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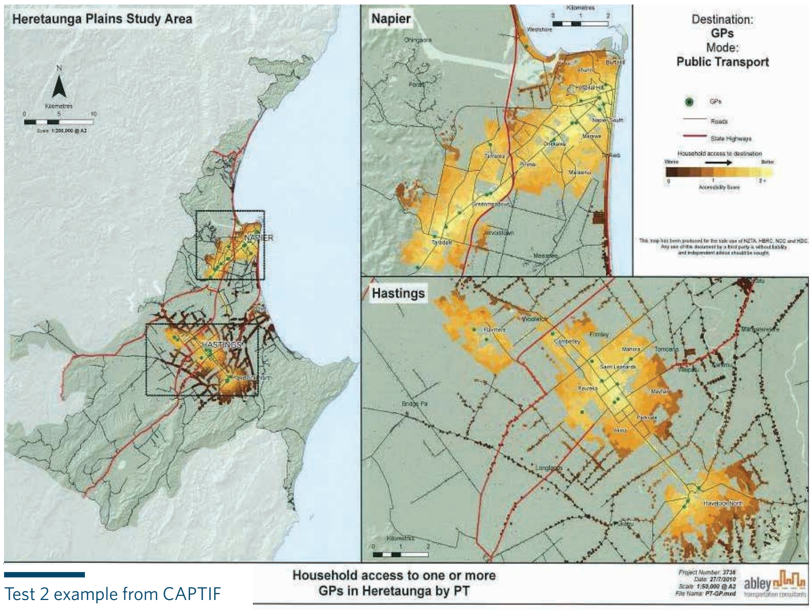

Test 2 example from CAPTIF

ADDING ACCESSIBILITY TO THE TRANSPORT AND LAND USE PLANNING MIX

How might accessibility best be measured and quantified, were the questions behind recent research into land use and transport accessibility in New Zealand.

WHAT IS ACCESSIBILITY, AND WHY WOULD WE WANT TO MEASURE IT?

This report looks at accessibility in its broadest sense and defines it as 'The ease with which activities, either economic or social, can be reached or accessed by people.' It does not focus on freight or disability access, although these can also be studied in a similar way.

Tim Hughes of the NZ Transport Agency said the report was commissioned because accessibility analysis was expected to contribute to better urban design and to support neighbourhood accessibility planning with a measurement tool that would enable better decision making. However the research also identified benefits for strategic planning of larger areas, with potential to better evaluate transport investment outcomes, land use changes, public service provision and as an indicator to monitor long term progress.

Steve Abley of Abley Transportation Consultants who, along with Derek Halden of Derek Halden Consultancy Ltd, undertook the research says, 'Traditional transport demand models do not answer all the questions that today's decision makers need answers to. Accessibility assessment, in the form of accessibility modelling and analysis, provides decision makers with new perspectives for old problems. By better understanding accessibility there's potential for a step-wise improvement in how transportation and land use can be better managed and integrated in New Zealand.'

THE BENEFITS OF ACCESSIBILITY

Because accessibility is concerned with both land use and transport systems, it provides an integrated way of measuring the effects of changes in both systems.

Most measures of transport focus on mobility and count or predict the number of people using each part of the transport network. Mobility is a very useful measure for assessing changes in land use on network capacity, but more movement is not always beneficial. Using the amount of travel to measure the

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performance of the land use and transport system is like assessing the health and wellbeing of people by measuring the size of their waistlines. While the transport network exists to provide for the movement of people and goods, this movement is for the purpose of accessing activities or services at a destination. European cities tend to be more prosperous, healthy and transport efficient because they are more accessible. People are able to meet their needs while travelling shorter distances, with more of them using more efficient modes.

Accessibility improves when destinations are located closer to homes, when time spent getting to them is reduced by direct routes, when transport services are frequent and close to both origins and destinations, when walking and cycling are attractive for many trips and where there is a choice of competing activities within range. Accessibility analysis includes all these dimensions.

Accessibility analysis can be applied from the point of view of homes or of destinations. In some overseas countries, providers of health, education and social services are required by law to analyse accessibility when planning for the provision of and changes to the location of services. In New Zealand, the method has been applied to the development of new subdivisions, to the effect of the closures of post offices, to changes to public transport routes and services, to the provision of services to whole communities, and to some major road projects that have the potential for causing severance to communities.

Measuring accessibility provides a more holistic representation of the transportation world (including people who may be transport disadvantaged). Accessibility is also a better measure for considering the long-term sustainability of the transportation network. The mode choice provided by public transport services is more accurately measured, as is provision for walking and cycling, which is typically poorly represented in strategic transport studies, due in part to the large areas typically covered in each zone.

Accessibility modelling also includes the various interchanges between these modes, such as walk–public transport–walk, car–walk, cycle–public transport–cycle–walk, and so on.

Quantification of accessibility provides:

- insight into the impact of people's capabilities (mobility) on the level of access they experience
- understanding of the effect of spatial factors in land use planning
- new forecasting indicators to enable decision makers to make better informed and optimum decisions
- a method to consider changes in accessibility, due to changing demographics
- an understanding of who wins and who loses from changes to the system
- a method to test changes in land use, transport networks, services and destinations
- a greater level of analysis whereby those being consulted can appreciate that decision makers are considering all perspectives
- more information about how users perceive transport opportunities
- better presentation methods, to show expected outcomes from recommendations
- analysis that can be performed in relation to the client catchment for locating activities or the accessibility of individual households.

MEASURING ACCESSIBILITY

The project's objective (having defined accessibility) was to propose a method for measuring and quantifying accessibility in New Zealand, both at a neighbourhood level and on a wider scale, for example for a suburb, city or region.

Drawing on other countries' experiences, the research explains how New Zealand can best develop and set explicit accessibility policy, and puts forward a new methodology (developed as part of the research) for calculating accessibility.

Although many other countries have well-defined policies on, and approaches for, assessing accessibility, it is still a growing area of expertise, with countries experiencing varying degrees of success. By understanding these experiences, New Zealand can determine how best to incorporate accessibility assessment into its own policy and practice.

