TECHNICAL PAPER

SHARED PATH WIDTHS

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ABSTRACT

Shared paths are off-road facilities for cyclists and pedestrians (including walkers, runners, skateboarders, mobility scooter users, people with pushchairs, etc). Despite the commonness of the shared path, little guidance on its design is currently available in terms of the width of paths in relation to the numbers of pedestrians and cyclists who use the path. The effects of mixing pedestrians and cyclists deserve careful consideration. The difference in speeds of the two modes, compounded by the bi-directional nature of shared paths, can reduce the level of service for all users if paths are not properly designed.

ViaStrada has recently undertaken significant research on behalf of VicRoads, the roading authority for Victoria, Australia, to determine appropriate path widths based on user types and volumes. An international literature review identified the Shared Use Path Level of Service (SUPLOS) calculator, commissioned by the USA's Federal Highways Administration (FWHA) as the most relevant method available. ViaStrada and SKM, Melbourne have since made several modifications to the original SUPLOS approach, including provision for tidal flows (i.e. different volumes in each direction of travel at different times of day) to make it more suitable for Australasian paths.

This paper details the investigations, tool development and ultimate conclusions of the research.

INTRODUCTION

Shared paths (referred to as "trails" or "greenways" in some countries) are off-road paths for cyclists and pedestrians. On shared paths both cyclists and pedestrians are allowed to use the same part of the paths. Some shared paths have a central line separating directions of travel, others allow users to travel in any direction anywhere on the path.

For various reasons, generally volume considerations, it may be preferable to segregate path users by use of paint markings or different surface types to delineate different areas for pedestrians and cyclists. Segregation allows users to move between the two areas if required, for example to pass or overtake a large group. At a higher level, pedestrian and cycle paths can be physically separated so that users do not deviate onto each other's path. Shared, segregated and separated paths should be considered as alternative options to determine the most appropriate solution for a specific location.

Despite that fact that the shared path is a common off-road facility in Australasia, only limited guidance on its design is available. The effects of mixing pedestrians and cyclists deserve careful consideration. The difference in speeds of the two modes, compounded by the bi-directional nature of shared paths, can have undesirable consequences if paths are not properly designed to accommodate the users. This has been highlighted in a recent tragedy in Melbourne, when a cyclist died as a result of a crash after avoiding a pedestrian on a shared path and a number of years ago when a pedestrian was killed in a collision with a cyclist on a shared path in Hamilton. In these cases, design flaws, either in terms of insufficient width or other factors such as visibility, may have contributed to the collisions.

This paper is based on research undertaken in Melbourne, Australia. The resulting guidance has not yet been adopted in Victoria, nor has it been assessed in a New Zealand context. However, we expect that it should be applicable to New Zealand, possibly with some minor calibrations required.

SHARED PATHS

User Types and Characteristics

Shared paths cater for a number of different user types. Generically, they cater for cyclists and pedestrians, but the term "pedestrian" can include a multitude of different sub-modes for example, walkers (including the very young and the very old), walkers with dogs (leashed and unleashed), runners, skateboarders, roller-skaters, wheelchair users and mobility scooter users. The term "cyclist" is also a wide-ranging concept – with a pre-school child on a tricycle at one end of the spectrum and an experienced adult on a fast road cycle at the other.

It is difficult to determine the travel speed of the "average" cyclist or "average" pedestrian as this is dependent on the user's ability and inclinations and on trip purpose (e.g. commuting or recreation). Thus modelling the interactions and flows on a shared path is a complex task. It is arguably more straightforward to model motor vehicles on a road as these can generally be represented according to a single distribution with a certain average speed and standard deviation (and other inherent distributional parameters such as 85th percentile speed). For shared paths, however, each of the sub-modes has its own distributions, often with higher variability than motor vehicles as personal ability and confidence is more likely to determine an individual user's speed than a designated speed limit.

User Interactions

There are two basic forms of interaction that occur between users on shared paths; passings and meetings. Passing occurs between two users travelling in the same direction whereas meetings occur between two users travelling in opposite directions. Due to modelling complexities, we have limited this analysis to midblock sections and are thus not concerned with interactions at intersections of paths.

