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NZ TRANSPORT AGENCY
WAKA KOTAHI

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Earthquake damage 2010 - Puente La Mochite, Chile

STUDY RECOMMENDS RETHINK OF BRIDGE SPECIFICATIONS

Bridge damage, especially at expansion joints, is a consequence of almost all major earthquakes. Recent research reveals that current specifications may not be adequate to minimise the risk and consequences of this damage and need to be revised.

Expansion joints between bridge segments are needed to accommodate the bridge structure's expansion and contraction as temperatures change. The gaps provided by these joints are typically only a few centimetres wide. While they can accommodate some movement during earthquakes, it is often insufficient, and extensive damage to the joints is common during major earthquakes.

Damage occurs due to the differing movements of adjacent girders, which can pound into each other when the closing movement of the bridge sections during an earthquake exceeds the size of the gap. At the other end of the spectrum is a risk that the bridge decks will become unseated, and the bridge collapse, when the girders move too far away from each other and are no longer held up by the supporting bridge piers and abutments.

Research has shown that how far neighbouring bridge segments are displaced, relative to each other, during an earthquake (and as a result how much damage is done) depends on:

- the dynamic properties of the adjacent structures
- the spatially varying ground motions at adjacent bridge supports
- the supporting soil conditions, and the soil and structure interaction (SSI).

Past research has largely overlooked the last two factors, and in New Zealand this is reflected in the NZ Transport Agency's Bridge manual (both the 2nd edition of 2005 reviewed during this research project and the 3rd edition of May 2013), which focuses on the fundamental frequencies of adjacent structures and does not instruct designers to consider spatially varying ground motion or SSI.

Research by a team from the University of Auckland's Department of Civil and Environmental Engineering has recognised this gap, carrying out extensive testing to determine how spatial variation in ground motions can affect the performance of bridges during earthquakes.

The outcome has been a series of recommendations for new bridge design that takes into consideration the spatially varying effect of ground motions. These include recommendations for updating the Transport Agency's Bridge manual to:

- prevent spans falling off their supports by providing guidance on the minimum seating length required (the distance by which girders overlap the support)
- prevent damage due to pounding between adjacent structures by incorporating modular expansion joints in bridge designs.

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University of Auckland field test

FOCUS ON GROUND MOTIONS

Nawawi Chouw from the University of Auckland, who headed the research project, says the team decided to focus on the influence of spatial variations in ground motions because 'most current design specifications ignore this critical factor'.

To this end, the team tested three bridge models (based on the dynamic properties of the Newmarket Viaduct), with a scale ratio of 1:125, using shake tables. One model had moveable abutments, another two segments, and the third three segments. For each model, the influence of the following factors was measured – spatial variations in ground motions, the dynamic characteristics of the bridge structures, and pounding – with the results obtained by isolating and varying each individual factor. A field test was also carried out on a 1:22 bridge to study the SSI effect in comparison with the fixed-base results from the models. More than 8000 tests were conducted in total.

The collected data was then compared to show the influence of each factor. What emerged was that all of the factors had a significant influence on the relative response of the structure, and on pounding damage and unseating potential. In particular, the spatially varying effect of ground motions increases the maximum relative displacements and pounding forces between adjacent bridge girders, even if adjacent segments have the same fundamental frequency. The combination of all of the factors could result in a substantially more severe bridge response.

This is significant, as specifications in the current Bridge manual do not take into account spatially varying ground motions and SSI. As a result, the manual's recommendations for seat lengths and clearance between sections may be inadequate and potentially in need of revision.

RECOMMENDATIONS FOR UPDATING THE *BRIDGE MANUAL*

Based on the outcomes of the research, the project team made the following recommendations for updating the Transport Agency's Bridge manual.