THE ACCESSIBILITY MODEL

The research report contains, and explains, a methodology to quantitatively measure accessibility, taking into account:

- different modes of travel (public transport, walk, cycle, private motor vehicle)
- travel behaviour (how far people are prepared to travel by each mode)
- destinations (origin or destination based)
- activities (shopping, education, employment, medical etc)
- multiple opportunities (benefits of choice between competing suppliers)
- demographics (age, car ownership etc).

Given the complexity of the calculations involved in the accessibility modelling method, the research team decided to automate them for use within a geographic information system (GIS). GIS was settled on as providing 'the best overall solution' after the researchers looked into and tested various programmes available overseas.

The methodology was then piloted in Christchurch, with the accessibility of every household to a number of destinations (including doctors, supermarkets and schools) quantified.

Steve says, 'The Christchurch pilot ran our proposed accessibility methodology within a GIS, then examined the various calculation methods and scenarios involved to see how responsive they were to change. This included measuring changes in accessibility flowing from new land uses, for example a new hospital, and changes in accessibility as a result of new infrastructure, for example a new pedestrian, cyclist and vehicle bridge.'

Several areas for refining the model, and for further research, emerged from the pilot. While the method was still under development, an Austroads study was also developing a method of accessibility measurement, and both methods were applied to a neighbourhood in Hawke's Bay. This trial contributed to changes in the proposed Austroads methods, which in turn informed the development of the New Zealand model, so the methods are now compatible.

'Although we made a number of recommendations to fine tune the method as a result of the pilots, realistically it will take several years to implement the refinements. The bulk of the New Zealand accessibility analysis methodology included in the research report is suitable, and sufficiently refined, for use by practitioners today.'

The pilot also demonstrated the spatial scalability of the GIS, with the methodology able to be run at both a mesh block (group of households) and an individual (household) level.

Further information on accessibility can be found at www.accessibility.org.nz

The research report also provides a useful resource for those new to accessibility planning, with clarification of what is meant by many accessibility terms in the New Zealand context and the inclusion of a comprehensive glossary.

The New Zealand accessibility analysis methodology, NZ Transport Agency research report 512.

– Abley Transportation Consultants

Available online at **www.nzta.govt.nz/resources/research/reports/512**

ECONOMETRIC MODELLING SHOWS HOW TO COPE WITH COMPLEXITY

Research into econometric modelling for public transport has recommended a change in how the sector analyses, models and plans for public transport investments.

The project by DMK Consulting, completed in 2012, used econometric analysis to examine public transport patronage growth in Auckland, Wellington, Hamilton and Tauranga.

David Kennedy of DMK Consulting says the primary objective of the research was to examine and explain historical trends in patronage growth and, in doing so, provide up-to-date public transport elasticities.

In economics, an elasticity measures how changing one economic variable affects others. In the current research, the impact on public transport patronage growth (the dependent variable) was analysed with respect to changes in the explanatory variables, namely fares, petrol prices, services and other economic variables such as employment and retail sales.

David says, 'We adopted a different approach for the research to that used in conventional econometric analysis because we analysed public transport patronage growth trends at the corridor level. For example, we looked at data for individual bus routes and train lines, rather than for the networks as a whole. One of the reasons we adopted this approach was in response to feedback from stakeholders who stated that they wanted a model that enabled them to produce forecasts at a route and corridor level.

'The corridor-level approach enables us to accurately estimate and control for corridor-specific events and factors, such as service changes on a particular route, and as such provides more accurate estimates and insights into the drivers for patronage growth.'

The more conventional approach, widely used for econometric analysis, is to model patronage across a whole city, using a single elasticity for all changes in services and fares.

'We think this is unrealistic, because the impacts of service and fare changes are likely to vary from situation to situation and across time. We're advocating that this uncertainty and variability should be accepted as inevitable, and that more accurate forecasting is to be gained by adopting the corridor-level approach.'

A related recommendation is that the current focus in public transport planning on pre-evaluation of proposed transport investments (ie researching and modelling the potential patronage gains that will flow from a proposed investment) should be balanced with regular post-evaluation of network changes, such as those examined by the research.

'The post-evaluation of historic service changes could be used to guide future investment or disinvestment decisions,' says David. 'Just as the post-evaluation of past fare increases could be used to make better decisions regarding future fare increases.'

The research made several key findings about the impacts that fare and service changes had on bus and rail patronage in all the cities examined. Interestingly, several quite minor initiatives were revealed as having relatively substantial impacts. For example, a free two-hour transfer introduced for Hamilton bus services from 2007 was believed to have played a significant part in boosting higher levels of off-peak patronage.

Also interesting were the considerable 'network effects' that flowed from improvements to Tauranga's and Hamilton's public transport networks. For both networks, changes to a timetable for a particular service during a certain time (peak, off-peak, Saturday, Sunday) were shown to have a direct impact on patronage during that time and also an indirect impact on patronage during other periods. So for example, doubling the frequency of a particular off-peak bus service in Hamilton not only had a direct impact on off-peak weekday patronage, but also a measurable indirect impact on peak weekday patronage and weekend patronage.

'Transport planners need to take a holistic view of the needs of public transport users and how they view the network,' says David. 'Altering one service in the right way can have a profound impact on patronage across the whole public transport network.'

THE KEY FINDINGS

The project's key findings in regard to fares and petrol prices are as follows.

- Bus fare increases: on the Auckland bus network, a 10% increase in real fares caused a 3% fall in patronage and a 7% increase in revenue. The impact of fare increases on the Wellington bus network varied by situation and appeared to have been distorted by the introduction of the SuperGold Card. Fare increases on the Hamilton bus network had no discernible impact on patronage.
- Rail fare increases: on the Auckland rail network, a 10% increase in real fares caused a 9% fall in patronage (during the peak) and hence only a 1% increase in revenue. Similarly, on a Wellington rail network, a 10% increase in real fares caused a 7% fall in patronage and a 3% increase in revenue.
- There was strong evidence of complex and non-linear responses to petrol prices, ie the crossing of the $2.00 nominal petrol price in 2008 was associated with a 'jump' in bus and rail patronage.
  - After controlling for the 'threshold effects', general petrol price moves had a modest impact on patronage in Auckland and Wellington – a 10% increase in real petrol prices caused a 0%–2% increase in patronage.
  - However, the impact of general petrol price movements in Hamilton and Tauranga was greater – a 10% increase in real petrol prices caused a 2%–3% increase in patronage.

