Managing icy conditions is an ongoing issue on some New Zealand roads, particularly in coastal and central Otago, and the central North Island. However, calcium magnesium acetate – the de-icing agent being used more and more frequently on New Zealand state highways – can introduce its own skid resistance hazards, which drivers need to be alerted to if they are to stay safe.

In the past, frost, ice and snow on New Zealand roads have been treated with common salt and mineral grit. Salt was discontinued in the early 1980s due to concerns about its effects on the environment and on vehicle corrosion. Mineral grit continues to be used extensively, although in the 1990s concerns began to mount about its use too. Grit build-up was found to be a factor in a number of crashes – when laid thickly it obscured road markings and reduced the effectiveness of raised pavement markers, and it was also found to be damaging vehicle paintwork and windscreens.

In 1996, Transit New Zealand (Transit) reviewed its options for managing ice and snow on state highways, looking at many of the de-icing agents commonly used overseas. Calcium magnesium acetate (CMA) was selected as the agent best suited to New Zealand conditions. Low risk of vehicle corrosion and minor environmental side effects were points in its favour and, importantly, it presented the lowest risks with respect to skid resistance when compared with the other agents that Transit looked at.

Since 1998, Transit has been trialling CMA as a de-icing agent on the state highway network and it has been found to be effective, both in removing ice and preventing it from forming. As a result, CMA’s use is spreading, and consultants and contractors in areas where it is now commonly used have been introducing best practice guidelines and methods for how it should be applied.

Although initial trends show that CMA is proving effective in reducing crashes and road closures attributed to ice, there have been a number of skid-related crashes on sections of road where CMA has been applied, raising some concerns about its effects on skid resistance and the potential hazards this can pose for motorists.

Understanding CMA’s effects

A Land Transport New Zealand (Land Transport NZ) research project has been looking at the relationship between CMA and skid resistance, in particular:

- the skid resistance of different road surfaces and how this is affected by applying CMA

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The three tools
Completed in 2004 in coastal and central Otago, the research was based on an on-road test programme, which gathered skid resistance measurements using:

- a GripTester
- a British pendulum tester
- a car instrumented for locked-wheel-braking tests.

An initial survey of quite long sections of the state highway network in coastal Otago, where CMA had been used the previous winter, used the GripTester to gather baseline data about skid resistance in dry and wet conditions. The GripTester was also used on one of these road sections, after CMA had been applied and over a period of time, to measure both how skid resistance was affected and how far CMA was being tracked down the road by passing vehicles. Selected road sections were then tested using the pendulum tester and instrumented car. These test sections included a variety of surfaces (fine chipseal, coarse chipseal, open graded porous asphalt, asphaltic concrete and slurry seal) and were tested over a range of conditions, including:

- dry, wet and following dewfall without CMA
- immediately following the application of CMA
- following dewfall where CMA had previously been applied.

The tests aimed to gather sufficient data so that comparisons could be made between results for different surfaces and in different conditions, both with and without CMA.

Measuring the risks
The baseline data collected by the GripTester showed that the skid resistance of road surfaces could vary dramatically, even within short distances on the same stretch of road. Roads in nearby locations would not necessarily have similar skid resistance properties in similar conditions – there were instances where the wet-road skid resistance values of one road were the same as the dry-road values of others nearby.

Applying CMA significantly reduced the skid resistance of roads when compared with dry-road conditions and, in some situations, could also reduce skid resistance below what would be expected in wet conditions. However, overall, when measurements were taken from along a section of road, the skid resistance after CMA had been applied was similar to when the road was wet.

Skid resistance reduced significantly immediately after CMA was applied, gradually improving over time – although after only three hours skid resistance where CMA had been applied could be less than in dry conditions on the same road. When freshly applied, passing vehicles could track CMA for up to 1 km beyond where it had been applied and skid resistance would also be reduced on these sections of road.

