodologies for consistently estimating the probability for different pedestrian risks, each practitioner is required to subjectively make their own estimation of “likelihood”. What limited risk management solutions are provided focus on the risks relating to detoured pedestrians being struck by an errant vehicle (i.e. a vehicle leaves the roadway and strikes a pedestrian either standing or walking on the footpath). This often puts practitioners in the position of determining risk by compliance (i.e. if compliance with the solutions proposed can be achieved then this is an acceptable risk). This ignores the risks associated with the volume and behaviour of pedestrians themselves, as well as the different forms of roadway crossing facility and factors such as surrounding land uses.

A review of Queensland crash statistics indicates that pedestrians accounted for 11.6% of all fatalities in the period 1 January 2006 to 31 December 2010 (QDTMR 2010). No detailed specific analysis of pedestrian crash patterns is provided in the 2010 report. From the 2009 report covering the period 1999- 2004, pedestrians are listed as most at fault about 82% of the time in pedestrian crashes and pedestrians crossing the road accounted for over 50% of pedestrian crashes (QDTMR 2009).

Other studies have found that that throughout Australia, illegal pedestrian movements accounted for between 33-45% of pedestrian crashes at signalised intersections and pedestrian signal crossings. The level of non-compliance with signalised intersection crossings at CBD locations (including Brisbane) was found to be in the order of 20-25% (King, 2008). These statistics highlight the fact that in terms of probability, illegal or uncontrolled pedestrian movements and crossings create far higher risks to pedestrians in comparison to the risks associated with errant vehicles leaving the roadway.

Several studies have looked at developing meaningful pedestrian risk exposure models, however all have limitations (Emo 2008). The development of a generally accepted and widely available

pedestrian crash risk exposure model would assist practitioners to estimate the likelihood of pedestrian related risks for estimated pedestrian volumes, traffic volumes or pedestrian/road interface (both in general and specifically at worksites).

Regardless of the availability of estimation tools, practitioners should take into account observed pedestrian behaviours and account for the additional risks created by high number of illegal pedestrian behaviours. Understanding the demographic and likely behaviours of the area in which construction will occur can assist in avoiding worksite designs that foster further illegal behaviours which may inadvertently result in higher risks associated with illegal crossings. For example, where a high number of illegal pedestrian crossings have been observed prior to construction, it is reasonable to assume the use of long pedestrian detours and physical barriers may potentially create scenarios where pedestrians will walk on the roadway (to avoid long detours) and even climb over barriers (to cross the road). By identifying these risks, additional measures can be undertaken to deter such behaviours (such as additional wayfinding signage and use of fencing or gawking screens). These introduced risks should also be documented in a risk assessment (which may find that the increased risks are acceptable given the risk mitigation benefits that barriers and detours provide).

Understanding the Temporary Traffic Barriers Limitations

The use of traffic safety barriers (or temporary traffic barriers) to separate traffic from pedestrians and workers can be a very effective method for managing pedestrian safety risks while providing for construction workspace. While not specifically the topic of this paper, it is important to understand some of the design constraints of these devices as well as the additional risks that may occur due to their use to contain or detour pedestrians around worksites.

Temporary traffic barriers are typically available in modular units that are made of either plastic modules (which can be filled with water), concrete or steel. In Queensland, a limited number of manufacturer's products have been accepted for use by the Department of Transport and Main Roads and are rated for different speed and vehicle mass impacts based on the US test standard NCHRP350. Each manufacturer provides information on the installation requirements and performance characteristics of each product, with wide ranging performance results. The two key criteria of interest to this paper are the characteristics of dynamic deflection and "length of need".

Dynamic deflection refers to the lateral distance a barrier will move under the impact of a vehicle (for a given speed, mass and angle of approach). This criteria is used to assess whether the barrier product being considered will ensure that in the event of an impact, the movement of the barrier doesn't injure a worker, or cause the barrier to fall into an excavation. As the majority of barrier products rely on mass to redirect the impact of a vehicle, a key associated characteristic is the "length of need" associated with achieving the maximum dynamic deflection specified by the manufacturer. Obviously if this length can't be achieved, the barrier performance will be substantially less. In constrained urban environments, where full length of need distance may not be achieved, estimating the risks to pedestrian safety due to barrier performance is particularly difficult.

