Land Transport NZ
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research

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Contents

Safety in numbers for pedestrians and cyclists

Walking and cycling may be better for our health compared to other transport choices, but only if we can do them safely.

With rising fuel costs, environmental concerns and recent government policy all aligning to encourage sustainable, non-motorised forms of transport, better information was needed about what this would mean for accident rates. What accident risks did cyclists and pedestrians face in urban environments? And how was this risk likely to change if more people heeded the messages and started walking or cycling rather than taking the car?

The government's *New Zealand Transport Strategy* places a strong emphasis on walking and cycling as alternatives to motor vehicle travel. Since the strategy's release, many local and regional councils have developed their own strategies to promote walking and cycling in their areas.

While the health and environmental benefits from walking and cycling are obvious, issues remain about exactly how safe these activities are. Especially in larger centres, the public perception is that cycling in particular, but also walking, are unsafe due to the large (and ever increasing) volumes of traffic now using the road networks.

But the fact remains that, for many of the trips we make, cycling or walking would be a practical and cost-saving option – 19 percent of motor vehicle trips made in New Zealand are less than 4 km in length, a distance easily covered on bike or on foot.

In the past, only limited research had been completed in New Zealand about accidents involving cyclists and pedestrians, while projects to develop models to predict accident rates have focused on motorised modes of travel.

A recent research project, completed by Beca Infrastructure Ltd and funded by Land Transport NZ, sought to extend both these areas of enquiry. Investigations sought to determine accident rates for cyclists and pedestrians in urban centres (Christchurch, Palmerston North and Hamilton), and understand (through modelling) how the risk to

continued on page 2 >>

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these road users would change if traffic volumes or cyclist and pedestrian volumes increased.

Shane Turner of Beca Infrastructure headed the research project and was co-author of the report. He says, 'The results are particularly heartening in terms of supporting government strategy and those people and organisations that are promoting cycling and walking as a sustainable means of transport for the future.

'Contrary to public expectations, there is a pronounced "safety in numbers" effect flowing from increased numbers of cyclists and pedestrians using the road network ie, the more people who do it, the safer it becomes. So what the research has really demonstrated is that there is no need for road controlling authorities to be deterring cycling and walking in urban environments on safety grounds.'

Getting the data

It was already known that rates of reporting to Police for accidents involving cyclists and pedestrians were poor. In addition, the Ministry of Transport does not usually record data about accidents that do not involve motor vehicles.

To address this information gap, surveys were conducted with people who had accidents while cycling or walking, and as a result attended Christchurch Hospital or after hours medical centres. More people were contacted through the ACC database.

The data was analysed for trends, including the proportion of accident casualties for different age groups of cyclists and how this compared with the number of trips each group made. The number of accidents that did and did not involve cars was also looked at, as were the major causes of accidents.

The need for new models

Researchers both in New Zealand and overseas have been developing accident prediction models during the past decade. Accident prediction models seek to predict changes in accident rates in response to changing traffic flows and other factors (eg, road layout). The majority of previous models had been developed for motor vehicle crashes occurring at intersections or on links between intersections and very few have considered other modes of travel specifically, such as walking and cycling.

If useful prediction was going to occur for cyclists and pedestrians, independent models were needed for these modes: the causes that contribute to accidents involving cyclists and pedestrians are quite different from those that contribute to motor vehicle accidents, and the models needed to reflect these.

Developing the models

Cycle, pedestrian and vehicle count data was collected from Christchurch, Palmerston North and Hamilton; cities chosen because of the significant numbers of cyclists using their urban road networks.

Using this data, and information about accidents gathered during the project, new accident prediction models were developed. These models used the generalised linear modelling technique to predict accident rates at urban crossroads with traffic signals, roundabouts and midblock locations. Models for other intersection types (such as T junctions with traffic signals) and for other types of accidents were also investigated but, due to lack of data, good fitting models could not be produced.

What the models tell us

Once developed, the prediction models could be used to calculate how accident rates would be affected if more people decided to travel by walking and cycling, rather than by motor vehicle.

