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BENEFITS FROM ROAD LIGHTING DEPENDENT ON CONTEXT

Road lighting can have significant safety benefits, with studies indicating potential improvements in crash reduction rates of around 30% where lighting levels are improved.

In 2012, a New Zealand study examined the impacts of lighting levels on the safety of urban roads. The current study extends this work by focusing on higher-speed (80 to 100km/h) roads on the urban fringe, where the types of traffic and dominant types of crashes tend to differ from those found in urban areas. As a result, the relationship between lighting levels and crash rates was also expected to differ.

EXAMINING THE PARAMETERS OF LIGHT

The 2012 study by Jackett and Frith found a clear dose-response relationship between the average luminance of roads and the night-to-day ratio of crashes that occur on them.

Average luminance is the average brightness of the road surface, as seen by a driver, and is the key parameter used during road lighting design to determine the category of lighting provided.

A dose-response relationship indicates the change in the night-to-day crash ratio that occurs as a result of changes in the level of lighting provided (in other words, how the rate of crashes varies with the level of light).

However, the clear average luminance dose-response relationship found in the earlier study did not extend to the lighting uniformity parameters (UI and Uo).

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Uo (or overall uniformity) measures how uniformly lit a road surface is; while UI (or longitudinal uniformity) measures (and aims to reduce) bright and dark bands of light appearing on lit road surfaces, as the effect of this variable luminance can be confusing for drivers and somewhat hypnotic.

All three of these technical light parameters (average luminance, UI and Uo) appear in the New Zealand road lighting standards, which set levels for the parameters depending upon the type of road that is being lit.

All three were also measured in the field as part of the current study, which used several different methods to evaluate the safety potential of increasing road lighting in this high-speed urban-fringe context.

- A generalised linear model – enabling the relative impact of different factors relating to the lighting (including traffic volume, as well as the three technical parameters) to be estimated.
- A corridor study – of the State Highway 1 and 2 corridors out of Wellington, which transition many times between lit and unlit sections along their length.
- A before and after study – of a previously unlit site in Auckland where new light-emitting diode (LED) lighting was installed in 2011, without any significant changes being made to the road alignment, enabling a true three-year before and after comparison to be made for the site.
- A relational study – comparing day-time and night-time crash rates at particular sites, and expressing this as a night-to-day crash ratio. Sites with similar lighting quality were then grouped and compared with other groups, enabling a relationship between lighting quality and night-time crashes to be established.

SUPPORT FOR GREATER LIGHTING LEVELS IN CERTAIN CONTEXTS

From the various sources, the study concluded that the largest reductions in night-to-day crash ratios, as a result of road lighting, on higher-speed roads were likely to be for motorways (where reductions in the order of 31% can be expected), followed by divided highways (24%) and single carriageway roads (17%). These figures related to all crashes, with the reduction rates for serious and fatal crashes were expected to be significantly higher.

However, once motorways were illuminated there seemed to be little benefit, in terms of crash reduction, in increasing the levels of average luminance. The level for motorway lighting currently recommended in the New Zealand standards (V3 – 0.75 cd/m2) was found to represent just about the optimum level, and there was little evidence of improved safety for levels higher than this.

For divided highways, a lack of suitable data made it more difficult for the study to draw strong conclusions about the likely impacts of increasing average luminance, although a suggested crash reduction rate of around 24% was derived using alternative data sources. Similar to motorways, no additional benefit was found from increasing levels above the V3 standard.

There was insufficient data for the study to draw strong conclusions about single carriageway roads (with just a centreline), although the data available suggested the dose-response for this type of road might be similar to that found in the 2012 urban study.

Increasing the overall uniformity of lighting on motorways also had a positive effect on crash rates, up to a Uo value of 0.50 (after which the benefits plateau). This reveals the importance of overall lighting uniformity as a factor affecting road safety on motorways.

Longitudinal uniformity (UI) on the other hand did not appear to have much effect on crash rates, although it is known to have a wider reaching impact on safety due to its fatigue-inducing effect on drivers. These wider effects would not be detected in a study such as this.

The importance of differentiating between types of crashes was highlighted in the study, as road lighting levels affect different types of crashes to different degrees.