In a 60km/h speed zone the expected deflection zone for a commonly used plastic water filled barrier is approximately 2 metres. To achieve this requires a minimum length of need of 30 metres. Concrete barriers (having higher mass) have lower deflection zone characteristics but the minimum length of need may be higher (and in addition these barriers require a separate end treatment to reduce injury in the event of an end on vehicle impact).

Manufacturers do not publish the performance characteristics of impacts with shorter sections of barrier. In many urban environments there are closely spaced driveways, intersections and pedestrian crossing facilities that must be maintained. Where the manufacturers' minimum length of need cannot be achieved it is difficult to estimate what the likely deflection zone behind a barrier might be. Another associated risk that is often overlooked is that very short sections of barriers (in particular single water filled barrier modules) have been known to become projectiles as a result of a vehicle impact. To understand the implications of this, consider that a single water filled module weighs no more than 600kg, whereas a small passenger car typically weighs 1,200kg.

Finally, as discussed previously, in some urban environments (where there are both high pedestrian volumes and pre-existing illegal pedestrian behaviours) the introduction of barriers introduces the potential risk of pedestrians climbing over barriers or attempting travel between the barrier and traffic (to make a staged crossing of the road). Although no statistics could be identified on the injuries or fatalities resulting from this type of pedestrian behaviour, the author has casually observed numerous occasions of this type of risky pedestrian behaviour. Designers of worksite barriers should be aware of such potential risks, and where it is not possible to eliminate or deter this behaviour, the introduced risks should be documented in a risk assessment.

Other Constraints on Pedestrian Safety

In the majority of road construction environments, the protection of pedestrians can be achieved by either detouring pedestrians around the works, or detouring the pedestrians between the works and traffic using a combination of reduced speed and positive barrier protection. In large infrastructure projects undertaken in complex urban environments, it is likely that there will be a number of constraints on providing an "ideal" pedestrian management solution. These constraints may come from stakeholder objectives and contractual constraints, the existing and new design feature of the infrastructure project, and the land uses and population demographic of the area the project is undertaken in. Typical constraints are likely to include:

- The economic need to minimise land resumption costs which limits space to simultaneously provide for construction activities, traffic and pedestrian movements.
- The desire of road authorities to maintain traffic capacity during the project.
- The desire of road authorities to minimise travel time delays resulting in higher speed limits than would be preferred from a construction and pedestrian safety perspective.
- Frequent, closely spaced direct property driveway access and the need to maintain continuous access to properties.
- High pedestrian volumes with multiple pedestrian desire lines and a mixture of land uses and pedestrian destinations (including public transport access).

- Demographic with higher than normal risk acceptance for illegal behaviours such as jaywalking or informal crossings (e.g. tourists, students, entertainment precincts).
- Lack of consideration of pedestrian access and safety issues during the concept and preliminary design planning stages of projects.
- Limitations of temporary barrier design and limited opportunities to provide continuous barrier protection.

Some of the pedestrian behaviours described above are examples of risks that can be inadvertently created in the attempt to minimise other safety risks. It is difficult to quantify these risks and to evaluate the balance between the increase in risks and decrease in risks associated with changes to the pedestrian environment.

While it is possible to eliminate with a high degree of certainty the risks that pedestrians have no control over (i.e. a barrier can be provided to protect a pedestrian from an uncontrolled vehicle), it is much more difficult to eliminate inadvertently introduced risks relating to pedestrian behaviour. For example, does the decreased risk of pedestrians or workers being struck by an errant vehicle (using a barrier as shown in Figure 3) outweigh the increased risk of potential consequences of pedestrians climbing over or walking around a barrier to cross a road?

