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Look both ways: improving children's safety - on and off the bus

Widespread concerns about school bus safety have been the catalyst for research and detailed recommendations for improvements.

Between 1987 and 2007, 22 children were killed, 45 were seriously injured and 91 received minor injuries when crossing the road to get on, or after getting off, a school bus. A further 6 children were killed, 35 were seriously injured and 112 received minor injuries while actually travelling on the bus.

Prompted by concerns about these statistics, and by calls from the community and professional groups to do something to address them, the Bus Safety Technical Advisory Committee initiated a research project to 'advance the measures that were seen as having the most promise' to reduce the risk and incidence of injury. Made up of representatives from the Ministry of Education, NZ Transport Agency, Ministry of Transport, NZ Police, Bus and Coach Association and the bus building and operating industries, the committee has been taking a long-term approach to identifying and managing the risks that can arise from travelling to school by bus.

A two-pronged approach

The research project sought to identify, prioritise and discuss the options available for reducing the number of children killed or injured while on, or crossing to or from, the school bus.

Peter Baas of TERNZ, who led the research project, explains that in considering these options the team took a health and safety approach.

'Standard health and safety practice is to address hazards by eliminating them where possible, or if they can't be eliminated, by isolating them, or if they can't be isolated, by minimising them. In our context, this equated to eliminating the need for children to cross the road, or if that wasn't possible, preventing them from heedlessly running out into the road, plus slowing down traffic around school buses to minimise the risk when children were crossing.'

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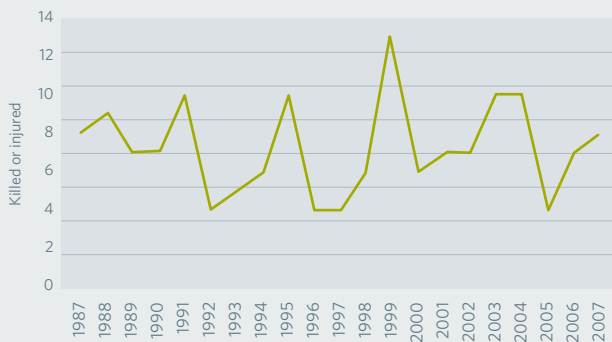
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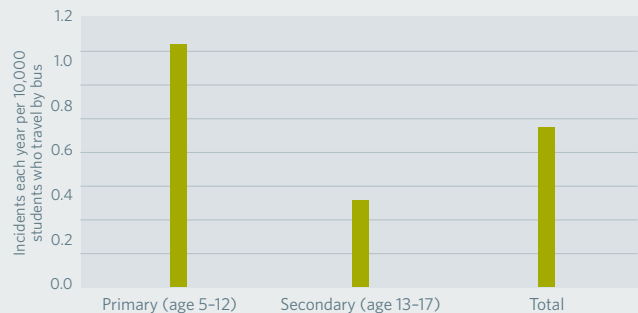
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Students killed or injured per year as school bus related pedestrians from 1987 to 2007



Primary and secondary aged students who travel to school by bus killed or injured each year from 1987 to 2007



Focusing on the potentially most effective measures, the team identified eight areas where changes could be made – six relating to the safety of children crossing the road to or from a school bus and two addressing their safety while travelling on the bus.

Safety measures while crossing to or from the bus

The first step was to eliminate the need for children to cross the road to catch their bus. This could be done by encouraging parents and other caregivers to meet their children at the actual bus stop (rather than waiting across the road in their car or outside their gate). Various agencies and schools have already been taking steps to encourage parents to park on the same side of the road that the bus stops. However, it is widely recognised that this is not sufficient and that, where caregivers perceive the risk to be low, they will still park on the other side of the road if this is more convenient. More tangible measures, such as providing better and more parking adjacent to bus stops, may be needed if this change is to be achieved.

Peter says, 'Some road authorities have already started improving school bus stops, including making greater provision for parking. In our report we've developed and included a draft bus stop guide, which should be helpful for authorities undertaking this work, especially in rural areas. In addition to recommendations for parking, the guide suggests measures for modifying the adjacent highway environment, and sets out a hierarchy of potential treatments, including indicative costs.'

Rearranging bus routes, so that where possible children are put down outside their gate, or on the same side of the road, is another option. The Ministry of Education and bus service providers try to configure routes so that as few children as possible have to cross the road. However, this often requires routes to be extended, which has implications in terms of increased running costs and the length of time that some children have to spend on the bus.

If there is no alternative for children but to cross the road, then the focus shifts to preventing children from running heedlessly out onto the road from behind or in front of the bus.

Peter says, 'Parents, bus drivers, schools and other agencies all have a shared responsibility to do what they can to make sure children cross the road safely. Although there are some questions about the efficacy of road safety education and awareness programmes, there are other inexpensive steps that can be taken

to protect children in this way. Parents, in particular, should model good road crossing behaviour and regularly remind children of how to cross safely. Schools and communities could have initiatives, such as delegated wardens or responsible adults to meet the bus and supervise children as they get on and off.'

Ensuring that traffic is travelling at reduced speeds around stopped school buses is another measure that can be put in place, until funding becomes available for more expensive bus stop and route

A popular (and relatively safe) way to travel

In New Zealand, approximately 20 percent (106,000) of all students at primary and secondary schools get to school by bus, with school bus services funded by the Ministry of Education (generally for rural services), regional councils (urban services) and parents.