Two scenarios were evaluated. The first scenario assumed an increase in cyclists and pedestrians of up to 300 percent at crossroads, midblock sections and roundabouts, with a corresponding decrease in traffic volumes. This model was applied to all the intersections where data had been collected in Christchurch.

The second scenario considered a 20 percent shift of motor vehicle traffic from selected roads in Christchurch, to people taking the same trip by bike.

The models were used to predict changes in accident rates at two levels. Firstly, the total likely change in numbers of accidents involving motor vehicles and pedestrians or cyclists and, secondly, the accident rate per individual road user for a change in mode, particularly motor vehicle trips to pedestrian and cycle trips.

What all the models showed was a pronounced 'safety in numbers' effect. This effect had been previously identified in overseas accident prediction models research projects and it was interesting to see it borne out in New Zealand modelling scenarios.

Shane Turner says, 'What this means is that for both cyclists and pedestrians, there is no substantial change in the number of accidents occurring as the number of people choosing to travel by each of these modes increases.

'In other words, more cyclists and pedestrians does not mean proportionately more accidents. In fact, the implication is that the risk to each individual pedestrian and cyclist decreases as the number of people choosing to walk and cycle increases.'

This held true at all the locations looked at – crossroads with signals, roundabouts and midblock sites – although for pedestrians at roundabouts there was insufficient data available to enable accurate modelling.

Shane says that the likely explanation for the safety in numbers effect is greater driver awareness.

'With increased numbers of cyclists and pedestrians, motorists become more aware of them and motorists' driving behaviour changes to accommodate the changed driving conditions.'

Other interesting findings from the research were:

- a significant proportion of cycle and pedestrian accidents happen off the roadway or on the road but do not involve a motor vehicle
- for pedestrians, the largest number of injuries was in the 10 to 20 year age group, but this tallied with the percentage of trips taken by this group. However, in the 80 plus year age group the percentage of accidents experienced was far higher than the percentage of walking trips taken by this group
- for cyclists, the most commonly injured age group was again 10 to 20 years, but the percentage of injuries was far less than the percentage of cycling trips taken by this group. By contrast, the 30 to 40 year age group suffered far more accidents proportionate to the percentage of trips undertaken by the group

- traffic failing to notice or give way to pedestrians and cyclists was a major factor in the accidents discussed in the interviews.

The research was hampered by insufficient data, and two of the project's main recommendations involved the need for better information about accidents and the numbers of cyclists and pedestrians using roads and intersections.

Shane says, 'Overall, what came out of the research was that road controlling authorities should not deter people from cycling and walking in the belief that this will increase the number of accidents. This belief is not borne out in the prediction models and, in fact, there is evidence that the reverse is true – the more people that choose to walk and cycle, the lesser the risk to individual cyclists and pedestrians of having an accident.'

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Land Transport NZ Research Report 289, *Predicting accident rates for cyclists and pedestrians*, $30.00. See page 7 for details about buying reports.

Crushing and skidding: is there a link?

Increasing the number of crushed faces on sealing chips has the potential to improve the skid resistance of New Zealand roads. However, there are production costs in requiring a greater degree of crushing and more information is needed before this innovation can be implemented.

Transit New Zealand is considering changing its specifications for the sealing chips to be used on New Zealand roads, but before it does so it needs more information. In particular, it needs to be able to quantify the benefits and justify the costs of increasing the crushed faces on sealing chips.

What exactly is the relationship between the number of crushed faces on sealing chips and their skid resistance? And how does this relate to the texture of the aggregates used and the size of the chips? A Land Transport NZ research project set out to answer these questions and others by examining the relationship between aggregate crushing and skid resistance.

Although additional crushing (and hence increased numbers of broken faces) of aggregates has been shown to improve skid resistance, it was not initially clear if this result would be the same for every type of aggregate.

It was possible that the microtexture of some aggregates would mean that they could meet skid resistance criteria without crushing. However, not enough information was available relating the effects of aggregate texture and shape to skid resistance to make this assessment.