The research also made a number of findings about service elasticities.

- Peak rail: the impact of additional peak-time rail services was difficult to estimate due to a lack of data on crowding levels. However, more accurate analysis will become more feasible with ongoing improvements to data collection systems.
- Inter-peak rail: a 100% increase in inter-peak rail service frequency (ie a doubling of the number of trains running) caused a 30%–40% increase in inter-peak rail patronage.
- Peak bus: a 100% increase in peak bus service frequency (ie a doubling of the number of buses running) induced a 30% greater peak-time patronage.
- Inter-peak bus: a 100% increase in inter-peak bus service frequency caused a 40%–50% increase in inter-peak patronage.
- Weekend bus and rail: for weekend service improvements, there was a wide range of impacts depending on the nature and location of the improvement.
- Timetable improvements and extensions of hours: in some cases there were surprisingly high patronage gains from minor timetable changes, such as more regular timetables or extensions of hours. However, there was also evidence of diminishing returns from extending hours beyond about 8pm.

The research report also contains extensive findings on the drivers of and explanations for historical trends in patronage growth.

David stresses though that, while the research has provided some general guidelines regarding service elasticities and fare impacts, the overwhelming evidence is that these impacts differ considerably from situation to situation.

'We envisage a transport planning process in which this variability is accepted as a given and public transport investments are regularly post-evaluated, with that feedback used to guide further decisions regarding public transport investment,' he says.

Econometric models for public transport forecasting, NZ Transport Agency research report 518.

– DMK Consulting

Available online at **www.nzta.govt.nz/resources/research/reports/518**

UNDETECTED CHLORIDE CORROSION IN BRIDGES COULD BE PROBLEMATIC

Many of New Zealand's pre-tensioned concrete bridges could be prone to deterioration despite appearing to be in good shape at first glance, says recent research.

Many precast pre-tensioned concrete bridges were built in New Zealand between 1953 and 1980. While most are still performing well and pass general inspection without causing alarm, they no longer meet current durability requirements. Some are therefore at risk of chloride-induced pre-tensioned reinforcement corrosion.

Corrosion of pre-tensioned reinforcement can lead to the replacement of the entire bridge superstructure because of difficulties specific to pre-tensioned concrete. These difficulties are associated with early identification of corrosion, arresting active corrosion, and with assessing and restoring the structural capacity of the deteriorated structure. In the case of Tiwai Point Bridge in Southland, the entire superstructure of the bridge was replaced due to the difficulty and cost associated with restoring the lost capacity and arresting severe, widespread corrosion within the pre-tensioned beams.

Rhys Rogers of the University of Auckland who led the recent research project into the state of the bridges says, 'This deterioration can be difficult to detect in visual inspections and has immediate structural implications, so prediction or early detection of at-risk structures is critical for bridges to achieve their required service lives.'

The 2013 study, *Assessing pre-tensioned reinforcement corrosion within the New Zealand concrete bridge stock*, looked at the type of beams used in pre-tensioned concrete bridges in the state highway network, and the era they were constructed, building on previous research into the deterioration of pre-tensioned I-beam bridges.

The exposure classification of the bridges was remotely estimated using a Google Earth based tool developed for the purpose and 30 bridges were physically inspected, looking at their current condition, chloride ingress and concrete cover depths. The data was then used to predict the corrosion of other bridges around New Zealand.

The study identified 137 pre-tensioned concrete bridges of various beam types, and from different construction eras, as potentially at risk of chloride ingress, either now or in the future. Most of these bridges are located within 1km of the coast or constructed over seawater where they experience breaking waves (C zone).

During the inspection of the 30 bridges, all but one showed some degree of chloride ingress, with eight bridges expected to experience reinforcement corrosion within a 100-year service life as a result.

The inspections determined that two bridges (A and B), which both appeared to be in good condition, were in need of prompt action to assess the full extent of chloride ingress and to stop existing or imminent corrosion. At present these two bridges are not expected to achieve a 100-year service life unless effective preventative measures are undertaken.

Google-Earth-based tool developed as part of the research

Bridge A was built in the late 1980s and exposed to the open sea. Profiles taken from this I-beam structure showed significant differences in chloride ingress on different beams and on different faces of the same beam. This showed that chloride build-up on different beams and on different faces of the same beam was not uniform for a given structure in a given exposure environment, making it difficult to predict the most critical site on a bridge unless chloride profiles were obtained.

For bridge A, the interior beam was the most critical corrosion zone, while for bridge B, a U-beam structure built in the early 1990s, the side of the beam was the most critical site.

But the results were not consistent. Bridges of similar design and experiencing similar exposure to bridges A and B were performing adequately. Therefore, physical chloride profiles needed to be obtained from each structure to identify exactly which coastal bridges were at risk of corrosion.

'Determining wind exposure – and hence the exposure zone – accurately was also a problem', the researchers said.

The wind direction data reported in NZS 3101:2006 was frequently inconsistent with the information from 23 climate stations. Sometimes this led to an over-estimation of the corrosion hazard, so wind data should be supplemented by environmental data recorded at each bridge.

Past research suggested that the concrete mix used in precast pre-tensioned bridges was an important factor in determining the corrosion resistance of bridge beams. This was because New Zealand's criteria for the concrete used in precast pre-tensioned bridge beams had varied over time, with respect to aspects such as water/cement ratio, cement content and cast-in chlorides (either from unwashed aggregates or through the use of calcium chloride as an admixture).

Concretes from bridges constructed before 2004 were not required to contain supplementary cementitious materials, which have been shown to improve chloride resistance. Therefore bridges from this era could have a lower resistance to chloride ingress, especially those in the most exposed coastal environments (C zone).

These bridges should be monitored for chloride ingress, researchers said, and further investigations should be made to find out why the concrete of bridges constructed in the period 1978 to 2003 had poor chloride resistance compared with earlier bridges, and the number of structures that were affected.

