PREDICTING WALKABILITY

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ABSTRACT:

Quantifying the quality of the walking environment is possible using the New Zealand Transport Agency Community Street Review methodology but the required resources to undertake citywide surveys are significant. Practically speaking, it is unrealistic to consider a local authority would undertake large area or citywide surveys. The problem is if a local authority doesn't understand the quality of their walking network, they may not be able to identify areas that are affecting suppressed demand, links that reduce the overall environmental success of an area, or specific elements that might be easily fixed to improve the liveability of a city or town.

Rather, if practitioners could quantify the quality of the walking network using measurements such as the width of footpath, gradient, number of hiding places, greenery and surveillance etc, it is expected that predicted walkability could more easily be created, and a large area or city wide assessment be undertaken for reasonable cost. This would enable the walking network to be assessed and if measured correctly, managed correctly thereby making best use of resources.

This presentation describes the preliminary research Abley Transportation Consultants and Beca Infrastructure are undertaking on behalf of the New Zealand Transport Agency. The research is creating a number of mathematical models that infer walkability perceptions based on certain physical and operational variables.

This presentation will interest those involved in the planning of large town or city wide transport networks and focuses on opportunities for use and development of the research.

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1. INTRODUCTION

The UK Audit Commission says *"If an organisation does not measure what it values, it will end up valuing what it measures"*.[1] The quality of the walking environment is a prime example of an important transport mode variable that is not measured and hence other transport modes are probably more favoured for investment.

Walking forms the start and end of every leg of every transport journey. Consequently walking is required to be weaved into the fabric of our towns and cities and hence its importance for measurement should not be undervalued. Given walking isn't measured it often remains an after thought for many decision makers. Walking is often the poor cousin in preference to other sexier, more technically complex or just more expensive modes of travel such as light rail, private motor vehicle and to some extent cycling. As a consequence the technical analysis, common terms of reference and financial investments in walking projects often tend to lag behind these other modes. Even if walking is considered, it is usually a binary provision meaning the opportunity to walk has or it hasn't been provided and the quality of provision for the walking environment often doesn't feature in strategic decision making.

The issue of determining the quality of the walking environment is often left up to others to determine. Prior to construction this is usually urban designers or landscape architects that determine 'prettiness' of the wider environment or engineers to determine the 'functionality' of the specific scheme. The problem is these professions are often detached from each other and occasionally their technical jargon is difficult for decision makers to understand. Even more confusing is where one profession considers high quality may be provided because of a particular element, and the other profession may consider the quality of the environment is less than desirable for exactly the same reason. Maybe even worse is that after implementation it is the community that ultimately determines if the correct quality of provision has been provided, but the community is infrequently asked if the professionals 'got it right'.

It is the opinion of the author that one of the main reasons these disconnects occur between professions and our communities is there are limited tools available to practitioners to measure the quality of the walking environment. In contrast there are a multitude of tools available to measure the quality of provision for other transport modes, and especially the private motor vehicle. This may be one reason for why a bias exists against providing quality, as opposed to just functional walking environments. To take the example of the private motor vehicle, engineers have a multitude of modelling tools available to them to determine the quality of service provided for this transport mode. Sitting parallel to these tools in New Zealand is a well structured economic analysis regime that fits hand-in-glove with the analysis tools that then fits nicely with central government funding streams. Remove the analysis tools and structured decision making would be far more complex.

To compete with these other transport modes walking also needs analysis tools to better balance recommendations being put to decision makers. Predicting walkability is about anticipating the quality of a walking environment prior to it being constructed, providing a network planning tool so the whole of the walking network is considered and ultimately providing a tool where economic analysis can be undertaken.

The purpose of the Predicting Walkability Research project was to link physical and operational variables to perception surveys for the development of mathematical models. The mathematical models allow walkability perceptions to be inferred from the physical and operational measurements in an existing or proposed walking environment. This aids practitioners to quickly identify walking level of service for the transport network in a similar manner that is currently available for identifying level of service for other transport modes.