For loss of control crashes, where the most important feature was usually the vehicle's position on the road, signs and road markings played a greater role in crash prevention than lighting levels. The study concluded that increasing lighting levels did not reduce crash rates for these types of crashes, and pointed out the important implications this finding had for the lighting design component of road design improvement projects on roads where loss of control crashes are the most common kind.

For rear-end crashes, which are influenced by drivers' perceptions of distance and speed, there was clear evidence of a relationship between lighting and crash rates, with lit motorways and lit divided highways showing lower crash rates. In general, the more serious the crash, the greater the rate of reduction that can be expected.

This differentiation between crash types, led the study to recommend that the advice given in the NZ Transport Agency's Economic evaluation manual (2013) for evaluating the likely benefits of road lighting projects should be revisited to include crash movement types, in addition to crash numbers.

Note: The version of the report published online on 1 October 2015 contained minor errors in section 10. The report has now been amended and the updated version is online.

The relationship between road lighting and night-time crashes in areas with speed limits between 80 and 100km/h, NZ Transport Agency research report 573

Available online at **www.nzta.govt.nz/resources/research/reports/573**

SCOPE EXISTS TO EXTEND VALUE OF STATISTICAL LIFE METHOD, BUT MORE RESEARCH NEEDED

A literature review has found some scope for expanding the current willingness-to-pay approach to answer broader research questions. However, there are also limitations in the knowledge and tools available at present.

The research drew on literature from New Zealand and overseas (in particular a number of meta-analyses completed by the Organisation for Economic Co-operation and Development (OECD)) to provide guidance on the best way to value injury and mortality risks in transport evaluations. It considered whether the willingness-to-pay approach of estimating the value of statistical life (VOSL) remains appropriate, and whether there are ways to fill gaps in current knowledge around the relative value between road safety risk, other transport benefits and safety risk in other contexts.

The New Zealand VOSL was established in 1991 from a survey of New Zealand residents. It is used in transport evaluations to determine the social value of loss of life and injuries as a result of transport activities. The VOSL sets a value on fatalities prevented according to people's willingness to pay for small reductions in the risk of fatality. It reflects both people's average incomes and the level of the risk that is being averted.

Peter Clough of the New Zealand Institute of Economic Research who headed the current study says, 'Our research focused on the human or welfare cost of injuries and fatalities, not the financial costs, such as medical expenses and lost productivity. These items are included in transport appraisals but were outside the scope for this project. Their value is dwarfed by the human costs of fatal and non-fatal injuries, reflecting the pain, suffering and aversion to the risk of such injuries.'

The literature review confirmed that the willingness-to-pay approach adopted in New Zealand is still appropriate and widely used across OECD countries, to the extent that it is even considered the 'standard method' by some international publications.

However, as New Zealand was one of the first countries in the world to adopt the approach, techniques for undertaking non-market valuations of risk have since changed considerably. In addition, the two key determinants that the VOSL is calculated on (namely the level of income of the affected population and the starting level of risk) have also shifted since 1991. Although the VOSL has been updated to some extent to reflect changing incomes, road deaths have dropped by almost two-thirds in the past two decades and this change in the underlying risk would have affected the valuation considerably.

'As a result, the value determined in 1991 no longer reflects the current public value of reducing risk,' says Peter. 'A new study to update the VOSL estimate to reflect current conditions in New Zealand would be timely.'

The research report provides useful background on why injury and fatality risk need to be valued for transport appraisal, and how New Zealand has arrived at its current practice of using VOSL in its transport appraisals. It also makes recommendations on the priority for further research into the three methodology-related research questions.

THREE RESEARCH QUESTIONS

The research explored the implications of three specific knowledge gaps relating to the VOSL and what should be done to overcome them.

The first of these was whether valuation of non-market impacts should be aligned within the transport sector. Examples of where VOSL (which is used to value transport-related fatalities) could be aligned with other impacts is in relation to the value of non-fatal injuries, the value of non-acute long-term health impairment or premature death (for example from transport-related environmental health risks) and the value of travel time.

The report concluded that the current practice of valuing non-fatal injuries as a fraction of the VOSL (with the fraction varying depending on the nature of the injury sustained) is also appropriate, although it would be useful to re-estimate these fractions if the VOSL is updated.

A similar approach has been mooted overseas, for linking VOSL values to those for ill health and premature mortality as a result of emissions levels, air quality degradation and other environmental health risks. Few countries have yet to put this into practice, although the current study considered it would be worthwhile considering such estimates here, if sufficient data was available.

