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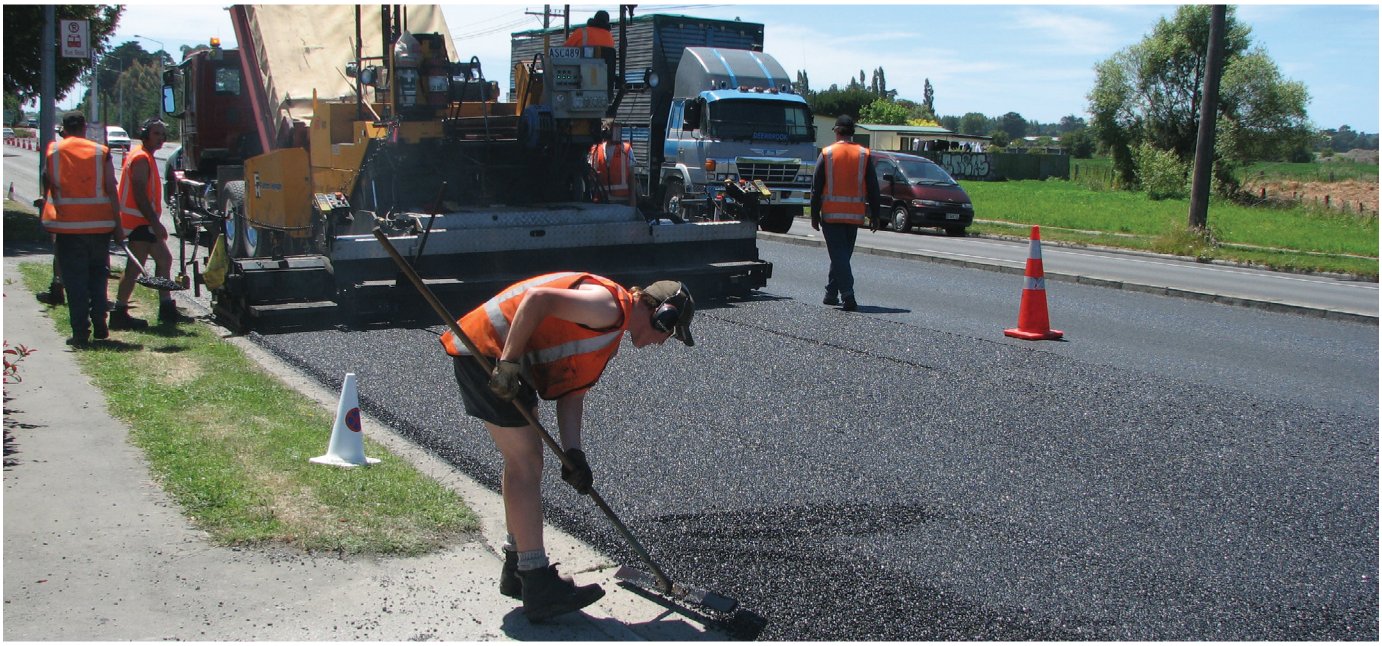
NZTA research

NZ TRANSPORT AGENCY
WAKA KOTAHI



NEW APPROACH WILL HELP STANDARDISE PAVEMENT REHABILITATION DECISIONS

Research has found that better guidelines are needed to help engineers decide when and where to rehabilitate pavements.

At present, the decision to recommend rehabilitation of pavements in New Zealand is based largely on the forecast cost of maintenance and other works needed to maintain a road in serviceable condition should the rehabilitation not be carried out. The costs of maintenance and other works include those of immediately repairing any faults in the pavement, the forecast costs of resealing when needed, and the forecast maintenance costs each year over the next 25 years. A recommendation to rehabilitate is made where that is the least cost option calculated using net present value (NPV) analysis. If these recommendations were more robust, then more would be adopted during field validation processes.

Two earlier Land Transport New Zealand-funded studies have found that there is a poor correlation between the recorded data about pavement condition stored in the road asset maintenance management (RAMM) database, eg rutting and roughness, and the pavement rehabilitation decisions being made. The research also could not develop a robust maintenance cost model from the data. This suggested that decisions were being influenced by factors not presently captured by the asset condition surveys that feed into the database, or that the factors are being captured, but not recognised as significant.