When considered from the point of view of a specific path user, passing can be either active or passive. An active passing occurs when the subject path user overtakes another path user travelling in the same direction. Active passings either occur smoothly or involve a delay component if the presence of other users or path geometry prevents the passing from occurring at the desired time and location. Passive passing occurs when a path user is overtaken by another user travelling in the same direction. Figure 1 illustrates the various possible interactions between users on a shared path.

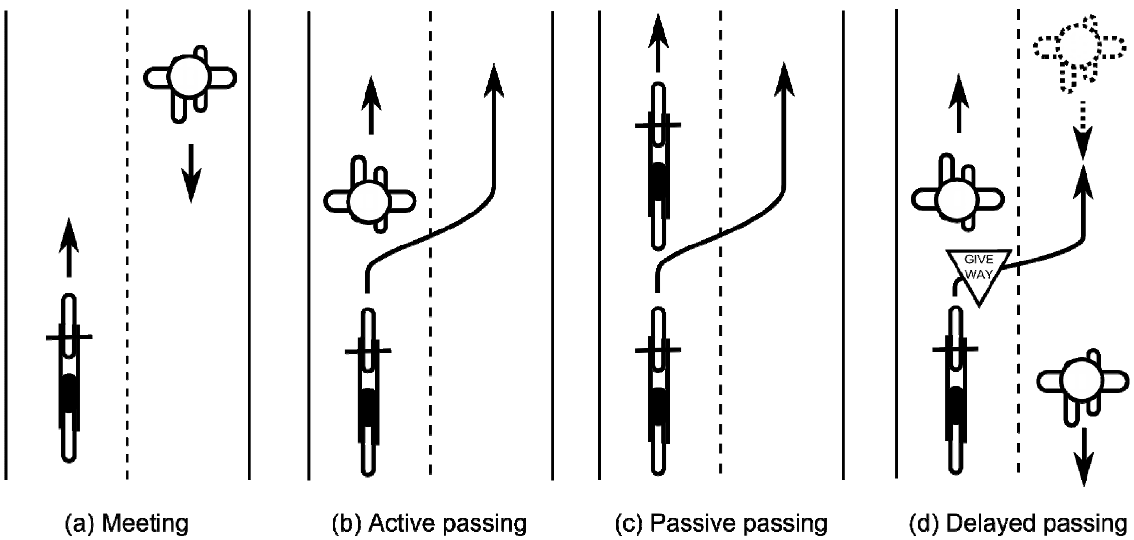


Figure 1: User interactions on a shared path

Delay is a critical factor in determining path users' efficiency, safety and enjoyment; thus immediate passing is preferred over delayed passing.

Passings involve a higher degree of uncertainty and therefore discomfort to users than meetings, due to the relative directions of travel of the users involved in the two situations. The user being overtaken in a passing may not have much advance warning and may feel uncomfortable when the passing occurs. The user performing the overtaking manoeuvre can feel uncomfortable because they cannot make eye contact with the person they're passing and may be worried they will move into their way. In a situation where users keep to the left, the person passing will have to move to the right side of the path, which can feel awkward, especially in high volume situations. For meetings, on the other hand, both users usually have clear visibility of the situation and advance warning. They can make eye contact and generally negotiate a suitable course of travel without either user having to significantly change their alignment or speed.

Travel Directions

Like many major roads, paths used by commuters are likely to be tidal in nature; i.e. a heavy flow towards the CBD or other major workplace locations in the morning and a heavy flow away from the CBD in the evening. The higher the tidal nature of the path, the higher the proportion of passings to meetings in terms of total user interactions becomes. However, if a meeting occurs at the same time as a desired passing, the user trying to pass is delayed further. This affects users' appreciation of the path due to the preference of meetings over passings.

Some paths will have relatively balanced flows in either direction during the peak periods. Such paths are likely to be recreational paths, where the peaks occur at weekends or outside of work hours. Paths within the CBD or in other areas where commuting occurs in both directions during the peak hour may also experience non-tidal peak flows.

LEVEL OF SERVICE

The most appropriate way to determine shared path width would be to relate it to user safety. However, there are few data available regarding crashes and conflicts on shared paths. This is partly because of the absence of crash reporting and data collection mechanisms for non-motorised traffic. Low travel speeds of path users also mean that crashes are relatively rare and generally of low severity. Thus it is difficult to model path performance in direct relation to safety and a proxy measure must be used. This paper assumes that Level of Service (LOS) is the most appropriate proxy measure for safety when determining path widths.