1. The current manual may not be sufficient for recommending the minimum seating length and the clearance at the girder joints or the joint for a span and its abutment if spatially varying ground motion is justified.
2. The recommended clearance by the current manual may still result in pounding even if pounding is not allowed in New Zealand bridge design.
3. With the influence of spatially varying excitation, having the same fundamental frequency for two segments does not necessarily suppress out-of-phase movement. Hence, spatial variation of ground motions should be addressed in the manual.
4. For high importance bridges, vigorous modelling of spatially varying ground motions is recommended.
5. Two equations have been proposed, based on the experimental results, for calculating the necessary gap or overlaps for bridge joints to exclude pounding and prevent unseating based on New Zealand design spectra.
6. Modular expansion joints could be used as a solution to accommodate large opening relative displacement while avoiding pounding.

Nawawi says that if these updates are accepted, the manual will represent some of the most advanced bridge design specifications in the world.

'There's significant potential for the outcomes of the project to affect bridge design worldwide,' he says. 'Already, our recommendations for bridge design specifications have been taken up by one of the largest construction companies in Japan, and translated and published in Japanese. This shows the influence that quality New Zealand-based research can have. With respect to understanding the influence of spatial variations in ground motions we're now leading the world.'

Seismic design of New Zealand highway bridges under spatially varying ground excitations, NZ Transport Agency research report 504.

– University of Auckland

Available online at **www.nzta.govt.nz/resources/research/reports/504**

Earthquake damage 2010 - Puente Llacolen, Chile

NEW WAYS TO REDUCE THE SEVERITY OF RUN-OFF-ROAD CRASHES

A recent study, Use of roadside barriers versus clear zones finds:

- For most situations, roadside barriers are more effective at reducing crash severity than the current practice of clear zoning.
- Flexible wire-rope barriers should be the barrier of choice for most New Zealand roadsides.

The February 2013 report has quantified crash risk and severity of outcome for different barrier types and different roadside conditions. The findings will make it easier for practitioners to estimate the reduction in severity for run-off-road crashes when implementing roadside barrier projects.

New Zealand has a high number of run-off-road crashes and the traditional approach to managing these crash scenarios has centered on the provision of clear zones. Developed in the United States, the clear zone concept usually involves a recommended 9m width of unobstructed road reserve adjacent to the sealed carriageway, which is intended to allow an errant vehicle to come to rest.

However, previous research showed that on a 100km/h stretch of road, up to 70% of vehicle encroachments were accommodated within the first 6m of lateral distance. But up to 20% of vehicles that ran off the road encroached further than 9m and, even with braking, these vehicles often had high forward speeds. Such findings have prompted questions about both the effectiveness and the practicality of clear zones.

The research, which was carried out in 2011 and 2012 by a team from Opus International Consultants, Statistics Research Associates and MWH New Zealand, measured the effects of roadside barriers and clear zones on run-off-road crash likelihood and severity of outcome, for a range of typical New Zealand roadside conditions.

The usual statistical approach would be to identify a large sample of clear zone situations and compare them against large samples of different roadside barriers under a variety of conditions. However, this approach was not practical. Some of the newer systems were not widely represented over a variety of roadside conditions.

The researchers used an innovative approach combining both crash prediction modelling and vehicle simulation to ensure that the analysis was robust over a wide number of situations. Where roadside condition and barrier data was readily available a statistical analysis was undertaken and for those situations where there was a scarcity of either crash data or barrier type, computer simulation modelling was used to gain an insight into how vehicles were likely to behave.

Using statistical analysis, the study looked at road condition and geometry data, roadside risk and hazard information from the New Zealand Road Assessment Programme (KiwiRAP), and the latest crash data for the New Zealand state highway network. It extended the existing crash risk model to include variables for the roadside condition.

Crash rates and crash severity ratios were statistically predicted for different roadside conditions, in terms of either the type of barrier or the roadside risk categories. Due to the high variance values for situations where data was scarce, the range of results for different types of barrier tended to overlap and it was not possible to differentiate between the performance of different types of barrier.

However, the researchers did caution against using clear zones, whatever the depth, unless the severity of the hazards that lay beyond the zone was assessed first. While the lateral distance offset to the nearest hazard or barrier was important, the type of hazard at the far side of this was also important in determining the crash rate.