Tests by both the instrumented car and the pendulum tester showed that skid resistance on all the road surfaces was reduced substantially after CMA had been applied (car: reduced by between 65 and 85 percent of dry road values; pendulum: reduced by between 35 and 75 percent of dry road values). Stopping distances for the car also increased after CMA application compared to the dry road values, rising from an additional 2 m (or 50 percent) at 30 km/h, to an additional 28 m needed to stop at 100 km/h. As a general rule, the coarser textured or better draining surfaces continued to provide better slip-resistance once CMA had been applied.

After it had dried, skid resistance levels for CMA were the same as dry road values. However, another finding of the measurements was that CMA is reactivated after dewfall, once again reducing the skid resistance on roads where it had been applied, although not as significantly as when first applied.

Implications for road management
Although CMA works very effectively to prevent and remove ice build-up on roads, the research highlights that how CMA is being used raises some important issues that will need to be effectively managed if risks to motorists are to be reduced.

Neil Jamieson says that, as a general level, these issues are about the time that CMA is applied and how, or if, the public are advised about CMA’s use and its effects on skid resistance.

‘Drivers’ expectations and perceptions play a large part in the way they drive and at present drivers in New Zealand have little, if any, knowledge of the use of CMA on roads and its effects. Obviously that poses some risks.

‘Many contractors currently use the standard Ice/Grit signs when they are applying CMA. CMA has quite specific effects with respect to skid resistance, and those effects vary depending on where and how long ago the CMA was applied, and whether the road conditions are wet or dry. It may be that a different type of road sign, such as Slippery Surface or Slippery When Wet, is more appropriate.’

Developing appropriate road signs, specifically to be used with CMA, is one of the recommendations to come out of the research, as is ensuring that any signs are placed appropriately and up to 1 km past the point where the CMA was actually applied.

Other recommendations include changing regional best practice procedures so that they include an assessment of the level of risk that applying CMA, will pose, taking into account factors such as road surfaces, environmental conditions (particularly humidity and dewfall) and anticipated traffic levels. Developing these risk models will require further work and the research report also recommends further investigation into the effects of CMA in various traffic conditions, and into the relationship between CMA, speed and wet or dry roads.
New roundabout design helps cyclists get around

A multi-lane roundabout designed with cyclists in mind? Welcome to the C-roundabout, a new concept in roundabout design, created here in New Zealand to improve roundabout use and safety for cyclists.

Although central government, local authorities and individuals throughout the country are seeking more sustainable ways than private cars to get people around, many aspects of the nation’s roads remain hazardous for cyclists. Multi-lane roundabouts are of particular concern, recognised by both cyclists and the Police as blackspots for crashes between cyclists and vehicles, a perception that is borne out in the statistics.

In 2003, scheme investigators developing cycle routes in Manukau discovered what appeared to be a deficiency in the road design standards – there was no adequate design available that enabled cyclists to navigate safely through multi-lane roundabouts, which are roundabouts where the circulating carriageway accommodates more than one lane of traffic. The cycle routes in question would pass through no less than eight multi-lane roundabouts.

A Land Transport NZ research project set out to tackle this gap, looking at the best of what was available overseas and what we already knew about crashes involving cyclists at New Zealand roundabouts, then combining this with new research to come up with a design – the cyclist roundabout or C-roundabout.

What the statistics said

Crash statistics from 58 multi-lane roundabouts in the Auckland region were examined to determine the most common types and causes of crashes involving cyclists. From 1995 to 2004, 59 Police crash reports had been completed for crashes involving cyclists at the roundabouts and in 39 of these the cyclist had been injured.

By far the most common type of crash (68 percent) was that involving a vehicle entering the roundabout colliding with an already circulating cyclist. These were followed by sideswipe crashes, where a circulating vehicle struck an already circulating cyclist (10 percent), and crashes where a vehicle exiting a roundabout hit a circulating cyclist (9 percent).

What these statistics illustrate is that if crashes involving entering vehicles and circulating cyclists could be minimised, then roundabouts could go from being one of the most hazardous intersection types for cyclists to one of the safest.

What’s happening overseas?

Previous research and literature from New Zealand, Australia, the United Kingdom, the United States, and several European countries, including the Netherlands and Finland, were looked at.