The increased concrete cover depth requirements of later eras could counteract the lack of supplementary cementitious materials, but in the cases of bridges A and B, the cover depths were expected to be insufficient to give a 100-year service life before reinforcement corrosion began.

Log beam, T-beam and I-beam bridges constructed between 1953 and 1977 and double hollow core beam bridges constructed during or before 1966 to 1970 generally contained unenclosed pre-tensioned reinforcement.

'Consequently, bridges of these types are at risk of pre-tensioned reinforcement corrosion initiating before corrosion damage is able to be detected by visual inspection,' says Rhys.

The researchers recommended that all bridges constructed between 1953 and 1977 that were in the C exposure zone be inspected to identify reinforcement corrosion. Where these structures were not found to be actively corroding, chloride profiles and concrete cover depth measurements should be taken so that the remaining service life before initiation of corrosion could be predicted.

As the presence of cast-in chlorides was a major factor in the prediction of corrosion in bridges in the coastal perimeter 'B1 zone', those containing cast-in chlorides should be identified and chloride ingress in these structures should be monitored.

They also suggested looking at all bridges in the 'B1' and 'B2' exposure zones that were constructed between 1978 and 2003 to see which ones contained cast-in chlorides and not supplementary cementitious materials, with chloride ingress then monitored for those bridges.

Future investigations could also focus on the large number of bridges near the coast with low surface chloride concentrations, which were mainly a result of the exposure environment. Criteria could be developed to identify other bridges near the coast with similar concentrations, which could be assigned to a lower exposure zone 'than would be suggested by coastal distance and wind direction alone'.

Assessing pre-tensioned reinforcement corrosion within the New Zealand bridge stock, NZ Transport Agency research report 502.

– University of Auckland

Available online at **www.nzta.govt.nz/resources/research/reports/502**

UNDERSTANDING IMPACTS WILL LEAD TO BETTER INVESTMENTS IN THE NEW ZEALAND ROAD SYSTEM

Improved post-implementation monitoring and evaluation of the impacts of major road investments in New Zealand will lead to enhanced project appraisal procedures and thus ensure better value for money from future road investments. This research was conducted during 2010–2012 and looked at historic practice. As noted at the end of this article a number of changes have been implemented to improve the monitoring of project outcomes.

Previously in New Zealand, only road projects under $30m were required to have a post-implementation review of their impacts. Reviews were conducted by the NZ Transport Agency and involved audits of a sample of smaller completed road projects (with an average cost of $4m) against their initial project objectives, costs and economic justification.

This has changed with larger projects ($30m to $400m) now subject to post-implementation review. A pre- and post-monitoring framework is also being developed.

Surprisingly little information is available, in New Zealand or internationally, about the actual impacts that road investment projects can have. This affects the accuracy and effectiveness of pre- and post-implementation reviews. Impacts that practitioners take into account in assessment procedures are less than comprehensive, with significant factors frequently not included in the analysis.

Research by Ian Wallis Associates Ltd (Ian Wallis, Don Wignall and Chris Parker) has sought to identify and describe the full range of impacts that can flow from major road projects. To this end, the project reviewed New Zealand and international evidence on the actual impacts that major road investments have, and used it to assess the strengths, weaknesses and priority areas for improvement of current pre-appraisal methods (including demand forecasting and economic appraisal approaches), and post-evaluation procedures and practices.

A FOCUS ON IMPACTS

The research focused on the impacts of projects in larger urban and metropolitan areas.

Ian Wallis says, 'Our project was designed to encompass the broader impacts that can flow from projects, to the extent that information is available about them, including those impacts that, at present, are often not examined in relation to individual road projects. These broader impacts tend to focus on the medium- and longer-term timescale, and can include such factors as increased car-based accessibility, induced travel, road crashes and their associated social costs, global environmental effects, and local environmental, social and health effects.'

The team developed a set of factor headings and sub-headings for use in appraising the impacts of roading projects, both in New Zealand and internationally. Having a common checklist of factors helps in achieving comprehensive and consistent appraisals, while recognising that information on some of these factors is unlikely to be available, or relevant, for many schemes.

THE FINDINGS

Having garnered the evidence about impacts, the researchers analysed it under five topic areas: travel behaviour; economic appraisal; social, environmental, health and safety effects; post-implementation procedures; and lessons from five post-evaluation case studies.

A summary of the main findings and recommendations in each topic area is given below.

Travel behaviour – methods and impacts

- Major urban road schemes in several countries resulted in significant increases in corridor traffic volumes ('induced traffic') in the short term, typically by around 5% to 10%.
- For most radial schemes, a major proportion of the traffic increase is from people switching from public transport.
- In the longer term, the extent of traffic induced by major road schemes is much larger than in the short term. As a result, a substantial proportion of the theoretical time savings (in the absence of induced traffic) is offset by the effects of the additional traffic.
- In congested urban situations, any benefits associated with induced traffic are often more than offset by the (economic) costs it imposes on the existing traffic.
- The main weaknesses in New Zealand procedures and practices for the economic appraisal of new road projects relate to the transport modelling aspects. Particular areas of weakness include the modelling for: trip generation and its relation to accessibility and economic changes; induced land use effects of transport system changes; and trip retiming, particularly in relation to any changes in peak road capacity, congestion or travel costs (eg tolls).

Economic appraisal methods

- The effects of transport system changes on inducing land use changes can be the dominant effect of some schemes in the longer term. Use of economic appraisal procedures (in New Zealand and elsewhere) is seriously deficient in that it does not often take account of this effect. Further development in this area should be given greater priority.
- Methods in New Zealand (and elsewhere) for the estimation of wider economic benefits are at a relatively crude stage of development and risk over-estimating project benefits. However, the methods for evaluating agglomeration benefits do not account for induced land use changes, which would be expected to be one of the main agglomeration effects of major schemes.
- Social cost-benefit analysis appraisal methods used in New Zealand provide estimates of the impacts of projects on national economic welfare. They give no information about: (i) how these benefits flow through the economic system and their ultimate effects on the national economy; or (ii) the distribution of the economic benefits, in terms of geographic area, different groups of households and individuals, etc.