'For example, if a vehicle is going to pass through a 6m clear zone with considerable remaining forward speed, the consequences are likely to be worse if the hazard in the way is a severe one, such as a large tree, than if the hazard is a minor one, such as a shallow embankment,' the researchers said.

The use of roadside barriers located about 2–4m beyond the seal is considered to be a better approach. However, as mentioned before, one of the problems with evaluating fairly recent technologies, such as roadside barriers, is that there has not usually been a sufficient number installed to enable a large-scale statistical approach.

Corner simulations suggested that placing the barriers further out, such as at 4m offset instead of 2m, would accommodate a greater number of encroaching vehicle paths without significantly increasing the risk of serious injury because of high normal speeds and incident angles – where normal means perpendicular to the barrier.

'However, placing barriers at much greater distances does raise the possibility of increased risk of rollover crashes and also removes the potential route delineation that barriers can provide, particularly at night,' the researchers noted.

'For example, it is likely that flexible (wire rope) barriers at around 4m offset will be more cost effective in most situations than a wide clear zone (>9m) when the purchase and construction costs are balanced against the crash costs,' they said.

The information could be useful in the design of safer, more appropriate and cost-effective treatments, in line with the Safe System approach to road safety.

Computer simulation modelled the most likely scenarios, ie drift-off, speed and emergency braking, for run-off-road crashes on straight roads and corners. The simulations showed that for run-off-road

encroachments either under constant speed or using emergency braking, normal speeds at lateral distances of 2, 4 and 9m – the typical distances for placing barriers and clear zones – were generally 40km/h or less.

Therefore, the modelled results for both impact speeds and angles were within the range of values experienced for central median barriers. The NZ Transport Agency (the Transport Agency) has already undertaken separate research on central median barriers and concluded that wire rope barriers show a greater reduction in crash severity compared with other types of barrier and less occurrence of rollover crashes. The ability to reduce rollover crashes is important as some roadside barriers are likely to be located on sloping roadsides.

The researchers also recommended that the cost implications of the different roadside barrier and rail risk categories, or roadside risk categories, be evaluated given the calculated crash rates. This would allow the variations in crash rate and severity for different roadside conditions to be included in the Transport Agency's *Economic evaluation manual*.

The study concluded that its findings support the view that for an effective Safe System approach it is important to consider the overall safety within the road reserve, starting with the road itself, eg in terms of geometry and friction, and carrying on to the roadside, including all roadside conditions such as friction, slope, gradient, offset to hazard and type of hazard.

This research has provided the Transport Agency with greater assurance for developing a policy to use wire rope roadside barriers to minimise the severity of run-off-road crashes. With the installation of more roadside wire rope barriers, the Transport Agency will be in a better position to follow up with a data-intensive statistical approach, once the data becomes available.

Use of roadside barriers versus clear zones, NZ Transport Agency research report 517

– Opus International Consultants, Opus Research

Available o–**w.nzta.govt.nz/resources/research/reports/517**

MEASURING PUBLIC TRANSPORT'S CONTRIBUTION TO THE ECONOMY

The New Zealand Government wants public transport investments to support economic productivity and growth. Quantifying public transport's contribution to economic productivity is important in the assessment of proposed projects.

At present, the NZ Transport Agency's (2010) Economic evaluation manual (EEM) describes methods for assessing the economic costs and benefits of transport investments. However, the EEM does not currently consider the potential for public transport to make a unique contribution to economic productivity.

Earlier this year, Stuart Donovan (MRCagney), Tim Hazledine (The University of Auckland) and John Bolland (John Bolland Consulting) reported the results of their project to 'quantify the contribution of public transport to economic productivity'.

Stuart says, 'We were tasked with assessing whether various economic appraisal procedures could be applied to public transport networks, and from there recommending a procedure that could be used to estimate the benefits that public transport brings to economic productivity.'

The researchers determined that public transport was likely to make a unique contribution to economic productivity in dense urban areas, where public transport is most commonly used and found. It is in these areas that public transport resulted in higher 'agglomeration economies'.