This research project set out to fill in some of these knowledge gaps. The objectives were to:

1. better understand how aggregate shape and texture affect skid resistance
2. determine the effect of broken faces on the skid resistance of aggregates.

Definitions

Microtexture is the small-scale roughness on an aggregate with a wavelength less than 0.5 mm. For this research, it was measured directly using a stylus-based instrument of the type normally used for measuring the roughness of machined metal surfaces (the Taylor Hobson Surtronic 3+).

Percentage crushing was defined for this research as the percent by weight of sealing chip (assumed 100 percent crushed) to total weight of the sample (ie, weight of completely uncrushed chip and sealing chip). In quarries, the percent crushing of an aggregate is controlled by settings on the crusher – usually either a Barmac or cone crusher.

continued on page 4 >>

The rock

Approximately three-quarters of New Zealand's quarries are producing sealing chip from greywacke aggregates (either hard rock or alluvial).

This project focused on alluvial greywacke aggregate from two quarries, one in Hastings and one in Canterbury. Reported evidence suggested there is a difference in the properties of the aggregates from the two regions. The Canterbury aggregate is harder and has a greater microtexture when polished.

This difference has been shown in the results of Transit's annual surveys of skid resistance on the state highway network: roads in the Canterbury region are generally found to offer adequate skid resistance, while this was not always the case in the Hawkes Bay.

The research

Three research questions were posed.

1. What microtexture and shape parameters contribute to a high skid resistance?
2. Can an aggregate with a low microtexture provide acceptable skid resistance by giving it a high percentage of broken faces (ie, more crushing)? Or, if an aggregate has a high microtexture, can it have fewer broken faces (ie, less crushing)?
3. What influence does chip size have on skid resistance?

Key research activities to answer these questions were:

- comparing the polishing action on aggregates from actual tyres on roads with that of laboratory polishing, using the polished stone value test. Polishing is the rounding off of angular chip faces by traffic. The polished stone value test aims to measure the susceptibility of aggregates to polishing
- performing GripTester and British Pendulum Tester tests to determine the effect of crushing on skid resistance. Tests were carried out in the laboratory on artificial road surfaces to measure how skid resistance varied depending on a) the region that the aggregate came from (Hastings or Canterbury) and b) the percentage of crushing of the aggregate
- assessing test procedures used to determine chip shape and the percentage of crushing
- developing a model to estimate the relationship between friction and the percentage of crushed chips.

Measurements were made on actual road surfaces on State Highway 2 in the Hawkes Bay and State Highway 1 in Canterbury. In addition, core samples were taken from 12 sites on the roads to enable further measurements in the laboratory. Laboratory-prepared chipseal surfaces using aggregate from the two quarries were also used.

Microtexture versus shape

The research found that skid resistance increased with crushing – the greater the percentage of crushed chips, the greater the skid resistance. For new, unpolished aggregate the British Pendulum Tester showed an increase in skid resistance of 25 percent between samples with 0 percent crushed chips and those with 100 percent crushed chips.

Crushing increased skid resistance in two ways:

- the microtexture of crushed faces is greater than the microtexture of uncrushed faces, and greater microtexture means more friction
- crushed chips are more angular or irregular in shape than the more rounded uncrushed chips, again resulting in greater friction.

However, shape only had an impact on skid resistance for new aggregate. Where crushed chips had been subject to heavy polishing by traffic, the difference in skid resistance provided by their shape was negligible. Chip size did not have any noticeable effect on skid resistance.

From this it was concluded that the increase in skid resistance from crushing comes mainly from the increased microtexture of the chips' crushed faces rather than their more angular shape. However, it is recognised more work is needed into the methods used to quantify chip shape, which would enable the contribution that chip shape makes to skid resistance to be more accurately predicted.

Achieving skid resistance

Working backwards from these findings, it was determined that the degree of crushing needed if an aggregate is to achieve a particular level of skid resistance depends on the aggregate's microtexture and chip shape in both its crushed and uncrushed form.

Aggregates with lower microtexture needed to be crushed more to achieve the given level of skid resistance, and vice versa: aggregates with naturally higher levels of microtexture required less crushing to achieve the skid resistance required.

