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DETERMINING MORE ACCURATE MEASURES FOR THE ECONOMIC VALUE OF ROADS

Research has developed new criteria for measuring the economic value of roads for moving people and goods. The criteria are for use within the One Network Road Classification (ONRC) and will feed into the further development of the ONRC's performance measurement framework over time.

CURRENT WEAKNESSES IN THE ONRC CRITERIA

The ONRC uses criteria to assess various aspects of a road's performance, so the road can be categorised into one of several hierarchical groups. The groups indicate the functional importance of the road.

The ONRC was developed to support:

- consistent and cost-effective asset management and investment decision making among road controlling authorities nationwide
- a consistent 'customer experience' for road users across the country. The intention is that, over time, road users can expect to have similar experiences on roads in the same category, no matter where in the country they are located.

The criteria used in the ONRC to classify roads aim to reflect the roads' roles in moving people and goods around. For example, there are criteria based on a road's annual average daily traffic count, heavy commercial vehicle traffic count, buses per hour and use for active transport modes. The criteria also aim to capture the economic and social role of roads, for example in linking communities and serving ports, airports, tourist locations and hospitals.

However, there are issues with the current criteria used for classifying and measuring the performance of roads.

These issues are due to the criteria's reliance on traffic volume measures. For example, a bus is valued similarly to a car, but may be moving many more people; and empty trucks are counted the same as full trucks, although the economic outputs from these two movements will clearly be different. As a

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result, the researchers found there was a tendency to understate the importance of public transport corridors in large urban areas, and to overestimate the amount of freight moved in public transport corridors (among other issues).

In addition, the proxies for economic productivity used in the classifications also tended to be indirect and therefore underdeveloped.

THE RESEARCH

The research team, which drew from PwC and MRCagney, explained in their report that the research aimed to develop measurable criteria with a more direct relationship to economic output.

'We explored indicators which could be used in conjunction with the current ONRC functional classification criteria. For the long term, we developed a framework to assess the absolute productivity of roads, which could be used to replace the current ONRC functional classification criteria,' the report says (p.7).

The framework is designed to capture the inputs and outputs of roads, as a measure of their productivity, which provides the opportunity to compare the performance of different roads.

The research proposes a broad scope of inputs, including fixed costs and variable costs. For outputs, because roads do not produce an economic output, but are themselves an input to economic production, the team proposes that outputs can be measured from the use they are put to, for example in moving commuters and freight.

To capture a more direct relationship between total vehicle movements and the actual economic output the trips generate, the research proposes trips should be weighted, depending on the specific purposes they are made for. So, for example, commuting trips are weighted by the income of the traveller, and freight movements are weighted by the market price of the goods being carried. By weighting the outputs, they provide a more accurate estimate of the economic value (for example, in terms of the value of labour or the goods) that is being enabled by the road.

The researchers recognised that a key challenge in developing new measures for roads was data availability; the desire for accurate and informative new indicators needed to be balanced against the practicality and feasibility of obtaining the data to inform them.

With this in mind, the team combined the output and input measures to develop four new productivity indicators that could be used within the ONRC in future.

$$\text{Freight productivity} = \frac{\text{Freight output measure}}{\text{total road input costs}} = \frac{\text{HCV}}{\text{total road input costs}}$$

$$\text{Public transport productivity} = \frac{\text{PT users}}{\text{total road input costs}}$$

$$\text{Total passenger productivity} = \frac{\text{Vehicle users + PT users +cyclists + pedestrian volumes}}{\text{total road input costs}}$$

$$\text{Commute productivity} = \frac{\text{Commute output indicator}}{\text{total road input costs}}$$

All the productivity indicators are relative, which means they must be compared against a benchmark.

'If the indicators are adopted, we recommend establishing a benchmark database against which the productivity of road segments is compared. These could be used within current ONRC functional classification categories (eg compare roads within the primary collector roads category) to determine whether road segments are 'high relative productivity' or 'low relative productivity', which could be used for road renewals and maintenance purposes, or in transport planning more broadly,' the report says (p.8).

In the report, the authors also highlight their research was focused on the relationship of roads to activities that produce economic outputs and the resources consumed in generating those outputs. None of the indicators take into account other important functions of roads and transport, such as place-making, welfare (for example, through leisure trips) or transport network efficiency (taking into account factors such as throughput, speed, safety, travel times and accessibility).

The authors also stress that the productivity indicators are at an experimental stage. Further research would enable them to be developed further and could guide their implementation within the ONRC. The intention is that the indicators would be implemented over time, while concurrent work was carried out to collect the required data and test their application through case studies.

Overall, though, the researchers concluded in the longer term it would be better to adopt an absolute measure of productivity. This could be achieved using a second-best route approach. Analysing the additional transport costs needed if a road segment was no longer available for use and an alternative route was required represents the opportunity cost of the road.

$$\text{Productivity relative to second best route} = \frac{\text{Cost of moving to second best route}}{\text{total road input costs}}$$

'This is an absolute productivity indicator, which measures the travel time difference between the preferred route and the second best route – it is a measure of the opportunity cost of the road. This has clear direct linkages to performance measurement targets,' the report concludes (p.70).

Measuring the value of the movement of peoples and goods to inform the One Network Road Classification functional categories criteria, NZ Transport Agency research report 592

Available online at **www.nzta.govt.nz/resources/research/reports/592**

TOOL AIMS TO REDUCE MAJOR RAIL INDUSTRY RISK

A new tool has been developed to allow rail operators to explore their organisational strengths and weaknesses for preventing railway signals being passed at danger. Outputs from the tool can then be used to develop risk mitigation strategies.

Internationally, and in New Zealand, signal passed at danger (SPAD) incidents are viewed by the rail industry as a major safety issue. Such incidents can cause train collisions, leading to fatalities. A high number of SPAD, even if no collisions result, can have a significant negative impact on the reputations of rail operators.