Crashes involving school buses, especially when there are fatalities, tend to attract a lot of media attention and hence community concern. Yet travelling by bus remains one of the safer ways to get to school and back.

Recent New Zealand research has estimated that the risk of injury during the trip to school by bus is 2.59 per million bus trips compared to 6.08 injuries per million for private motor vehicle trips and 10.3 injuries per million for walking trips. Similar research in Scotland found that children were seven times more likely to be injured while travelling to school in a car than by bus.

Despite these findings, the high number of children travelling to school by bus in New Zealand means that there is scope to substantially reduce their risk of injury by introducing measures to make bus travel safer. The current research identified and discussed eight areas where improvements could be made, both while on the bus as well as when children are crossing the road to or from the bus. The most promising measures included slowing down traffic when it is passing a school bus that is picking up or dropping off children, encouraging caregivers to meet their children at the bus stop, helping younger children to cross the road, and improving the visibility and condition of bus stops.

modification options. At present the legal requirement is for traffic to slow to 20km/h when passing a school bus, although in practice this is seldom observed or enforced.

Peter says, 'We recommended that the speed limit be reviewed to bring it more into line with limits in other high-risk areas and that it should be more actively enforced. Speed signs, to be activated when students are likely to cross the road, should be installed on all buses, and as part of the project we carried out a trial to determine the most effective signs. There are recommendations about these included in the full report.'

'Driver awareness will also continue to be important, but given the cost and efficacy issues around these programmes, the signs, combined with better bus stops and revised, enforced speed limits, were our recommended priority actions.'

Measures while on the bus

Options for improving children's safety while on the bus relate to bus management standards and occupant protection measures. Occupant protection measures included safety belts and higher seat backs (US research has found that these offer the greatest potential safety improvement per dollar invested). However, it was recognised that retrofitting either of these options into older buses would be expensive.

Peter says, 'While the mandatory use of safety belts would undoubtedly improve safety, at this stage reducing the number of children killed crossing the road would produce greater benefits at lower costs and should be given priority. In terms of bus management, steps recently introduced by the Ministry of Education to improve the construction and maintenance of school buses appear to have been effective, and we recommend that these should continue and be promoted.'

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School bus safety. NZ Transport Agency research report 408.

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Light vehicles crucial in achieving emissions targets

Reviewing the role of low-powered electric vehicles and replacing road user charges with fuel excise duty for small, fuel-efficient diesel vehicles were just two of the recommendations from a recent project that looked at the correlation between New Zealand's light vehicle fleet and greenhouse gas emissions.



A street scene in the Netherlands showing a selection of fuel-efficient vehicles.

New Zealand has committed to reducing its per-capita greenhouse gas emissions from transport to half the 2007 levels by 2040. To understand how best to achieve this target, a recent NZ Transport Agency funded research project looked at the available (and soon to be available) options for private and commercial light vehicles. Coupled with information about standard and alternative fuels, the question becomes how best to configure these technologies in order to reduce emissions, now and in the longer term.

John de Pont of TERNZ who carried out the research explains that reducing the emissions of the nation's light vehicle fleet is crucial if New Zealand is to achieve its target reductions.

'Around 81 percent of New Zealand's greenhouse gas emissions come from light vehicles, with light vehicles accounting for over 90 percent of the total kilometres travelled by vehicles.'

'Greenhouse gas emissions are primarily carbon dioxide, which in the research enabled us to use CO₂ emissions as a surrogate measure for all greenhouse gas emissions. Because CO₂ emissions are directly related to fuel consumption,

improving fuel efficiency reduces greenhouse gas emissions. As a result, a major focus of the research was on the various ways that we could change and reduce fuel consumption here in New Zealand.'

Reviewing the options

The project's full report begins with a review of the light vehicles available today, including human-powered and hybrid human-powered vehicles, low-powered urban vehicles (restricted in terms of their speed and power), and the unrestricted vehicles currently favoured by drivers.

For each of these classes of vehicle, the fuel and engine technologies (both available at present and soon to be available), the emissions and fuel efficiency performance was evaluated, with fuel efficiency compared using greenhouse gas emissions.

John says, 'Comparing fuel efficiency tends to be complicated because of the variations in energy density of various fuels. By using greenhouse gas emissions, which we measured in g/km of CO₂-e, we could reflect the combined effect of energy

content and the efficiency of the engine in using that fuel.'

Key findings from the evaluation included:

- diesel, LPG and CNG are all well-established fuels and can reduce greenhouse gas emissions at the tailpipe by about 20 to 30 percent (compared to petrol)
- biofuels generate similar levels of greenhouse gas emissions at the tailpipe as the fuels they replace, but because the production of the plants they are made from removes CO₂ from the atmosphere, there is potential for net reduction in greenhouse gas emissions when the whole fuel cycle is considered
- second generation biofuels are expected to reduce greenhouse gas emissions by around 80 to 90 percent

What's in an emission?

Most vehicle emissions fall into one of two categories with very little overlap between them. This enables the two types of emissions to be considered separately.

- Greenhouse gas emissions are those that have been identified as contributing to climate change. They are usually measured in units of equivalent weight of carbon dioxide (CO₂-e), as most greenhouse gas emissions are CO₂, with small contributions from other gases.
- Air-quality-related emissions (also known as regulated emissions) are those primarily regulated by emissions standards. They have adverse effects on human health and are claimed to cause around 500 premature deaths each year in New Zealand. The various standards that target air quality emissions do not address greenhouse gas emissions.