Where different aggregates have the same microtexture, an aggregate that is crushed to provide more irregular shaped chips will provide more skid resistance than uncrushed, rounded chips.

The skid resistance benefits of crushing that come from chip shape reduce progressively as aggregates become more rounded by passing traffic. Although the benefits that come from increased microtexture also reduce with the polishing action of traffic, some skid resistance benefits still remain.

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Land Transport NZ Research Report 295, *The effect of crushing on the skid resistance of chipseal roads*, $65.00. See page 7 for details about buying reports.

Keeping a cap on noise

Road traffic noise is a major environmental concern in New Zealand, yet the latest research shows that the effect that road surfaces can have on traffic noise, even in urban environments where traffic speeds are lower, has been significantly underestimated.

The effects for the community are obvious: more noise means more annoyance, but by selecting road surfaces with noise in mind, road authorities can make a real difference to the amenity of towns.

In the past, road authorities have relied on, and based their engineering on, research and road noise models that show that, where traffic speeds are below 60 km/h, the effects on noise levels from the type of road surfacing used are insignificant (ie, between 1 and 2 dBA).

It was also thought that changes in noise level of 3 dBA were only just noticeable for most people, which meant that the type of road surface used in urban environments was relatively unimportant in terms of noise.

However, this approach did not tally with the often marked increases in community annoyance from noise that occurred when roads were resealed. If the surface did not make a material difference to the noise level and people could not detect any changes in noise level that did result, then why were people reacting to it?

And react they did! Many local authorities received strong complaints and even petitions as a result of noise increases after suburban streets were resealed.

A Land Transport NZ funded research project revisited the issues of road surfacing and its effect on noise and the community, with some surprising results. Not only can the variation in noise generated by different road surfaces at 50 km/h be quite significant, but people can detect and react to much lower changes in noise level than previously thought.

From the community point of view, these changes in noise level from road surfaces, even at the lower end of the scale, can be significant. They are also a factor that road authorities can do something about. Many elements that contribute to road noise, such as road layout, speed limits and the types of cars and tyres that people choose to buy are beyond the easy control of road authorities, but the type of road seal used is firmly within their domain.

From the research, updated and more accurate guidelines for best use of lower noise road surfaces have been developed, giving road authorities the information they need to make the best choices when it comes to noise.

The approach

The research was carried out by Opus International Consultants Ltd in 2002 and made use of resealing being undertaken by road authorities in Wellington and Lower Hutt.

The project set out to investigate the effect that road surface type has on road noise at urban driving speeds (50 km/h) and the consequent effect on community annoyance. There were two areas to be investigated.

1. how the most common road surface types used in New Zealand affect noise level and tonality
2. what influence a change in noise level has on community annoyance.

The first area was investigated using controlled sound measurements from test vehicles driving over 13 different surface types. Measurements were taken before and after resealing at 21 different sites, enabling the acoustic properties of both old and near-new road surfaces to be measured.

The second area was investigated through surveys with residents living next to roads that were being resealed. Surveys were completed before and after resurfacing to detect any changes in participants' behaviour or level of annoyance as a result of noise from the new surface.

A question of noise

Before the project, current knowledge (including road noise models in use in New Zealand) was that the variations in noise levels between different types of road surfaces when vehicles were travelling at around 50 km/h were small (between 1 and 2 dBA).

It is also thought that changes in noise levels of 3 dBA are just noticeable to most people. The implication was that changing road surface types in urban areas should have no appreciable effects on community annoyance levels.

The findings from the research project painted a very different picture. A significant variation in noise from different road surfaces was measured: for light vehicles there was a difference of 7 dBA between the quietest bituminous seal and the loudest chipseal, while for heavy vehicles the difference was 4 dBA.

Other significant findings included:

- the noise effects of the different road surfaces at 50 km/h are the same at 70 km/h and 100 km/h (true for both cars and trucks)
- newer chipseal generated louder low-frequency components and quieter high-frequency components compared to older chipseal, and this was consistent for all chipseals studied
- the mean profile depth (often used as a predictor of surface-generated noise) did not sufficiently describe the noise-generating potential of a surface
- there was no significant difference between the noise generated by dense asphalt and open graded asphalt at 50 km/h for cars (this was contrary to expectations and to Transit guidelines).