As a general rule of risk management, any increase in risks associated with a particular solution are acceptable only if these increased risks are substantially outweighed by the reduction in risks the solution provides. Without quantitative evidence this is difficult to evaluate. Crash statistics indicate that pedestrians crossing the road are far more frequently involved in fatalities than pedestrian crashes involving a vehicle leaving the roadway (QDTMR 2009), but statistics indicating whether worksites contribute to a statistical increase in either occurrence could not be found. Further research and investigation into pedestrian crash statistics at worksites is needed to evaluate whether pedestrians are more likely to be killed or injured as a result of illegal behaviours (in comparison to the reduction of injuries and fatalities expected as a result of use of barriers). In the absence of further research, the use of barriers should be encouraged, but designers should document any introduced risks that are identified and evaluate mitigation options.

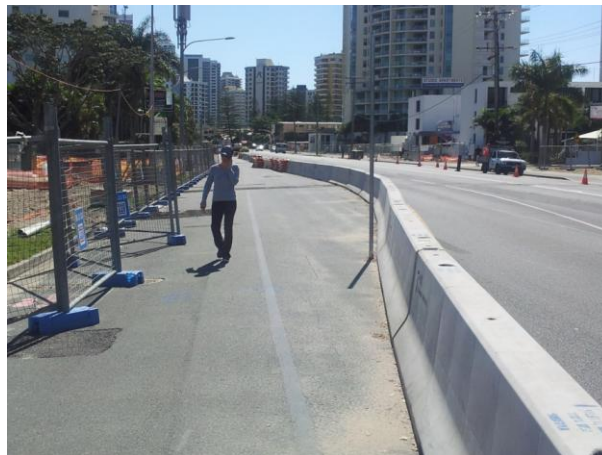


Figure 3 – Typical Pedestrian Diversion with Protection by Temporary Barrier

Case Study

The construction of the Gold Coast Light Road Roadworks South project provides several examples that illustrate some of the issues with estimating and mitigating pedestrian risks in urban environments. This project is one of several early works projects undertaken to prepare for the construction of the Gold Coast Light Rail - which will provide a 13 kilometre light rail system between Broadbeach and Southport. The Roadworks South project in the heavily populated areas of Surfers Paradise and Broadbeach involved road widening and service relocations to reconfigure two kilometres of the Gold Coast Highway for the future light rail project.

The Gold Coast Highway carries approximately 45,000 vehicles per day, and serves as one of the few north-south road connections on the Gold Coast. Land uses directly fronting the highway include permanent, semi-permanent and temporary tourist accommodation, restaurants, service stations, public parks and a fire station. The Gold Coast Highway also serves the major public transport bus services in the area. The combination of land uses and mixture of trip destinations creates complex pedestrian desire lines and pedestrian behaviours, including frequently illegal or high risk activities. Figure 4 illustrates the density of the project environment (the Gold Coast Highway runs directly up the centre of the image)

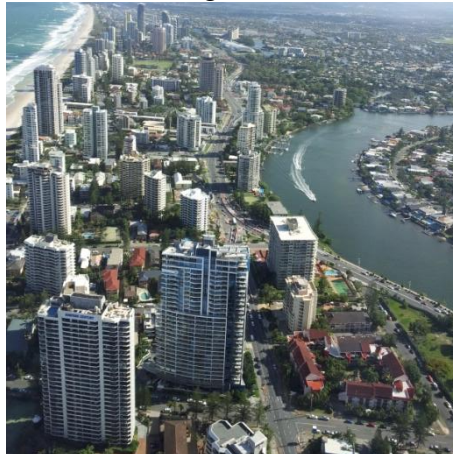


Figure 4 – Aerial View of the GCRT Roadworks South project

A large proportion of pedestrians in this area are tourists (both international and domestic) who are unfamiliar with the land uses and pedestrian network in the area. Some pedestrians may be unfamiliar with Australia traffic rules, while in general holiday makers may simply be less likely to comply with traffic rules due to a variety of reasons. This is particularly an issue at night, with high numbers of intoxicated pedestrians (due to the proximity to entertainment areas of Surfers Paradise) being much more likely to take increased risks, and make illegal crossings or undertake risky activities as pedestrians.

