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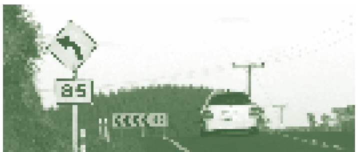

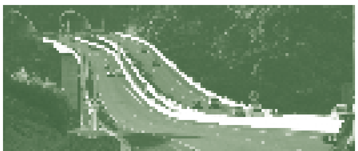

Research addresses the ‘forgotten’ transport mode: walking

A recent project has aimed to fill the ‘walkability knowledge gap’ by developing formulas to quantify the quality of the pedestrian environment, in the same way as is done for other modes of transport.

Walking is often referred to as the ‘forgotten’ mode of transport, mainly because while other modes have been subject to significant amounts of study, walking has not. As a result, practitioners have had few tools to hand when it comes to measuring the quality of the walking environment, and hence to improving provision for pedestrians.

In 2009, the NZTA commissioned Abley Transport Consultants Ltd and Beca Infrastructure Ltd to carry out research to address this knowledge gap.

Steve Abley says, ‘Our aim was to provide practitioners with a tool that uses engineering measurements to predict the walkability of urban environments. The output of the tool is a level of service for the area being examined, which practitioners can use to identify areas of low performance suitable for potential improvements. The tool can also be used to test, and measure, the significance of proposals.’

A popular transport choice

Despite its forgotten status, walking remains the second most popular form of travel in New Zealand (after the private car). NZTA data shows that nearly 20% of all household trips are made on foot, with walking especially important for those households without a car (10%) or without access to a car for much of the day, and for those individuals who cannot or do not drive. Many people – the elderly, those with impaired mobility and those on low incomes – could not achieve their basic day-to-day tasks if they did not go on foot.

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The terms walkable and walkability have become common in engineering, planning and health circles as walking's positive contribution to the social, physical and economic well-being of society has been increasingly recognised. Defined as 'the extent to which the built environment is walking friendly', the concept has been adopted by the NZTA as 'a useful way to assess the characteristics of an area or a route, although it can be subjective'*.

Yet how walkable an environment is often remains an afterthought for decision-makers, a situation not helped by the fact that, until now, it has been a difficult quality to measure.

Steve says. 'We know that a low-quality walking environment can deter or prevent people from choosing to walk, making it vitally important that we have a way to identify and improve any infrastructure that is not meeting pedestrians' needs.'

Filling the knowledge gap

The research drew on previous studies into aspects of walkability to develop its methodology. The adopted approach combined surveys of the physical and operational characteristics of particular street environments, with measurements of how people felt about those environments, in terms of their safety and pleasantness (among other things).

Urban streets in Christchurch, Gisborne, Auckland and Wellington were targeted, with pedestrians' perceptions gathered from paid survey participants representing a cross-section of the population.

The main products of the project were a number of mathematical formulas for calculating the quality of the walking environment (its walkability) when walking along or crossing the road. Quality is taken from the perspective of the user (pedestrian) using operational and physical variables. The formulas are then used to derive a 'level of service' for the path length or road crossing being examined.

The full research report describes the process for obtaining the data and deriving the formulas, and explains the three formulas particularly recommended for practitioner use: one for path length, and two for road crossings (zebra and uncontrolled).

Steve says, 'What we hope is that the tool will enable practitioners to give walking more attention, and so move the country closer to achieving a more balanced, integrated and sustainable transport system.'

Recommendations flowing from the research included more data collection at sites with a low level of service ratings, at signalised road crossings and zebra crossings, and about traffic volumes (to enable traffic flow to be included in the final walkability models). Other recommendations include studies into the walkability of specific sections of road at different times of the day, and an analysis of the differences in walkability ratings between able-bodied pedestrians and those with physical or visual impairments.

* NZ Transport Agency (2007) *Pedestrian planning and design guide*, NZTA, Wellington.

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Predicting walkability, NZ Transport Agency research report 452

Freely available online at www.nzta.govt.nz/resources/research/reports/452/index.html

Revised approach needed for South Island concrete

The discovery of alkali silica reaction (ASR) and delayed ettringite formation (DEF) damage in two Southland bridges led to research into the extent of the problem, and potential causes.

The discovery, which followed a routine inspection in 2006, revealed extensive cracking, spalling and surface erosion to the bridges' concrete piles below high-tide level. The cause was found to be the interaction of two chemical reactions in the concrete – ASR and DEF – which had caused it to expand and ultimately crack.