[1] Audit Commission, On Target: The practice of performance indicators, London: The Audit Commission, 2000

2. BACKGROUND

2.2 Measuring Walkability

In 2005 Abley Transportation Consultants published a research paper that recommended that walkability and walkable were defined as *'the extent to which the built environment is walking friendly'*[2]. It was concluded that this definition enabled the opportunity for a subjective or qualitative assessment against specific criteria and the New Zealand Transport Agency (NZTA) later adopted[3] this definition.

The research also identified three broad techniques to assess the performance of the built environment (and therefore walkability); these are:

- Reviewing: Applies to existing situations and may include audit and rating as well as other assessment tools. Develops options for and assesses how well proposed options improve walkability qualitatively.
- Auditing: Can be applied to existing and proposed designs. Identifies deficiencies against recognised standards and can propose solutions. Ideal for identifying maintenance issues and simple remedies both qualitatively and quantitatively.
- Rating: Tool for scoring walkability for an environment or facility. Can be used on existing or proposed designs, enables a practitioner to compare different walking environments quantitatively.

The similarities, differences, subjective or qualitative elements of each of these techniques are described in **Table 1**.

Table 1: Reviewing, Auditing and Rating Comparison

Performance Design Technique	Procedure	Situation	Identifies Problems	Analyse Deficiency	Proposes Solutions	Undertaken by	Relative Cost	May Require	Example Methodology	Discussion
Reviewing	Qualitative	Existing	Yes	Yes	Yes	Professional	High	Everything below plus: safety records, traffic surveys, more observation	Good practice	Can include other tools such as auditing and/or rating
Auditing	Qualitative and Quantitative	Existing and Proosed	Yes	No	Sometimes	Technician / Advocate / Community	Medium	Everything below plus: camera, and consultation.	• LTNZ Safety Audit • Living Streets DIY Community Street Audits	Can include elements of rating
Rating	Quantitative	Existing and Proposed	Yes	No	No	Technician	Low	Mapping, site visit, incidentals such as pen paper, calculator, level, measuring tape etc	• RAMM • Cycle for Science • PERS	Attempts to infer a level of performance from a qualitative process that is transferred to a quantitative assessment

[2] Abley, S.J. (2005), "Walkability Scoping Paper", Available online at: http://www.levelofservice.com/walkability-research.pdf

[3] NZ Transport Agency, Pedestrian Planning and Design Guide, Glossary. http://www.nzta.govt.nz/resources/pedestrian-planning-guide/docs/chapter-1.pdf

The initial research identified there was a need for a consumer style audit to be combined with a rating system to meet both the qualitative and quantitative aspects of measuring walking environments. This is slightly different to the methodologies applied when determining the quality of provision say for motorised vehicles that tend to be based on efficiency and safety issues.

Quality of service issues for vehicles have limited regard to the motorist's perceptions of the specific environment they are moving through because motorists are not explicitly interacting with that environment. Basically motorists are typically on their way to somewhere else. In contrast pedestrians, because of their speed, are very engaged with their environment. To a great extent the pedestrians' vehicle is the 'environment' and because a pedestrian doesn't have the luxury of choice that a motorist does in terms of the specific quality of vehicle, 'place' is considered an important factor for walkability. Consequently any new tool for measuring walkability would have to be very cognisant of the feelings the consumer[4] (being the pedestrian) was experiencing in those environments.

2.3 Community Street Reviews

In response to the issue regarding a lack of tools to determine the quality of the walking environment a new tool was developed by Living Streets Aotearoa and Abley Transportation Consultants for the Health Sponsorship Council in May 2007. This new tool was titled a Community Street Review (CSR) given it built upon and combined the Community Street Audit[5] concept that was developed by Living Streets (UK)[6] with a numerical rating system.