The report identified only two research papers that investigate the relative values of safety and time.

Peter says, 'There are limitations to deriving relative values for safety and time with the knowledge and tools available at present. Therefore, further research in this area is required to understand whether such practical limitations can be overcome to make the approach viable.'

The second information gap considered by the study was whether the VOSL should vary with the age and life expectancy of the people at risk. At present, one value is used for people of all ages, but there is a perception that people may be more willing to pay for the reduction of risks, depending on the age cohorts that the risk relates to.

From the literature review, the study found there was no clear evidence that people's willingness to pay varied with the age of the affected population. However, what it did show is that people attach different values to reducing acute risks of immediate injury and latent risks of long-term impacts on life expectancy. From this, the report recommended that consideration should be given to valuing these different types of risk directly and to calculating the VOSL year by age.

Further research could identify whether the value of life years varies with different broad levels of quality of life arising from a non-fatal traffic-related injury, but issues around data and practical application would not make this the highest priority for extending the valuation.

The third research question posed was whether the VOSL should be aligned between the different injury risk sectors. Examples of other sectors that could use the concept are workplace safety and health interventions.

The research found that because the transport VOSL is affected by the base risk of road fatalities and people's income it is unlikely to be the same as the VOSL assigned in other public safety risk areas (which would be determined by quite different factors). However, there may be scope for the transport VOSL to provide an anchor or benchmark for these other risk areas, with appropriate adjustment for the different risks being estimated.

METHODS TO UPDATE THE VALUE OF STATISTICAL LIFE

The method recommended in the research to estimate a new transport VOSL is a stated preference valuation study. This approach offers more flexibility and has less onerous data requirements than the other principal option (revealed preference).

The update study could be either a contingent valuation survey to estimate the public's willingness to pay for specific risk reduction scenarios, or a choice modelling approach, in which people's relative preferences for different travel attributes are estimated. However, the latter approach would only be useful where the data on the various attributes was either already or soon to be available.

Peter says, 'Whichever method is chosen, it will need to be tailored to fit the information needed to develop practical policy and project appraisals. This would be done in developing the survey questionnaire, once the scope of the survey and the policy issues it needs to serve have been determined.'

Approaches to valuing injury and mortality risk in transport assessments, NZ Transport Agency research report 571

Available online at **www.nzta.govt.nz/resources/research/reports/571**

COMING TO GRIPS WITH CHIPSEAL FLUSHING

Flushing – the process whereby chipseal texture depth is lost over time – is the single most common reason for pavement resealing in New Zealand. New research has looked at the mechanisms that cause flushing and at modelling to predict the growth of flushing on the New Zealand state highway network.

Chipseal flushing is an international problem, reducing the skid resistance of road pavements and contributing to other common pavement problems such as bleeding and bitumen tracking.

In the worst cases, the chipseal texture of the pavement will be reduced to the point where the bitumen binder completely covers the surface of the pavement aggregate. But pavements will be considered flushed, and hence require resealing, at much lower rates of texture loss than this. The Transport Agency defines a flushed seal as one where the texture depth is less than 0.7mm (for roads with speed limits under 70km/h) or less than 0.9mm (for limits over 70km/h).

The current research project tackled the problem of flushing on New Zealand roads on two levels. The first part of the work aimed to identify and investigate the physical mechanisms that cause flushing. The second was to use pavement condition data to develop a model that could predict the rate of flushing progression in chipseals.

CAUSES OF FLUSHING

The study brought together the findings of earlier research and used a variety of laboratory studies, as well as sampling and assessing field sites, in order to explore and understand the physical mechanisms that cause flushing.

The key physical mechanisms identified and examined included:

- chip reorientation, compaction of the seal layer and loss of trapped air voids in the body of the seal
- excess binder application
- abrasion of the seal aggregate to produce fines
- water-induced migration of bitumen to the surface, through the formation of blisters (also known as volcanoes)
- embedment of the sealing chips into the basecourse or substrate (this could include underlying asphalt patches)
- low binder viscosity as a result of excess kerosene remaining in the bitumen
- thermal expansion of the bitumen volume.