LOS is a way of attempting to quantify the quality of use experienced by a facility user. It is commonly used in road modelling based on motor vehicle delays and queue lengths. For shared paths delay can also be a critical component in determining LOS but is likely to be more subtle than for road modelling in that delayed path users are those forced to travel at slower speeds rather than being stopped altogether. Queues are uncommon and other more subjective factors are also likely to be of importance to non motorised path users.

Positioning is an important factor. Path users prefer to be able to travel along a desired alignment without having to change course to negotiate other users.

Path users also value predictability – the ability to see other users well in advance and easily predict their movements and behaviour. If there is poor predictability "dilemma zones" are likely to develop where path users experience periods of indecision when determining the best way of avoiding conflict with other users or obstacles and they may have to stop completely.

The level of cognitive demand a path places on its users is also important. Path users generally want to be able to perform additional tasks, for example looking at scenery, riding or walking side by side or communicating with other users. Other activities such as using a cell phone or riding hands-free can also indicate path users feel comfortable on a path and the riding or walking experience itself does not demand their full concentration.

EXISTING DESIGN GUIDANCE

We investigated current New Zealand and international standards and guidelines relating to the determination of shared path widths.

New Zealand paths are generally designed according to the Austroads Guide to Traffic Engineering Practice part 14: Bicycles (Austroads, 1999 – referred to as "GTEP part 14") and the corresponding NZ Supplement (Transit New Zealand, 2005). At the time of this research the new Austroads design series had not yet been released but we note that it does not offer any more quantitative guidance for shared path design than what is in GTEP part 14.

The guidance given in GTEP part 14 is vague. Seven scenarios for different path types are given, but these rely on qualitative levels of use ("low", "heavy", "frequent" etc) that do not have any defined values. If volumes are important in determining width they should be quantified to aid consistency of design. For example, what is considered to be "low usage" in Christchurch may well be considered "heavy usage" in Whanganui.

GTEP part 14 also provides little advice relating to whether paths should be shared, separated or segregated. The NZ Supplement provides no additional advice on the topic of shared paths.

From our review of international guidance, we found little quantitative guidance for determining the widths of shared paths elsewhere in the world. Of the international guidelines reviewed, most recommend that the determination of a shared path's width depends on the volumes of cyclists and pedestrians using it. However, like GTEP part 14, very few international guidelines quantify the user volumes that warrant certain path widths. The most comprehensive guidance available is a spreadsheet tool named SUPLOS (Shared Use Path Level Of Service) recently developed for the USA Federal Highways Administration (Patten et al, 2006).

The SUPLOS calculator gives a level of service (LOS) for a segment of two-way shared path. It was developed by the US Department of Transportation Federal Highways Administration based on European traffic flow theory and LOS guidelines from the Highway Capacity Manual and calibrated according to observational studies of 15 shared paths throughout the United States. Several variables were used to calibrate the LOS model including the number of desired and actual passings and meetings, speed distributions of different user groups, path characteristics and users' perceptions of the path's adequacy.

The SUPLOS calculator was designed to evaluate the LOS (ranging from A to F) of existing or planned paths based on four main factors:

1. Path width;
2. Design hour user volume;
3. Presence of centreline dividing directional lanes (a yes/no variable); and
4. Mode split (adult cyclists, child cyclists, pedestrians, runners and in-line skaters).

SUPLOS assumes a balanced flow in each direction. While mode split is an important component of the calculator, the LOS produced is intended from a cyclist's perspective, although the developers suggest that it is generally appropriate for all users.

MODEL DEVELOPMENT

We determined that the SUPLOS model developed in the USA may be a useful starting point to create an Australian or New Zealand model but validation was required. Teams from ViaStrada (Christchurch, NZ) and SKM (Melbourne, Australia) each worked on this validation process, first independently and then collaboratively to develop a model suited to the Melbourne context. The model has not yet been tested in New Zealand but we expect similar results to apply.

The SUPLOS calculator was designed to evaluate LOS based on various inputs, one of which being path width. However, the process used in SUPLOS can be manipulated to determine the appropriate width required to achieve a target LOS for given user volumes and mode split characteristics.