ASR is a chemical reaction between alkalis in hardened cement paste and silica minerals that occur in some types of rock found in concrete aggregates. The product of the reaction expands in moist conditions, and can create enough stress to crack the concrete.

DEF occurs when the temperature of concrete exceeds 70°C during the early stages of curing. As the concrete cools, ettringite forms, taking up more space than the reaction product it derives from. Like ASR, this creates internal stress, which (where there is sufficient water available, such as in submerged bridge piles) can be sufficient to crack the concrete.

DEF is often associated with ASR. However, unlike ASR, the risk of DEF can be generally controlled by ensuring early curing temperatures remain below 70°C.

Until the 2006 discovery, ASR had not generally been considered to affect South Island concrete. The discovery prompted concerns that the problem could be more widespread.

The research, conducted by Opus International Consultants, aimed to mitigate the risk for both existing and future structures by:

- identifying the extent and severity of ASR and DEF in South Island precast concrete bridge piles (so that affected bridges could be appropriately managed)
- examining how ASR and DEF are influenced by the types of aggregates and the construction practices used, and the conditions that the concrete is subsequently exposed to (so that the risk of the reactions can be minimised in future construction).

Sue Freitag of Opus says, 'Concrete deterioration as a result of ASR and DEF is not easily detected or identified until it is well advanced, which meant that, in undertaking the research, there was a very real risk that other cases might have existed, but had not yet been detected. Initial damage tends to resemble cracking caused by reinforcement corrosion, then later on it can look like impact damage or surface erosion or chemical attack, so it can take a while until the real problem is diagnosed.

'In the South Island, this difficulty was exacerbated by the fact that no-one was expecting to find it. But ASR and DEF damage can significantly reduce the load capacity of affected piles, and the cracks can also make concrete more susceptible to other types of degradation, so it is important that it is detected or, ideally, prevented.'

Potential alkali reactivity of South Island concrete aggregates

Previously, ASR had been considered to present a low risk for South Island concrete. Its detection in two sets of extensively damaged bridge piles in 2006 required a re-examination of this belief. Therefore one of the research tasks was to evaluate the potential alkali reactivity of South Island aggregate sources.

Laboratory tests showed that aggregates from Oreti beach and nearby alluvial deposits are potentially alkali reactive, but may react slower than fresh volcanic materials, and concrete temperatures may need to exceed 60°C to produce significant concrete expansion.

The reactivity is associated with strained quartz, microcrystalline quartz, chalcedony, glass and devitrified glass found in the constituent rock types, which include minor acid and intermediate volcanics, sedimentary rocks containing volcanic constituents, and partly metamorphosed sediments and volcanics found in particular geological terranes.

Similar assemblages are found in alluvium throughout Southland and south-east Otago, and in the Waimea and upper Motueka catchments in the north-west of the South Island.

Alkali- and silica-rich phonolites and trachytes from sources in the Dunedin volcanic group may be alkali reactive, but are not necessarily used in concrete and have not been tested for alkali reactivity.

No other sources of potentially alkali-reactive aggregates were identified in other South Island areas, including Canterbury, north Otago or the West Coast.

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However, an examination of 51 bridges and two wharves considered most likely to be affected (because they were constructed between 1955 and 1970, when high and medium alkali cements were available, in damp or wet conditions, and in areas where aggregates may be alkali reactive) found very few cases of pile damage that resembled damage caused by ASR and DEF. Core samples taken from six of the structures found evidence of ASR reaction products in five of the samples, and evidence of DEF in only one.

The cores where ASR was found came from both cracked and un-cracked piles, leading to the conclusion that while ASR may be relatively common in South Island concrete, it does not necessarily cause sufficient expansion to crack concrete unless it is particularly severe or widespread.

Sue says, 'Our findings suggested that ASR and DEF may be associated with curing temperatures higher than those specified in current industry guidelines for managing ASR expansion. The guidelines are nearly 10 years old and we recommended that they should be updated to highlight the risks associated with elevated curing temperatures and to acknowledge the existence of alkali reactive aggregate in the South Island.'

Implications for bridge inspections and management

Because the most widespread cracking was seen on piles that had been cleaned before being inspected, the research recommends that partly immersed precast concrete piles in marine or estuarine conditions should be cleaned of dirt and biological growth before they're inspected. Ideally, this should occur before every detailed inspection, but at least at every second one.

If this leads to more cases of suspected ASR and DEF being detected, then buried precast piles in damp ground should be excavated and cleaned (for selected structures) to enable further inspection and sampling. This will help to confirm whether the risk of ASR and DEF for buried piles is similar to the risk for submerged ones.