The project considers both types of emissions, as it is important to consider the total effect of changing the emissions profile of the nation's vehicle fleet. Reducing greenhouse gas emissions at the expense of air quality emissions, or vice-versa, is not desirable.



A Volkswagen concept prototype that uses less than 1 litre per 100km.

- mild hybrid vehicles (which stop the engine when the vehicle is stationary, with an immediate restart when the accelerator is touched, and use regenerative braking to help charge the batteries) and fully grid-independent hybrids can achieve reductions in overall greenhouse gas emissions of around 10 percent and 25 percent respectively
- battery electric vehicles produce the lowest greenhouse gas emissions, especially in New Zealand where a large proportion of electricity is generated from renewable sources.

Changing what and how we drive

At present, 85 percent of New Zealand's light vehicle fleet is petrol-powered and 15 percent diesel powered. Around 87 percent of this fleet is light passenger vehicles (the remainder is commercial) and these vehicles account for 85 percent of the total distance travelled by the fleet.

John says, 'What these statistics show is that the largest potential gains for reducing greenhouse gas emissions will come from promoting alternatives for petrol-powered light passenger vehicles. In the report we outline three main ways that the fuel efficiency and greenhouse gas emissions of New Zealand's light vehicle fleet can be improved, namely downsizing (using smaller engine, lighter cars), changing to more fuel-efficient, lower-emission fuel and engine technologies, and encouraging people to use more fuel-efficient vehicle types.

'The factors that influence the type of vehicles that people select are complex and include such things as size and capacity,

economics, safety, and the perceived status that particular vehicles have for their owners. Understanding these factors and their interplay is important if we are to develop effective policies for encouraging people to choose lower-emission, more fuel-efficient vehicles in the future.'

Recommendations flowing from the research provide food for thought for the government, transport sector and consumers. Strategies such as including information about electric vehicles on government consumer information websites and promoting a positive image for fuel-efficient, smaller-engine vehicles on sites such as www.rightcar.govt.nz and www.fuelsaver.govt.nz would help change consumer behaviour in the short term. Encouraging technologies that meet the latest regulated emission standards and replacing road user charges with fuel excise duty for light diesel vehicles would have more enduring effects. In the longer term, exploring New Zealand's potential to become a significant biofuels producer, and in the process become self-sufficient in transport fuel, is an exciting option to be pursued by the transport sector.

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Low-emission fuel-efficient light vehicles.
NZ Transport Agency research report 391.

Freely available online at
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Process for indicators will keep integrated projects on track

A framework to help project teams develop and evaluate suitable indicators was the outcome of a research project that had effective integrated land use and transport planning as its starting point.

The NZ Transport Agency has called for integrated regional and local land use and transport strategies. Such strategies can provide context for funding applications for land transport projects, and the agency is encouraging ‘packages’ of projects that address and achieve both land use and transport outcomes.

Monitoring these projects, and being able to identify appropriate indicators for this monitoring, will ensure that the projects remain accountable to their funders, decision makers and the public. It will also help manage the development, implementation and monitoring of integrated planning projects so that they have the best chance of success.

The current research project has sought to put in place a framework for developing indicators for integrated land use and transport planning in New Zealand. The framework is methodological, in that it identifies the process that should be followed in developing indicators, rather than seeking to determine a set of best-practice one-size-fits-all indicators for projects.

Richard Dunbar, director of CityScope Consultants Ltd, says, ‘The framework is intended as guidance for project teams that are developing sets of indicators appropriate for their particular strategy or project. The approach we’ve taken in the framework is a generic one, and as such should have broad application in the land use and transport planning fields. It represents a project management approach to monitoring, in that it monitors whether specified targets are achieved within their established timeframes and budgets.

‘However, it is important to note that the framework is policy neutral, in that it

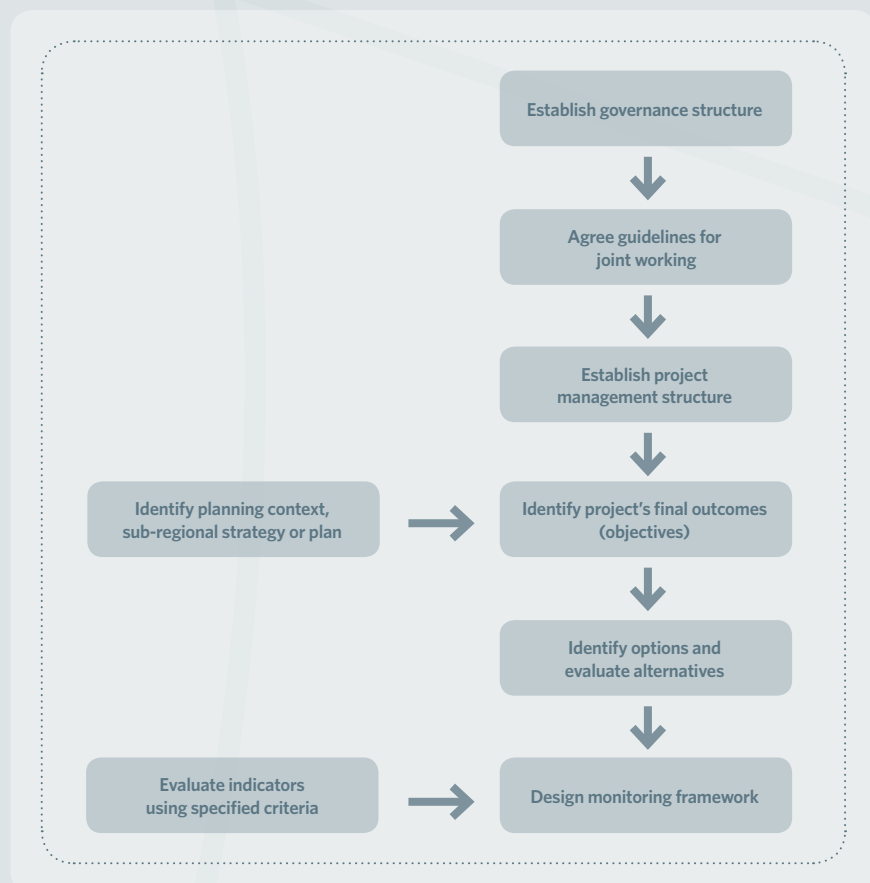
avoids any suggestion of what the outcomes of integrated planning should be. These outcomes are to be determined by the stakeholders in each project. In the report, we provide examples of indicators taken from the transport planning field, so that users can understand the types of indicators that might apply at each stage of the process.’