SUPLOS assigns relative weightings to active passings, delayed passings and meetings. Delayed passings were identified as being by far the least desirable. These factors were based on user perception surveys on the 15 USA paths studied. We predicted that Australian (or New Zealand) users are likely to behave differently and place different emphasis on the various components of LOS. Australia and New Zealand have higher cycle commuting rates than the USA, where paths tend to be mainly for recreational use, which affects users' perceptions. Commuters are more likely to place a higher value on travel time and therefore their LOS is more susceptible to delays incurred.

The SUPLOS model showed delayed passings to be by far the most influential form of user interaction on LOS. Based on our professional experience and site observations we concurred with this and decided to simplify our model to include only delayed passings. We assumed that delayed passings are most likely to pose safety hazards due to the user being passed not being able to see the passing user. The delayed user is also likely to get frustrated which decreases their LOS and makes them more likely to perform unsafe manoeuvres thus decreasing the path safety. Thus we used delayed passings as the measure of LOS.

The model worked on the premise that the act of having to slow down and wait for a passing opportunity is more critical to cyclists' LOS than the actual amount of time spent waiting. Thus it assessed the number of delayed passing events rather than the total time delayed. A threshold of 12 delayed passing events per hour was used as the maximum tolerated by the "average" cyclist. If a certain path width produced more delayed passing events than the threshold a wider path would be required.

We initially assumed that the SUPLOS calculator's assumption of flows split equally in either direction would severely limit is applicability to Australia and New Zealand. As opposed to paths in the USA, which are highly recreational, paths in Melbourne and New Zealand are highly tidal due to the prevalence of commuter cycling. Thus we produced a model that allowed different directional splits to be modelled. The modelling showed that the 50/50 directional split scenario was actually the worst case due to the effect of users travelling in the opposing direction delaying those desiring to undertake a passing manoeuvre. While it would have been possible to develop a series of design charts based on different directional splits, we decided to use only one chart for all situations and thus retained the conservative 50/50 directional split as the design scenario. Thus, through the process of investigation, we concluded that SUPLOS's 50/50 direction split assumption was in fact applicable.

SUPLOS works on a lane-based model where users require a certain width on the path. Therefore, to achieve a change in LOS, path widths must increase at discrete intervals according to the additional width required to accommodate an extra user adjacent to existing users. A small increment in path width will not necessarily affect the LOS generated by the model. For our research, behavioural observations of Melbourne paths were used to determine the appropriate values for the new model and it was determined that the same width can be used for pedestrians and cyclists. A minimum user width of 0.8 m plus additional 0.3 m between adjacent users was used in the model. Site observations were also used to determine the appropriate cyclist and pedestrian average speeds and standard deviations. Figure 2 shows how these user widths relate to various lane widths of shared paths.