The current study sought to address this, and to improve and standardise decision-making around rehabilitation, by developing an improved means of modelling the decision to rehabilitate a typical New Zealand thin surfaced unbound granular pavement. It was hoped that the model for forecasting pavement maintenance costs would also be refined. Both models would allow for more effective asset management of pavements to optimise their useful lives.

The refined models would be informed by interviews with network managers around the country and examinations of sample pavement treatment lengths from each network.

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WHAT THE STUDY FOUND

John Patrick of Opus Central Laboratories headed the research. John says, 'We suspected that factors such as the local environment and local practices were having a strong influence on actual and forecast maintenance costs, and hence diagnoses that particular lengths of pavement required rehabilitation. Our hope was that by talking to the practitioners and surveying the actual pavements, we would be able to capture the important factors that influence rehabilitation decisions and that these could be incorporated into existing models. It may also have expanded the pavement condition details that are collected as part of a road authority's annual visual surveys.

'However, what we found is that the drivers behind rehabilitation decisions are not obvious or consistent, and that decisions appear to be based on factors that are not captured in the current condition surveys and are more of a subjective assessment by the engineer. There was a wide difference between regions in the methods being used to determine the need for rehabilitation.'

Factors influencing the decision included such things as the engineers' desire not to have a rapid catastrophic pavement failure; this is a risk judgement and so is not currently captured in RAMM and therefore can't be modelled.

Also of significance was that, in many cases, pavements needed a significant amount of deferred maintenance, which affected the forecast maintenance costs but was not readily apparent from the data in RAMM.

THE COST OF REHABILITATION

In the year ended 30 June 2006, around 170 lane-km of state highways and 740 lane-km of local roads were rehabilitated in New Zealand. With an average cost of $250,000 per kilometre, this equates to a total cost of almost $230 million.

Earlier studies suggest some pavements are being rehabilitated before it is strictly needed to avoid perceived risks, so there is potential for significant cost savings. Even deferring 10% of proposed rehabilitation by one year would potentially save $23 million in the first year, with similar savings in subsequent years. These savings, and the attendant extension of a network's life, would need to be balanced against the possibility of the asset condition being consumed, if insufficient rehabilitation occurs.

This research therefore supports the similar findings of the Road Maintenance Task Force and the State Highway Maintenance and Operations reviews. The Road Efficiency Group and the NZTA Highways and Network Operations Group are leading initiatives to address and resolve the issues raised in this report.

At present, potential sites for rehabilitation are identified using a combination of historical data (including RAMM ratings), visual drive-over inspections and formal site inspections.

The latter include an assessment of the backlog of repairs that are needed to bring the site up to an acceptable standard.

The decision about whether a particular site should be rehabilitated is then a simple matter of comparing the continuing maintenance costs of the site with the cost of rehabilitation. The procedure used is called net present value (NPV) analysis and is described in the NZTA's *Economic evaluation manual* (NZTA 2010). Deferred or backlog maintenance costs appear on the continuing maintenance side of the equation and can therefore have a significant impact on the outcome, especially when the outstanding repairs are numerous.

Although data such as the roughness, texture, rutting and shoving of sites are taken into account in the RAMM rating, and so form part of the initial identification of sites, they are only considered to be indicators of a site's readiness for rehabilitation. No limits have been defined for when their prevalence or degree becomes unacceptable and the site must be rehabilitated. The current study suggests that developing such definitions and limits would improve the consistency of rehabilitation decisions, as would robust guidelines to help engineers make decisions.

Methods used to determine future maintenance costs varied widely from network to network, as did the timeframes used for assessing a pavement's maintenance cost history. Another shortfall was that distress mechanisms, such as rutting and flushing (which were two of the most common mechanisms cited by engineers to justify rehabilitation decisions), are not currently part of the rehabilitation model.

John says, 'We considered that a more robust model of rehabilitation prediction could not be developed until there was more consistency in the decision process. The model would need to be able to capture the risk assessment process that appears to be subjectively applied in the field. Developing this type of model would require the use of focus or Delphi groups to capture the factors involved, and determine the level of risk or concern that would prompt a decision to rehabilitate.