From this, the research team concluded, 'Flushing is a complex process involving multiple physical mechanisms that may be operating simultaneously and contributing to the loss of surface texture in different proportions (which may also change over time).'

Overall, however, the factors that made a major contribution to flushing were:

- aggregate abrasion and breakdown, which leads to a reduction in the size of the sealing chip and the build-up of fines in the seal void volume
- compaction and reorientation of the seal layer under traffic, reducing the available void volume in the seal layer
- water venting and sub-surface stripping in seal layers, due to water trapped at the seal-basecourse interface. Venting and stripping probably mainly arise as a result of water ingress through the seal surface.

Factors that the team found made no, or only a minor, contribution to flushing included:

- thermal expansion of the bitumen
- excess bitumen application (high bitumen application rates will obviously fill the seal void volume, but are uncommon in practice)
- binder viscosity, which has a major effect on bleeding and tracking, but does not tend to affect the rate of seal texture loss (at least for standard sealing grades of bitumen).

Although embedment into the basecourse was recognised as a potential mechanism, the team had insufficient information to draw conclusions about the extent to which it affected seal texture.

From these findings, the research concluded there is no single simple method to prevent flushing in chipseals. Instead, a multi-pronged approach that tackles the various individual mechanisms is needed.

Recommended measures include developing a test to control aggregate breakdown based on aggregate source; improving the permeability and drainage of basecourse layers in order to prevent water build up at the base of the seal; addressing (as a matter of some urgency) the reasons why seals leak; using very high-strength, thermosetting polymer modified bitumens to minimise chip reorientation and seal layer compaction; building more seal void volume into seal designs, minimising bitumen application and maximising the development of a stone-on-stone skeleton in the pavement layers.

PREDICTING FUTURE FLUSHING

The research team developed a two-part model using the parameters from the Transport Agency's Long-term Pavement Performance Database.

The first part of the model used a logistic model to predict the onset of flushing. The second part used a linear regression model to predict the rate of flushing progression and was modelled with variations for first-coat seals, and second and higher generation seals.

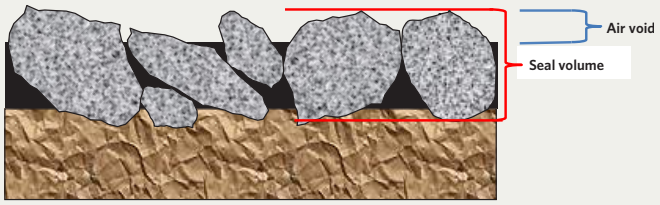
Both parts of the model performed well. The first part demonstrated 74% accuracy when used to predict the initiation of flushing on a data set, and the predictions from the second part demonstrated the model's ability to robustly predict the progression of flushing.

To develop the model further, the research team recommended that data from accelerated pavement deterioration studies using different seal types should be used to investigate the model's accuracy and improve its performance.

Another recommendation was that data collected for the Long-term Pavement Performance Database could be extended to include data about the soil moisture environment of a pavement. Such data is known to be an important predictor for flushing, but was unavailable in the current study.

CHIP SEAL FLUSHING

What is meant by chipseal flushing can be understood by looking at the composition of the seal layer volume.



Chipseal layer volumes

The seal layer is the pavement layer between the top and the bottom points of the sealing chip. The height of this layer is generally somewhat greater than the average least dimension of the sealing chips that it encompasses. The volume of the seal layer is made up of air voids, sealing chip, bitumen and basecourse material (due to chip embedment).

Flushing results from any process that causes a gradual loss in the surface air void volume (texture) in the seal layer.

In theory, seals in New Zealand are designed to result in bitumen occupying no more than 60% to 70% of the seal void volume. Even if the chips in a pavement seal layer become fully reoriented under trafficking (so that the chips are lying with their average least dimension perpendicular to the seal surface), a properly designed seal should still not be in a flushed condition.

However, the reality is that many New Zealand roads do become flushed and require resealing over time.

Flushing in chipseals, NZ Transport Agency research report 576

Available online at **www.nzta.govt.nz/resources/research/reports/576**

PRACTICAL APPROACH AIMS TO IMPLEMENT IMPROVED TRAVEL INFORMATION SYSTEMS

A new report into travel information systems, builds on previous NZ Transport Agency funded research to provide practical market and customer research into the travel information delivery systems that customers prefer. The report also examines which of the many travel information system technologies available is likely to have the greatest impact on the quality of customers' travel experiences.