NZ Transport Agency funded research, carried out by SNC Lavalin Rail and Transit Engineering, in New Zealand and the UK, has developed a SPAD strategy evaluation tool.

The tool draws on an extensive literature review into the human factors that can lead to SPAD, the measures being used by rail and non-rail organisations worldwide to address human-factor risks, and the barriers to the implementation of these measures. It is based on concepts derived from the 'Swiss cheese model' of incident causation, and has been developed with input from rail experts within the Transport Agency and the New Zealand rail industry.

The literature review identified the importance of adopting a multi-factorial model for SPAD causation and risk reduction. The tool applies the principles from organisational assessment tools used by the UK rail and health industries and derived from the Swiss cheese model.

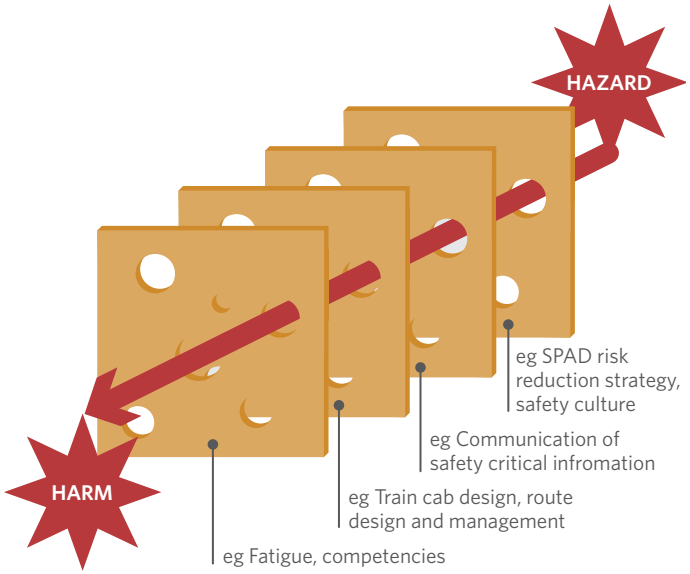
The Swiss cheese model is commonly used with respect to incident causation, and is widely known within rail and other high-hazard industries, such as the health, chemical process, aviation and nuclear sectors. The model describes layers of protection within the organisation used to control risk. The layers of protection are likened to 'slices of cheese'. The principle of the model is that at any one time there will be weaknesses and inadequacies in these layers of protection, which are likened to the 'holes' in the Swiss cheese. Incidents can occur when these holes align.

The research used these tools and models to develop a systems approach to preventing SPAD, based on the principle that humans cannot be expected to perform 100% error free, but that human error can, to some extent, be predicted. Within the tool, the systems approach is used to identify four layers where risk mitigation protection measures can be targeted:

- organisational factors
- work practices and processes
- work environment
- individual factors.

The figure on the next page shows how the Swiss cheese model and systems approach interact within the tool.

Simplified Swiss cheese model



THE EVALUATION TOOL

The SPAD strategy evaluation tool aims to help rail participants evaluate how their organisations address SPAD risk. It is designed for use as a self-assessment tool, rather than for external audit purposes.

Organisations can use the tool to understand the different practices and processes that provide resilience against SPAD risk. It provides a basis for discussions about the initiatives that work well within an organisation, what can be improved, the benefits from improvements, and any barriers or limitations to implementing those improvements.

The tool also provides a consistent means of evaluating the resilience of the organisation at the four different levels identified in the systems approach –organisational factors, working practices and processes, work environment and workplace, and individual factors. This means organisations can track their improvements over time.

The tool consists of a user guide and a Microsoft Excel evaluation spreadsheet. Both parts of the tool are available in the research report.

The user guide provides background on the tool, its aims and objectives, and detailed guidance on how to use the tool as a self-assessment process to inform an organisation's SPAD risk reduction programme. It incorporates a five-step self-assessment process, which culminates in the development of a SPAD risk reduction plan, and its ongoing monitoring and review. An important initial process of the tool is to help users understand there is no one fix to addressing SPAD risk, and that all parts of the organisation need to be considered.

The SPAD strategy evaluation spreadsheet incorporates an evaluation matrix, against which organisations can assess their levels of performance in terms of SPAD risk reduction, record evidence and identify potential areas for improvement. Once completed, the evaluation spreadsheet generates a graphical profile for the organisation against each of 16 critical dimensions (representing the layers of protection within the organisation).

OPERATORS' EXPERIENCE IN USING THE TOOL

The research project incorporated a trial of the evaluation tool by three rail industry participants.

Two of the participants (both large operators) found the tool useful, and have adopted it to guide their future SPAD risk-reduction strategies. The third participant (a smaller rail operator) found it more difficult to apply, largely because some aspects of the tool were not appropriate to smaller scales. This led to a recommendation that the tool could be modified to remove those points that were less relevant for smaller operators.

Overall the research concluded the tool was successful in shifting organisational focus away from individual events after the fact, towards a broader, proactive consideration of contributory causes and mitigation strategies, which will be more effective for addressing risk.

'There is a danger that SPAD investigations emphasise single events leading to action plans put in place for the driver (locomotive engineer) involved, while the company misses the opportunity to look for common patterns across events and the more systemic issues that the tool considers,' the report says (p38).

Another advantage of the tool is that it provides a dashboard of leading indicators for organisations to adopt, as opposed to the traditional SPAD lag indicator measurement. Lead indicators are forward-looking, proactive measures that can indicate 'holes' in safety, rather than lag indicators that only identify these after an incident.

'This is especially important for those organisations, such as small heritage operators, that may not have comparable opportunities to learn from near misses in the way that larger operators do,' the report says (p8).

While focused on the prevention of SPAD, the research project is of value to anyone attempting to make organisational activities more robust to human error.