One obvious conclusion to emerge from the research findings was that the road noise models and related community noise impact models being used in New Zealand need to be updated.

continued on page 6 >>

What the community thought

Surveys conducted with people living adjacent to resurfaced roads found a strong correlation between the degree of change in the noise generated by surfaces (measured in dBA) and how annoyed people were. The greater the noise increase, the more the annoyance.

However, even small changes in noise levels (below 3 dBA) caused people to change their behaviour (closing widows, raising their voices and shifting the time of day that they did certain activities). People could detect changes in noise levels as small as 1 dBA, especially when the existing noise level was already high and it increased by 1 dBA.

The results also negated the common perception that people become annoyed at the consequential effects of resealing (dust, odour, etc), rather than the noise itself. The survey clearly showed that people identify noise from resurfacing as the source of their annoyance. It also appeared that people got used to (and hence less annoyed by) noise level changes over time, although changes in behaviour brought about by the noise tended to be more permanent.

Guidelines for road surface noise

The outcome of the research was to produce guidelines for the best use of lower noise surfaces. For any given street, road engineers can use the table below to assess the effect, and benefits, of choosing one surface type over another.

Surface effect on noise

Ratio of light vehicles to heavy vehicles	Surface effect on noise (combined light and heavy vehicles) dBA				
	Dense asphalt	OGPA	Fine chip #4, 5, 6	Medium chip #3	Coarse chip #2 and two coat seals
100:3	0.0	0.7	2.5	3.6	4.5
100:5	0.0	0.5	2.3	3.5	4.4
100:10	0.0	0.1	1.8	3.1	4.0
100:15	0.0	–0.1	1.4	2.8	3.7
100:20	0.0	–0.3	1.0	2.6	3.3
100:30	0.0	–0.6	0.6	2.4	2.9
100:50	0.0	–1.0	0.0	2.0	2.5
100:80	0.0	–1.3	–0.6	1.7	2.0
100:100	0.0	–1.4	–0.8	1.4	1.9

The research also sought to develop initial guidelines to help road engineers determine the extent that the noise environment would be improved for the adjacent community by selecting different road surfaces. These are set out in the table below.

The impact of the change in noise is related to both the existing noise environment, as well as the extent of change in the noise. The table provides guidance about situations where selecting a quieter surface will have the most benefit.

Extent that the noise environment is improved for the adjacent community by selecting a quieter or noisier road surface

<table>
<tr><th colspan="2">Change in noise level from road surface change</th><th>Less than 60 dBA Leq24</th><th>Between 60 and 69 dBA Leq24</th><th>Above 70 dBA Leq24</th></tr>
<tr><td>Reduction</td><td>More than 3.6</td><td rowspan="2">Small improvement</td><td>Improvement</td><td>Big improvement</td></tr>
<tr><td></td><td>–3.5 to –1.1</td><td>Small improvement</td><td>Improvement</td></tr>
<tr><td></td><td>–1 to 0</td><td>Little change</td><td>Little change</td><td>Small improvement</td></tr>
<tr><td>No change</td><td>0</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Increase</td><td>0 to 1</td><td>Little change</td><td>Little change</td><td>A little worse</td></tr>
<tr><td></td><td>1.1 to 3.5</td><td rowspan="2">A little worse</td><td>A little worse</td><td>Worse</td></tr>
<tr><td></td><td>3.6 and greater</td><td>Worse</td><td>Much worse</td></tr>
</table>

The table above is based on a new disturbance measure, which has been defined as the percentage of people acutely affected by the change and the percentage of the population that is exposed to this acute level. People 'acutely affected' is analogous to people 'highly annoyed', but refers to their actual changes in behaviours in response to the change in noise rather than their feelings about the change. More work is needed on this new measure to enable comprehensive guidelines to be produced. More investigation is also needed into the complex relationship between annoyance and behavioural disturbance as a response to noise.