Social, environmental, health and safety effects – methods and impacts

- Approaches adopted in New Zealand for road scheme assessments do not (in general) cover the full range of actual or potential significant impacts of road schemes, being commonly limited to Resource Management Act 1991 consent conditions.
- A more comprehensive pre- and post-assessment framework is required, particularly for larger schemes. Established techniques to improve and extend current practice are available for incorporation into New Zealand procedures.
- Any monitoring or assessment work is currently carried out only at the project level: there is a need for some monitoring at the multi-project or programme level and over the longer term, to identify any wider effects.

Post-implementation review procedures

- At the time of the review, New Zealand post-implementation review procedures fell short of good practice internationally, and the value of the present procedures in a number of aspects was questioned.
- Specific aspects identified for improvement, as a matter of priority, included project sampling, the scope of post-implementation reviews, assessment biases, assessments of short- versus longer-term impacts, programme performance indicators, learning and feedback, integration of processes and transparency.
- Since this review the Transport Agency has made a number of improvements to its post implementation review processes, which address most of the shortcomings noted.

New Zealand post-evaluation case studies

This topic area focused on post-evaluation case studies of five medium-size New Zealand road projects (in the cost range $30 million to $360 million) completed in recent years: Auckland northern motorway extension, Auckland Northern Busway, Auckland southern motorway ramp signalling, Tauranga Harbour link and Wellington inner city bypass.

- The out-turn costs for four of the schemes were within ±10% of the prior estimates: for the fifth scheme, the costs were substantially lower than the estimate.
- There was no evidence of significant induced traffic in the short term. In the case of the Auckland northern motorway extension (toll) road, the extent of traffic relief to the old (bypassed) route was significantly lower than forecast.
- Travel times for general traffic in the corridors affected were reduced for four of the schemes, with the reductions generally reflecting the size of the scheme. There was no evidence of changes in the reliability (variability) of travel times.
- The Auckland Northern Busway scheme appears to have been successful in reducing bus travel times and increasing public transport use in the corridor. It has also significantly reduced peak period car use on the adjacent northern motorway, by around 5% in the morning peak period. No monitoring of modal effects was undertaken in the other cases.
- In general, the pre-appraisal forecasts of crash reductions were not achieved: only one of the five schemes appeared to result in significant reductions in crash costs. In the light of these findings, the team recommended that crash forecasting methods should be reviewed and that greater attention should be given to safety aspects in the scheme development or assessment stages.
- No post-implementation review or monitoring of vehicle operating cost changes, associated fuel consumption, greenhouse gas emissions or local environmental impacts was undertaken for any of the case studies.
- For all five schemes, the estimates of shorter-term transport benefits (principally in terms of travel time savings) at the post-evaluation stage were within around 20% of the pre-appraisal estimates for this period (assuming the same unit value of time savings etc in each case). This indicates reasonably good predictive accuracy over the shorter term.

FUTURE NEEDS AND RECOMMENDATIONS

With a much stronger understanding of the full scope of impacts that can flow from projects, the team was then able to make a number of recommendations on how existing New Zealand forecasting and pre-appraisal methods, and post-evaluation procedures and practices, could be improved.

Ian says, 'Overall we identified that New Zealand lacks a comprehensive framework to adequately guide pre-implementation appraisal and post-implementation evaluation. As well as being focused only on the smaller roading projects, the scope of the current post-implementation monitoring of the New Zealand roading programme is limited in terms of the range of impacts examined. In many cases a comprehensive understanding of project effects is lacking. Consequently, there is currently very limited useful feedback from experience with actual scheme performance to enhance pre-appraisal procedures, and hence to take future investment decisions on a sounder basis.'

To address the current deficiencies, the team recommended the development and introduction of a strengthened pre-implementation appraisal and post-implementation evaluation framework, and a requirement for projects to be more comprehensively monitored within it.

Following the completion of the research report, in July 2013 the Transport Agency board agreed to improve and strengthen the current post-implementation review process, including:

- Post-implementation reviews are to cover both new and improved infrastructure for state highways and local roads, public transport and walking and cycling projects.
- A stratified sample of projects (that have been in use for at least two years) will be selected annually for post-implementation review.
- Reviews are to assess the value for money of completed projects or packages against their main expected transport benefits.
- Reviews will have a greater focus on identifying lessons learned, which will then be fed back into making business improvements (including project evaluation procedures). The processes will be more transparent than in the past and approved organisations will have an enhanced involvement.

The implications of road investment, NZ Transport Agency research report 507.

– Ian Wallis Associates Ltd

Available online at **www.nzta.govt.nz/resources/research/reports/507**

Test 2 example from the Canterbury Accelerated Pavement Testing Indoor Facility (CAPTIF)

Gisborne local road – material used for Mangatu Road (from Mangamaia)

NEW LIGHT SHED ON THE PERFORMANCE OF STABILISED AGGREGATES

Areas of New Zealand are running out of the premium aggregates needed to build unbound granular road pavements. There are alternatives available, but pavement designers have lacked data to support their use. This gap has now been addressed through research into the use of stabilised materials in pavement design.

Unbound granular pavements have traditionally been a popular form of construction for New Zealand roads. However, they require premium-grade aggregates in order to meet demanding construction specifications and to continue to perform adequately over time.

Aggregates, especially premium quality ones, are a finite resource. With current sources being depleted and restrictions on the development of new quarries, some areas of the country are facing a shortage. New Zealand has tripled its annual requirement for road aggregate (from a 30-year industry low in 1991). Related issues are arising on the North Island's east coast where the costs of bringing in high-quality aggregates are making road improvement projects economically unviable.

Dave Alabaster of the NZ Transport Agency says potential alternatives to premium aggregates already exist.

'There has already been extensive research into the possibility of using recycled road materials and modified marginal aggregates in pavement construction. Pavement designers trying to use these alternative materials have been constrained, however, by the lack of data available on how they will perform when stabilised,' says Dave.

Stabilisation is the process used to modify an aggregate's properties, so that it meets performance criteria. It involves the addition of a stabilisation binder (generally cement, lime or foamed bitumen) to the pavement mix, to enhance such things as rut and fatigue resistance, which would otherwise be undermined by the use of lower-quality aggregates. Pavements are considered to fall along a continuum depending on the amount of stabilisation binder used in their construction: from unbound (no binder), to modified (small amounts of binder), to bound (high amount of binder).