'Because of this, within our broader remit we placed a particular focus on the benefits of relieving congestion in Auckland and Wellington, as this is an obvious priority for the government in terms of increasing the country's productivity and growth,' said Stuart.

'As a result, our research focused on the productivity implications of public transport improvements in major urban employments areas, which tend to benefit commuters. In smaller urban areas, commuting distance and congestion are not such big barriers, and the economic benefits of public transport projects are able to be adequately captured by existing methods.'

The initial task was to review the international literature on the economic implications of transport systems, from which the team identified a 2007 microeconomic model developed by AJ Venables as the most promising starting point (see Venables' article 'Evaluating urban transport improvements: cost benefit analysis in the presence of agglomeration and income taxation' in *Journal of Transport Economics and Policy 41*, no.2, 2007, pp173–188).

Venables' model focuses on the benefits for productivity that flow from the agglomeration economies generated in city centres and other areas of concentrated employment. Commuting costs are key to this, as they shape how willing people are to travel to these areas to work (and hence the level of agglomeration economies). The benefits of agglomeration economies are captured by workers (in the form of higher wages), landowners (in higher rents), and the government (in higher income taxes).

Stuart says, 'For us, the intuitive strength of Venables' model is that it considers how two opposing yet intertwined forces, namely agglomeration benefits and commuting costs, explain the level of employment that an area can expect to attract and retain. Using this framework we can predict the effect of a change in commuting costs on employment levels.'

The researchers 'added value' to the Venables model in several ways. For example, they adapted the model to incorporate non-linear travel-time functions, which are more representative of congested urban environments. They also incorporated a land use response, whereby public transport investments enable more intensive land use development through the redevelopment of car parking, which in turn generates agglomeration benefits. A detailed explanation of the model, including graphical and mathematical representations, is given in the report.

The researchers applied the model to two recent public transport improvement projects – the Central Connector bus corridor in Auckland, and double tracking and electrification of the rail corridor in Waikanae (DTEW). In both cases, additional productivity benefits were found, which varied from 3% for the DTEW to 19% for the Central Connector. These benefits were additional to conventional transport benefits. Note that the EEM allows for agglomeration benefits to be included in evaluations.

Stuart says, 'These findings have implications for how we approach the economic evaluation of public transport improvements in this country, and for transport funding priorities.

'In particular, our current modelling approaches need to be updated to take into account the additional contribution that public transport improvements have on economic productivity in areas with strong local agglomeration efficiencies, such as major city centres. We're recommending these issues are considered the next time the Transport Agency revises the EEM.'

The report recommends further analysis and verification of the model and exploration of related research areas, such as the (positive) impacts of public transport on population health and the (negative) impacts of road transport improvements on demand for car parking. The results of this ongoing research could eventually be incorporated in the EEM.