The Transport Agency has a variety of rail safety prevention and assessment resources available online. See: www.nzta.govt.nz/roads-and-rail/rail/resources/

Best practice international solutions for mitigating human factor causes of signal passed at danger, NZ Transport Agency research report 595

Available online at **www.nzta.govt.nz/resources/research/reports/595**

COST-EFFECTIVE OPTIONS FOR REDUCING THE IMPACTS OF DUSTY RURAL ROADS

Research provides a framework for assessing the health risk of dust from unsealed roads and identifying appropriate dust mitigation.

The research project, which involved a two-month monitoring campaign, showed dust levels arising from vehicle traffic along an unsealed road were greater than background dust levels, at a distance over 80m from the road. The fine-particulate component of dust is of particular concern to human health.

The project also involved a dust suppression trial, with the results from this and the monitoring used to develop a dust risk and mitigation decision framework. Local authorities can use the framework when deciding whether to take steps to mitigate dust emissions from unsealed roads, including assessing the best mitigation options for the site, and weighing up the costs and benefits involved.

THE ISSUE

Around 40% of New Zealand's road network is estimated to be unsealed roads. In general, unsealed roads service sparsely populated rural areas, with a greater proportion of the roads in these districts remaining unsealed.

However, the recent increase in lifestyle blocks in rural areas has meant a greater number of people are being exposed to dust from unsealed roads, especially as, for economic reasons, new houses tend to be built closer to the road than traditional farm houses. As a result, district health boards and local residents are expressing concern about the health impacts of exposure to dust from roads, encouraging local authorities to consider their options.

Health concerns are not the only adverse effect that can arise from unsealed roads. Dust, generated mainly by the action of vehicle wheels, especially during periods of dry weather, can also have nuisance and ecological impacts. Dust soiled surfaces, both inside and outside buildings, reduce amenity values, and dust is known to interfere with the photosynthesis process in plants, with ramifications for the horticulture and forestry sectors, and the environment.

Nuisance dust is typically made up of larger size particles, referred to as total suspended particulate (TSP). TSP are those particles with an aerodynamic diameter of up to 100 microns. The finer size dust particles, with an aerodynamic diameter of less than 10 microns (referred to as PM10) are the ones that raise concerns with regards to health. Potential health effects from prolonged exposure to high levels of PM10 include coughs, bronchitis, exacerbation of asthma, and other respiratory and cardiovascular-related complaints.

THE RESEARCH

The primary purpose of the research, undertaken by Golder Associates (New Zealand), was to improve the understanding of the impacts that dust emissions from unsealed roads have on people, and to provide a framework for assessing dust risk and identifying sustainable and cost-effective dust mitigation measures.

The Far North District was selected as the location for the monitoring and dust suppression trial. The Far North District Council area has one of the highest proportions of unsealed roads in the country, with around 1,800km of its 2,542km of roads remaining unsealed (71%).

Monitoring was carried out between February and April 2015 on a section of unsealed road 10km south of Kaikohe, with data about meteorological conditions at the site and traffic types and frequencies collected throughout.

The monitoring aimed to collect representative data on dust levels and the extent of the dust plume arising from the roads, and to assess the effectiveness of a dust suppressant. Monitoring was also undertaken to measure nuisance dust deposition rates.

A network of optical nephelometers was used to measure PM10 dust concentrations in air. This method allowed dust data to be recorded on a fine temporal scale and to be collected at distances of up to 100m from the roadside at locations around the trial area. Supplemental beta-attenuation monitoring was also undertaken to calibrate the nephelometer data. In addition, a network of deposition gauges was deployed to measure TSP at 5m from the road and at a background location (80m from the road).

The effectiveness of the dust suppressant was assessed by monitoring dust along a transect adjacent to a section of road treated with a dust suppressant and comparing it with data collected from an untreated section of road. A magnesium chloride dust suppressant was selected, due to its relative ease of application, and continuing effectiveness over time and in differing traffic and weather conditions.

DUST LEVELS – UNTREATED ROAD SECTION

The measured dust deposition rates at a distance of 5m from the road were between 4 and 12 times higher than the Ministry for the Environment's trigger level (4g/m^2/month, above background levels) for dust nuisance. However, it is unlikely receptors would be typically located that close to an unsealed road.

The PM10 concentration exceeded the threshold concentration of the National Environmental Standard during 15 of the 52 days monitored (approximately 30% of the days) at a location representative of typical rural–residential setbacks (approximately 30m) from the road. The measured dust plume (PM10 levels above background) extended a distance greater than 80m from the road.

DUST LEVELS – TREATED ROAD SECTION

The PM10 plume from the treated section of the road extended for less than 30m (compared with over 80m for the untreated section). The PM10 concentrations did not exceed the threshold concentration of the National Environmental Standard at the monitoring location 30m from the treated section of the road during the monitoring period (compared with 30% of the days for the untreated section).

Dust deposition rates measured at a distance of 5m from the treated section of the road were similar to background levels, suggesting the suppressant was effective and acted to reduce nuisance dust levels even close to the road source.

From this, the research team concluded the dust suppressant was effective at mitigating both nuisance and fine-particulate dust discharges from roads. What is more, the effectiveness of the dust suppressant did not appreciably decrease over the two-month duration of the monitoring programme.

Application of magnesium chloride to Mataraua Road

THE DUST RISK ASSESSMENT AND MITIGATION DECISION FRAMEWORK

A principal outcome of the research was a framework that road controlling authorities can use to support their decision making around whether to mitigate dust from unsealed roads. Three key questions for authorities to ask are:

- Do we need to mitigate road dust?
- What mitigation options are suitable for the site?
- Which mitigation option provides the best benefit-to-cost outcome?

The framework, and its associated tools, enable these questions to be answered.