- o A Community Street Audit is a technique for assessing walkability that was developed by Living Streets UK in 2002. Community Street Audits *"involve working with groups of stakeholders, including local residents and businesses, to identify improvements which will create a safe, attractive and enjoyable environment for all users "*
- o A rating system enables problem environments to be identified analytically and comparisons made with other walking environments. Consequently funds can be used wisely where value or benefit/cost considered greatest.

The ownership of maintaining and promoting the CSR methodology has since transferred to the NZTA and the NZTA considers a CSR a *"standard procedure for gaining pedestrian perceptions of particular walking environments"*[7]. The NZTA has recently launched a practitioner's guide for how to[8] undertake a CSR and to promote the usefulness of CSRs.

A CSR is an assessment of the walkability of a route from the point of view of the people using the route. It focuses on peoples perceptions regarding the road or crossing environment and how they feel when walking. It collects data on safety, functionality of the pedestrian space, ease of road crossings, effects of urban design and other walkability factors.

CSRs include not only a qualitative consumer audit but also a quantitative rating. This benefits the immediate community and provides practitioners with an asset management tool to prioritise walking schemes. Combining an audit and rating system enables practitioners to prioritise improvements, to provide a better walking experience, connect walking networks and to aid the highest number of affected users. Further benefits of a rating system are problem environments are able to be identified analytically where comparisons can be made with other walking environments. Consequently funds can be used wisely where value or benefit/cost is considered greatest.

CSRs are very useful for communities to instigate and provide qualitative and quantitative appraisals of routes for specific projects[9] such as that recently undertaken by the Waimakariri District Council for the Rangiora Town Centre 2020 project[10].

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[4] Consumer surveys were a major thrust of the presentation Steve Abley delivered to the inaugural New Zealand Walking Conference in Wellington in 2004.

[5] http://www.livingstreets.org.uk/index.php/expert-help/community-street-audits/

[6] http://www.livingstreets.org.uk/

[7] http://www.nzta.govt.nz/resources/pedestrian-planning-guide/resources.html

[8] http://www.nzta.govt.nz/resources/community-street-reviews/

[9] A sample CSR report undertaken by the Waimakariri District Council for Kaiapoi Town Centre is available to view at www.levelofservice.com.

2.4 Physical and Operational Variables

Quantifying the quality of the walking environment is possible using the CSR methodology but the required resources to undertake say a citywide survey are very significant. Practically speaking, it is unrealistic to consider that a local authority would undertake large area or citywide CSR surveys without significant funding.

Unfortunately though the need remains for local authorities to undertake a comprehensive stock take of the quality of their walking networks. If a local authority does not understand the quality of their walking network, they may not be able to identify areas that are affecting suppressed demand, links that reduce the overall environmental success of an area or specific elements that might be easily fixed to improve the liveability of a city or town. The UK audit commission statement about 'valuing what you measure' or indeed, 'not measuring what you value', is case in point.

Most towns and cities in New Zealand now have a walking or active transport strategies that are expected to contain targets that are specific, measurable, achievable, realistic and time-related ("SMART"). As explained, when it comes to network quality it is difficult for local authorities to justify the expenditure to undertake CSRs on their entire walking network. This means then that SMART targets for walking network quality are often not set because they cannot be measured within available resources. The result is there remains a gap in the tools available to local authorities to measure their transport network and they tend to focus on vehicular transport quality. This is a significant problem because it does not encourage whole network management or planning and perpetuates the focus on transport modes that do have comprehensive analytical tools.

In contrast, if practitioners could quantify the quality of the walking network using measurements such as the width of footpath, gradient, number of hiding places, greenery and surveillance etc, it is expected that walkability could more easily be ascertained, and a large area or city wide assessment be undertaken for reasonable cost. This would enable the walking network to be assessed and if measured correctly, managed correctly thereby making best use of resources.

The concept is simple; forecast user perceptions from operational and physical measurements so saving time and cost. The first step in achieving this goal was to create a methodology to measure the built environment from the perspective of the pedestrian.