Where potential ASR and DEF damage is observed on a structure, core sampling can be used to determine the cause and extent of the damage, and the likelihood of future deterioration. Where ASR and DEF are confirmed, an engineering assessment will be needed to understand the impact on the structure's durability and structural performance.

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Concrete pile durability in South Island bridges,
NZ Transport Agency research report 454

Freely available online at www.nzta.govt.nz/resources/research/reports/454/index.html

Re-visiting rotation rates for New Zealand roads

Research into rate-of-rotation design criteria looked at the effect of different rates on various types of vehicles, from the perspective of both occupant safety and comfort.

Rate of rotation, or warp factor, is a measure of the variation in cross-fall of a road surface. This is commonly used in the case of where the road changes from a straight section to a bend, and the road's cross-fall is tilted more in the bend ('superelevation cross-fall') to help keep vehicles on the road.

Historically the New Zealand rate-of-rotation design criteria drew from Austroads' *Rural road design: a guide to the geometric design of rural roads* (2003), which has now been replaced by *Guide to Road Design, Part 3 Geometric Design* (2009). These criteria are aimed at providing reasonable levels of ride comfort for vehicle occupants and are generally consistent with current international practice.

However, they are arguably based on relatively conservative vehicle designs (for example, with regard to suspension and handling) and comfort factors, and contain no guidelines or limits about what rate of rotation should be to optimise safety. In addition, New Zealand's rugged geography means it can be a challenge for road designers to marry the topographical constraints of a particular curve with the rate-of-rotation design criteria. In many cases it cannot be done, and there are sections of New Zealand roads where the cross-fall geometries produce rates of rotation far in excess of those specified by the guide. This raises queries about the appropriateness of the criteria in the New Zealand context.

The research set out to improve the knowledge about curves and curve transitions (superelevation development lengths), and from that develop design criteria for rate-of-rotation limits that could be appropriate for New Zealand roads and the vehicles used on them. Part of this involved determining how valid the current Austroads criteria are for rural New Zealand roads, as well as whether there was a threshold limit for rate of rotation above which vehicle safety became compromised, and if this limit varied with vehicle type.

The research combined statistical crash modelling, computer simulations to determine vehicle handling behaviour, and field trials with instrumented vehicles to gather data about different rural road geometries and how different vehicle types responded on them. Three different vehicles were used – a passenger car, a 4-wheel drive sports utility vehicle, and a high-sided rigid truck. These were instrumented to measure orthogonal accelerations (longitudinal, transverse and vertical) and orthogonal rotations (pitch, roll and yaw), as well as driving speed and path. Computer modelling was then used to establish the rates of rotation that would result in a loss of control for the different vehicle types over a range of road geometries and travel speeds.

Principal conclusions reached by the research included:

- rates of rotation are a statistically significant predictor of crash rates
- there does not appear to be a rate-of-rotation threshold above which rollover crashes increase dramatically
- measured rates of rotation for a particular curve are typically greater than those predicted from the geometry alone, indicating the important contribution made by horizontal alignment, load shifts and suspension behaviour
- measured rates of rotation often exceed the limits in the Austroads guideline
- drivers generally perceive ride quality becoming uncomfortable at higher rates of rotation than those set in the Austroads guideline
- all of the vehicles used in the field trials were more likely to slide off the sealed lane than roll over when unloaded, but for loaded trucks rollover became more likely
- the limits in the existing design criteria were not particularly accurate for curves with higher superelevation levels. This suggests that either computer simulation should be used to identify how susceptible particular curves are to rollover, or more specific rate-of-rotation guidelines should be developed that incorporate horizontal curve radius, curve superelevation and curve speed.

The research also recommended a number of areas for further research to build on understanding of rates of rotation and their relationship to rollover crashes in the New Zealand context.

Rates of rotation explained

The following excerpt is from page 10 of the full research report. (See the next page for how to obtain a copy.)

'The geometric design of roads is a complex process of combining straight and curved road sections with transition curves, in order to provide for the safe, efficient and economical movement of all types of traffic. When a vehicle travels along a straight, the pavement has a relatively constant crossfall to facilitate drainage. However, around a curved path a vehicle is subject to a radial force which tends to cause it to slide outwards. To resist this force, the road is usually sloped to a greater degree than on straights and this is referred to as superelevation. The superelevation that is adopted will take into account a variety of factors, such as safety, appearance, grade, speed and drainage. The curves used to change from a straight to a constant radius curve are referred to as transition curves, or alternatively the superelevation development length. Over these transition lengths, the crossfall changes from the normal, often adverse, crossfall to the full superelevation crossfall. This change in crossfall over distance is called the 'rate of rotation' or 'warp factor'. It is usually specified in terms of either a rotation rate (radians/s or %/s) or a transition length (m).