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Land Transport NZ Research Report 292, *Road traffic noise: Determining the influence of New Zealand road surfaces on noise levels and community annoyance*, $25.00. See page 7 for details about buying reports.

New research reports

Road surface texture measurement using digital image processing and information theory
Research Report 290
Jeff Waters, Fulton Hogan Ltd
$20.00

This report details the progress made in tests in Oklahoma, USA and Christchurch, New Zealand during the period August 2004 to June 2005, exploring digital imaging technology to measure chipseal surface texture. It details the research methodology to develop technology to replace the sand circle test as a means to measure chipseal surface texture more accurately and safely. The project used digital imagery and exploited information theory to develop a quantitative relationship between texture measured by the sand circle test and the fast Fourier transform of a digital image of the surface taken at the same spot as the test. The preliminary correlation achieved and reported in the interim report has been confirmed by a larger group of data collected after the interim report was written. A reliable statistical correlation using linear regression analysis with a coefficient of determination of 80 percent between digital image processing output and sand circle measurements taken at the same spot was found. Thus, both concept and scientific principle were conclusively proven. A key finding was that separate regression models would have to be developed for each chipseal design type and possibly for each aggregate nominal size or chip grade.

Natural hazard road risk management Part III: Performance criteria
Research Report 296
Pathmanathan Brabhaharan, Opus International Consultants
$35.00

Road networks are lifelines for the community and are essential for the economic and social wellbeing of New Zealand. Natural hazard events can cause significant and widespread damage to transportation networks, leading to significant repair costs to road controlling authorities, access difficulties for emergency services and disruption to road users and the community at large.

Currently, no guidelines for setting levels of service and performance measures for roads that are subject to natural hazard events are available. This study, made in 2002–2005, explores which performance criteria are acceptable for various hierarchies of road networks in order to develop a framework that can be used nationally by various road controlling authorities for setting performance measures and levels of service for road links forming New Zealand's road network.

Land transportation and noise: Land use planning for a quieter New Zealand
Research Report 299
Matthew McCallum-Clark, Incite (Christchurch)
$30.00

This research, carried out in Christchurch in 2004 and 2005, looks at the problem of land transport noise in New Zealand and examines the effects of noise and the options for its reduction.

Lessons from international examples show that land use planning methods can be applied to New Zealand to ensure sustainable transport and development outcomes. Land use planning is most effective as a preventive tool while technical options may be more effective for existing noise problems.

A key lesson from international case studies is the need for integration of policies within different government departments to achieve sustainable outcomes. An approach that integrates traditional land use planning measures with transport planning has proved effective in many European countries and is being used by state planning authorities in Australia and the United States.

Obtaining research reports

Research reports are available online at www.landtransport.govt.nz/research. They can also be purchased in hard copy. To order any of these reports, or for questions regarding Land Transport's research programme, please email research@landtransport.govt.nz.

Introducing the Research Programme Analyst

As noted in previous editions of *Land Transport Research*, management of Land Transport NZ's research programme moved location mid-year from Christchurch to the national office in Wellington. Tracey Hughes joined the team at national office on 16 October and took over responsibility for the coordination of the research programme. Tracey has only recently arrived in New Zealand, having spent 20 years working with central government in the UK. She brings to the role her experience as an analyst, along with project and operational management experience. Tracey works with Senior Analyst Nigel Curran and the Research Programme Manager Patricia McAloon.

2007/08 Land Transport Research Programme – reminder for expressions of interest

This is a reminder that expressions of interest for research projects to be included in the 2007/08 Land Transport Research Programme need to be addressed to the Research Programme Analyst, Land Transport NZ and received on or before Wednesday 20 December 2006. Copies of the Land Transport NZ expression of interest and research strategy documents can be obtained electronically from our website, www.landtransport.govt.nz, or by email to research@landtransport.govt.nz. Contact details:

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Contributed articles are welcome, and should be typed in double spacing and not exceed 1000 words. Illustrations may be either black and white or colour, and must be of high quality. *Land Transport Research* reserves the right to edit, abridge or decline any article.

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