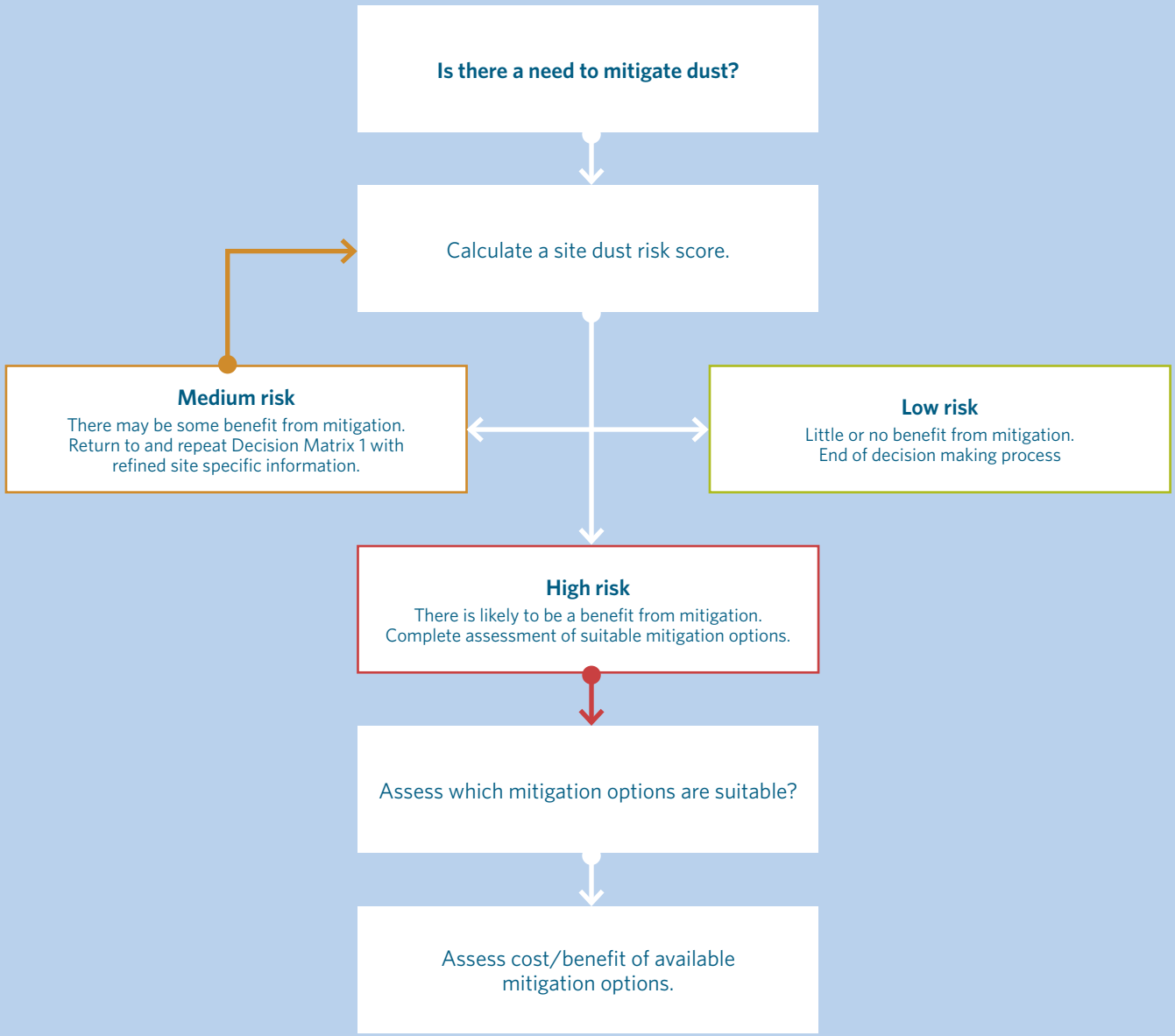
The first question (need) is answered by calculating a site dust risk score for a particular section of road. The score categorises sites as low, medium or high risk. Factors taken into account include:

- traffic characteristics (number, nature and speed of vehicles)
- site characteristics (local meteorology and topography)
- the location and number of receptors sensitive to dust (residential dwellings and sensitive ecological or horticultural areas)
- how long significant volumes of heavy vehicle traffic (eg logging trucks) are anticipated to operate in the area.

For high-risk sites, assessment criteria are then provided to answer the second question as to which (if any) dust mitigation measures are suitable.

Once the best option or options have been identified, guidance is provided on how to undertake a basic cost–benefit assessment with respect to them. This assessment monetises the health benefit of dust mitigation using a New Zealand health effects model, and compares it with the implementation cost. The health benefit is directly related to the population density adjacent to the road and the effectiveness of the dust mitigation measures.

Dust mitigation – decision-making process



Impacts of exposure to dust from unsealed roads,
NZ Transport Agency research report 590

Available online at **www.nzta.govt.nz/resources/research/reports/590**

PREVENTING PREMATURE FAILURE OF SPECIALIST SURFACE SYSTEMS

New research explores the relationship between specialist surfacing systems, and their underlying substrates, to understand whether and why the surface is likely to fail.

Specialist surfacing systems, such as high-friction surfaces (as used in known trouble spots to prevent skidding) and coloured traffic-calming surfaces (as used in bus and bicycle lanes) have gained huge popularity since they were first introduced in New Zealand.

However, they have also been plagued by premature failures, due to cracking, delamination, chip loss and other causes. Many of these failures have been found to originate from, or at least be associated with, the performance of the underlying pavement substrate.

Specialist surfacing systems are very expensive when compared with other surfacing treatments. To be cost-effective, expectations are that the systems need to last seven years or more. Premature failures add to the overall costs of using the systems, as well as undermining their functional effectiveness.

At present, New Zealand has a pilot performance-based specification for calcined bauxite systems (NZTA P25: 2011). In addition, a draft specification for coloured safety surfacing is being developed (NZTA P33).