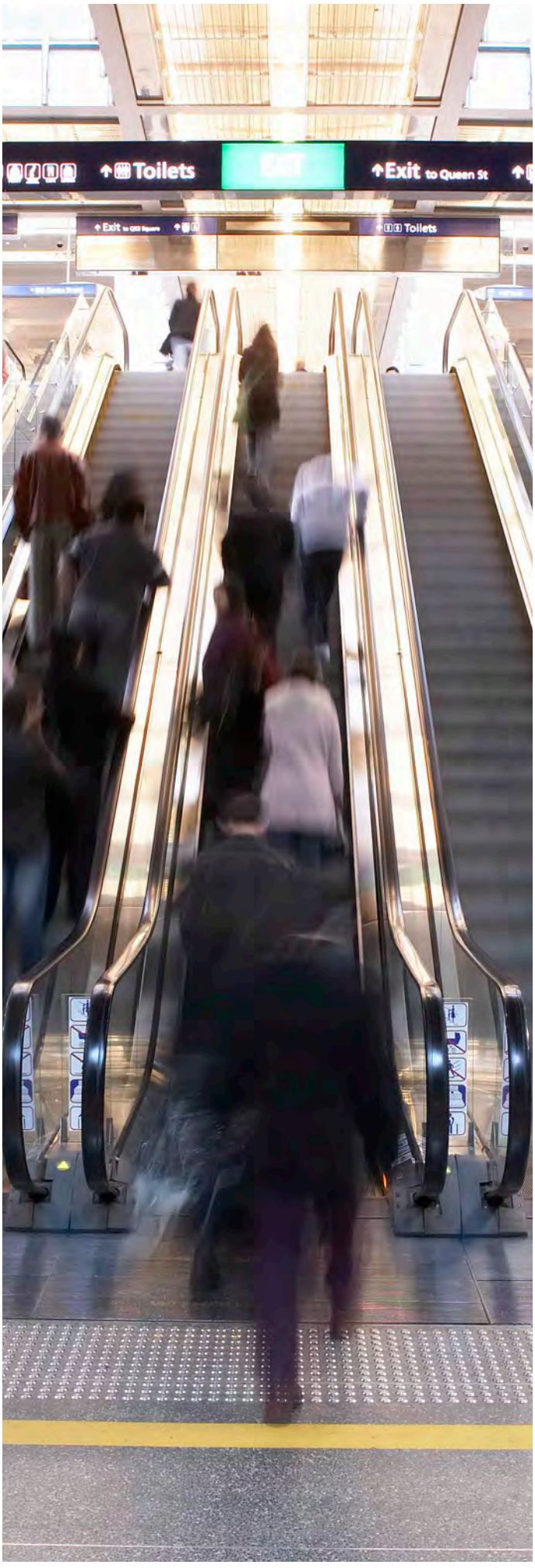
The report also includes in-depth discussion of various issues encountered during the research process, such as the strength of the link between transport and agglomeration, and whether greater use of public transport could actually be expected to free up car parking.

Based on their findings, the researchers suggest government agencies consider opportunities to increase funding for public transport projects that improve access to dense city centres, including initiatives that enable commuters to access public transport services by walking or cycling.

The contribution of public transport to economic productivity, NZ Transport Agency research report 514.

– MRCagney Ltd

Available online at **www.nzta.govt.nz/resources/research/reports/514**



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.

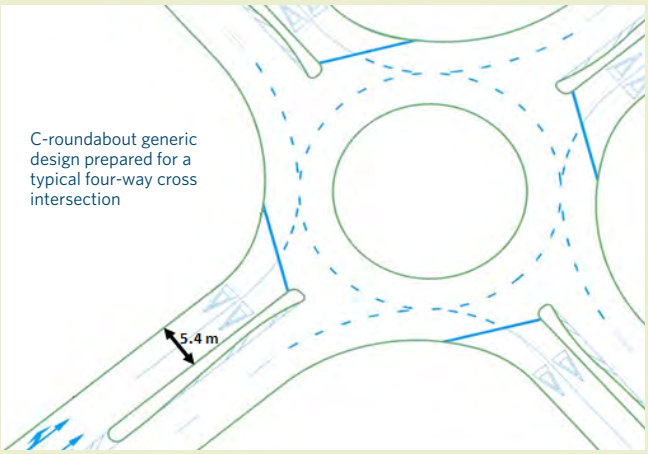
The research team's first project in 2006 sought to address this by developing an on-road design solution named the C-roundabout. The current research project aimed to test the design's effectiveness.

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

THE IMPORTANCE OF URBAN FORM

Urban form is set to become increasingly important in New Zealand where 85% of the population already lives in urban areas.

Research by MRCagney Ltd and Urbanism+ has explored the relationship between urban form and transport and economic outcomes in New Zealand. The researchers concluded that urban form does matter, especially with respect to economic outcomes, and that councils have a number of opportunities to improve urban form in their areas.

AN URBANISED WORLD

Since 2008, more of the world's population has lived in cities than in rural areas. This trend is predicted to continue, with the world's urban population forecast to double in the next 40 years, while the population of rural areas plateaus.

In New Zealand, 85% of the population already lives in urban areas (or rural ones with a notable urban influence). This trend looks set to continue, with the 'scale effect' suggesting that the bigger a city is now, the more likely it is to grow in the future. Against this backdrop, it is apparent that councils need to take a long-term view of urban development in their areas.