Dave says, 'Stabilisation offers a viable alternative and our research fills the current knowledge gap by presenting data on the performance of a range of stabilised materials. The results will improve the sustainability of New Zealand roads by increasing the use of locally available materials and promoting recycling of existing materials. This, in turn, will reduce pavement construction, rehabilitation and maintenance costs, without compromising performance.'

Other benefits expected from stabilised pavements include less frequent and shorter travel time delays associated with rehabilitation work; modified materials should last longer before they need rehabilitation and the construction techniques associated with their use, such as in-situ modification, are very fast (taking days rather than months) when compared with traditional overlays. In addition, stabilised pavements will be less affected by increases in traffic volumes and heavy vehicle mass limits predicted for the future, and tend to perform better in wet conditions.

THREE-PRONGED TESTING

The data presented in the study was gained through accelerated pavement testing at the Canterbury Accelerated Pavement Testing Indoor Facility (CAPTIF), laboratory experiments and a field study.

The CAPTIF tests investigated a range of cement-modified and foamed bitumen-stabilised aggregates, focusing on how they affected the pavement's performance in terms of rutting and fatigue resistance.

In addition to the standard CAPTIF tests, the team carried out laboratory experiments on the sample pavements to characterise the properties of the treated materials, with the aim of linking these properties to the pavements' expected field performance. The repeated load triaxial test resilient modulus and permanent strain rate of all the materials was measured. The unconfined compressive strength and indirect tensile strength of all the modified and bound materials were also measured.

The CAPTIF tests showed that modifying the tested aggregates with 1% cement could reduce rutting and improve the rutting life of the pavement by 200% to 300%, compared with the unbound pavement, although there was also some resultant stiffness loss (fatigue). However, modifying the aggregates with foamed bitumen and cement reduced rutting and created a 500% improvement in life compared with the unbound pavement, without any loss of stiffness during the project.

The field study looked at various modified or stabilised pavements around the country. A CIRCLY analysis was used to assess the characteristics of the stabilised aggregates, as well as pavement damage relative to pavement cross-section, traffic loading and strains at critical locations for each pavement. Pavements were selected using the RAMM database, and included those that had performed well for more than 20 years through to those that had failed within four years.

In addition to testing at each site, the team examined records and data on pavement structure, falling weight deflectometer test results, subgrade Californian bearing ratio test results, layer thickness and historical trends in rutting, roughness, maintenance activities and costs, and traffic loading. In addition, 150mm diameter cores of the modified or stabilised layers were obtained and tested for resilient modulus and indirect tensile strength.

The field data was then analysed in terms of the Austroads and South African pavement design guide methodologies. A particular focus was on the Austroads tensile strain criterion for bound aggregates, as many New Zealand designers consider this criterion overly conservative.

Dave says, 'Our analysis supported this perception, with both the field study and the CAPTIF tests indicating that the Austroads criterion produces inappropriate results for New Zealand conditions. The South African approach appears to produce better results. Materials with 4% cement, tested at CAPTIF, led to a 1000% increase in rutting life compared with the unbound pavement; however, there was significant stiffness loss.'

The report recommends that 2% cement content is a prudent limit for designers to start taking into account bound behaviour for cement modified pavement layers (ie the point at which a pavement layer might be considered to slip from modified to bound), and that this should be the 'upper limit' for using the recommended design process. Layers with cement content above the 2% limit create a risk of the pavement cracking due to stiffness loss, leading to potential rapid failure.

The team then collaborated with researchers working on other Transport Agency funded projects, to develop a comprehensive design process for modified pavement layers. This process is presented in draft in the report, but is expected to be finalised in the next edition of the New Zealand supplement to the Austroads pavement design guide. It can be used to design new and rehabilitated pavements, as well as to estimate design life from the laboratory mix design data for any proposed materials.

The design of stabilised pavements in New Zealand,
NZ Transport Agency research report 498.

– NZ Transport Agency

Available online at **www.nzta.govt.nz/resources/research/reports/498**

NOTE TO READERS

The following article, on research report RR 510 – *Evaluation of the C-roundabout – an improved multi-lane roundabout design for cyclists*, was published in the November supplementary edition of NZTA research. However, unrelated text was inadvertently included at the end of the article. Therefore, the article has been reprinted correctly in this issue

NEW ROUNDABOUT GETS THUMBS UP FROM CYCLISTS

The second stage in a two-part research project to design and evaluate a new cyclist-friendly roundabout has now been completed.

The C-roundabout (short for cyclist roundabout) is the fruit of a 2006 Land Transport New Zealand (now the NZ Transport Agency) research project 'to improve the safety of cyclists at multi-lane roundabouts and make multi-lane roundabouts more cyclist-friendly'.

The C-roundabout design combines decreased vehicle speeds, as a result of increased deflections, with reduced-width approach and circulation lanes, so that cyclists are required to travel in the centre of the lanes. The slower vehicle speed of around 30km/h means that cars and trucks are negotiating the roundabout at about the same speed as cyclists, significantly improving cyclists' chances of surviving a crash, should one occur. The design is also considered to be safer for pedestrians and other motorists, due to the lower speeds.

The multi-organisation research team that developed the original C-roundabout design has now published the results of a three-year project to test its efficacy. This second stage of the project has involved the conversion of a standard multi-lane roundabout into a full C-roundabout, at a relatively uncongested site in Auckland.

In parallel with this, the team also converted the approach lanes at a standard roundabout, from a wide single lane to two narrow lanes. The purpose was to see whether the capacity of a standard roundabout could be increased in this simple, low-cost way, without any adverse impacts on safety.

The research team at TES Ltd (Ivan Jurisich, Deborah Asmus and Duncan Campbell) say that the C-roundabout could be considered for use on designated cycle routes and in other areas where cyclists form a significant proportion of local traffic.

'Following our recent evaluation of the roundabout, we're recommending that the techniques used to support the principles of reduced approach and circulating speeds should be considered for other locations where more cyclist-friendly multi-lane roundabouts are wanted.