Putting the pieces in place

The process for developing indicators starts at the opposite end of the project chain to the monitoring process, ie it begins by identifying the final outcomes (or objectives) of the policy or project, then works backwards from there to

identify the inputs and outputs required. (Monitoring on the other hand usually starts with the inputs in terms of resources, and moves from there to project outputs or deliverables, to intermediate and final outcomes.)

In the suggested methodological framework for developing indicators, setting the process of integration is the first component. This involves working together to decide the appropriate method of collaboration for the project. In the full report, an integrated planning process checklist is provided to help project teams with this stage.



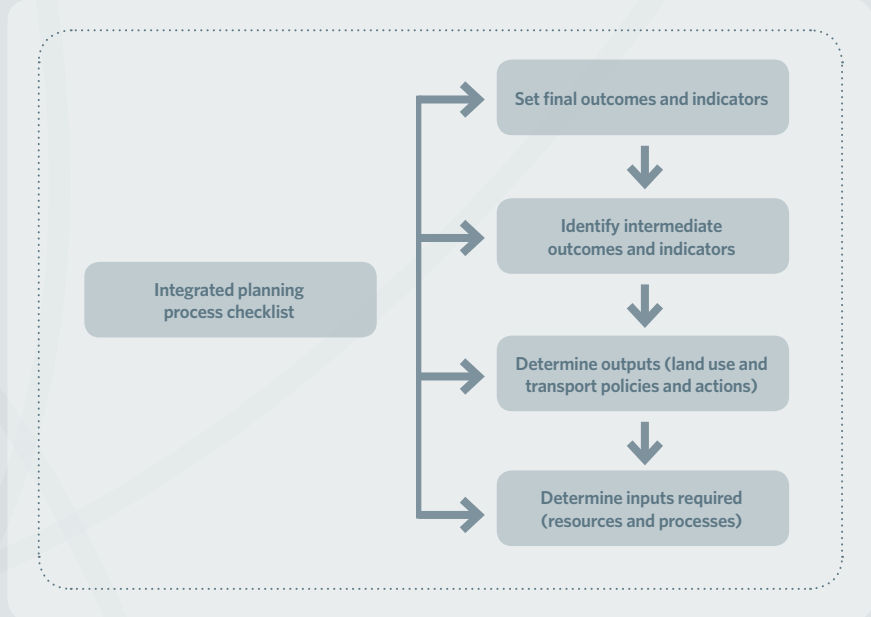
Once this component of the framework is achieved, the focus shifts to determining what the final and intermediate outcomes for the project will be, and what inputs and outputs will be needed to achieve these outcomes. The remaining components of the framework are:

- Final outcomes - what are the desired long-term impacts of integrated planning? What are the higher order outcomes to be achieved?
- Intermediate outcomes - what near-term outcomes can be used to measure progress towards final outcomes?
- Outputs - what policy measures (both land use and transport) are needed to achieve these outcomes?
- Inputs - what resources need to be provided to achieve these outputs?

Richard says, 'The second stage is arguably the most important for monitoring. This is the identification of intermediate or near-term outcomes, which can be used as a proxy measure for the final outcomes. Final outcomes often relate to long-term targets and can be influenced by a range of events and trends outside the control of the project. By monitoring intermediate outcomes, project teams can maintain a focus on the likelihood of achieving final outcomes and meeting the project's underlying objectives, even beyond the implementation stage. Indicators for intermediate outcomes are really only required where the final outcomes are difficult to measure in a timely fashion.'

Having identified the outcomes, outputs and inputs, appropriate indicators can then be developed for measuring and monitoring these components. The full report provides examples of these indicators, plus criteria for evaluating whether particular indicators are appropriate. Criteria include:

- Validity - is the indicator a true reflection of the issue under investigation? Is it defensible?
- Relevance - does the indicator measure trends and patterns in our target area? Does the indicator measure what we may consider to be a priority issue?



- Measurable - is the indicator measurable? Is information available for the indicator, what form will measurement take, and is the information capable of being interpreted in an unambiguous manner?
- Data - are data sets available to measure the indicator?
- Time related and repeatable - are time series or records available to provide a historical perspective against which to assess future changes? Will future data and series be available?
- Understandable - is the indicator meaningful and communicable, capable of being presented in an easy-to-understand way?