'Our report recommends the establishment of such an expert group, and proposes a method for standardising decisions about whether rehabilitation is needed.'

RECOMMENDATIONS

The study recommends the development of a more consistent decision-making process that places more emphasis on the present condition of the pavement than does the current approach, which emphasises the NPV of forecast maintenance costs on each section of road.

An expert group could be set up, which, together with modelling and analysis of pavement trials, would enable an acceptable definition of pavement distress to be developed, as well as a rate of increase for this distress that should trigger rehabilitation.

The new approach would consider both the engineering judgement about the inherent strength of the pavement, and the tension between the economic and risk factors that drive decisions about maintenance and rehabilitation. While the assessment of the NPV of future maintenance costs would form part of a maintenance–rehabilitation cost ratio, it would not be the final step in the decision-making.

It was considered that adopting such an approach would lead to more consistent decision-making across networks and minimise unnecessary field validation. It would also better reflect the risk-and-consequence approach favoured by engineers.

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Factors influencing the decision to rehabilitate a pavement,
NZ Transport Agency research report 491

Available online at www.nzta.govt.nz/resources/research/reports/491

INTEGRATED PLANNING BOOSTED NOW THAT GEOSPATIAL DATA IS HELD BY THE NZTA

A project to source and collate geospatial data will support future integrated planning by enabling information about land use, transport and other key infrastructure to be viewed and considered together.

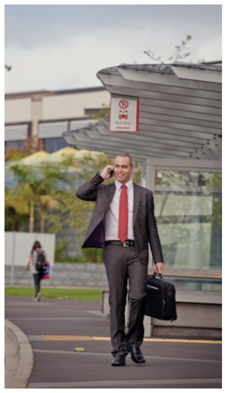
The research, conducted by Beca Infrastructure and the NZ Transport Agency (NZTA) in 2010 and 2011, gathered together data from numerous local, regional and national sources, which was then combined in the NZTA's Spatial Viewer. The aim is to help the NZTA better understand how transport networks, land use, and demographic and environmental constraints interact.

The NZTA is required to take an integrated approach to land transport planning, and its Integrated Planning Strategy sets out how investment in land transport activities will 'support appropriate land-use patterns and connect major cities and ports'.

Previously, though, the NZTA has had access to a limited amount of geospatial data to support this approach.

Helen Lane of the NZTA explains, 'The lack of layers of data available to us meant we were not able to generate a comprehensive visual representation, at a national level, of how land uses and transport and other key infrastructure interact. The information was available, but was held by a number of different public and private organisations, mainly at a local and regional level.

'What the National Mapping Project did was hunt out and collate these many different datasets. Data was collected from a wide variety of sources, including the broader NZTA, Ministry of Transport, Civil Aviation Authority, Transpower, Vector, New Zealand Refining Company, KiwiRail, the then Ministry of Economic Development, commercial parking building providers, Statistics New Zealand, and all of the territorial, unitary and regional authorities. In total, 154 datasets were collected from 89 different sources.



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'The data was then collated and massaged for loading into the NZTA's Spatial Viewer, which enables staff to generate visual representations of different layers of geospatial data and how they interact. For example, the figure over the page shows land use, utility and airport data for an area of Christchurch. This has already improved our ability to visualise the interactions, and in future it will ensure that our long-term integrated planning addresses land use planning, transport planning and investment decisions together, and not separately.'

The next step will be to analyse and check the collated data for 'hot spots'. Hot spots are areas where there is a greater need for integrated transport planning (for example, due to significant change pressures such as population growth). Identifying them will mean that planning work for these areas can be prioritised.

THE AVAILABLE DATA

The full research report summarises the data that was collected, organising it into categories, layers and sub-layers of data, and summarising the datasets that relate to each and their sources.