Urban form describes the shape and settlement or land use patterns of towns and cities. It is influenced by various physical factors, such as environmental conditions and natural amenities, public policies and socio-economic trends, including where people prefer to live. A considerable body of research has found that urban form influences matters as diverse as how easy a city is to live in and get around, the types of migrants that are attracted to an area, how conducive a neighbourhood is to walking and cycling, how close people live to where they work, and energy efficiency.

Stuart Donovan of MRCagney says that the potential scope of any project looking into the impacts of urban form is extremely broad. 'We decided to narrow the scope of our project early on, to address two key research questions, namely how urban form impacts on transport and economic outcomes; and how regional and local council policies can contribute to a more efficient and durable urban form,' he says.

The project team drew on census and employment data to investigate the impact that urban form has on transport and economic outcomes in New Zealand. They also considered how two urban form variables – residential density and regional centrality – impacted on vehicle ownership and drive mode share. They then used a hypothetical compact urban development scenario (with an additional 250,000 residents and 125,000 employees accommodated in Auckland's 50 densest census area units) to illustrate the impacts of urban form on transport outcomes in Auckland.

From this, the team concluded that urban form does matter, as far as transport and economic outcomes are concerned.

Stuart says, 'We found that a compact and centralised urban form is associated with modest, but not insignificant, reductions in the rates of vehicle ownership and use. Perhaps more importantly, a compact urban form appears to deliver relatively large economic benefits, primarily due to its impacts on agglomeration economies.

'For example, looking at the relationship between the location of employment and land values in Auckland, we found that a form that encouraged a centralised employment scenario would be associated with additional economic benefits of $30,000 per employee, compared with a more dispersed employment scenario, if all other factors remained unchanged. This is strong evidence of the impact that form has on agglomeration economies, both in production and consumption.'

The research found that while the impacts of individual urban form attributes on transport may be relatively modest, their cumulative impacts may be significant.

For example, a city's overall urban form can have large impacts on the uptake or public transport and whether people walk and cycle around it. This might not be evident with respect to one attribute, such as the location of employment, but will be when other factors, such as the proximity of residential and employment areas and the supply of various forms of transport infrastructure are taken into account.

OPPORTUNITIES IN NEW ZEALAND

The research also concluded that regional and local councils in New Zealand have a number of opportunities to improve their urban form by making changes to their planning, transport and land use policies.

The team identified the following priorities:

- Street networks – these provide the 'bones' of an efficient and durable urban form. Important attributes of the street network include structure, street integration and intersection design. Councils should also consider how to make best use of street networks in areas of medium-to-high density to ensure they provide an appropriate balance between amenity and mobility.
- Public transport – New Zealand's larger cities and towns would benefit from a step-change in the way urban form is conceived and delivered with respect to the needs of public transport. Key opportunities to improve the effectiveness of public transport (and hence its ability to positively influence urban form) arise from locating key destinations 'on the way'. Councils and planners need to think carefully about how their town's or city's urban form can support simple and frequent public transport networks.
- Land use policies – the team considered the extent to which land use policies may act as impediments to efficient and durable urban forms, namely exclusive zoning, building height limits and minimum parking requirements. It then considered a range of policy responses through which regional and local councils could create incentives for a more desirable urban form. To finish, it looked at issues stemming from efforts to manage urban expansion.

Stuart says, 'We suggest that a concerted multi-pronged focus on improving policy outcomes in several areas will significantly improve New Zealand's prevailing urban form over time. In the long run, this should also improve housing affordability, reduce congestion and increase transport choices.'

The team also identified several promising areas for further research that would strengthen and deepen understanding of the links between urban form, transport and economic outcomes.

Impact of urban form on transport and economic outcomes, NZ Transport Agency research report 513.