'The geometric design process uses a number of design standards, which have been shown to provide acceptable road design. Included among these are the Austroads (2003) *Rural road design: a guide to the geometric design of rural roads*, the NZ Transport Agency (2005) *State highways geometric design manual*, and more recently Austroads (2009) *Guide to road design: part three.* These guidelines specify desirable and absolute rates of rotation of 0.025 radians/s and 0.035 radians/s respectively.'

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Improved rate-of-rotation design limits, NZ Transport Agency research report 456

Freely available online at www.nzta.govt.nz/resources/research/reports/456/index.html

Towards an integrated pollutant exposure assessment model

NIWA has developed two new models for assessing people's exposure to road traffic emissions, to help fill the gap in the current tools available.

The project focused on two of the main ways that people are exposed to elevated concentrations of road traffic air pollutants:

- when they are living, working or otherwise spending extended amounts of time next to major roads (the roadside corridor model)
- while they are travelling in a vehicle.

Although there are several existing tools for assessing exposure, many are not suitable for the uses that assessments are generally required for (such as health risk assessments and screening assessments).

For roadside air assessments, the tools tend to be either crude and conservative, or complex and demanding to use (but with no guarantee of improved accuracy). For in-vehicle emission assessments, the tools just don't exist, even though car travel, especially on motorways, is known to be a major source of exposure.

The project aimed to develop a general method for predicting people's exposure to emissions in both of these situations, using simple, semi-empirical predictive models. The longer-term aim (which has now been taken up beyond this project) was to incorporate these models in a more comprehensive multi-modal exposure assessment tool, and the models were developed with this future use in mind. Both models were treated as starting points, with acknowledged limitations to their current use and more work ongoing to develop and validate them.

Why new tools are needed

Recent research has shown that spending extended periods of time close to transport emissions can cause major illness, with the cost to society (in terms of health care, etc) similar to that imposed by traffic crashes. There is also a rapidly expanding body of epidemiological and toxicological literature linking living near major roads with adverse health effects.

However, models currently used in New Zealand to estimate the risks posed by traffic emissions are suspected to lead to chronic underestimation of risk. In addition, limitations in accurately modelling vehicle emissions and their dispersion undermine our ability to draw causative links between emissions and illness.

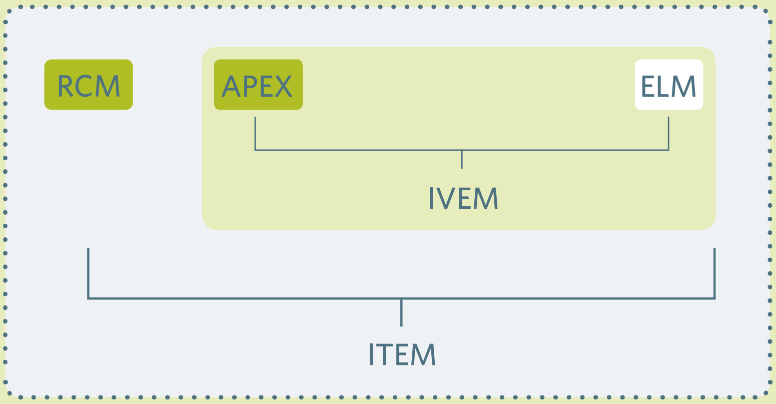
On the operational side, accurate means of predicting vehicle emissions are needed to improve the management of New Zealand's highways, in particular for identifying places where transport emissions are significant. Guidance being developed by the NZTA for the assessment of air quality effects associated with state highway projects requires projects to be assessed and compared to a number of thresholds (which in turn will trigger more in-depth assessment). Having a better means to define (and assess) these thresholds will lead to more sustainable outcomes for transport projects.

The roadside corridor model

The roadside corridor is the area or zone adjacent to the road, within which emission concentrations are significantly higher than they would be if the road was not there or in other urban locations further away. Vehicle emissions tend to disperse and dilute rapidly, with the rate that this occurs affected by meteorological conditions and local topography. The type of pollutant being measured also affects the dispersal rate, with different pollutants potentially leading to different corridor widths.