The purpose of the latest research, undertaken by Opus Research, Opus International Consultants, was to extend the scope of these specifications so they could be used to minimise premature failure in specialist surfacing systems. For example, the current draft of NZTA P33 does not yet deal comprehensively with substrate condition, creating an obvious gap.

To this end, the research project assessed test methods that focused on the performance of the underlying substrate and its interaction with the specialist surfacing systems.

Specialist surfacing systems are multi-layered and can fail cohesively or adhesively. For them to work effectively, the bond strengths between the binder and the aggregate, as well as between the surfacing systems and their underlying substrate, are very important. Being able to predict surface failures, due to one of those bonds breaking, was a vital part of the research.

A number of commercial resin systems, namely epoxy, polyurethane and methyl methacrylate were tested using the standard tensile bond (pull-off) and percentage elongation (tensile) test methods in ASTM C1583-13 and D638-10. Thermal effects were also investigated through thermal cycling experiments.

The outcome was a general guideline for preventing premature failures, and a draft test method, with recommendations for the method's further refinement. The overall intention was to develop a test that could be implemented in the field.

THE DRAFT GUIDELINES AND TEST

Based on the findings of the test assessments, the project team developed a general guideline. Provided the three criteria in the guideline are met, the risks of the specialist surfacing system failing prematurely, for either adhesive or cohesive reasons, can be minimised.

- The system must be applied according to best practice. The surface must be clean and dry, and the resin system mixed according to the supplier's notes. Both of these steps will minimise the risks of adhesive or cohesive failure of the resin used in the system.
- The adhesive and cohesive strengths of the resin used on the substrate must be greater than the cohesive strength of the substrate itself. This will ensure loads are transferred from the thin specialist surfacing down to the substrate (to prevent delamination).
- The cohesive strength of the substrate, at various temperatures, must meet or exceed the expected traffic loadings (to prevent cohesive substrate failure).

The next step was to develop a draft test method that could be used to determine the various adhesive and cohesive strengths required by the guidelines.

As a starting point, it was recommended a tensile bond (pull-off) test should be incorporated in the draft specifications for calcined bauxite and coloured surfacing systems (NZTA P25 and NZTA P33, respectively). This would help ensure the adhesive bond strength of the resin used in the surface meets the cohesive strength of the substrate (the second criteria in the guidelines).

The apparatus used for this test should be capable of controlling the loading rate, and the equipment (load cell and loading speed) should be calibrated regularly, to ensure consistency. (The research report makes recommendations about the tensile loading test apparatus, based on models currently available on the market.) In addition, it is important to carry out testing on a representative set of samples.

It was also recommended a pull-off test should be conducted before the specialist surfacing system is applied. This will help ensure the underlying substrate is of sufficient strength to withstand potential traffic loading (the third criteria in the guidelines).

Based on the data from the research, the project team have set a preliminary benchmark that asphalt substrates have to be able to withstand – namely, tensile stresses of at least 750kPa (or approximately 1.5kN on a 50mm diameter test area) when tested at 23ºC. This tensile strength could be achieved either by using a binder with a higher cohesive strength, or through allowing the asphalt substrate to age. The latter approach precludes specialist surfacing system being applied on freshly laid substrate; which is not recommended in any event. The research report recommends a way to conduct the testing to accommodate temperature variations in the field.

The test method is still in a draft stage, and one function of the research report is to make it available for further comment and refinement. Recommendations in the report to inform this process include field trials, and work to address gaps and create benchmarks for the testing processes.

Cracking in specialist surfacing systems, NZ Transport Agency research report 598

Available online at **www.nzta.govt.nz/resources/research/reports/598**

A RENEWED LOOK AT BITUMEN PERFORMANCE

A recently completed research project supports the development of a New Zealand performance-based specification for bitumens when used in chipseals.

Undertaken in 2015 by Opus Research, Opus International Consultants, the project investigated three specific aspects of bitumen performance in chipseals:

- compatibility with kerosene
- adhesion to aggregate in the presence of water
- chip retention in relation to binder cohesive energy.

The Transport Agency is currently developing a performance-based bitumen specification, which will ultimately replace the current M/1:2011 bitumen specification for chipseal binders. A performance-based specification is one where the bitumen properties specified are directly related to the key performance properties required from road surfaces. So, for example, a future specification might specify bitumen properties relating to chip retention or surface failure modes (such as water-induced adhesion failure).

COMPATIBILITY WITH KEROSENE

Kerosene is added to bitumen to temporarily lower its viscosity to assist with chip wetting and allow sealing chips to reorient during and following construction.

In the existing M/1 specification there is a requirement that bitumen is 'compatible' with kerosene. The concept of compatibility means that the addition of kerosene to a bitumen results in consistent changes in its viscosity.

The research found that, in fact, differences in the base (unmodified) viscosity of the bitumen have a far greater impact than those produced by small differences in kerosene compatibility. Anecdotally, there is no evidence that kerosene compatibility differences have any practical impacts.

This conclusion was reached following an analysis of data from the past decade. The data demonstrated there would be no need for a kerosene compatibility requirement to be included in a new performance-based specification. If it was to be retained, then the overall effect of slope and base viscosity of the bitumen on its response to kerosene should be included in the assessment.

The research report notes, however, that the new performance specification for chipseal bitumens must make allowance for the fact that kerosene will be added during seal construction. This will affect the properties of bitumen, especially in the early life of the seal.

ADHESION TO AGGREGATE

Good chipseal performance depends on there being adequate levels of bitumen adhesion to the sealing aggregate and of bitumen resistance to water-induced stripping.

Any test to assess potential adhesion problems with chipseal binders needs to take into account chemical affinity (between the bitumen and the chip), potential degradation of adhesion agents at high temperatures (during handling) and the physical wetting of the aggregate at ambient temperatures. At present, contractors use Vialit plate adhesion tests to test particular bitumen-chip-adhesion combinations. The research found no better, practical test that warranted replacement of this test, but was able to suggest some changes to the test methods that may potentially improve its precision.