The problem was the walkability of the street environment had never been measured and the importance of certain variables had never been determined. Consequently it wasn't known what exactly were the correlated variables, for example traffic noise and distance from traffic, so it was decided to collect all the variables no matter how small or seemingly irrelevant. It was anticipated the list of variables would be reduced later when the important variables were better understood.

Abley Transportation Consultants were commissioned by the NZTA to determine the collection methodology and undertake a collection of CSR and operational and variable surveys. The current methodology[11] contains detailed instructions on the collection of 51 physical variables and 37 operational variables. The physical and operational variable types are defined below.

1. Physical variables measure aspects of the environment that generally do not vary such as footpath width or cross fall. Physical variable data can be collected at any time, either shortly before or after the CSR is completed.
2. Operational variables measure aspects of the environment that experience fluctuations such as traffic volume or the weather. Operational variable data must be collected when the CSRs are in progress to accurately record the condition of the walking environment at the time it is being reviewed.

[10] www.rtc2020.co.nz
[11] Abley Transportation Consultants (July, 2006), "Walkability Research Tools - Variables Collection Methodology", Available in pdf format at http://www.levelofservice.com

The results of the initial research regarding operational and physical research were published in 2008 in NZTA Walkability Research Tools - Summary Report. Report 356[12].

3. PREDICTING WALKABILITY

3.1 Introduction

There has been a significant body of work completed in the area of measuring walkability up to this point that includes:

- Raising awareness regarding the need to undertake consumer reviews in 2004
- Initial review, audit and rating research undertaken in 2005
- The development of the CSR methodology that was completed in May 2007, and
- The development of the variable collection methodology in 2008.

The next step was to combine CSR data with physical and operational variables to develop a mathematical relationship where walkability (CSR results) could be inferred from important operational and physical variables. Abley Transportation Consultants Limited and Beca Infrastructure Limited were commissioned by NZTA in 2009 to undertake this research into predicting the walkability of urban street environments in New Zealand. The research is due for publication in late 2010. The preliminary results of the research are published here for information although some of the model conclusions may change as work concludes.

The intent of the study was to understand the relationship between walkability scores that are collected during CSRs and the physical and operational characteristics of the walking environment that are collected using the operational and physical variables collection methodology. If such a relationship was established, then transport professionals can assess the walkability of a route including path lengths and path crossings based on the characteristics of the walking environment. The research derives prediction equations for path lengths and road crossings where a number of variables can be input and a level of service for the link or path derived. The research enables practitioners to quantify the quality of the walking environment from which improvements can be identified and the significance of implementing those improvements measured.

If successful, and all indications are currently positive of meeting the research objective, this would be an immensely powerful practitioner tool where practitioners could vary certain operational and physical variables and predict changes in the quality of the street environment. A later hypothesis (some would say obvious) is that improving the street environment would encourage mode shift for short journeys. This would help NZ meet the targets in the New Zealand Transport Strategy[13] for a doubling of walking trips by 2040.

3.2 Data collection

The website www.levelofservice.com is created to house and facilitate the CSR data management process. The website runs on php scripting language and the data is stored in a MySQL database. Users are allocated a user level based on their role in the CSR process that allows access to tasks relevant to the specific role. All users are given a unique username and password to access the database.

Accessing the database via a website allows users to login from any location and be confident they are always using the same standardised system where all CSR data is held. The development of the website and database has been designed and tested in alignment with the development and testing of the CSR process to ensure it is comprehensive and easy to use. Regular backups of the database and source code are taken to ensure that data is always recoverable.

Users enter the CSR data and physical and operational variables into the database via 'lookalike' forms. The site also has the ability to execute analysis and produce automated reports. Users are also able to extract information from the database as Microsoft Excel spreadsheets to perform more complex analysis. A separate report[14] was produced to assist

[12] http://www.nzta.govt.nz/resources/research/reports/356/docs/356.pdf
[13] Ministry of Transport (2008), "New Zealand Transport Strategy", Ministry of Transport, Wellington, New Zealand.
[14] Abley Transportation Consultants (April, 2007), "Walkability Tools Research – Database User Guide".

navigating and operating the database as part of the variables collection methodology development.