Together, the datasets yielded information on:

- transport networks and corridors – including road networks (state highways, roads of national significance), freight routes, tourism routes, airports, ports, coastal shipping routes, high-level public transport (quality transit networks, rapid transit networks), cycle networks, rail networks, rail designations, and limited access roads
- the locations of parking facilities – eg parking buildings, and park and ride
- land use and demographics – including land use zones, metropolitan urban limits, growth and intensification (centres, corridors), and major utilities (Transpower, Vector for national high-pressure gas lines, New Zealand Refining Company for oil pipelines)
- populations (density, age)
- environmental risks – including the climate and weather (flooding, ice), and hazards (earthquakes, coastal erosion)
- areas where there are supported strategies and endorsed packages.

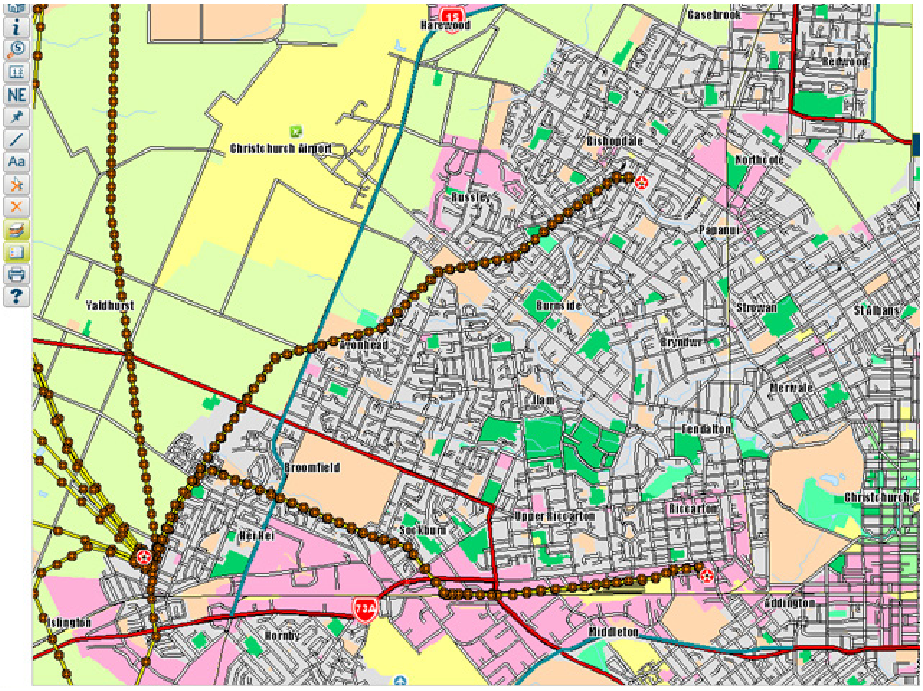
Contact for more information

Anyone wanting more information about the data layers can contact the Geospatial Team at the NZTA – spatial@nzta.govt.nz.

National mapping of integrated transport and land use, NZ Transport Agency research report 490

Available online at www.nzta.govt.nz/resources/research/reports/490

Excerpt of Spatial Viewer showing land use, utility and airport data



ACCOMMODATING CHANGING PRICES IN TRANSPORT APPRAISALS

Cost–benefit appraisals (CBAs) are required for transport projects to gain funding approval. They identify value for money and help prioritise investment. Over the longer run CBAs also influence in some indirect way the total amount of funding available for land transport.

It is thus important that CBAs are done as well as they can be, within the resources available to analysts. This includes making best use of available information and professional judgements about changing future circumstances.

The NZ Transport Agency's (NZTA) *Economic evaluation manual* (EEM) provides prices (or more specifically, 'unit cost parameters') to value specific impacts such as time savings or crash risk savings. This is coordinated centrally by the NZTA for various reasons, including the need for project appraisals to be consistent.

One characteristic of the EEM is that the unit cost parameters apply the same value to an impact for every year in a project's appraisal period. That is, the value in 'real' (ie inflation-adjusted) terms of, say, a minute of time savings is the same whether it occurs next year or 30 years from now.

However, recent research by the New Zealand Institute of Economic Research (NZIER), commissioned by the NZTA, has looked into whether it would be feasible to allow for real changes in prices for classes of impacts over the appraisal period. The research also assessed whether this would have a material impact on the benefit–cost ratios (BCRs) of projects, and the priority they were afforded as a result.