Inclusion of the Vialit test in a new bitumen specification would not be practical. Instead an acid number screening test and a rheological measurement related to the ability of the binder to adhere to wet chip were recommended for inclusion in the new performance-based specification.

Such tests would provide protection against bitumens likely to perform poorly, and would help ensure batch-to-batch consistency. The existing Vialit plate adhesion tests by contractors would continue to be required when new chip sources or adhesion agents were used.

CHIP RETENTION IN RELATION TO BINDER COHESIVE ENERGY

One of the main functions of the sealing binder is to retain chip under traffic loadings. In the current M/1 bitumen specification, chip retention under traffic stress is only controlled for indirectly.

In the field, chip loss due to the cohesive failure of the bitumen film that is holding the chip tends to occur at either very low or very high road temperatures. As a result, the research recommended the new performance-based specification should include tests for bitumen properties at both low (-10°C to 0°C) and high (50°C to 60°C) temperatures.

The research also looked at the possibility of including binder cohesive energy in the new performance-based specification, and the methods available to measure this. Cohesive energy is defined as the energy expended to create two new bitumen surfaces.

At present, the only standardised method for measuring bitumen cohesive energy in relation to chip retention in chipseals is the Vialit pendulum test, used in the UK and Europe. The test has fundamental problems, however, that affect its accuracy.

The research also concluded that cohesive energy alone may not be the most suitable parameter for assessing the ability of a bitumen to resist chip loss. This was because the measured cohesive energy of a binder is strongly affected by its viscoelastic properties. Highly ductile materials can have high cohesive energies but also have yield strains that would in practice (in a chipseal), be unsatisfactory.

Alternative tests, for use at high and low temperatures were suggested, along with a recommendation that the new specification should include parameters for using these tests.

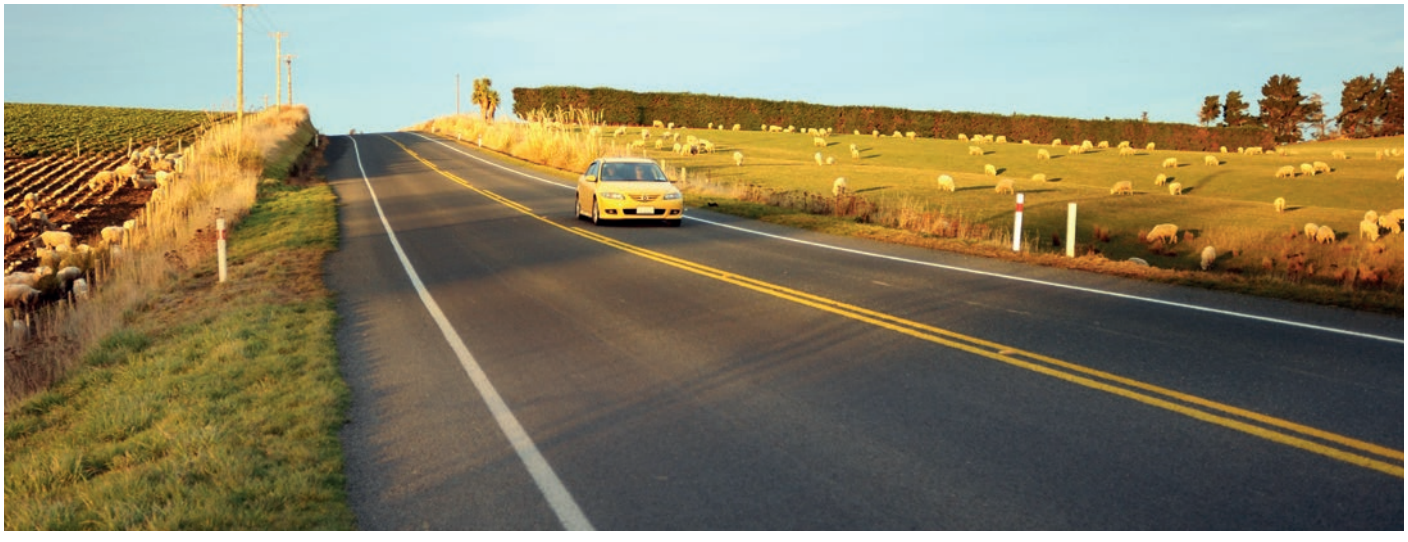
At low temperatures, a simple tensile test to measure and control the bitumen yield stress and strain was cited as a better alternative. Minimum yield (rupture), stress and strain values would be specified.

At high temperatures, tensile tests on bitumen become impractical. In addition, at high temperatures large non-recoverable deformations of the binder below the yield strain must also be controlled for. The research suggested that the multiple stress creep recovery (MSCR) test could be used at high temperatures instead, with a maximum value for the creep compliance and a minimum value for the percent recovery specified.

The research report sounds a note of caution, however, stating that additional research is needed before either the tensile or MSCR test approaches are adopted.

Bitumen performance tests, NZ Transport Agency research report 587

Available online at **www.nzta.govt.nz/resources/research/reports/587**



MIXED RESULTS FOR EMISSIONS AND ROADSIDE AIR QUALITY

The Kiwi penchant for diesel and older passenger vehicles may be limiting our ability to achieve cleaner air at the roadside despite advances in emission control technology and legislation, according to new research.

The Transport Agency's *Understanding trends in roadside air quality* study found mixed results for roadside measurements of vehicle emissions and roadside air quality.

Recent vehicle emissions control technology has led to general improvements in emissions of pollutants. In addition, monitoring of ambient air at roadside locations has shown that both carbon monoxide (CO) and oxides of nitrogen (NOx)[1] concentrations have decreased since 2006.