Richard says, 'The research focused on large-scale integrated urban development projects. However, because the framework is a methodological approach, we anticipate it will have broader application in the land use, transport planning and urban design fields.'

'In projects of this type, there is a huge range of aspects that the monitoring team need to keep track of, from high-level concerns about sustainable development through to construction timetables and budgets. Monitoring also needs to span right from project initiation and planning through to the long-term impacts of the outcomes, which may be years after physical implementation of the project is finished.'

'During project implementation, when the focus is on outputs or intermediate outcomes, the monitoring function may be closely linked in with the project management team, but before and after it may be more closely aligned with the strategic planning group. For this reason, we suggest that the main monitoring function is managed jointly by the governance and strategic planning groups, with the day-to-day monitoring of project implementation passed at that stage to the project managers.'

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Development of indicators for monitoring land use transport integration projects.
 NZ Transport Agency research report 402.

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Injecting a mechanistic slant into pavement capacity models

A study aimed at improving systems for predicting the structural life of pavements has based its recommendations on pavement data that is already routinely measured in current practice.

The adjusted structural number parameter (SNP) is the basis for most pavement capacity prediction models currently being used. For example, both the World Bank highway design and maintenance models and the dTIMS maintenance planning models incorporate it.

SNP is a single parameter used to provide a representation of the load-bearing ability of a pavement. Using SNP, pavements are ranked according to the permanent deformation that can be expected within the subgrade of a pavement when it is subjected to a given number of standard load repetitions. This enables SNP to be used as an approximate indicator for the structural life of pavements.

SNP is currently the only measure available that tells asset managers how much capacity or life can be expected from their networks. It has its origins in American road tests in the late 1950s, and as such is well overdue for refinement. Limitations in its application, including variability in the methods used to determine what it should be, and its inability to indicate how a particular pavement structure would behave for a given

configuration of layers, led to a research project to find and test an alternative.

Graham Salt from Tonkin Taylor and Theuns Henning from the University of Auckland who led the research team say, 'Mechanistic appreciation of pavement structural performance is already the subject of extensive research underway in the US. Although, in the long term, mechanistic analysis is likely to provide the most effective procedures for pavement design, this is not yet at the stage where it can provide reliable models for the progression of all distress modes in all the materials available.

'As a result, our project focused on providing an interim solution that improves the SNP concept by enabling practitioners to use mechanistic procedures when deriving the structural parameters for network modelling. In our report we have proposed as a replacement for SNP an alternative structural parameter in the form of a set of structural indices. A structural index is required for each of the currently recognised distress modes, namely rutting, roughness, flexure and shear. In our report we describe how they can be used to obtain improved prediction of

pavement performance, both at network level and for project level rehabilitation of individual roads.'

Each of the four structural indices is mechanistically derived and has the same range and general distribution as the traditional SNP, allowing straightforward implementation (by way of substitution) of the new parameter. The result is that minimal additional calibration is needed for existing asset management systems. As the amount of data available from long-term pavement performance sites grows, the improved mechanistic understanding of pavement performance can be readily incorporated by refining the structural index for each of the four distress modes. Updated structural indices will be able to be generated at any time, based on the latest available data, for any future network. All four of the indices require further work and calibration as more data becomes available, although the study was able to provide the basis for indices for rutting and roughness. Both the flexure and shear index models require further development. The table below sets out the further work required on all of the indices.

ITEM	DESCRIPTION OF FURTHER WORK REQUIRED	DATA SOURCE/METHODOLOGY
SI _{rutting}	Minor refinement. Calibrate to those regions with subgrades known to perform anomalously (eg Taranaki brown ash and Central Plateau ashes)	Roads or networks with well-known performance (rutting distress and known past equivalent single axle)
SI _{flexure}	Wider calibration particularly to different surfacings: asphaltic concrete (AC) versus open-graded porous asphalt versus multiple seal layers	Project level testing of terminal sites
SI _{roughness}	Major refinement, as this is an important yet the most difficult parameter to characterise	The challenge is to find roads that have not been complicated by unknown past maintenance or 'non traffic' damage (eg service trenches)
SI _{shear}	Separation of shear instability: <ul style="list-style-type: none"> • beneath AC surfacings • beneath thin seals on unbound basecourse • within multiple seal layers 	Project level testing of terminal sites
Pavement prediction models	This research has demonstrated that pavement prediction models need to be redeveloped/refined from first principles if new indices are incorporated	LTPP and some limited network data
Network applicability	Extend the range of the indices by conducting more tests on other networks	Do this as part of the overall network testing programme
Pavement modelling	Investigate further adoption of the indices within the dTIMS system. For example, it may well be utilised as triggers and additional reporting measures within the system	Deliver the structural indices to the modelling community for further investigation
Risk index development	The indices promise a significant value to defining a risk index. Fundamental development work needs to occur in this area	Development needs to be based on a combination of network, LTPP and CAPTIF data

Graham and Theuns say, 'Although initially we only set out to adjust the SNP concept to update it and incorporate a mechanistic element, in fact we were able to deliver a new concept, which will significantly improve the usefulness and applicability of the structural number concept, both for asset management and maintenance design purposes.'