'However, we're also recommending that further research into the key features of the roundabout design takes place. Due to the low congestion and cycle crash numbers at the location where we installed our prototype, it was hard to get a proper gauge on how the design influenced such things as crash rates and capacity. Early indications are positive, but further research would confirm whether or not this was the case.'

What the evaluation did show was that the treatments used on the approaches to the C-roundabout were successful in reducing vehicle speeds: the vast majority of vehicle through-speeds were reduced to the desired 30km/h. There was no significant change in the crash rate (there were no cyclist crashes at this site either before or after the conversion), although the injury crash rates did drop.

'With the lower vehicle speeds we would expect the injury crash rate to reduce,' says the research team. 'But another couple of years' data will enable us to be conclusive about this.'

Capacity appeared to be largely unaffected by the conversion, but this was difficult to assess due to the low traffic flows and limited congestion at the site.

What was clear was the positive response that the new design garnered from cyclists and pedestrians using the roundabout. Cyclists found the layout simpler to use and safer, and stated they would like to see the treatments used on other approaches. Pedestrians also found the narrower crossing distance made the roundabout safer and easier to cross. Both cyclists and pedestrians noticed that car speeds were slower.

Car drivers, however, were not so positive about the new design, with around half not in favour of it. In particular, drivers noticed the slower speeds and narrower lanes, and around half found it less intuitive to use.

'There was a perception by car drivers that the design was less safe,' says Ivan. 'But this is not backed up by the crash statistics, and we think this impression is likely to change as drivers get used to the configuration. Many drivers also wouldn't recognise the roundabout's benefits for cyclist, but again this may change as cyclist support for the new design becomes more known.'

Results at the second test site showed that in order to increase capacity of a single-lane roundabout by using two narrow lanes in place of the one approach lane, vehicles had to slow down to 30km/h to ensure there was no increase in crashes on the approach. The research team stressed that this second test site only looked at capacity effects for a low-cost measure and did not incorporate design principles for slowing vehicles down.

While the result of the evaluation was positive, in the sense that it showed the capacity of a single-lane roundabout could be almost doubled at very low cost by converting the single approach lane into two narrow lanes, this was accompanied by a significant decrease in safety (there were increases in both the overall crash rate and the injury crash rate after the conversion). However, slowing approaching vehicles to 30km/hr would be a positive effect on cyclists' safety.

The report recommends that, where roundabouts are being converted to have two narrow approach lanes, steps should also be taken to reduce vehicle speeds to 30km/h.

Evaluation of the C-roundabout – an improved multi-lane roundabout design for cyclists, NZ Transport Agency research report 510.

– Traffic Engineering Solutions Ltd

Available online at **www.nzta.govt.nz/resources/research/reports/510**

ABOUT C-ROUNDABOUTS

Multi-lane roundabouts are viewed by cyclists as one of the most hazardous types of intersections to negotiate. Police crash statistics confirm this, with 68% of crashes at multi-lane roundabouts happening at their entrances, and involving an entering vehicle and a circulating cyclist. This was mainly attributed to vehicles entering the roundabout too fast and the driver not seeing the cyclist on the circulating part of the roundabout. If these crashes could be eliminated, then the multi-lane roundabout would be the safest type of intersection for both cyclists and cars.

In 2003, scheme design investigators in Auckland discovered there was no adequate on-road design available that would enable cyclists to ride through multi-lane roundabouts.

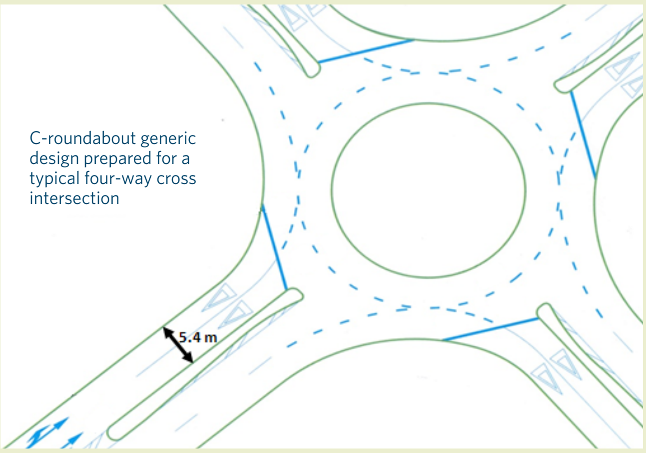
The research team's first project in 2006 sought to address this by developing an on-road design solution named the C-roundabout. The current research project aimed to test the design's effectiveness.

The principle of the C-roundabout is for through-car speeds to be reduced to around 30km/h, a speed considered to be amenable to cyclists mixing with vehicle traffic: at this speed a cyclist's chances of having a serious crash or dying from a collision are minimal. The geometric layout of the roundabout is critical to achieving this aim, requiring the C-roundabout to have narrow entry and circulating carriageway widths.

The key features of the C-roundabout design are:

- two-lane configuration (ie multi-lane roundabout)
- geometric layout so that unimpeded vehicle through-speed is around 30km/h
- narrow entry width – approximately 5.4m, kerb-to-kerb (ie 2.7m lane widths)
- narrow circulating carriageway width allowing for two cars to travel side by side with a minimum of 0.5m clearance between cars and kerbs
- large vehicles are required to straddle lanes on the approach and through the roundabout
- in some cases, where extra width may be required, mountable areas can be provided, eg to be used by a semi-trailer
- buses are required to straddle lanes, but not use mountable areas (for passenger comfort).

Two new C-roundabouts have now been installed and are in operation in Auckland. The research team considers this should provide enough data to conclusively assess the safety of the C-roundabout design over the next few years



C-roundabout generic design prepared for a typical four-way cross intersection

NEW RESEARCH REPORTS

An investigation into the deployment of an advisory ISA system in New Zealand

Research report 521

G Waibl, R Batt, J England – MWH New Zealand Ltd, Dr J Thomas, K Mora, B Frith, G Rive – Opus Research, Dr S Jamson, Prof. O Carsten, Dr F Lai – University of Leeds, UK

Freely available online at www.nzta.govt.nz/resources/research/reports/521

Excessive and inappropriate speed on our roads is a significant issue in New Zealand, and loss-of-control crashes, on rural curves in particular, are a key crash contributor. This research investigated the deployment of an advisory Intelligent Speed Adaptation (ISA) system in New Zealand.