However, the study found the increased percentage of light duty diesel vehicles and the presence of older 'gross emitting' vehicles within the New Zealand fleet may be partly responsible for the slowing down in improvements to roadside ambient NOx concentrations between 2011 and 2014.

Report author, Jeff Bluett, of Golder Associates (New Zealand), notes, as a result, 'We may not be realising the anticipated benefits in roadside air quality.'

THE STUDY

This 2015 study used a roadside remote sensory device (RSD) to measure vehicle emissions from about 38,600 light-duty vehicles and 630 heavy-duty vehicles on Auckland roads. This study is a continuation of earlier RSD campaigns conducted in Auckland in 2003, 2005, 2009 and 2011.

While the RSD measures a number of parameters in vehicle exhaust emissions, the focus of the current study was on NO and CO. The study notes that the ratio of NO and NO2 in vehicle exhaust varies. Because of this there are some limitations on using NO alone to assess trends in vehicle NOx emissions, but overall it was considered a useful marker.

The RSD findings were compared to ambient air quality data from permanent roadside monitoring sites in Auckland and Christchurch to gain a better understanding of trends in roadside air quality over time in New Zealand.

VEHICLE FLEET TRENDS

As part of the RSD campaign, the characteristics of the monitored vehicles were also documented. This included vehicle age, mileage, fuel type (petrol or diesel), vehicle size (heavy or light duty), emissions control standard, mileage and whether the vehicle had been imported to New Zealand new or used from Japan.

Analysis of the light-duty vehicle data showed a marked age difference between petrol and diesel vehicles, with an average age of 11.3 years for the petrol vehicles and 8.2 years for the diesel ones. New Zealand-new light-duty vehicles were an average 7.9 years old compared with the average age of 14 years of a Japanese used import. All of these figures are younger than national averages, reflecting the make-up of the Auckland vehicle fleet.

Diesel vehicles comprised 18% of the monitored light-duty vehicle fleet, compared with 12.5% in 2003. This trend is consistent with changes seen in national fleet statistics.

The heavy-duty vehicle data showed an increase in the average age of these vehicles: from 12.3 years in 2015, compared with 9.2 years in 2003.

[1] Oxides of nitrogen or NOx is a collective term used for nitrogen dioxide (NO2) and nitrogen monoxide (NO).

VEHICLE EMISSIONS FINDINGS

The RSD study found CO and NO emissions from light duty vehicles in New Zealand decreased significantly between 2003 and 2015, with an average vehicle in 2015 emitting about half the CO and NO levels of the vehicles monitored in the earlier 2003 study. A similar trend was observed for CO emissions from heavy-duty vehicles, with NO emissions from these vehicles remaining relatively stable.

The study found that most of the drop in measured NO vehicle emissions occurred before 2009. Emissions then stabilised in the 2011 and 2015 monitoring campaigns. Between 2009 and 2015 the average NO emissions from diesel light-duty vehicles actually increased.

The RSD also confirmed diesel vehicles emit disproportionately more NO, with diesel light-duty vehicles emissions approximately 60% higher than those of petrol light-duty vehicles. The opposite trend was observed for CO, where in 2015, the mean CO emissions measured from petrol light-duty vehicles were more than 10 times greater than those from the diesel light-duty vehicles.

When these results are 'considered in the context of an increasing number of diesel light-duty vehicles within the fleet profile, a significant challenge is created for managing future roadside concentrations of NOx,' the author said.

For petrol vehicles, newer emissions control technology resulted in improvements to vehicle emissions for both CO and NO. However, increased vehicle age and mileage were associated with decreased emissions performance.

Diesel vehicles were a different story; the average NO emissions from light-duty diesel vehicles have not improved significantly with recent emissions control technology. Mileage did not appear to have a significant impact on diesel vehicle emissions. These findings are consistent with other international studies and are not unique to New Zealand.

For petrol vehicles, it was found that 'gross emitting' vehicles had a significant impact on average CO and NO emissions. The impact of gross emitters on average emissions has increased since the first 2003 monitoring campaign. Overall the effect of gross emitting vehicles on mean diesel emissions is less, and does not appear to be increasing.

WHAT THIS MEANS FOR ROADSIDE AMBIENT AIR

Roadside ambient air NOx concentrations measured by regional councils in both Auckland and Christchurch decreased between 2006 and 2010, and then appeared to stabilise between 2011 and 2014.

The initial improvements may be related to significant improvements in vehicle emissions control technology implemented over that period.

The recent stabilisation in roadside ambient NOx concentrations may result from a balancing of negative and positive pressures. That is, the negative pressure of an increased proportion of diesel light-duty vehicles in the New Zealand fleet, combined with the poor emissions performance of older and gross emitting petrol light-duty vehicles, may be being more or less balanced by the generally better emission performance of newer petrol light-duty vehicles. Combined, these result in relatively stable roadside NOx concentrations in 2011 and 2014 ambient monitoring, the study concluded.

The roadside ambient CO concentrations measured in Auckland and Christchurch decreased between 2003 and 2014. This decrease is consistent with the overall reduced CO emissions from both the light- and heavy-duty portions of the vehicle fleet measured during the RSD monitoring campaigns.

WHERE TO NEXT?

The study recommends continuation of the RSD monitoring campaigns. Tracking this data over time provides many benefits, such as validating vehicle emission models, understanding the effect of a changing fleet profile on vehicle emissions and identifying the effect of gross emitting vehicles.

The author identified gaps in the data recorded at the roadside air quality monitoring sites and suggested that key sites be identified and 'future proofed' to enhance the analysis of air quality trends.

Stakeholders, such as regional councils and transport providers, should be involved to help ensure the longevity, quality and value of such record keeping.

Further research could also focus on particulate emissions, particularly from diesel vehicles, as this was an important consideration in terms of human health effects and could further enhance the understanding of vehicle emissions and their effect on air quality in New Zealand.