Prior to commencing this part of the research the www.levelofservice.com database contained 1,352 observations on 67 path lengths and 47 road crossings involving 49 participants. In an effort to improve the quality of the predictive models three further CSRs were commissioned in Auckland, Gisborne and Christchurch to gather more data and specifically a range of each of the engineering measurement and participant variables. The collection of physical and operational data at additional sites in Wellington and Rangiora was also undertaken to coincide with CSR being undertaken by the Wellington City and Waimakariri District Councils.

With this extra data the database now contains 6,380 observations on 307 path lengths and 218 road crossings from 117 participants. A summary of the additional data related to the Predicting Walkability project is outlined in **Table 2**.

Table 2: Summary of Data Collected for Predicting Walkability

Area	Number of sections		
	Path lengths	Road crossings	Total
Auckland	31	34	**65**
Christchurch	40	41	**81**
Gisborne	40	39	**79**
Wellington	52	23	**75**
Rangiora	16	9	**25**
Total	**179**	**146**	**325**

For the purposes of creating a statistical model, collecting additional data was an excellent opportunity to ensure the pedestrians' perceptions being modelled were not over represented by age, location, gender, walking experience etc.

The initial walkability modelling uses the perceptions of full-sighted able-bodied pedestrians although a similar research methodology could be used to model the walkability scores of sight-impaired or mobility-impaired pedestrians.

3.3 Model development

The CSR data has been used to develop linear regression equations that link the raw walkability scores with the physical and operational variables that are expected affect the quality of the pedestrian environment.

For the purpose of developing a model for predicting walkability, it was not considered feasible for all the variables to be included as predictor variables during the model development stage. A methodology was developed for narrowing down the number of variables that were eventually used for developing the walkability prediction models.

The methodology for narrowing down the number of predictor variables involved comparing variables to see how highly correlated they were. The most highly correlated variables would not be used together in a prediction equation. If they had, the influence of those variables on walkability would be over represented.

Following are some of the key observations from the correlation analysis of path lengths:

- The high correlation coefficient between the number of utilities and comfort features suggests that paths which have more utilities such as bus stops, ATM machines and telephone booths are also better provided with comfort features such as seating and drinking fountains.
- Paths with more utilities and comfort features are associated with higher pedestrian usage.
- The presence of utilities and comfort features contributes towards increasing the number of obstacles on a path.

- The effective width of permanent regular and non-regular obstacles is found to be highly correlated with the effective width of the path. This suggests that paths that have a larger number of regular or non-regular obstacles are usually wider than those that have fewer obstacles
- As is expected, roads with a high traffic volume were generally wider than those with low traffic flows.
- The correlation between effective path width and road width suggests that paths adjacent to major roads are usually wider than those adjacent to narrower roads.
- A moderate correlation was found between distance from moving vehicles and road width. This, along with the correlation between road width and traffic volume, indicates that paths adjacent to busier roads are usually further away from the road than those adjacent to roads with lower traffic.
- The number of stumbling hazards and trip hazards are observed to be correlated.
- Paths next to roads with high traffic usually had a higher amount of noise.

Following are some of the key observations from the correlation analysis of road crossings:

- The large negative correlation between crossing type and number of traffic lanes shows that the number of traffic lanes to be crossed by pedestrians decreases from signalised crossings to uncontrolled crossings, with zebra crossings lying in between the crossing types.
- The correlation between hourly traffic volume and comfort features suggests that more comfort features are provided on road crossings with a higher volume of traffic.
- As in the case of path lengths, volume of traffic is found to be correlated to the level of noise at a road crossing. The correlation between noise and crossing type also leads to the expected conclusion that signalised crossings are noisier than zebra and uncontrolled crossings due to higher traffic volumes.
- As expected, the footpath gradients on entry and exit kerbs are also highly correlated.