The research by Opus International Consultants builds on the previous report by the same authors, 'Customer's requirements of multimodal travel information systems' NZ Transport Agency research report 540, which looked at the wide range of apps and technologies available to the transport sector for providing timely travel information, and examined exactly what customers required from these systems.

The focus of this second tranche of work was on developing a practical implementation plan for the transport sector to guide:

- what delivery methods the sector should focus its efforts on, and the order of priority
- what recommendations and best-practice guidelines should be used for each of the different delivery methods
- how the traveller information delivery methods should be evaluated to compare their benefits and effectiveness
- what prioritised tasks the sector should undertake to improve how it provides travel information.

The research was conducted in several stages, including a literature and best-practice review, an analysis of baseline customer information needs, a review of traveller information systems currently used in New Zealand, workshops and interviews with transport information systems users and developers, and intercept and online surveys.

The outcome is a detailed Information Provision Implementation Plan covering:

- customers' information needs and delivery methods – by means of transport and location
- best practice for travel information systems – both general and channel-specific, and for public transport
- monitoring recommendations for each type of information delivery method
- a prioritised list of tasks for the transport sector to develop more efficient and integrated travel information systems
- potential barriers to the plan's implementation.

UNDERSTANDING CUSTOMERS' TRAVEL INFORMATION NEEDS

The main message to emerge from the information gathering and analysis stages of the project was that travel information needs to be accurate, timely and user friendly.

The preferred means of accessing travel information varied depending on the type of transport being used. For private motorists and commercial operators, the most popular methods were websites, smartphone apps, radio and navigation systems. For public transport users, however, smartphone apps, websites, paper timetables and brochures, and voice announcements were ranked as the highest priorities.

The type of travel information required also varied according to the location of the user. In rural areas, users wanted information about whether particular routes were open during events such as floods, storms, and periods of snow and ice. Public transport information was less of a priority for these users, due to the limited services available to them.

In less congested areas, users wanted advance notice of any scheduled delays and detours, parking information, and information about delays caused by unexpected weather events. This was particularly the case for inter-city travel, where there might be limited alternative routes available to users. In the main metropolitan areas, however, users wanted more detailed and timely information, for example about delays due to congestion, crashes and other incidents, so they could plan their journey routes and times.

Although feedback at all stages of the project emphasised the need to provide a range of information delivery methods, and not just focus on one or two, the project team identified the top three delivery methods for each type and stage of a journey to focus on further. Given that one of the aims of the research project was to prioritise methods for future development, this was a necessary step. The prioritised methods are shown in the table blow.

PRIORITIES FOR INFORMATION CHANNEL DEVELOPMENT ACROSS CENTRES, MODES AND TRIP TYPES

	REGIONAL CENTRES		MAIN METROPOLITAN CENTRES	
	PRE-TRIP	**IN-TRIP**	**PRE-TRIP**	**IN-TRIP**
Public transport	Smartphone app Website Paper timetable/ brochure and information on signs and screens at stop	Smartphone app Website Paper timetable/ brochure	Smartphone app Website Paper timetable/ brochure	Information on signs and screens at stop Smartphone app Voice announcements at stops
Private motor-vehicle	Website Smartphone app TV/radio	Smartphone app GPS navigation Website	Smartphone app Website GPS navigation	Smartphone app GPS navigation Radio
	REAL-TIME INFORMATION		**ADVANCED WARNINGS**	
Commercial	Websites Email (at regular intervals, eg every Monday morning) Push out notification via email Smartphone apps		Websites Email (at regular intervals, eg every Monday morning) Push out notification via email Smartphone apps VMS	

BEST-PRACTICE FOR SYSTEMS

Feedback from participants in the research emphasised that, as a general rule, travel information should be current, regularly updated, and as accurate and reliable as possible. Reliability was particularly important, as it determined whether or not the information systems would be used, how often, and with what level of confidence.

Other findings were that travel information should be resilient (so that it can operate in an emergency, or disturbed and unusual circumstances); be easy to understand and speak the users' language; meet the needs of both tech-savvy and non-tech-savvy users; be targeted at both first-time and regular service users; and should be available where it is most needed (for example in situations where trip arrival is time sensitive, or when travel times are uncertain or variable). Users also need to be made aware of the full range of, and ways to access, available travel information, as this lack of knowledge was identified as a major reason why travellers might not access the information.