Chris Parker of the NZIER says 'People would commonly expect New Zealanders to be wealthier many years from now. That is, the average person will consume more goods and services than they do now. With increased wealth comes increased willingness to pay for normal good and services. Some key questions that motivated this research were: should we factor expected changes in real prices into appraisals, or should we ignore it? Does it matter? We found the answer to these questions was "yes".'

Rather than use a single value for a unit of impact for each and every year of a transport project's life, a schedule of values that potentially differs for each year in a project's appraisal period could be used instead. The use of a schedule that differs by the year is referred to as 'time indexing'.

WHAT THE RESEARCH COVERED OFF

The research considers some of the issues involved with allowing time indexing in transport CBAs, and provides recommendations.

In particular it:

- explains the concept of adjusting for real-price changes in the CBA of a project over the project's life, and the various ways that project appraisals may be affected by such adjustments
- summarises how time indexing is currently approached in New Zealand and overseas
- reviews the factors that govern price changes, such as people's willingness to pay for particular benefits, and income forecasts
- identifies a range of indexes that could be applied to a wide range of CBAs
- assesses how material time indexing is to the BCRs of a large number of diverse transport projects
- makes recommendations about how CBAs could be improved with respect to valuing future impacts.

MATERIALITY

Different time-index schedules were applied to a large set of diverse projects that had been collated as part of previous NZTA-funded research on the social discount rate*.

The project found that time indexing materially increased project BCRs for most types of projects, with some more affected than others. For example, motorway projects were found to increase by 22%, on average, while congestion and safety improvement projects increased by 13%. Maintenance and road-quality projects, on the other hand, were generally unaffected by time indexing (however, it was not clear whether the original maintenance appraisals had included cost escalation or not). Projects that delivered a substantial proportion of benefits later in their appraisal periods (such as public transport infrastructure, bridge renewal, and walking and cycling network projects) benefited most from allowing for real-price changes, compared to those with flatter rates of benefit growth.

FEASIBILITY

The research also found that time indexing unit cost parameters in transport CBAs was feasible. Time indexing is already used overseas. Some countries, such as the UK, require it to be included in CBAs for transport projects and they provide guidance on how it should be done.

RECOMMENDATIONS

Including time indexing of unit costs in transport CBAs would be both feasible and material. A key recommendation was that the NZTA considers using time index unit cost parameters when calculating transport CBAs and provides guidance on the assumptions to use.

* The implications of discount rate reductions on transport investments and sustainable transport futures (research report 392) is available at www.nzta.govt.nz/resources/research/reports/392/.

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Scoping approach and measuring the impact of indexing unit cost parameters in cost–benefit analysis, NZ Transport Agency research report 492

Available online at www.nzta.govt.nz/resources/research/reports/492

REPORT DOCUMENTS ORIGINS OF THE NZTA'S CRASH RISK MODEL

Opus International Consultants and Statistics Research Associates were among the first researchers to successfully develop a statistical crash prediction model that combined road geometry, road surface condition and carriageway characteristics to provide reliable estimates of crash risk on rural two-lane carriageways.

Crash risk relationships for improved road safety management (NZTA research report 488)* documents the development and validation of this model. The report was prepared as a companion to Modelling crash risk on the New Zealand state highway network (NZTA research report 477)*, which presented refinements to the original model.

Peter Cenek of Opus says, 'This report is of interest because it documents the origins of the crash prediction models now regularly used by the NZTA for setting policy and managing the safety of the state highway network.

'We were only able to carry out the modelling because for the past 15 years the NZTA has used high-speed surveys to measure road condition and road geometry data for New Zealand's entire state highway network. By combining that data with information about fatal and injury crashes (also from the NZTA), we were able to use statistical modelling techniques to match crash rates with road characteristics. We tested the model, and the crash rate estimates it produced were sufficiently accurate to be used for safety management purposes.'

THE MODEL

The team investigated four road crash subsets – all reported injury and fatal crashes, selected injury and fatal crashes for loss-of-control events, reported injury and fatal crashes in wet conditions, and selected injury and fatal crashes in wet conditions.