'Among the benefits of the indices for practitioners is the opportunity to make more effective use of all the data currently stored in the national road asset management and maintenance system, more reliable assignment of forward work programmes for the network, reduced costs by targeting only those sections of the road that require maintenance, and more efficient design of pavement rehabilitation through a more informed appreciation of the distress mechanism that will govern the structural life of each treatment length of pavement.'

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Rationalisation of the structural capacity definition and quantification of roads based on falling weight deflectometer tests.
NZ Transport Agency research report 401.

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Achieving the research objectives

The research objectives were to provide a method of deriving a structural measure that would deliver a parameter based on fundamental principles relating directly to the performance of pavements that have been closely monitored.

To this end, the project:

- developed structural indices, on the basis of fundamental mechanistic principles, to quantify the pavement structural capacity of road networks in New Zealand
- tested the new structural indices in terms of their applicability to pavement performance modelling, maintenance decision processes and road network reporting
- investigated the potential of these indices to forecast the risk of pavement failure.

New research publications

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The influence of surface treatments on the service lives of concrete bridges

Research report 403

Opus Central Laboratories

Freely available online at www.nzta.govt.nz/research
Hard copy \$20.00

The corrosion of reinforcing bars and prestressing steel is the most significant risk to the durability of concrete road bridges in New Zealand. The application of water resistant surface treatments has been suggested as a means of delaying corrosion damage. This research, carried out between 2007 and 2010, reviewed international research findings and the use of preventive surface treatments by road controlling authorities in Australia, the UK and North America to develop a guideline for selecting appropriate surface treatments for delaying chloride-induced corrosion damage on concrete road bridges in New Zealand.

The findings indicated that the effectiveness of surface treatments for reducing corrosion activity and extending service life depends not only on the chemical composition of the treatment but also on the condition of the concrete substrate, the application process and environmental exposure conditions.

A process was developed to identify the potential benefits of such surface treatments for individual bridges and for bridge populations. Recommendations were made to help bridge owners and asset managers implement this process, including means of investigating concrete condition to complement economic evaluations, and considerations of monitoring and maintenance requirements for at-risk bridge elements before and after treatment.

Public lighting for safe and attractive pedestrian areas

Research report 405

Opus Central Laboratories

Freely available online at www.nzta.govt.nz/research
Hard copy \$15.00

The Australian/New Zealand standard *Lighting for roads and public spaces, part 3.1: pedestrian area (category P) lighting – performance and design requirements* (AS/NZS 1158.3.1:2005) sets out specifications for pedestrian lighting. The standard defines adequate and acceptable pedestrian lighting practices to make walking safe. This research project complements and extends the standard by investigating pedestrian lighting practices to make walking not only safe, but also more attractive. The project highlights issues and perspectives from which to view the effectiveness of the pedestrian lighting.

This research is partly based on the observation that most lighting in the public arena has traditionally been driven by the needs of motorists, but pedestrians' needs are different. It studies those differences and guides on lighting techniques that can appropriately and specifically cater for pedestrians. The findings are based on a review of literature incorporated with information from the lighting industry.

Quantifying the benefits of waste minimisation

Research report 406

Opus International Consultants

Freely available online at www.nzta.govt.nz/research

Hard copy \$15.00

Over the period 2006–2009, a methodology was developed to quantify the benefits of waste minimisation in road construction. The methodology uses estimates of the energy and emissions involved in all operations, raw and recycled materials used, and the costs, energy use and emissions associated with traffic delay. A spreadsheet was developed as a tool for road controlling authorities to decide on the merits of using a waste minimising technique, and to compare the associated benefits and costs.

Epoxy-modified porous asphalt

Research report 410

Opus International Consultants

Freely available online at www.nzta.govt.nz/research

Hard copy \$15.00

Investigations into the cohesive properties and oxidation resistance of an acid-cured, epoxy-modified open-graded porous asphalt (EMOGPA) were undertaken, and an associated field trial constructed on State Highway 1 in Christchurch in December 2007.

Open-graded porous asphalt (OGPA) specimens were treated in an oven at 85°C for up to 171 days, resulting in oxidation equivalent to approximately 20 years in the field. The modulus (25°C) of the oxidised epoxy mixture (12,000MPa) was also much higher than that of the control OGPA (7800MPa). Results from the Cantabro test at 10°C indicated that the cohesive properties of the oxidised epoxy OGPA were markedly superior to those of conventional OGPA. On the basis of the Cantabro test results, lifetimes of up to 144 years were estimated for an increase in cost of up to 2.3 times that of conventional OGPA. Similarly, the fatigue life of oxidised EMOGPA was found to be more than 25 times that of the control. Epoxy bitumen diluted with up to 75% standard 80–100 penetration grade bitumen had an estimated life of up to 93 years for 1.3 to 1.6 times the cost of conventional OGPA. The fatigue life of the oxidised 25% and 50% EMOGPA mixes were similar to that of the control.

The field trial demonstrated that full-scale manufacture and surfacing construction with epoxy OGPA could be easily undertaken without any significant modification to plant or the necessary operating procedures. Epoxy OGPA sections with 20% and 30% air voids were constructed. Monitoring of the trial site for 27 months showed no difference in performance compared with the control section.