3.4 'Overall Walkability' Models

Linear regression models for predicting walkability were developed for path lengths and road crossings. Separate models have also been built for male and female participants, and for young, middle-aged and old participants. These models are:

<u>Overall models</u>
These are the main models that take into account the full sample set of sites and variables available for both path lengths and road crossings and describe the best variables for predicting the walkability of each.

<u>Gender models</u>
These models identify the variables that have the most effect on walkability for each gender.

<u>Age group models</u>
These models identify the variables that have the most effect on walkability for different age groups. Participants were classified into three age groups as shown in **Figure 1**.

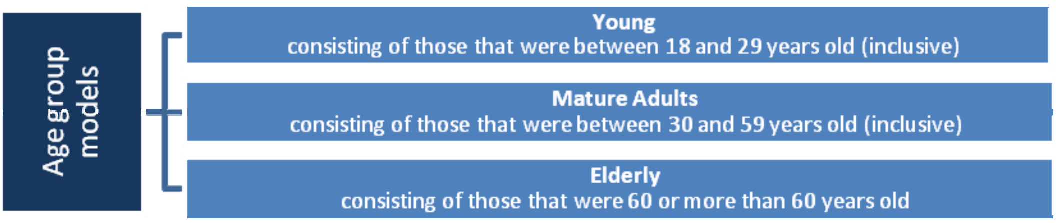

Figure 1: Age group categories

3.5 Environmental models

CSR participants were asked to rate certain environmental variables e.g. safe from traffic, safe from falling, pleasant etc. in addition to the overall walkability of a section. These variables were separately adjusted on the basis of the rating of a common participant, and were used as response variables after being averaged across each section and site to develop prediction models for the respective environmental variable.

The environmental models that were developed for path lengths and road crossings are shown in **Table 3**.

Table 3: Environment variable models

Path lengths	Road Crossings
▪ Safe from falling	▪ Safe from traffic
▪ Pleasant	▪ Delay

A summary of the model types for path lengths and road crossings is shown in **Figure 2**.