While no satisfactory complete design solution emerged, the literature did establish some important features that any new cyclist-friendly roundabout should accommodate. In particular, designs should seek to reduce the speed differential between cyclists and vehicles, by lowering the speeds at which vehicles enter, exit and circulate. Lower vehicle speeds make it more likely that drivers will spot and accommodate cyclists, and make it easier for cyclists to establish their presence on the road and carry out their manoeuvres.

What the literature also revealed was that throughout the world multi-lane roundabouts are considered hazardous for cyclists when compared with traffic signals and that, in common with New Zealand, incidents between entering vehicles and circulating cyclists posed the most risk, backing up perceptions that efforts to improve this aspect of roundabout usability and design are warranted.

Seeking the views of cyclists

The research team prepared a survey to assess the level of concern that cyclists have about multi-lane roundabouts and the main safety issues they thought these roundabouts posed, as well as to gather some preliminary feedback on low-speed roundabout designs. The survey was widely circulated to cyclist organisations and retail outlets in the Auckland region, and was available to download from the web.

Mainly experienced cyclists responded to the survey and the common perception was that multi-lane roundabouts pose a significant obstacle, with the result that many cyclists avoid them if possible. In general, the types of conflicts that cyclists were concerned about at roundabouts were the same as those where the most crashes do in fact occur, ie, entering or exiting vehicles versus circulating cyclists. An additional area of concern was for cyclists entering the roundabout. Even though this had not featured as a major cause of crashes in the statistics, it was obviously an area of roundabout use where cyclists felt vulnerable.

Despite these negative perceptions of multi-lane roundabouts, most of the cyclists surveyed preferred a solution that would enable them to stay on the road, as opposed to being diverted to a pedestrian bypass, and the majority (87 percent) agreed that reducing vehicle speeds on roundabouts was the best way to enable this to happen.

Focus on speed

With both the research from overseas and the evidence of New Zealand cyclists highlighting the importance of speed reduction, a good starting point was to look at the design options already available to lower roundabout

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The effect of crushing on the skid resistance of chipseal roads

Robert Henderson, Opus International Consultants

The research was carried out between 2003 and 2005 at Opus International Consultants, Central Laboratories, Lower Hutt. Research has focused on chipseal surfaces constructed using greywacke aggregate from two quarries.

This research was to determine the relationships between (a) aggregate microtexture, (b) percentage of crushed faces, (c) chip shape and (d) skid resistance, with the main focus being on determining the effect of crushing on skid resistance.

The polished stone value, GripTester number and British pendulum number results from core samples and laboratory-prepared chipseal surfaces that show the relationships are presented and discussed.

Obtaining research reports

Research reports are available online at www.landtransport.govt.nz/research. They can also be purchased in hard copy. To order any of these reports, or for questions regarding Land Transport NZ’s research programme, please email research@landtransport.govt.nz.
Past research on the effectiveness of road warning signs does not inspire confidence. Studies have found that as few as 6 percent of drivers notice warning signs and that the failure of signs to adequately warn drivers of potential hazards ahead is a significant contributor to road crashes. Signs can in fact be counter-productive, especially if unclear, as they may divert a driver’s attention away from the road as they try to understand what is meant.

Although other studies suggest that drivers may react correctly to some types of warning signs, even if they don’t recall having seen them, the compliance rate recorded is still relatively low, with well below half of drivers managing to do what was required of them.

This failure of hazard warning signs to achieve what they are designed to do is perhaps not surprising when you consider that it is only in the past 30 years that sign design and evaluation has been based on behavioural and cognitive principles – before this, signs were designed by engineers, planners and the Police.

What makes a good sign?

Seeking to understand what sorts of signs work best, and in what conditions, was the purpose of a recent Land Transport NZ research project on hazard signs. Although it is a subject that many road safety and other researchers have tackled aspects of before, a review of the international literature on signs’ effectiveness showed little or no consistency in the way hazard warning signs are designed or evaluated.

Relatively few studies had looked at hazard warning signs that were actually in use (as opposed to being developed) and there were very few studies of newer hazard warning methods such as variable message signs (where the sign’s message varies depending on conditions at the time) and perceptual countermeasures (implicit clues designed into the road environment, such as pavement markings or chevron sight boards, which appear to work at a subconscious level to alter driver behaviour). There was also very little previous New Zealand research available on the subject.