The research report also details best practice, where available, for the various travel information channels, including variable message signs, websites, smartphone apps, social media, radio, television and traffic cameras where commercial and public transport operators use them to feed information to drivers and passengers.

SECTOR WORK PLAN

The final part of the implementation plan is a recommended prioritised list of tasks for the transport sector, flowing from the research, including the formation of a working group to agree on the purpose and priorities for developing and providing an improved travel information provision system, and to get industry buy-in for it.

The six steps in the work plan can be summarised as:

- Agree priorities and get buy-in within the wider transport industry.
- Improve the data quality and the ease with which it can be exchanged.
- Develop operating procedures for people putting out information to ensure it is consistent.
- Formalise incident management communications between the agencies involved in distributing this information.
- Apply the developed standards to existing travel information systems and trials.
- Carry out ongoing monitoring of the system.

More detail on each of the steps is given in the report, alongside a discussion about the possible barriers to the plan's implementation.

Detailed customer requirements of travel information services, and the effectiveness of current channels, NZ Transport Agency research report 572

Available online at **www.nzta.govt.nz/resources/research/reports/572**

GEOSYNTHETICS CREATE POSSIBILITIES FOR MARGINAL AGGREGATES

Tests on the use of geogrids for stabilising basecourses constructed from suboptimal aggregates have returned promising initial results. Further testing will help identify the best ways to make use of these materials in pavement construction.

Finding ways to enable marginal materials to be used in road pavement construction has become a topical issue in recent years, as quality aggregates become increasingly difficult and expensive to source and transport.

An example of such a suboptimal material is the Canterbury River Run aggregate tested in the research project, which although low cost and readily available, is generally considered unsuitable for use in pavements. The aggregate's rounded particle shape means it is unlikely to interlock effectively, making it highly mobile and leading it to shear readily.

The current research project investigated how effective geogrids were in stabilising basecourses prepared from the River Run gravel. The aim was to identify the possible pavement performance enhancements – in terms of pavement lifetime, maintenance and material use – that might be achieved by incorporating geogrids, and, in particular, whether it was possible to improve the shear resistance and rutting rate of what would otherwise be a compromised (in terms of geology and particle size and shape) aggregate.

The project focused on the geogrid's ability to provide stabilisation (which implies strength retention through locking particles into place), rather than reinforcement (which implies lending additional strength).

GEOGRIDS

Geosynthetics, which include geotextiles, one- and two-dimensional geogrids and three-dimensional geo-cells, are widely used for stabilising soils and rocks in walls, banks and other landforms. In New Zealand, they are now also being used increasingly for pavement stabilisation purposes.

Several studies overseas have tested the use and effectiveness of geogrids in pavement design, with the vast majority of this work looking at situations where the geogrid is incorporated at the interface between the basecourse and sub-base. In this usage, the idea is to stabilise the sub-base (and by extension the basecourse), rather than reinforce the basecourse itself. However, a couple of recent studies have also looked at the impact of placing geogrids at different positions within the basecourse.

The current study drew on this research to understand how geosynthetics are manufactured and designed, and how they operate in pavement stabilisation contexts. Two designs of two-dimensional geogrids were subsequently tested – one bi-axial and one tri-axial.

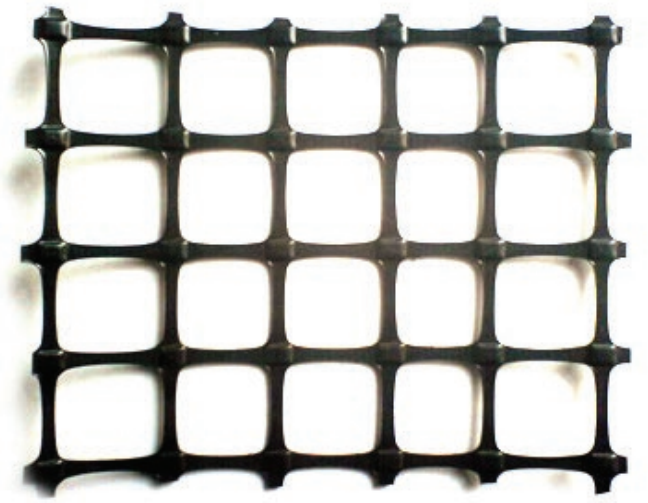


Figure 2.2 Two-dimensional geogrid (punch and draw)