– MRCagney Ltd

Available online at **www.nzta.govt.nz/resources/research/reports/513**

NEW RESEARCH REPORTS

Experience with the development of off-peak bus services

Research report 487

IP Wallis - Ian Wallis Associates Ltd

Freely available online at www.nzta.govt.nz/resources/research/reports/487

This research was undertaken in 2010–11 to appraise evidence from three New Zealand cities (Auckland, Dunedin, Hamilton) and four Australian cities (Adelaide, Brisbane, Melbourne, Perth) on the market impacts of improvements in urban bus services at off-peak periods. The primary focus was on the estimation of patronage changes and the corresponding demand elasticities in response to service frequency changes.

Particular attention was given to the following aspects of service frequency impacts, as measured through elasticities: impacts in the various off-peak periods (principally weekday interpeak, weekday evening, Saturday, Sunday); progressive impacts over time following the service change; and variations in elasticities according to initial service frequency, extent of service change, direction (increase/decrease) of service change, and other service and market characteristics.

Recommendations are made on the most appropriate set of service frequency elasticities for the various off-peak periods, to be used in New Zealand and Australia for assessing the impacts of bus service improvement schemes over the short and medium terms.

National long-term land transport demand model

Research report 520

J Stephenson and L Zheng – NZIER

Freely available online at www.nzta.govt.nz/resources/research/reports/520

This report describes a National Long-term Land Transport Demand Model (NLTDM) for evaluating transport demand scenarios looking out 30 years and taking account of mega-trends in population growth dynamics, spatial demographic trends, technology trends, income and economic growth, industrial composition and policy.

Steel-concrete composite bridge design guide

Research report 525

R El Sarraf, D Iles, A Momtahan, D Easey and S Hicks – HERA

Freely available online at www.nzta.govt.nz/resources/research/reports/525

This report provides guidance for both the novice and experienced bridge designer on the design of steel-concrete composite bridges, which consist of steel girders and reinforced concrete slabs on top. Two common forms are considered: multi-girder and ladder deck bridges. Guidance is given on the general considerations for the preliminary and detailed design process, in addition to guidance on the verification of structural adequacy in accordance with the NZ Transport Agency Bridge manual and relevant design and material standards. Additional guidance on cost-effective design philosophy and durability design is also provided.

Improving bus service reliability

Research report 527

Ian Wallis Associates Ltd in association with The TAS Partnership

Freely available online at www.nzta.govt.nz/resources/research/reports/527

The objective of this research (undertaken in 2010–12) was to provide urban bus operators and public transport contracting authorities in New Zealand with practical guidance on methods for diagnosing urban bus service (un)reliability, the causes of unreliability, how unreliability is best measured and monitored, and experience and best practice on measures and methods to improve reliability and punctuality.

The research outputs were intended to assist urban bus operators and planning/contracting/funding authorities in New Zealand to gain a better understanding of bus reliability and punctuality issues and how best to address them. The report addressed the causes of unreliability, reliability standards and measurement, data collection and analysis methods, and the approaches available to tackle reliability problems through planning and timetabling measures (when problems can be anticipated in advance) and/or through operational measures (for problems arising on a day-to-day basis).

Recommendations are made on: the continuing refinement and adoption of outputs from automated (GPS-based) data sources as the primary means of monitoring reliability performance, replacing operator self-reporting methods; on using these data sources to optimise running times; and on the adoption of some form of 'quality partnership' arrangement between regional authorities and their operators to jointly pursue continuous improvements in reliability performance.

Experience with value-for-money urban public transport system enhancements

Research report 531

G Currie, R Scott and K Tivendale - Booz & Company

Freely available online at www.nzta.govt.nz/resources/research/reports/531

This report reviews research literature and published evidence regarding the value for money of urban public transport enhancements. The improvements most likely to be of value are peak period fare increases (which increase revenue but cause a decline in patronage), bus priority measures, rationalising peak network and service design (reducing vehicle and crew requirements), and bus route and network simplification.

Several improvement measures are thought to be 'on the edge' of profitability including bus route and network restructuring (where the focus is on reducing costs and refocusing resources on more patronage and revenue effective routes and services), new buses, personal safety and security measures (low-cost measures), real-time passenger information measures and branding, promotion and signage measures.