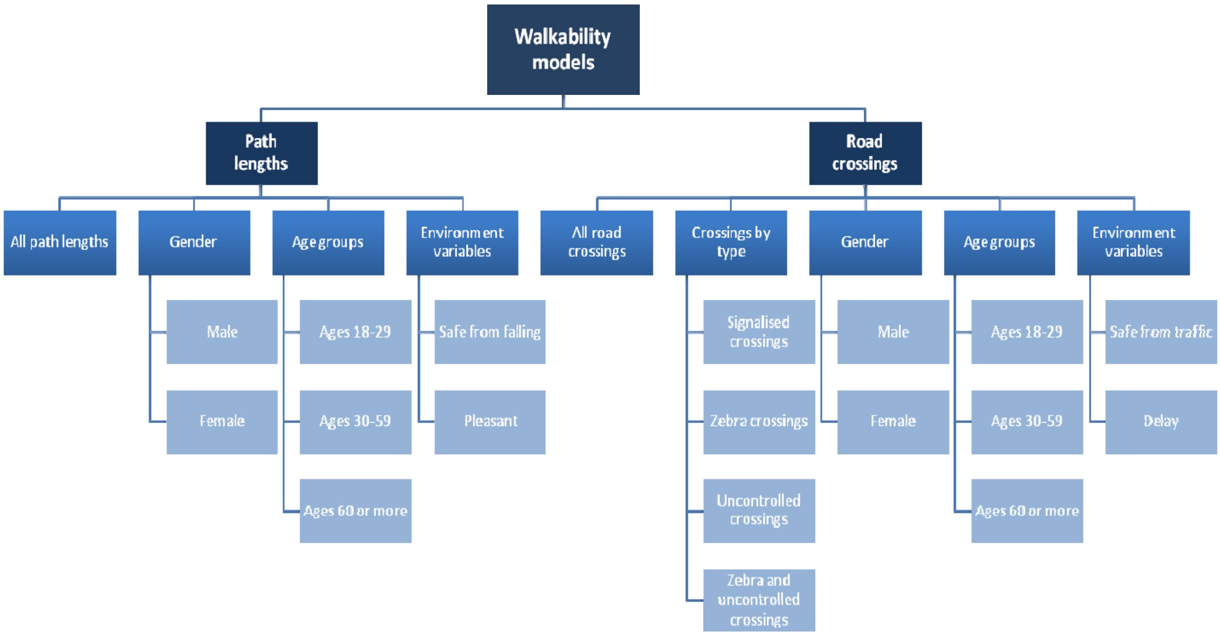

Figure 2: Walkability prediction models

3.6 Model discussion

The most important factors that have a strong effect on the walkability of a path length are footpath condition, quantity of greenery, presence of comfort features, deviation in path and adjacent vehicle speed. Obstacle effective width, temperature, setback of adjacent buildings, quantity of detritus, number of hiding spaces and land-use also feature in most of the models.

The models also suggest that windy weather conditions can result in a decrease in the walkability of a path depending on the specific model.

The environmental models suggest that footpath condition and presence of comfort features are the two biggest factors that increase the perceived safety from falling on a path, while greenery, footpath condition, weather (wind) and presence of comfort features significantly affect the path's pleasantness.

Crossing type, vehicle speed, visibility to traffic and footpath condition are the most important factors affecting walkability of road crossings, and feature in all models except those for zebra crossings and delay. The coefficient for crossing type suggests that traffic signals are considered to be more walkable as compared to zebra or uncontrolled crossings. The presence of a central island is also shown to positively affect the walkability of a crossing.

No statistically significant model could be developed for signalised crossings. The model for zebra crossings suggests that road condition and crossing distance are important factors. The time taken to cross is also found to be a factor in the case of uncontrolled crossings.

The environmental models suggest that reducing vehicle speeds and improved visibility results in pedestrians feeling safer while crossing. As expected, signalised crossings are perceived to be safer and have less delay than zebra and uncontrolled crossings.

4. CONCLUSIONS

Quantifying the quality of the walking environment is possible using the New Zealand Transport Agency Community Street Review methodology but the required resources to undertake large area or citywide surveys are significant.

Practically speaking, it is unrealistic to consider a local authority would undertake large area or citywide Community Street Reviews. The problem is if a local authority doesn't measure and understand the quality of their walking network, they may not be able to identify areas that are affecting suppressed demand, links that reduce the overall environmental success of an area, or specific elements that might be easily fixed to improve the liveability of a city or town. They are then not making best use of resources and are probably perpetuating the issue of not measuring what is important, and rather investing in other transport modes that are more easily measured.

The research currently being undertaking by Abley Transportation Consultants Limited and Beca Infrastructure Limited on behalf of the New Zealand Transport Agency has resulted in a number of mathematical models that allows large areas of a town or city to be surveyed and the quality of the street environment inferred. This work builds on earlier work undertaken by Living Streets Aotearoa and Abley Transportation Consultants that culminated in the production of the Community Street Review methodology.

The mathematical models that have been developed are undergoing refinement with an anticipated publication date later in 2010. What has been found so far though is interesting and has proved that certain environmental variables are important predictors for how a pedestrian perceives their environment. This does not mean mathematical models are necessarily preferable to actual consumer surveys; rather mathematical models are a practical alternative to undertaking Community Street Reviews over large areas that would be very expensive.

The models that are developed as part of this research will allow practitioners to estimate the quality of the walking network using engineering measurements and for assessment to be undertaken for a reasonable cost. This will enable the walking network to be assessed, and if measured correctly, managed correctly thereby making best use of resources.

Disclaimer: The opinions expressed in this technical paper are those of the author and do not necessarily represent the views of Beca Infrastructure Limited or the New Zealand Transport Agency.