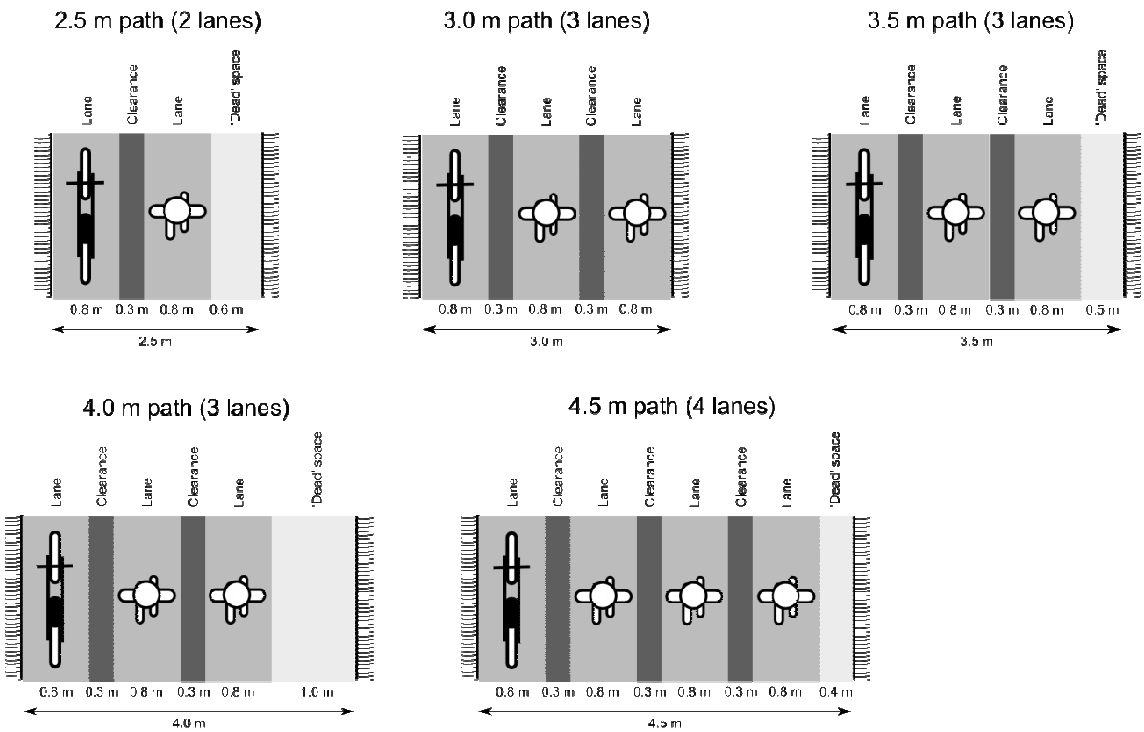


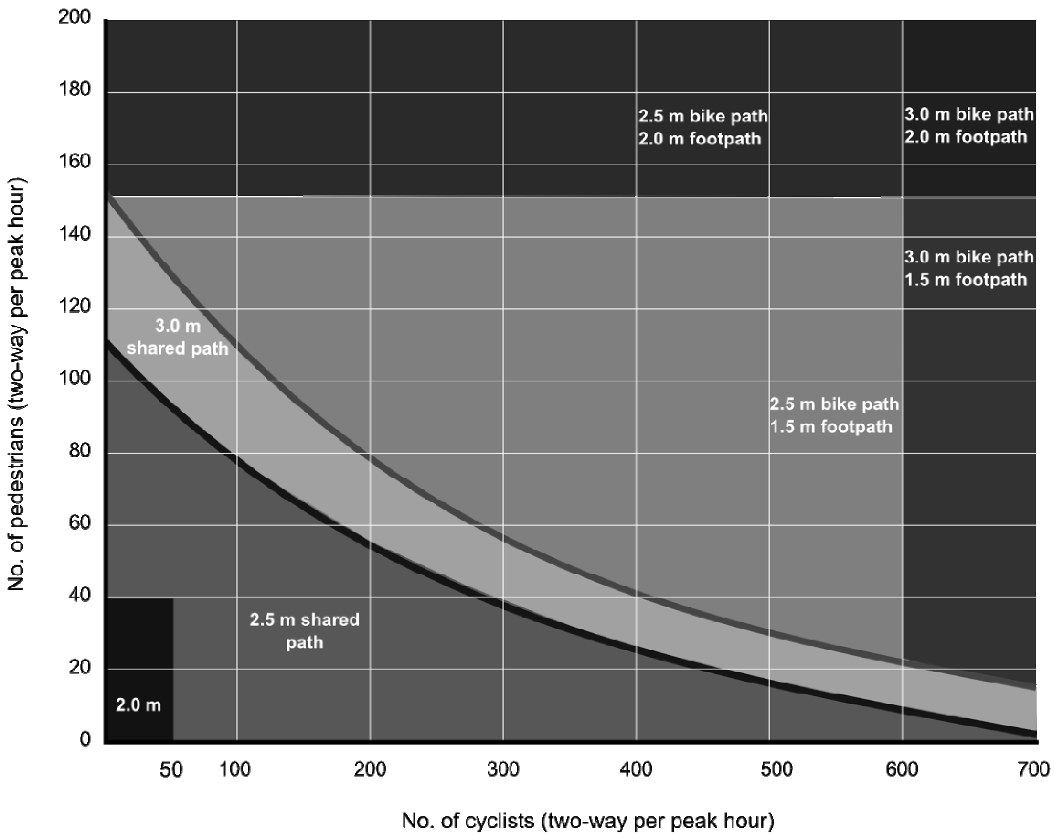
Figure 2: Various shared path widths related to lane-based model