There are already a range of different modelling approaches and tools available to predict roadside air quality, typically classifiable as emission-dispersion models, regression models (spatial or temporal), and simple banding or interpolation options. However, all of these models have shortfalls. Ian Longley of NIWA explains, 'All of the methods currently in common use for roadside corridor assessments suffer from limitations of one type or another. These can manifest either as inconsistency in the results being returned, or an excessive and unhelpful complexity in using them, which has its own implications for accuracy.

Intended eventual model structure



The following excerpt is from page 8 of the full research report. (See the next page for how to obtain a copy.)

'The [dark green] boxes show components developed within this project. The air and particles exchange model (APEX) is intended to combine with the emission link model (ELM) to form the in-vehicle exposure model (IVEM). IVEM combines with the roadside corridor model (RCM) to form the integrated transport exposure model (ITEM).'

'Our aim was to develop an alternative approach, better suited to applications where the need for accuracy and detail was more relaxed, but greater spatial coverage may be required. We wanted to make the model as easy as possible to use, to empower a greater variety of end users, and to minimise the amount of input data that was needed to return the maximum possible number of model scenarios.

'Inevitably, we sacrificed some fidelity in return for greater speed and accessibility. But the model we finished with is particularly suitable for health risk applications and planning purposes, which was one of the identified gaps that we wanted to address. It will also be useful for identifying locations where there are significant impacts from transport, as it can be used alongside monitoring to help differentiate traffic sources of pollutants from other sources.'

The roadside corridor model developed in the study is a parameterised implementation of a more complex emission-dispersion model. It is designed to predict long-term roadside elevations in concentrations of certain passive contaminants in urban locations, and allows independent predictions for either side of the road to account for local wind conditions.

The model is implemented as a spreadsheet, and is now being integrated into a GIS-based tool. It has already been used to inform guidelines being developed by the NZTA for the assessment of air quality effects associated with state highway projects.

Limitations with the model include its application to urban areas only, its restriction to passive contaminants for which data about emission rates is already available, and the fact that it describes typical dispersion in typical areas (leading it to underperform in 'atypical' areas, such as CBDs and areas with complex terrains or local microclimates).

The research report demonstrates the model's practical application in several case studies, including in assessing a road project, defining a risk corridor around roads, and distinguishing local and remote sources of pollution in roadside air quality monitoring data.

Emissions while travelling in a car

The second part of the study focused on assessing in-vehicle emissions. At present, little is known about vehicle occupants' exposure to emissions while travelling and there were no off-the-shelf tools for assessing this.

Most of the studies on the health effects of air pollution conducted to date have been based on the assumption that the level of air pollution at a person's home address represents their personal exposure. However, this approach overlooks that fact that many of us (especially children) spend a large proportion of our lives travelling in cars and risks significantly underestimating a person's exposure to pollutants as a result. This is backed up by a small but growing number of studies showing that our exposure to traffic pollution is strongly influenced by how long we spend in close proximity to busy traffic (within a couple metres, as when we are travelling in a car in urban areas).

Ian says, 'Because the existing body of knowledge and tools in this area was slim, our research on in-vehicle exposure focused on an earlier stage of model development than we took with respect to

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the roadside corridor. Principally we gathered observational data that we then used to inform a preliminary in-vehicle exposure model.'

This model is an air and particles exchange model (APEX), which predicts the concentrations of air pollutants inside a moving vehicle in traffic if the external concentrations are known.

The model was informed by many hours of air quality measurements made inside a car travelling on a wide range of routes across Auckland. Greater concentrations of on-road pollutants were found on motorways, at busy intersections, close to high-emitting vehicles and when travelling uphill. The resulting model requires only one parameter – the vehicle's air exchange rate, which is influenced by such things as whether or not the windows are open, the speed of the ventilation fan, whether the air vents are open or closed, and how airtight the vehicle cabin is.

Ian says, 'Essentially we found that opening the windows only has a minor influence on the amount of in-car pollutants that people are exposed to, but that occupants could significantly reduce their exposure in high-emission environments by recirculating the air in the vehicle cabins. Situations where occupants were exposed to higher rates of pollutants inside the car than were present outside were when polluted air came from the exhaust of the vehicle in front and was injected into the vehicle through a fan or vent, and then became trapped.

'The APEX model we've developed from our findings is the first step that provides the technical underpinning of a broader policy tool.'

This policy tool is outlined in the full report.