Compaction of thick granular layers

Research report 411

Opus Central Laboratories and University of Technology, Dresden

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Hard copy \$20.00

There have been a number of high-profile early failures in New Zealand pavements (rut depths greater than 20mm observed early in the pavement life) associated with 'greenfield' pavements (pavements not subjected to traffic during construction). It is uncertain if the rutting was due to poor construction control, difficulties of measuring density of thick layers or a function of lack of traffic on the pavement. In response, a research project was initiated to investigate in the NZ Transport Agency's accelerated pavement testing facility (CAPTIF) the effect of constructing the basecourse and sub-base to a range of densities (88% to 95% of maximum dry density).

In addition to the CAPTIF trial, a more theoretical analysis, comparing the theoretical stress and strain distribution under a vibratory roller and a standard heavy vehicle, was performed.

The conclusion of the research was that by using conventional New Zealand construction techniques and specifications, some post-construction deformation of greenfield pavements appears to be inevitable. The permanent strain developed will manifest itself into a larger rut depth as the granular thickness increases. However, the rut depth should not approach the levels (20mm) that prompted the initiation of this research.

Durability specification limit for asphalt bitumen grades

Research report 412

Opus International Consultants Ltd

Freely available online at www.nzta.govt.nz/research

Hard copy \$10.00

The object of this study was to gather data on the levels of bitumen oxidation found in dense asphalt surfacings. The information was used to determine if the proposal to raise the 100MPa modulus (at 5°C, 9Hz) limit set in the NZTA bitumen specification (NZTA M/1:2007) to 120MPa and 130MPa for 60–70 and 40–50 bitumen grades respectively was appropriate. Samples of dense asphalt manufactured with 60–70 or 80–100 grade bitumen (excluding polymer modified bitumens) were sampled from field sites of varying ages up to 40 years. The oxidised bitumen was extracted and the modulus measured.

The research highlighted serious limitations in the current durability test procedure (originally developed for chipseal binders) when applied to asphalt grade bitumens, and review and modification of the procedure is required. However, based

on the results obtained, setting the durability test limits in the NZTA M/1 bitumen specification to 120MPa for 60-70 and 130MPa for 40-50 grades, as recently proposed, is considered reasonable until further information is available.

Feasibility study of a national trip-end model for New Zealand

Research report 413

John Bolland Consulting

Freely available online at www.nzta.govt.nz/research

Hard copy \$20.00

This report presents the findings of a research project to investigate the feasibility of developing a national trip-end model (NTEM) for New Zealand. The rationale for this is to allow policy issues to be addressed nationally in a consistent manner with trip generation, distribution and mode split considered at the national level.

The research examined large area models from overseas and concluded that while there were a number of parallels with the 'four-stage' modelling paradigm used in urban areas, there were also a number of differences.

If an NTEM is to be developed in New Zealand there are a number of forecasts which could be used for the input variables. However, there is very little trip data available nationally which could be used for calibration so the development of a national model would require a substantial data gathering exercise, through either household or roadside surveys. The area between Auckland, Tauranga and Hamilton includes three recently developed models which together comprise a rich source of data. It is therefore suggested that this area serve as the starting point for an NTEM, with traffic growth in other areas forecast on the basis of simple variables.

Bike Now: encouraging cycle commuting in New Zealand

Research report 414

Pinnacle Research and Policy Ltd

Freely available online at www.nzta.govt.nz/research

Hard copy \$50.00

The aim of the Bike Now research project was to explore specific 'actions' that could be undertaken in the workplace to encourage people to take up (and continue) cycling to work. The actions included:

- bike mentoring/buddying
- establishing 'bike buses'
- providing cycle skills training
- creating secure parking at the workplace

- providing a cycle fleet at the workplace for travel during working hours.

The Bike Now project involved approximately 40 workplaces in Auckland, Wellington, Nelson and Blenheim for a 12-month period over 2007 and 2008. Specially trained coordinators worked with 'champions' within each workplace to identify the initiatives of interest in their particular location (through an online survey of employees), implement them (as was feasible), and then complete a follow-up survey online. This paper reports on the strengths and weaknesses of the process used and the effectiveness of the initiatives implemented, and provides some guidance for future programmes to encourage cycle commuting. The range of activities/initiatives and the presence of the Bike Now programme in the workplace had a noticeable influence, increasing cycling behaviour in a small but consistent way across our self-selected sample.

Case studies and best-practice guidelines for risk management on road networks

Research report 415

University of Auckland, Brian Smith Advisory Services and National Asset Management Steering (NAMS) Group

Freely available online at www.nzta.govt.nz/research

Hard copy \$35.00

The requirements of the Local Government Act 2002 have led to a greater emphasis on local authorities having a holistic approach to risk management. However, it is widely considered that compared with other disciplines, the practical application of risk management is still lacking in the area of transportation.

This research project aimed to establish a comprehensive yet simple best-practice guideline for risk management in the transport area. This was achieved through a literature review and a pilot study across nine representative transport authorities throughout New Zealand in November 2008. These guidelines provide the minimum requirements of an integrated risk framework and also describe ways to overcome some practical obstacles to the effective use of the risk management process.

Forecasting the benefits from providing an interface between cycling and public transport

Research report 418

Beca Infrastructure

Freely available online at www.nzta.govt.nz/research

Hard copy \$25.00

The integration of cycling and public transport (cycle-PT) can provide additional transport modal choice and flexibility in the use of existing public transport and also increase cycling trips and transit patronage. A model was developed for forecasting demand

for bike racks onboard public transport and secure storage at stations and terminals in different contexts and for different public transport modes. The NZTA's *Economic evaluation manual* was used to calculate the economic justification in terms of a benefit-to-cost ratio (BCR) for implementing cycle-PT in New Zealand's larger centres. Cycle-PT is economically justified in New Zealand with BCRs from two to more than 10 depending on the centre and the scenario. The implementation of cycle-PT in New Zealand's six largest centres could produce more than 1.7 million cycle-PT trips per annum. This research has provided sufficient analysis for practitioners to be able to systematically plan and evaluate the demand and economics for cycle-PT schemes in New Zealand.