We chose to use the two generic mode categories: cyclists and pedestrians. While (as discussed previously) these two categories cover a wide range of travel characteristics and user abilities, surveys showed that by far the two main groups using Melbourne paths were adult cyclists and walkers. Runners, skaters and dog walkers made up an insignificant proportion of the total survey sample. Although not many child cyclists were observed we expected that some situations may exist (or could be encouraged) where a high proportion of child cyclists would be observed. To accommodate this, we specified a width increment to allow for a wider travel envelope required by child cyclists and increased passing frequencies for other users.

Having only two mode categories allowed the development of a single design chart with pedestrian volumes on the y-axis and cyclist volumes on the x-axis. This simplifies the task for designers.

The model showed that, for certain scenarios of mode split and user volume, segregated paths require less total path width than the equivalent shared path. This is due to the interactions between cyclists and pedestrians with high volumes of one user group complicating matters for the other. However, it may be considered preferable aesthetically to have one wider path than two parallel separate paths.

The proposed design chart resulting from the model is presented in Figure 3. It shows the various path widths and types (shared or segregated) required to achieve no more than 12 delayed passing events per cyclist per hour. Note that this chart has not been officially adopted for Australian design guidance, nor has it been based on any New Zealand data.



Notes:
(1) An additional 0.5 m should be added to each edge if the path is bounded continuously or has fall hazards on either side.
(2) An additional 0.5 m should be added if during the critical design hour the path is serving both a commuting function and has significant numbers of child cyclists, such as would occur if the path is near a school.

Figure 3: Required widths for shared paths according to user volumes

DISCUSSIONS

The design chart presented in Figure 3 and its underlying model are based on empirical evidence and traffic flow theory and attempts to establish a quantitative link between user volumes and path widths. However, it still has many limitations due to the complexity of the shared path situation. As with all modelling, compromises have been made to balance the accuracy of the output with the demands of the parameters used for calibration and input. Even so, we believe that the resulting product represents the most in-depth research that has been performed for Australian shared path design and is a significant improvement on the "low / heavy / frequent" qualitative guidance used in GTEP part 14.

Although the chart requires only two inputs (cyclist and pedestrian peak hour traffic volumes) determining these requires significant consideration. The chart is likely to be used mainly in the design of new shared paths and therefore assumptions will be required to predict future user volumes. Assessments of similar facilities and surrounding walking and cycling networks can be useful in this. The path designer must have a good understanding of when the peak periods will occur and the effects of seasonal variations. It is also important to consider the design year for the path; it is not sufficient to design infrastructure based on volumes predicted for the first year of operation. New Zealand research (McDonald et al, 2007) presents a formula for predicting growth of cycle traffic on a path and the census-based travel to work data to be used for each district. The research found an annual cycle traffic growth rate of 14% due to the installation of a new off-road cycle path. While more research into walking and cycling growth trends is required to properly estimate design volumes, a growth rate of 14% for off-road paths is recommended.

The delayed passing threshold is used to represent LOS and, in turn, safety. A path where users experience frequent delays does not provide the capacity required to cater for its demand. It is unsafe to combine pedestrians and cyclists on a path of insufficient width, largely due to the great variability in travel speeds between and within the two user groups. Consider the analogy of half the vehicles on a road driving at only half the speed limit! Although pedestrians and cyclists travel at slower speeds than motor vehicles it is feasible for cyclists to travel up to eight times the speed of pedestrians. Also, cyclists who are overly delayed can become frustrated and likely to be tempted to make unsafe manoeuvres that they wouldn't normally attempt.

In general, paths in Melbourne tend to have higher user volumes than those in New Zealand. This in itself does not negate the usefulness of the design chart in New Zealand, it just makes it more likely that New Zealand paths will fall comfortably into the shared path category without requiring segregation of users. Efforts are being made to increase New Zealand cycling rates and therefore designers should be prepared for higher volumes in the future.

There are some differences between Australian and New Zealand paths and users. The design chart presented here would need to be validated and calibrated before use in New Zealand. For example, the 2.0 m shared path option recommended for a maximum of 40 pedestrians and 50 cyclists per hour would need to be changed, as funding regulations state the minimum width of a shared path in New Zealand is 2.2 m. The footpath widths should also be reconsidered to align with best practice as presented in the New Zealand Pedestrian Planning and Design Guide (NZTA, 2007).