The RCM and APEX form two of the building blocks that NIWA is assembling to build an integrated exposure management policy tool, part of an ongoing long-term commitment to this area of research, and a personal passion for Ian. The RCM is currently being evaluated and improved, and its capabilities expanded.

Meanwhile, Ian's future plans include combining the APEX model with an emission-link model (ELM), which looks at the effect of the route chosen and the traffic on in-vehicle exposure to produce an operational in-vehicle exposure model (IVEM).

The IVEM would enable in-vehicle exposure to pollutants to be predicted for any given route, trip or traffic conditions. It could then be combined with the roadside corridor model developed in the project to provide an integrated pollutant exposure assessment package.

Ian says, 'This is an ambitious journey we're on, but I believe we are developing a unique product that, although based on leading-edge science, will provide simplicity for a wide range of users in research, planning and environmental management. There's still some way to go, but the modelling and observational data gathering and analysis we've done so far provides a solid foundation for this eventual integrated approach.'

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Tools for assessing exposure to land transport emissions,
NZ Transport Agency research report 451

Freely available online at www.nzta.govt.nz/resources/research/reports/451/index.html

Looking inside surface layers helps predict longevity

Research to help predict maintenance needs for open-graded porous asphalt (OGPA) pavements has found that New Zealand's unique multiple-overlay approach is not ideal from a structural point of view.

Much of New Zealand's road network is now well developed, and the focus has shifted to improving and maintaining existing roads. Effective maintenance requires a sound understanding of the behaviour and performance, under loading, of the various materials that make up the pavement structure and surface.

Recent research has focused on the part that binder ageing and layer stiffening play, as primary causes of OGPA surface failures. The study sought to relate OGPA layer stiffness to a pavement's field performance, by analysing new and historic data about OGPA pavements, both local and overseas.

The outcome was a proposed method for predicting an OGPA pavement's stiffness from its volumetric properties. This could then be compared with terminal stiffness values for OGPA mixes (the point at which failure occurs), to inform decisions about when maintenance needs to take place.

The New Zealand approach

OGPA surfacing is widely used on New Zealand motorways because of its low noise, reduced wet weather spray and glare, and skid-resistance properties. An approach for maintaining OGPA pavements has evolved, and become widely adopted, that involves overlaying the existing OGPA surface with a membrane seal, then applying a new overlay of OGPA (with relatively little pavement rehabilitation undertaken at the same time).

This process is repeated, as needed, until the upper pavement consists of up to four layers of OGPA.

The aim of this approach, which appears to be unique to New Zealand (overseas, surface layers are milled off and replaced), has always been to restore the functional properties of the upper layer, with relatively little consideration given to the effect on structure. However, despite dramatic increases in traffic over the years, these pavements have continued to

perform well, to the point that it has been suggested that this multi-layer approach is also contributing to the pavements' structural capacity.

Debra Olney of MWH New Zealand Ltd who conducted the research says, 'We found that, compared with asphalt overlay practices in Europe and the UK, New Zealand's practice of using multiple overlays for maintenance was not optimal from a structural point of view. Although it has been based on observed good performance, our analysis showed that the life of the multiple layers shortened with each successive overlay, with binder ageing appearing to be the limiting factor.'

Studies from the UK have suggested that an OGPA pavement will fail rapidly after binder stiffness reaches certain values (for all types of binder). When the binder stiffens it is no longer able to withstand the strain created by repetitive wheel loads and thermal stress and begins to fail. Failure is generally indicated through increased ravelling (stone loss) and texture depth, and surface cracking.

Debra says, 'It follows that being able to measure the binder stiffness of the surface of an in situ pavement would give us valuable information about when the surface is likely to fail, and hence when maintenance should optimally occur. We developed a method that can be used to track the stiffening of asphalt over time. By extracting samples from the layer at regular intervals, testing them for stiffness and comparing the results to values for terminal stiffness, we can predict when that terminal state is likely to be reached and when failure will start to occur.'

The study

Using statistical analysis of data from the Auckland South state highway network, the study found that the average time until initial crack development in an OGPA surfacing layer was 7.5 years (although some pavements could go over 14 years before failure began). This time did not depend on the structural strength of the pavement, with binder stiffening occurring in all pavements, regardless of their structural strength.

The study also analysed core pavement samples from the network, and production mixes from the 2006/2007 network maintenance contract, to assess the stiffness of OGPA mixes. Stiffness was measured using a repeated-load indirect tensile strength test, with the results then related to the ultimate binder stiffness using rheological models and the Shell monograph. Terminal stiffness values were derived from failures in New Zealand, the UK and the US. Terminal OGPA stiffness was found to be in the order of 2300MPa at 25°C, with corresponding binder penetration of 11Pen.