Integrated transport assessment guidelines

Research report 422

Steve Abley and Paul Durdin, Abley Transportation Consultants Limited

Malcolm Douglass, Douglass Consulting Services Limited

Freely available online at www.nzta.govt.nz/research

Hard copy \$20.00

This research provides a methodology for assessing the effects of a development proposal within the context of the New Zealand regulatory structure. The integrated transport assessment (ITA) guidelines are based on the varying scopes of assessment (simple, moderate, broad and extensive). The possible content for each ITA assessment type and the matters to be discussed are described, as is the process for how the ITA is to be undertaken. The practice notes were developed from 2008 to 2010, and include information on how to undertake site trip generation surveys, how to estimate design trip generation rates for retail activities, some relevant case law and a discussion of the permitted baseline.

Effectiveness of transverse road markings on reducing vehicle speeds

Research report 423

Andrew Martindale, Opus International Consultants, Wellington

Cherie Urlich, Opus International Consultants, Hamilton

Freely available online at www.nzta.govt.nz/research

Hard copy \$15.00

Transverse road markings as a speed mitigation device may be a cost-effective method of reducing fatal and serious injury crashes as a consequence of speeding on a high-speed hazard approach. As no established marking layouts have been formally applied in New Zealand, investigations into the use and application of transverse road markings have been conducted over 2008-2010. The culmination of this research was to develop and undertake two field trials on the New Zealand state highway network.

The field trials assessed vehicle speed in a before-and-after study. Vehicle speed was recorded two weeks prior to, two weeks after and six months after the installation of a 300m long transverse bar arrangement, starting at a distance of 410m from a high-speed rural hazard. It was found that the markings reduce vehicle speeds, particularly upon the entrance into the marking treatment. This trend was found to occur both in the short and long term. Based on these results, it was recommended that further trials be conducted with a slightly modified marking arrangement and a larger assessment period. The results of the trials conducted as part of this paper will contribute to the formalisation of a standardised procedure for transverse road marking in a New Zealand road environment.

Pavement thickness design charts derived from a rut depth finite element model

Research report 427

Dr Greg Arnold, Pavespec Ltd and Dr Sabine Werkmeister, University of Canterbury

Freely available online at www.nzta.govt.nz/research

Hard copy \$40.00

Repeated load triaxial (RLT) tests were conducted on the granular and subgrade materials used at CAPTIF (the NZ Transport Agency's test track). Permanent strain relationships found from RLT testing were later used in finite element models to predict rutting behaviour and magnitude for the pavements tested at the CAPTIF test track. Predicted rutting behaviour and magnitude were close to actual rut depth measurements made during full-scale pavement tests to validate the methods used. This method of assessing rutting in granular materials was used to predict the life or number of axle passes to achieve a rut depth defining the end of life for a range of pavement thicknesses, and the subgrade types to produce new pavement thickness design charts. The results of these rut depth predictions showed the Austroads guide required thicker pavements for low traffic volumes, while the rut depth predictions showed significantly thicker pavements were required for high traffic volumes. In fact the rut depth predictions indicated the traffic loading limits for granular pavements were around 7 million equivalent standard axle passes (ESAs) for the subgrade California bearing ratio (CBR) 2% and 11 million ESAs for the subgrade CBR 8%.

National Programmes team

The Research Programme is now managed by the National Programmes team which is part of the NZTA's Regional Partnerships and Planning group. Patricia McAloon and Nigel Curran welcome Bill Greenwood and Karen Johnson to the team.

Karen is the Coordinator National Programmes and was previously the Research Programme Coordinator. She is covering the position for Virginia Skilton, who is on 12 months' parental leave.

Karen is enjoying being back in the workforce after spending 17 years as a mum, albeit with part-time employment during recent years. She has two boys, aged 17 and 13. She enjoys being physically active, mainly running and at the gym, spending time in the garden and reading.

Karen is finding the Coordinator National Programmes position to be a perfect match for her skills and experience, and is rising to the challenge of coordinating the programme of research projects for the NZTA.



Karen Johnson

ARRB Group - road research register

Formerly the Australian Road Research Board, ARRB Group was formed in 1960 and incorporated in 1965.

ARRB Group's library provides information products, resources and expertise sharing across Australian and New Zealand transport libraries.

For further information see www.arrb.com.au/Information-services/MG-Lay-Library.aspx. Its role is supported by the National Interest Services (NIS) programme and for further information about this programme see www.arrb.com.au/Information-services/MG-Lay-Library/NIS.aspx.

While the ARRB Group's library includes a range of subject databases and alert tools, an example of the library's leadership in knowledge sharing is its role in developing and maintaining the Road Research Register (www.roadresearch.com.au). The register was designed to foster opportunities for research cooperation and to decrease the likelihood of duplication through improved knowledge sharing. The register includes over 1700 records of current and completed research activities. If you have information you believe suitable for inclusion in the register, please email the details to info@arrb.com.au.

NZTA research

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