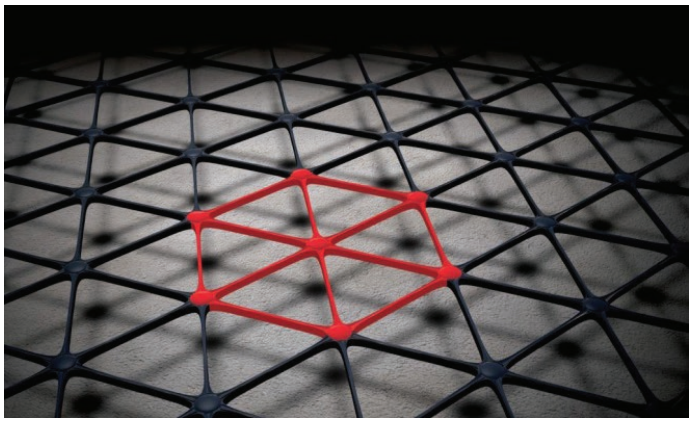


Figure 2.5 Triaxial geogrid

THE TESTS

The aggregate material chosen for the research consisted of an abundant river gravel aggregate from the Canterbury region (known as River Run aggregate). The aggregate consists of greywacke gravels originating from the Southern Alps, carried down rivers to the Canterbury Plains area. As such, it is weathered and very tough, but also almost round with no flat faces and also contains significant amounts of river sand (also round), but very small amounts of intermediate-sized particles.

Aggregate sample before placement in triaxial cell
Dry sample, 1.99tm-3

By current industry standards, this type of aggregate material is considered poorly suited for use as a basecourse aggregate due to its tendency to shear readily or flow under load conditions. However, asset managers and contractors in the Canterbury region are already using the aggregate to prepare bases for pavements, due to its low cost and ready availability.

During the project, initial tests of sample basecourses prepared using the aggregate with no stabilisation confirmed that, unsupported, the rutting rate was very high. The rutting rate did not improve significantly when a single-coat chipseal was applied, but did improve markedly with a 20mm thick cold-mix asphalt surface.

Having established the unstabilised rutting rates for the aggregate, the project then trialled two different geogrids at three different positions in the basecourse – at the interface between the sub-base and basecourse, at basecourse half-height, and at basecourse three-quarter height. A chipseal surfacing was applied for all the tests.

The constructed basecourse samples were then tested using repeated load tri-axial testing and also using Opus Research's accelerated pavement testing facility, to apply loads that mimic those applied in the field.

RESULTS AND CONCLUSIONS

The results highlight that geogrids can provide substantial stabilisation against shear when installed at the base or at mid-height of the basecourse – the rutting rates for the tested samples that had the geogrid placed either at the bottom of the basecourse or at half-height were reduced by up to 75% over that of the unstabilised basecourse.

However, a geogrid located closer to the top surface appears to provide no stabilisation – the sample with geogrid placed at three-quarters height in the basecourse showed no reduction in rutting rate.

From these tests, the project concluded that (pp7–8):

The results of this mid-scale laboratory study demonstrate the potential for geogrids to stabilise River Run gravel aggregate against shear, as long as the surface of the basecourse is confined with a binder or a resilient surfacing such as asphalt. The lack of particle interlock makes the River Run aggregate highly mobile and if the surface is not confined it will shear under the wheel load. However, if the surface of the basecourse is confined, and the bulk of the basecourse is further stabilised, then it appears the aggregate skeleton along with the grading are sufficient to provide some degree of pavement strength and stability.

There were several limits on the study, including the inability to carry out repeat tests on the samples, which are discussed in detail in the report.

The authors recommend that future research could explore the effect of using different binders in the pavement surface and of different binder and geosynthetic stabilisation combinations.

'Analysis of the stress and strain relationships within the basecourse, as affected by geosynthetics, via the use of embedded sensors might also be investigated,' the authors say.