The predicted crash-reduction benefits of two ISA variants were determined following real-world trials of a 'fixed' ISA system, which provided drivers with speed limit information and warned them when they were exceeding the speed limit, and a 'variable' ISA system, which provided drivers with feedback on their speeds while negotiating curves and other road features that were signposted with advisory speeds. These crash-reduction benefits were compared with estimated implementation and operating costs to determine the economic viability of deploying an advisory system in New Zealand.

The research examined a range of potential barriers. Focus groups were used to identify user acceptance issues, and local and central government and the motor industry were consulted to identify potential institutional, regulatory or other barriers.

This research also looked at how speed limit and advisory curve information might be transferred to a vehicle. GPS reliability and coverage in New Zealand was assessed as part of the research, and a framework on which to build an e-speed limit management system was developed.

Optimising expenditure on roadside safety barriers

Research report 536

NJ Jamieson, Opus International Consultants, S Richardson, Delta-V Experts, Victoria

Freely available online at www.nzta.govt.nz/resources/research/reports/536

This research, which was carried out in New Zealand in 2013, used computer simulation modelling to identify whether it was better to rectify or replace existing roadside crash barriers that were of substandard height or corroded, or to install new roadside crash barriers at locations with significant hazards where there were currently no barriers. This information would assist road controlling authorities in establishing spending options and priorities.

The computer simulation modelling quantified the effects of barrier height on crash severity for a selected range of barrier types (W-beam/wooden post and wire rope), vehicles (models, speeds and paths) and physical contexts. Crash severity costs were also derived for a limited selection of rectified and reinstalled barriers, new barriers in the same locations and new barriers at untreated locations that have significant hazards.

The key finding was that for both barrier types, those that were lower than specifications could result in increased crash severity. However, this was not generally found to be severe, even when the computer modelling used height differences thought to exceed those found on the New Zealand state highway network. The research results suggested that in many cases (especially for wire-rope barriers) it would be much more cost effective to install new barriers at previously untreated locations than to raise existing barriers to the correct heights.

Reliability and freight – literature and practice review

Research report 538

I Bone – Beca Ltd, in association with I Wallis – Ian Wallis Associates Ltd, C O'Fallon – Pinnacle Research and Policy Ltd, Dr A Nicholson – University of Canterbury

Freely available online at www.nzta.govt.nz/resources/research/reports/538

The NZ Transport Agency's *Economic evaluation manual* (EEM) provides guidance on the evaluation of journey time reliability in private road vehicle trips. The EEM does not currently provide for the evaluation of reliability for commercial vehicles and freight.

Austroads has recently reviewed the question of including reliability in project economic appraisal but has concluded that a number of methodological and measurement challenges need to be overcome before the concept of travel reliability becomes standard in project appraisal.

There are two general approaches to identifying and assessing the impact of freight time delays and variability. The first approach, usually called the 'factor cost method' involves an analysis of the consequences of lateness in the freight transport operation and the related quantifiable costs. The second approach is to elicit perceived values for journey time, departure and arrival punctuality from the shipper or transporter in relation to cost, using any model of shipper or carrier behaviours including stated preference and revealed preference techniques.

The research highlights the need for three main areas of further research:

- reliability in general road traffic
- reliability in personal transport
- value of time, reliability and demand elasticity for freight transport.

OBTAINING TRANSPORT AGENCY RESEARCH REPORTS

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

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

NEW RESEARCH REPORTS

Accurate and affordable location technology for New Zealand

Research report 535

D Barnston, R Brill, A Harding, NJ Jamieson, M Ladd, N Stillwell - Opus International Consultants

Freely available online at www.nzta.govt.nz/resources/research/reports/535

A potential gap between available location technology and its use on the ground was identified in the New Zealand land transport sector. This research sought to bridge that gap and support the NZ Transport Agency's goal to increase the use of appropriate location technology by its key providers. Consultation with key providers was undertaken to understand the requirements for location technology and any lessons learnt from previous implementations. A literature and technology review and evaluation identified suitably accurate and affordable location technologies for use in road asset management in New Zealand.

Mapping grade global navigation satellite systems (GNSS) and consumer grade GNSS combined with mobile geographic information systems and imagery were found to be the most appropriate options for immediate use. Other promising technologies include augmenting GNSS with ground-based networks like Locata or other wireless systems (Bluetooth, WiFi, ultra wide-band). There is also potential for the wider use of ground-based LiDAR for desktop surveys.

The use of these technologies requires clear guidance. It is recommended that current Transport Agency manuals are updated to include guidelines for the use of location technology, with clear accuracy requirements. This will assist providers in choosing the most appropriate location technology for a given situation.

DID YOU KNOW...

That there is a spreadsheet on the Transport Agency website listing all published Transport Agency research reports?

The spreadsheet is searchable by several criteria and can be found at **http://www.nzta.govt.nz/planning/programming/research**

The spreadsheet has two worksheets; the first worksheet lists research reports with associated key words and the second lists research reports with the report abstracts.

Wishing you a Merry Christmas from the NZ Transport Agency

A NOTE FOR READERS

NZTA research newsletter

NZTA research is published quarterly by the NZ Transport Agency. Its purpose is to report the results of research funded through the Transport Agency's Research Programme, to act as a forum for passing on national and international information, and to aid collaboration between all those involved. For information about the Transport Agency's Research Programme, see www.nzta.govt.nz/planning/programming/research.

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

Contributed articles are also welcome, should not exceed 1000 words and are to be emailed to research@nzta.govt.nz. Illustrations must be of high quality. *NZTA research* reserves the right to edit, abridge or decline any article.

All general correspondence, queries related to conference notices, and requests for additions or amendments to the mailing list, should be made to research@nzta.govt.nz.

Editions of this newsletter, NZTA research, are available in hard copy or on the Transport Agency website at www.nzta.govt.nz/resources/nzta-research/. Back editions are available online only.

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Do we have your correct details?

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