Some observed differences between Melbourne and New Zealand path use were that Melbourne users were more compliant with "keep left" etiquette and tended to travel at faster speeds than their New Zealand counterparts. This may affect the model's inherent variables such as user widths and clearances, user speed distributions and the delayed passing threshold. It may be that, as New Zealand path use increases, user behaviour will improve as users see the benefits of a more ordered "keep left" system. The recent changes to the road user rule are also likely to support this change. However, New Zealand's focus on encouraging recreational cycling as a means of maintaining physical health and higher volumes of child cyclists compared with Australia mean that it is unlikely that the average New Zealand cyclist speed will increase to the Australian level.

As it stands, the design chart produced for Australia may still give a reasonable indication for

New Zealand paths. Consider the example of the busiest section of Hagley Park path, near the Armagh Street bridge. This path has around 2,000 cyclists and 900 pedestrians per day. Applying the standard traffic modelling heuristic that the peak hour flow is 10% of the daily flow gives 200 cyclists and 90 pedestrians per hour; this relates to the 2.5 m bike path and 1.5 m footpath. From our professional experience and also as frequent users of this path, we suggest that the path's current provision does not adequately cater for its demand and the design chart's recommendation is more appropriate. This example does not, however, prove that the transitions between facility types are appropriate for New Zealand.

Figure 3 shows that segregation of cyclists and pedestrians may be the most suitable outcome for high volume situations (as indicated in the figure, this is a function of both pedestrian and cyclist volumes). This paper has not outlined how this segregation can be achieved but we believe that a painted white line and mode markings generally will not be likely to achieve the desired effect. Observations of a segregated path on Hagley Ave, Christchurch, and several similar facilities in Melbourne attest to this. We suggest that use of different textured and coloured surfaces each suited to the intended mode would be the most appropriate method; further research is required to fine-tune this approach and identify the most useful materials. In some cases physical separation may be the best method; this may be achieved through fences, bollards, raised medians or grass berms. Each of these features is likely to generate additional safety and design considerations. Figure 3 does not distinguish where separation should be used over segregation as it is more related to site-specific factors rather than user volumes.

CONCLUSIONS

There is currently little quantitative guidance available in New Zealand or Australia regarding the determination of shared path widths. This is also the case internationally, with the exception of the SUPLOS calculator developed in the USA.

The shared path situation has many complexities due to the wide range of user characteristics, mode splits and volume directional splits possible. It is also difficult to quantify safety given the lack of relevant crash or collision data. However, when simplified to a situation involving only pedestrians (modelled as walkers only) and cyclists (adult), with a conservative 50/50 directional split assumption and threshold of 12 delayed passing events per cyclist per hour, it is possible to determine appropriate shared path widths. The delayed passing threshold is not simply a measure of inconvenience to travel time but is used as a proxy for safety.

The model presented in this paper shows the shared path widths required for various pedestrian and cyclist volume combinations. It also shows where segregated paths would be more appropriate. We anticipate that this model will be of significant use in properly designing shared paths in Australia and, after some site-specific calibration, New Zealand.

To use the design chart, designers must first have a good appreciation of how to predict path volumes, including allowing for future growth.

RECOMMENDED FURTHER RESEARCH

Observations of user interactions on New Zealand paths should be undertaken to determine the values of user widths, clearance requirements, user speed distributions and delayed passing threshold appropriate to New Zealand conditions. This can be fed into the model to develop a New Zealand design chart for shared paths.

The design chart requires understanding of the input volumes. Further research is needed in this area as most of these volumes need to be predicted based on experiences at existing facilities, modal changes and external factors (e.g. fossil fuel availability is likely to have a large impact on cycling levels). By properly predicting the future demand we can design adequate facilities and ensure they achieve an appropriate design life.

Further investigations are also required to identify the most appropriate way of detailing segregated paths so that users are happy to comply with the segregation. We have observed that simple paint markings are ineffective and suggest research into colour and texture differentiation. This could be done by before and after surveys on a group of test treatments to determine the most effective.

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