The proposed methods were tested out on samples from sites from across the Auckland South state highway network. Results indicated an increase in OGPA stiffness in the network of 16% per year, with an apparent correlation between the mix stiffness and the appearance of the pavement's surface condition. The remaining life of the surfaces at the tested sites could be predicted based on the rate of stiffening.

Decision tree

The research recommended a gradual move away from the current multiple overlay approach, with OGPA continued to be used for its functional rather than its structural integrity. In situ OGPA layers should be measured for stiffness, using the method developed, to help identify when failure is imminent and intervention needed.

The research report includes a maintenance decision-making tree, which incorporates stiffness values alongside the structural soundness of the pavement, site constraints and functional requirements. Decision-makers can use the tree alongside dTIMS CT optimisation software to assess the maintenance needs of particular sites.

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Performance of open graded porous asphalt in New Zealand,
NZ Transport Agency research report 455

Freely available online at www.nzta.govt.nz/resources/research/reports/455/index.html

New research reports

Improved multi-lane roundabout designs for urban areas

Research report 476

Duncan Campbell – Auckland Transport

Ivan Jurisich – Traffic Engineering Solutions Ltd

Roger Dunn – Department of Civil and Environmental Engineering, Auckland University

Freely available online at www.nzta.govt.nz/resources/research/reports/476/index.html

This research, undertaken 2008–2010, investigated the comparative safety of multi-lane roundabouts versus signalised intersections, pedestrian facilities, vertical deflection devices and visibility to the right. Guidance for practical application of the relevant measures to enhance roundabout safety has been developed and is included in this document. The Dutch turbo-roundabout was reviewed and considered to be feasible for application in New Zealand.

For intersections with four arms or more, a well-designed multi-lane roundabout should be significantly safer for vehicle users than traffic signals. Several means of adequately catering for pedestrians and cyclists at multi-lane roundabouts are feasible to implement in many cases.

In the interest of road safety, a 'Roundabouts First' policy is recommended for adoption by the NZTA. The legal use of flashing signal displays and part-time signal operation is also recommended, which would potentially allow for 'Pelican' pedestrian crossing installations, and also for signalised roundabouts to operate with less vehicle delay during off-peak periods.

Gap acceptance road safety modelling: pilot study

Research report 480

S Turner, R Singh, M Soper and D Sun – Beca Infrastructure Limited

Freely available online at www.nzta.govt.nz/resources/research/reports/480/index.html

A key problem for local authorities is the lack of robust techniques for evaluating crash risk at high-volume, urban, priority-controlled intersections. Some crash prediction modelling tools are available, but they do not accurately predict crash rates at the higher-volume priority-controlled intersections where at times there are limited gaps in main road traffic flows, which often gives rise to safety problems. This research project aimed to develop safety models that would enable practitioners to better understand crash risk at urban intersections.

Video data was collected at eight Christchurch sites for the peak traffic periods. The data was analysed to measure vehicle headway and the gap acceptance profile (bell graph) of drivers making two movements – the right turn in and the right turn out. This pilot study established a framework procedure and presents the results from the data analysis.

Further work is required to collect data from a larger sample of priority-controlled intersections across New Zealand. Ideally, automated analysis of video data would be applied. Using this additional data, the development of a safety model linking gap selection and crashes should be possible.

Fleet management commitment to fuel efficiency

Research report 482

PH Baas – Transport Engineering Research New Zealand Ltd

Freely available online at www.nzta.govt.nz/resources/research/reports/482/index.html

The aim of this research, undertaken in 2009–2011, was to identify ways of overcoming the barriers faced by managers of New Zealand's light and heavy vehicle fleets in attempting to implement fuel efficiency as part of their normal way of doing business. It included a review of best practice documents, interviews and meetings with fleet managers and key stakeholders, and case studies.

A strong link can be found between fuel efficiency and safety. Many of the ways of improving them are the same: managing speed, anticipating the situation ahead, reducing aggressive driving, checking tyre pressures, maintaining vehicles and reducing the amount of travel.

The common feature of fuel efficiency programmes and the successfully implemented fuel efficiency and safety management practices is the adoption of evidence-based practice. The report provides a model based on what worked best for the case study fleets and others who have improved fuel efficiency and safety.