Geosynthetics in basecourse stabilisation, NZ Transport Agency research report 574

Available online at **www.nzta.govt.nz/resources/research/reports/574**

NEW RESEARCH REPORTS

Criteria and guidance for the design of integral bridges in New Zealand

NZ Transport Agency research report 577

Available online at www.nzta.govt.nz/resources/research/reports/577

The use of integral and semi-integral bridges in New Zealand is fairly common practice due to advantages in ease of construction and savings in maintenance and whole-of-life costs. The aim of this report is to provide a summary of current best practice relating to the design and construction of integral and semi-integral bridges in New Zealand.

The issues considered throughout the report included the definition and performance of integral bridges, non-seismic effects such as concrete creep and shrinkage and thermal effects, seismic effects, geotechnical issues, and considerations pertaining to design and detailing. The aims of the report were achieved through a combination of review of existing literature, consideration of case studies of integral and semi-integral bridges, and consultation with bridge designers experienced in the design of integral bridge construction. The overall performance of integral bridges in New Zealand was found to be very good, while several issues relating to seismic effects, soil-structure interaction, concrete creep and shrinkage, and detailing were investigated.

Removing barriers to the use of crumb rubber in roads

NZ Transport Agency research report 578

Available online at www.nzta.govt.nz/resources/research/reports/578

The purpose of this research was to identify the barriers to using tyre-derived crumb rubber in bitumen binder in New Zealand roading and the methods to remove these barriers to create market demand for New Zealand waste tyre-derived products. As a result of the comprehensive literature review and stakeholder consultations, it was found that the key barriers in New Zealand were high initial cost of specialist equipment, the relatively small market, security of supply and implications of the industry's switch to emulsion binders. Fortunately, with a growing appetite for better performance in roading infrastructure and continued technological advancement, a number of solutions were identified. These include growing the use of modified binders over the network and investigation into the use of devulcanised rubber. The combination of these proposed changes will effectively remove the barriers identified and allow tyre rubber to be incorporated into the New Zealand roading network cost effectively and enable this waste stream to be diverted away from landfills.

The costs and benefits of inner city parking vis-à-vis network optimisation

NZ Transport Agency research report 575

Available online at www.nzta.govt.nz/resources/research/reports/575

This research project investigated the monetary and non-monetary costs and benefits associated with reallocation of inner city kerbside parking to new uses in New Zealand. This research developed a framework of relevant costs and benefits, based on evidence collected from case study examples of kerbside parking reallocation in New Zealand and overseas, and feedback from industry experts provided at workshops held in Wellington, Auckland, Hamilton and Dunedin. This framework was compared with current approaches to business case development and evaluation of transport projects in New Zealand.

The study shows there are a number of costs and benefits commonly attributed to reallocation of inner city kerbside parking, both in New Zealand and overseas. At present, there is a lack of local evidence for the potential impact of projects in local settings that in some cases has created a barrier to change. This may be overcome with best practice guidance for pre- and post-assessment of kerbside parking reallocation impacts. Other potential benefits are improved decision making and the delivery of knowledge of the effectiveness of kerbside parking reallocation as a 'lever' for achieving transportation and land use benefits.

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

A NOTE FOR READERS

NZTA research newsletter

The *NZTA research* newsletter is published quarterly by the NZ Transport Agency. Its purpose is to profile 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.html.

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

Published articles may be reproduced and reference made to any part of this publication, provided appropriate credit is given.

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.

Disclaimer

The views expressed in the *NZTA research* newsletter are the outcome of research and should not be regarded as being the opinion, responsibility or policy of the Transport Agency or of any agency of the New Zealand Government.

Availability of *NZTA research*

The current edition of the *NZTA research* newsletter is available in hard copy or on the Transport Agency website, along with all previous editions of the newsletter, at www.nzta.govt.nz/resources/nzta-research/.

Email alerts of newly published research reports

Email notifications are provided when new issues of the *NZTA research* newsletter are published. Notification is also provided when new Transport Agency research reports are published on the Transport Agency's website at www.nzta.govt.nz/planning/programming/research.html. 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:

- add or update names, email or address details
- receive the *NZTA research* newsletter in hard copy format
- receive email notification of the publication of the *NZTA research* newsletter and research reports
- alter the number of *NZTA research* newsletter hard copies you receive.

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

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 AND SAFE JOURNEYS FROM THE NZ TRANSPORT AGENCY

NZ TRANSPORT AGENCY WAKA KOTAHI

New Zealand Government