One- and two-way tables and Poisson regression modelling were then used to identify the critical variables (those road characteristics that had a significant effect on crash rates) and their relationship with crash risk. Critical variables identified included the highways' horizontal curvature (which as expected had a strong effect on crash rates), skid resistance (also a strong correlation) and lane roughness (a somewhat weaker effect): all were common in the investigated crash subsets.

Traffic flow rates also emerged as a critical variable linked to lower crash rates. This is probably because a road's average daily traffic count is, in general, a good indicator of its quality (more heavily used roads tend to be better designed and maintained), leading to an observed drop in crash rates as traffic counts increase.

The final outcome was a Poisson regression model that uses 2nd or 3rd order polynomial functions of the critical variables. The model enabled the expected number of injury crashes for any 10m length of two-lane highway to be calculated, based on data about the road's condition, geometry and traffic use stored in the NZTA's road assessment and maintenance management (RAMM) database.

APPLICATIONS

Potential uses of the model are illustrated in the full research report in relation to actual highway surface treatment and realignment projects. Actual and predicted before and after crash rates for the example sites are compared, in order to demonstrate the model's predictive abilities.

Peter says, 'The comparison confirmed the model to be a very useful tool for managing the safety of New Zealand state highways as it allows the cost effectiveness of engineering-based interventions, such as high skid surfaces and road realignments, to be reliably quantified.'

Please note that the model was refined after it was developed, as noted in paragraph two of this article. The NZTA research report presenting the refinements to the original model is, as stated, *Modelling crash risk on the New Zealand state highway network* (NZTA research report 477). This report was profiled in issue 18 of NZTA research (www.nzta.govt.nz/resources/nzta-research/docs/nzta-18.pdf), and is available online at www.nzta.govt.nz/resources/research/reports/477.

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Crash risk relationships for improved road safety management, NZ Transport Agency research report 488

Available online at www.nzta.govt.nz/resources/research/reports/488

* Available at www.nzta.govt.nz/planning/programming/research.html

NEW RESEARCH REPORTS

Improvement of the performance of hotmix asphalt surfacings in New Zealand

Research report 508

JE Patrick, Dr H Arampamoorthy and Dr P Kathirgamanathan – Opus, Central Laboratories

JI Towler – NZ Transport Agency

Freely available online at www.nzta.govt.nz/resources/research/reports/508

This research project aimed to identify areas where changes could be made in the use of thin layers of asphalt to improve performance. The project was not designed to investigate quality issues, but concentrated on materials and selection. The project was initiated because Transit New Zealand (now the NZ Transport Agency) had found that the costs of resurfacing using asphalt had escalated and the lives being achieved appeared to be short.

This research was undertaken between 2007 and 2012. It investigated the following areas:

- analysis of currently achieved lives
- whole-of-life costs
- fatigue of thin surfacings
- shear strength
- durability of open-graded porous asphalt (OGPA)
- acceptance schemes.

Evaluation of the C-roundabout – an improved multi-lane roundabout design for cyclists

Research report 510

D Asmus, I Jurisich – TES Ltd, Auckland

D Campbell – Auckland Transport

R Dunn – University of Auckland

Freely available online at www.nzta.govt.nz/resources/research/reports/510

The C-roundabout (cyclist roundabout) is a new multi-lane roundabout design that was developed as part of a 2006 Land Transport New Zealand-funded research project (reported on in *Improved multi-lane roundabout designs for cyclists* – research report 287, available on the NZTA website at www.nzta.govt.nz/resources/research/reports/287). The C-roundabout aims to improve the safety of cyclists at multi-lane roundabouts and make multi-lane roundabouts more cyclist-friendly.

A C-roundabout was installed at the intersection of Palomino Drive and Sturges Road in Auckland. It was evaluated between 2008 and 2011 in terms of its safety, capacity, and the opinions of cyclists, pedestrians and car drivers. The C-roundabout successfully reduced vehicle speeds to 30km/h, which is close to the speed of cyclists. This made the roundabout safer for cyclists and other road users. Having a C-roundabout at this uncongested site had little impact on capacity. It drew positive feedback from cyclists and pedestrians, but about half of the car drivers were not in favour of it. This could be expected as they may prefer the standard, wider roundabouts.