These factors, in combination with the mixture of land uses and need to provide temporary pedestrian detours while maintaining a high level of property access, result in high levels of risky pedestrian behaviour. Casual observations by the author during the Gold Coast Rapid Transit have included the following pedestrian behaviours:

- higher than usual jaywalking activity

- risky pedestrian behavior (e.g. using double barrier lines as refuge point while crossing highway in peak hour traffic) – see Figure 5
- pedestrians climbing over barriers to cross the road
- pedestrians walking on the traffic side of the barrier (in order to short cut a detour)
- pedestrians walking on top of barriers (for amusement)



Figure 5 - Risky Pedestrian Behaviour

Where it is not physically possible to provide a pedestrian detour around or through (due to the size, location and method of the works, the use of temporary scaffolding structures should be considered as an option. The design of such temporary structures needs to consider gradients for disabled access, however there may be situations where some compromise on gradients may need to occur. An example of this is the structure shown in Figure 6. This structure was constructed over a private property (with the owner's permission) in order to allow the construction of a 4m by 2m Telstra pit in an existing verge of only 4m. Pedestrians couldn't be diverted onto the roadway as works on the other side of the highway prevented any further traffic switching. As the property shown in the photo is separated from the verge by a retaining wall approximately 2 metres in height, the structure needed to ramp up and around the worksite. As the alternative (to close the footpath an attempt to detour pedestrians via backstreets) would have lead to high risk pedestrian movements, a compromise needed to be made on the grade of the ramp.



Figure 6 - Temporary Pedestrian Structure

Consideration of Pedestrian Risks and Questions for Additional Research

This paper does not aim to promote or encourage the use of specific pedestrian management solutions. Rather, it hopes to encourage further research into pedestrian risk management at urban worksites. The following questions are provided as both a source of potential research topics and to provide some guidance for considering pedestrian risks in urban construction projects.

1. What are the quantitative risks to pedestrians at worksites? Can the risks associated with various metrics and characteristics of each specific environment be estimated using quantitative methods? Can risk exposure models be developed that account for pedestrian volumes, demographics, land uses, roadside environment and traffic volume?
2. Will lowering existing speed limits be accepted politically and will drivers comply with lower limits (if no changes other than signage are made)? What is an appropriate road speed for pedestrian roadsides?
3. Is the volume of pedestrian movements high? Where do the majority of current legal and illegal pedestrian movements currently occur? Will these locations be impacted by worksites?
4. How high is the volume of pedestrians outside of working hours?
5. Do adjacent land uses and pedestrian demographics indicate that pedestrians are more likely to engage in high risk behaviors (e.g. is the location near an entertainment district, a school, a holiday destination)?
6. How far apart are formal crossing opportunities if a detour is put in place? Regardless of actual detour distance, are pedestrians likely to perceive the detour to be an inconvenience and take risks to reduce perceived inconvenience?

7. Can temporary barriers be installed in accordance with manufacturer's recommendations? If not, can an assessment be made on the potential deflection characteristics of the barrier? What are the quantitative risks of barrier deflection and movement associated with pedestrians (as opposed to workers)?
8. Would the introduction of a barrier break an existing pedestrian desire line, or create a potential for pedestrians to walk on the highway or climb over the barrier?
9. What level of pedestrian protection is provided in the existing situation by standard barrier kerb?
10. Can pedestrian desire lines be changed or discouraged through pavement markings, wayfinding or educational signage?
11. Is lighting sufficient for the proposed temporary detour? Have Crime Prevention Through Environmental Design (CPTED) principles been considered?
12. Would a temporary structure provide an alternative detour route? What property access and ownership and liability issues would prevent the use of a structure?
13. Have any introduced risks associated with illegal pedestrian behaviours been documented in a risk assessment process and strategies to mitigate these introduced risks been considered?

Conclusion

Understanding how to quantify and mitigate risks to pedestrian safety is an important part of construction traffic management. Unfortunately, current guidelines and standards typically are more applicable to smaller scale construction activities and suburban roads. Limited information on how to manage and assess risks to pedestrians in urban areas is available. Further research, more in depth reporting of pedestrian crash statistics and development of industry accepted risk exposure models would assist practitioners in estimating pedestrian related risks and therefore increase safety at worksites.

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