The report recommends a number of ways to help fleets adopt evidence-based practice for saving fuel, improving productivity, improving safety and reducing emissions. Examples include raising awareness, using incentives, encouraging the appointment of fuel champions in fleets, and providing advice and training.

Ground vibration from road construction

Research report 485

PD Cenek and AJ Sutherland – Opus International Consultants Ltd, Central Laboratories

Freely available online at www.nzta.govt.nz/resources/research/reports/485/index.html

There is an increasing requirement to control and manage ground vibrations generated by road construction and maintenance activities through project-specific construction management plans. The objective is to minimise any potential adverse effects. The ability to reliably estimate vibration levels of specific construction activities at the project planning stage and to assess their likely effect on structures and their occupants is therefore required. Typical vibration characteristics for various activities, including site preparation, dynamic compaction and piling, were measured for representative equipment and soil types to obtain baseline values for use in preconstruction assessments and to enable validation of available prediction methods. A review of international standards was also undertaken, leading to two proposed criteria against which predicted vibrations can be assessed for damage and human perception. The possible application of data acquired from commonly used geotechnical methods, notably scala penetrometer for estimating soil attenuation and falling weight deflectometer to generate site-specific predictor curves for impact-related construction activity, was additionally investigated. This led to the recommendation of three methods, which make use of readily available data, for estimating vibration levels from construction activity at any specified distance from the vibration source.

Demand for transport services: impact on networks of older persons' travel as the population of New Zealand ages

Research report 481

William Frith – Opus Central Laboratories, Lower Hutt, New Zealand

M Kelly Mara – MKM, Wellington, New Zealand

Jim Langford – Monash University Accident Research Centre, Monash University, Melbourne, Victoria, Australia

Freely available online at www.nzta.govt.nz/resources/research/reports/481/index.html

This research, undertaken in 2010, aimed to provide predictions of older persons' (age 65+) demand for transport until the mid-21st century in New Zealand, and how this will affect our networks.

- Projections that do not take an ageing population into account overstate the increase in household travel by ~40%.
- Assumptions about population health factors make a small difference in travel estimates to 2020 but have greater impact thereafter.
- Changes in the age structure of the workforce increased total household travel demand by about 1%.
- Wide regional variations mean that each region will require its own approach to future transport and safety.
- Public transport will be a minor mode without improved public transport for suburban neighbourhoods.
- Vehicle safety, operator and accessibility issues need to be addressed.
- People aged 65–80 years are relatively content with the transport system, but those who are older indicated they would travel more if they could.
- Older women feel more constrained in their travel choices than older men.
- Road deaths and injuries will be similar to those expected for a population without any age structure change. However, older persons' injuries will become a greater proportion of all road trauma.

Australasian Road Safety Research, Policing and Education Conference

The Australasian Road Safety Research, Policing and Education Conference is the most inclusive annual road safety event in Australia and New Zealand. It brings together leading researchers, practitioners and policy-makers from New Zealand, Australia and overseas to discuss and share developments in road safety. This year the conference will be held jointly with the New Zealand Local Authority Traffic Institute (TRAFINZ), highlighting the role of local authorities in road safety and traffic management.

The conference will take place from Thursday 4 October to Saturday 6 October in Wellington, New Zealand.

The theme of the 2012 conference is 'Reducing the cost of road safety'. It will reflect the four pillars of the Safe System approach – safe roads and roadsides, safe vehicles, safe users, and safe speeds – as adopted in New Zealand's 10-year strategy Safer Journeys (www.saferjourneys.govt.nz). The conference will have a particular focus on innovation and cost-effectiveness.

Bookmark our website, and keep checking it for updates – www.roadsafety2012.co.nz.

Another related conference is being held in Wellington at this time. The first day of the Road Safety Research, Policing and Education Conference will overlap with the final day of the 2012 World Safety Conference and some sessions will be shared. For more information about the World Safety Conference, go to www.conference.co.nz/worldsafety2012.

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NZTA research welcomes letters from readers. Letters should be addressed to:

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www.nzta.govt.nz

The NZTA has a number of other publications you might be interested in.

NZTA connect provides a snapshot of the NZTA's projects and initiatives that are relevant to the work approved organisations are doing in the area of land transport in New Zealand.

Exchange is the Public Transport Leadership Forum's quarterly e-newsletter. It informs transport sector leaders and rail, bus and ferry operators across New Zealand about the forum's vision, synergies, and planned initiatives to improve the effectiveness of public transport in New Zealand.

For more information about these newsletters, go to www.nzta.govt.nz/about/newsletters.

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