Another site (at the intersection of Margan Avenue and Hutchinson Avenue) was also reviewed. At this site, two approaches were changed from wide single lanes to two narrow lanes, without altering the kerbs or reducing the design speed. The evaluation showed the capacity of a single-lane roundabout can be improved (almost doubled) at very low cost. However, the safety of the roundabout decreased. A reduction in design speed was recommended to address this.

An important technical note specific to this report

Non-standard signs and markings, which do not comply with the Land Transport Rule: Traffic Control Devices (TCD Rule), were used to undertake this research. These unauthorised signs and markings should not be used on public roads without the prior approval of the NZTA. See NZTA Traffic Note 10 (revision 3): Trials of traffic control devices – guidelines (www.nzta.govt.nz/resources/traffic-notes/docs/traffic-note-10-rev3.pdf).

The effect of rainfall and contaminants on road pavement skid resistance

Research report 515

DJ Wilson – Department of Civil and Environmental Engineering, University of Auckland

Freely available online at www.nzta.govt.nz/resources/research/reports/515

This research project, undertaken between 2003 and 2006, aimed to improve our understanding of the effect that environmental factors (eg rainfall and detritus) have on the variation of measured skid resistance, in both the short and longer term. Phase 1 of the research was a field study of seven sites in the Auckland and Northland regions over 2.5+ years, with regular skid resistance measurements primarily using the GripTester. Phase 2 involved developing a new laboratory-based accelerated polishing device and methodology for testing large (600mm × 600mm) chipseal surfaces with the Dynamic Friction Tester.

Phase 1 results demonstrated that significant and previously unpredictable variations (greater than 30%) in measured skid resistance could occur over short time periods. These variations were the result of a number of interrelated factors, including the geological properties of the aggregates and the contaminants themselves.

Phase 2 results demonstrated that large aggregate samples could be prepared for accelerated polishing tests in the laboratory and that significant variations in measured skid resistance could be achieved by adding contaminants and simulated traffic action. Significant behavioural differences were related to the geological properties of the aggregates, as well as the contaminants used in the accelerated polishing process.

Further research is proposed to investigate a greater sample of geological and artificial aggregates, and ‘mix designs’ that may lessen the variation in measured skid resistance during the surface asset life and subsequently improve the prediction and safety performance of surfacings in the long term.

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NEW RESEARCH REPORTS *cont*

Development of a public transport investment model

Research report 524

Nick Allison – Logic Partners, Wellington

David Lupton and Associates, Wellington

Ian Wallis Associates Ltd, Wellington

Freely available online at www.nzta.govt.nz/resources/research/reports/524

This research was the first stage in developing an investment model aimed at helping regional authorities and the NZ Transport Agency to make public transport (PT) investment decisions. The approach assumed that PT subsidies should be invested to maximise allocative efficiency – ie in a way that ensures society gains the greatest overall net benefit from PT.

To do this, the investment model applies a second-best pricing method to estimate optimum fare and implied subsidy levels for urban PT. The model takes into account operating costs and externalities of alternative transport modes (cars and PT), including safety and congestion effects. It also incorporates network spillover effects for existing PT users from changes in frequency. The result is an economic model that incorporates the interactions between prices, service levels and patronage for PT (bus initially) and private car, and associated performance indicators.

The model was developed initially only for Hamilton and detailed in a separate Excel workbook that is capable of expansion to include rail and other cities. The model shows that the costs of PT are high in Hamilton, and that plausible alternative policy responses include significantly reducing fares or cutting services, with dramatically different budgetary implications. It shows that the idea of a single optimum solution is overly simplistic.

Obtaining NZTA research reports

All research reports published since 2005 are available free of cost for downloading from the NZTA's website – www.nzta.govt.nz/planning/programming/research.html.

PDF scans of research reports published prior to 2005 are available by emailing research@nzta.govt.nz.

A NOTE FOR READERS

NZTA research newsletter

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Advertisements of forthcoming conferences and workshops, that are within the newsletter's field of interest, may be published free of charge when space permits.

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