Understanding trends in roadside air quality, NZ Transport Agency research report 596

Available online at **www.nzta.govt.nz/resources/research/reports/596**

TRANSPORT KNOWLEDGE CONFERENCE 2016

On Thursday 10 November the Transport Knowledge Conference 2016 was hosted in Wellington by the Ministry of Transport, the NZ Transport Agency, Maritime NZ and the Civil Aviation Authority.

Further to the development of the Transport Knowledge Hub about two years ago, and the release of the Transport Research Strategy and Transport Domain Plan, www.transport.govt.nz/research/transport-research-strategy/, the partnership of agencies and parties with interests in transport data, analysis and research has continued to grow.

The annual conference provides a forum for people working across the transport sector to share, build and maintain their transport knowledge and relationships. Researchers and experts contributed to the 2016 event from across research organisations, the public sector and the academic community.

The theme of the 2016 conference was customer-focused transport. Almost 200 attendees enjoyed key note addresses from Hon Craig Foss, the Associate Minister of Transport, Mr Fergus Gammie, the Chief Executive of the Transport Agency, Mr Peter Carr of the Ministry of Transport and Dr Mike Reid of Local Government NZ. They addressed the role of data and research, policy and regulation, and community engagement.

Parallel session presentations were designed around the four knowledge themes as described in Transport Research Strategy – user behaviour and needs, transport impacts, system planning and management, and future funding and charging. There were also discussions on specific topics including big data, youth offences, the 30-year transport outlook and transport pricing. The conference was well received by attendees, who indicated their appreciation of the opportunity to find out what is happening in current research and policy development.

As technology changes, the New Zealand population ages and international economies become more globalised, the sector is facing a number of strategic challenges around how we fund, build and manage the transport system. Improving our understanding of our customers, and improving the visibility and accessibility of research, data, statistics and information, helps to improve the quality of evidence-based decisions which are critical to the developing customer focused transport.

New Zealanders are going places – and we need an effective, efficient, resilient, safe, and socially and environmentally responsible transport system to get us there. High-quality data, information and research enriches our understanding of the transport system and how it works. Our transport system supports the needs and wants of all New Zealanders to go places – whether to work, meet family and friends, transport goods, deliver services or connect with the rest of the world.

The 2017 conference will be combined with the 39th Australasian Transport Research Forum to be held in Auckland. We will publicise the date once it is determined.

NEW RESEARCH REPORTS

Why are some urban traffic signals much less safe than others?

NZ Transport Agency research report 588

Freely available online at www.nzta.govt.nz/resources/research/reports/588

Research undertaken to inform the High risk intersections guide shows there is a higher risk of death and serious injury at some urban signalised intersections than at other intersections using the same control types. The reasons why some urban signalised intersections are less safe than others are not well understood. The research presented in this report compares urban signalised intersections with good safety performance with those that perform poorly to understand the reasons for their differences.

The environmental, physical and operational factors identified as contributory factors to poorer safety performance are determined qualitatively in this research. The results of the research will assist practitioners by:

- identifying factors or combinations of factors that should be implemented or avoided to enhance safety outcomes
- specifying potential safety issues when designing urban signalised intersections
- providing an indication of the likely reduction in fatal and injury crashes when installing remedial treatments at urban signalised intersections.

Review of the NZ Transport Agency treatment selection algorithm

NZ Transport Agency research report 599

Freely available online at www.nzta.govt.nz/resources/research/reports/599

The objective of this research, carried out between 2012 and 2015, was to improve the treatment selection algorithm (TSA). The TSA is used to forecast the timing and treatment type of works required to maintain roads in good condition for the least whole-of-life cost in the short to medium term. The output is a candidate list of sites intended for validation in the field combined with recommended drainage improvements and funding estimates.

Since the TSA was developed, the long-term pavement performance monitoring sites have yielded much practical information; pavement and surface condition measurement techniques and parameters have developed; and economic analysis parameters have changed.

The algorithm, used to guide future surface and pavement works, needs to be updated to reflect current knowledge and recent experience. Recommended improvements include the consideration of thin asphaltic surfacings and maintenance cost data. The vehicle operating cost model and benefit-cost ratio funding mechanisms have been superseded and a new present value model is recommended. This incorporates new data sources now available such as falling weight deflectometer and high-speed data capture.

Safety and efficiency at intersections

NZ Transport Agency research report 600

Freely available online at www.nzta.govt.nz/resources/research/reports/600

This report considers evidence on safety and efficiency at intersections, using New Zealand data and international research, and outlines a systematic approach for evaluating the safety and efficiency benefits at intersections, as part of the project development process.

The research project reviewed New Zealand and international practices, analysis tools, guides and processes. The authors found very little in the literature to define what is considered to be an acceptable trade-off between safety and efficiency at intersections, largely due to the existing separation of the two fields in all jurisdictions researched. A recommended solution has been presented in the form of a 'proof of concept' evaluation framework, which takes into account a range of factors and case studies. It is recommended the transport sector considers utilising this framework as a decision support tool in ensuring the correct decisions for delivering against safety and efficiency outcomes, are made at the appropriate stage of the project development.

CORRECTION TO INDEX TITLE OF ISSUE 33

The index of the September issue 33 hard copy version of the NZTA research newsletter showed an incorrect title. The title for page 9 read:

Taking a renewed look at bitumen performance

The title should have read:

Creating a framework for economic appraisal of network operations

The online version of the newsletter has been corrected and is available at: www.nzta.govt.nz/assets/resources/nzta-research/docs/nzta-33.pdf.

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.

THE NZ TRANSPORT AGENCY WISHES YOU A VERY MERRY CHRISTMAS AND SAFE JOURNEYS THROUGHOUT YOUR HOLIDAYS.

NZ TRANSPORT AGENCY WAKA KOTAHI

New Zealand Government