New services including new routes, extended service hours and spatial coverage plus increased frequency are considered to be higher cost items with medium impacts. Increased frequency and reduced fares are identified as measures with medium-to-high patronage and revenue impacts but with high costs. Hence these are likely to be high net cost items requiring subsidy. Understanding customer needs in each market is important for targeting improvements and maximising value to existing and potential customers.

Economic appraisal of public transport service enhancements

Research report 533

I Wallis and A Lawrence - Ian Wallis Associates Ltd

N Douglas - Douglas Economics

Freely available online at www.nzta.govt.nz/resources/research/reports/533

This research project was undertaken to provide guidance on appropriate methods and benefits parameters to use in the economic appraisal of public transport proposals (in particular service enhancements) in New Zealand.

The research involved two focus areas and a case study. The first focus area included an international review of economic and project appraisal approaches and procedures, followed by a detailed assessment of selected international appraisal procedures. The second focus area involved a comprehensive review of existing New Zealand and Australian research evidence on public transport user benefit parameter values. Finally, a case study based on the Wellington public transport spine study short list evaluation was undertaken to illustrate the potential application of recommended improvements to economic appraisal procedures and recommended user benefit parameter values.

The research found that social cost benefit analysis and cost effectiveness analysis were the most appropriate methods for economic appraisal of public transport proposals in New Zealand, and that an appropriate level of analysis should be undertaken. Recommended default values for appropriate user benefit parameters were also identified.

Drivers of demand for transport

Research report 534

Aleksandra Simic and Robert Bartels - Frontier Economics, Australia

Freely available online at www.nzta.govt.nz/resources/research/reports/534

Frontier Economics (Frontier) was engaged by the New Zealand Transport Agency (Transport Agency) to assist in identifying a 'best fit' methodology for assessing the historical relationship in New Zealand between: 1) economic activity and road freight activity; and 2) income growth and passenger vehicle travel. The Transport Agency would like to use these models to develop long-term road transport forecasts.

The present report represents an initial step in this modelling exercise. The objective was to inform the development of demand models by exploring both data availability and analytical steps that should be considered when developing demand models. The actual development of the models and the estimation of the key parameters are outside the scope and will be undertaken under a separate research project.

The findings, mainly based on literature reviews, are organised in terms of the key analytical steps we recommend the Transport Agency consider when developing the models: data preparation, selection of candidate demand drivers, data investigation and model selection, and model testing and validation.

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ERRATUM

In the September issue of *NZTA research* the figure accompanying the story on research report 509 – *The next generation of rural road crash prediction models: final report* was incorrect. AADT was shown as ADDT, and the arrows on the header row were missing.

	Base scenario		→ Improve road surfacing		→ Mitigate roadside hazards	
Model parameters	**Straights: loss-of-control**	**Straights: head-on**	**Straights: loss-of-control**	**Straights: head-on**	**Straights: loss-of-control**	**Straights: head-on**
AADT	4000	4000	4000	4000	4000	4000
Length	500	500	500	500	500	500
Seal width	7	7	7	7	7	7
Gradient	0.02	0.02	0.02	0.02	0.02	0.02
KiwiRAP weighted severity rating	2.8		2.8		0.7	
%time SCRIM below threshold	0.6	0.6	0	0	0	0
%time MTD below threshold	0.6		0		0	
Injury crashes per year	**0.618**	**0.069**	**0.206**	**0.025**	**0.180**	**0.025**
			Crash reduction compared to base		**Further reduction in crashes**	
			-67%	-64%	-13%	0%

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.

Disclaimer

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Email notification is provided when new Transport Agency research reports are published on the Transport Agency's website at www.nzta.govt.nz/planning/programming/research. Please email research@nzta.govt.nz if you would like to receive these email alerts.

Do we have your correct details?

We would like to hear from you at research@nzta.govt.nz if you wish to update your name or address details, or to alter the number of hard copies of NZTA research you'd like to receive.

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NZ TRANSPORT AGENCY WAKA KOTAHI

New Zealand Government