Given this background, the study set out to systematically evaluate the effectiveness of hazard warnings and, from this, develop a method by which both existing and new warning signs in New Zealand could be assessed. The approach used attempted to assess not only the signs but also the consistency and sensitivity of the assessment measures themselves.

Collecting the data

The research combined field observation with laboratory testing. The first step was to select 16 sign types and formats and assess their effectiveness in consultation with road safety practitioners. The signs chosen included ones for road works, school, pedestrian crossing, curve, chevron sight board, slippery surface (both the permanent and temporary versions), pedestrians and flag person, in standard, large and variable message format, and various colours.

The next step was to collect field observations of drivers’ immediate reactions to these signs, including covert collection of vehicle speed data both before and after the sign.

Following this, the signs were tested in the laboratory. Participants were shown video sequences and still photos in the Traffic and Road Safety Research Group’s driving simulator at the University of Waikato, and asked to comment on what they saw. The sequences and stills contained, among other things, the hazard signs being tested.

With the data collected from the field observations and laboratory trials, the effectiveness of each of the signs was assessed against a range of measures identified from the literature.

• Sign conspicuity – how a sign’s reflectivity, size and placement affects its ability to attract driver attention.
• Sign recognition memorability – how likely drivers were to recall seeing signs that they passed.
• Sign priming – the extent to which signs affect how prepared and responsive drivers are to approaching hazards.
• Sign comprehension – how well the intended meaning of a sign is understood by drivers.

Which signs performed well?

The research found that of the nine signs tested, road works and school warning signs were most often detected, remembered and understood by the participants. Slippery surface warning signs, on the other hand, had some of the lowest detection and comprehension rates.

It was apparent that the effectiveness of the different formats of hazard sign depended on the type of sign it was.

They’re there to warn you, but just how effective are hazard warning signs? And how would we improve them if we could?

New research from the Land Transport NZ research programme looks at some of the features of effective, and not so effective, road signs and suggests a range of measures that could be used in the future to assess how well road signs work.
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• For road works warnings, the flashing variable message format was only slightly more conspicuous than the large dimension format (1200 mm x 1200 mm), was equal in how comprehensible drivers found it and somewhat worse in terms of its memorability.

• For the school warnings, the flashing variable message format appeared to convey a greater sense of potential hazard, produced superior search conspicuity and priming, and was equal in terms of memorability and comprehensibility.

Where to now?

The second goal of the research project was to establish a method of assessing the effectiveness of hazard warning signs for roads in New Zealand. The four measures used in the project were considered to have worked well as a whole, with the two measures of conspicuity and static comprehension showing the greatest consistency. (Static comprehension was the participant’s correct identification of a sign when presented with a still image at the end of the experiment, as opposed to dynamic comprehension, which was the participant’s correct identification of a sign when asked to look out for and name it during a video sequence.)

If local authorities and transport bodies were looking for a subset of measures to use at this stage, then these two – conspicuity and static comprehension – would be of the most use. The remaining measures – sign priming, dynamic comprehension and sign recognition memorability – all also offered considerable benefits, but needed additional work to refine the methods used to collect and test data about them.

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Assessment of hazard warning signs used on New Zealand roads, Land Transport NZ Research Report 288. See page 4 for details about obtaining reports.

Research funding 2006–07

To see the full list of research projects funded through the National Land Transport Programme for 2006–07, please visit www.landtransport.govt.nz/funding/nltp/docs/research-education-training.doc.

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Expressions of interest due soon

Land Transport NZ is shortly to seek expressions of interest for its 2006–07 research programme. The expression of interest document for the 2006–07 research programme tender process is available on our website at www.landtransport.govt.nz/research/funding-process.html.

Change of research management

Previously Land Transport NZ’s research programme has been coordinated through our Christchurch Regional Office. This responsibility has recently shifted, with all aspects of the Land Transport NZ research programme now being managed by the Land Transport NZ Programmes team at National Office in Wellington.

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