There's a Fraction, too little Friction

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ABSTRACT

In the mid-90's, Transit New Zealand embarked on an intensive programme to improve the state highway surface friction. This work involved policy development, establishing risk-based investigatory levels, extensive training/upskilling of managers/suppliers combined with a range of extensive remedial treatments to improve road surface friction.

Initial indicators displayed a dramatic reduction in wet-road loss of control crashes on the state highway network. Eight years on, measurement and investigation of problem sites and proactive treatments of these sites is an integral part of the overall pavement maintenance and management methodology.

Transit is now embarking on a review of the current investigatory levels with a view to targeting an appropriate level of funding related to the potential risk of wet road loss of control crashes. The key attribute in determining initial Investigatory Levels was the relationship between wet road crashes and surface friction. A significant investment in appropriate surface treatments has seen a vast improvement in overall skid resistance. The review of Investigatory Levels will allow Transit to focus on high-risk areas and target appropriate surface treatments to areas of greatest need.

1. INTRODUCTION

Skid resistance is important – *where the rubber meets the road* is a key determinant for any driving experience. All road users require a smooth and safe surface to drive on, which in turn provide adequate braking characteristics.

Transit New Zealand as a responsible Road Controlling Authority places huge importance on providing a safe road surface. Typically, more than 50% of the annual maintenance expenditure for the state highway network is focussed on maintaining and improving road pavement formation and surfacings. Transit New Zealand's policy for skid resistance was developed back in the early 90's and initially paid huge dividends in reducing the wet-road loss of control type of road accidents. This policy is now in the refinement stages where the focus has shifted to addressing the upper and lower extremities of network surfacing issues, to ensure that all road users get the best 'bang for the buck'.

Continuous improvement and the implementation of new innovative techniques and technologies, together with continual upskilling of roading engineers and practitioners, is required to ensure road surfaces provide the road users with safe, effective and durable driving surfaces.

Background

In the 1970's and 1980's, what was then the National Roads Board, developed broad guidelines for improving skid resistance on road surfaces. Developments reached a milestone in 1990 when the newly formed state highway (SH) road controlling authority Transit New Zealand carried out the first network skid resistance survey of the state highway network using Sideways-Force Coefficient Routine Investigation Machine (SCRIM). Following this survey Transit New Zealand decided to repeat a survey of the network every three years. Subsequent to this first survey the resealing specification P/4 was altered to ensure roading engineers considered using appropriate polish stone value (PSV) aggregate when resurfacing roads, but at this stage it was not mandatory albeit more of a guide. The next SCRIM survey took place in 1995, with the results showing that more than 25% of the SH network was at, or below international criteria, for skid resistance. This prompted a Board Submission to be written to the Transit New Zealand Authority suggesting that an interim policy for treating any road surface that had a value of 0.15 or greater, below the international criteria.

Given the significant work that was happening in Europe and the UK at this time, WDM (UK) Ltd were engaged to review the international investigatory levels and subsequently produced a report entitled "Investigatory Wet Road Skid Resistance Levels for the New Zealand State Highway Network" in 1997. This policy statement adopted the UK standards, analysed against the New Zealand road environment and New Zealand accident rates with some minor modifications. The stunning outcome from this report was the fact that a benefit cost ratio of 40 was derived, demonstrating the potential benefits for Transit New Zealand in adopting this policy through treatment of the high-risk areas on the state highway network.

The Submission to the Board in 1997 No.CS/097/6/2670 stated "Correlation and regression analysis of the 1995 survey data have shown that there is a statistically significant relationship between wet road accident rate and skid resistance although this relationship was found to be second order rather than direct". An independent statistician also endorsed the findings from this report. This Submission to the Board was a landmark event and recommended the development and implementation of a targeted policy, supported by various improvement initiatives.

A taskforce was set up to look at skid resistance called Transit's Skid Technical Advisory Group, which continues to operate today, assessing and prioritising various skid resistance developments.

Following the WDM report, Transit New Zealand developed its own technical specification called T/10 for management of skid resistance across the entire SH network. The implementation of this specification was supported by various skid resistance workshops held throughout the country to raise the level of awareness and practitioners understanding. T/10 sets out a table with various investigatory levels outlining the levels of risk across the network and provides skid resistance values, which are termed Investigatory Levels. Trigger Levels were then derived at 0.1 below these Investigatory Levels, where prompt action was required to investigate and treat sites, and this is typically defined as the current levels of service for network skid resistance.

Following the implementation of T/10 the Australian states got together through the Austroads research programme and initiated a research project to develop a set of Australasian Guidelines for the management, measurement and analysis of skid resistance for road controlling authorities. The results from this 5-year project came to fruition in early 2005 when the Austroads *Guidelines for the Management of Road Surface Skid Resistance"* were published.

Benefits

Following the implementation of the T/10 specification in 1997, Transit New Zealand engaged a consultant to carry out an investigation of the crash rate, both pre and post the implementation of this policy. This was necessary to demonstrate whether or not the specification had been effective in reducing the wet-road crash rate. Because the policy had been based on predictive accident savings, it was extremely pleasing to find that a survey in 1995 pre the specification implementation and post in 1998, clearly showed that there had been a significant reduction in the wet-road crash rate in the order of **30%**. These savings were outlined in a Submission to the Transit New Zealand Authority No.CS/00/9/3746. This submission demonstrated that there was a significant decrease in wet-road loss of control crashes on the state highway network.

This finding vindicated the original benefit cost ratio of 40. A dramatic example, which emphasises the drop in crash rate following targeted improvements to particular sites, is a section of State Highway 2 north of Wellington under the Petone overbridge. This site had an unusually high crash rate post treatment (both wet and dry weather loss of control crashes). Following treatment with a premium high friction clacined bauxite surfacing the crash rate dropped dramatically – with the higher friction surfacing reducing crashes from 11 per month on average, to only one or two per year.

Other benefits to come from the implementation of Transit New Zealand's policy in the mid 90's was ensuring that the dollars invested were targeted on the high risk, high gain areas. The policy outlined three stages of action on the results from the annual skid resistance surveys:

1) Significant lengths of network below Threshold Levels requiring prompt investigation and treatment,
2) Lengths of network below the Investigatory Level but above the Threshold Level that could be programmed for the following years treatment.
3) Isolated short lengths of network that could be treated as part of the normal maintenance regime.

Other initiatives to come from the implementation of this policy included:

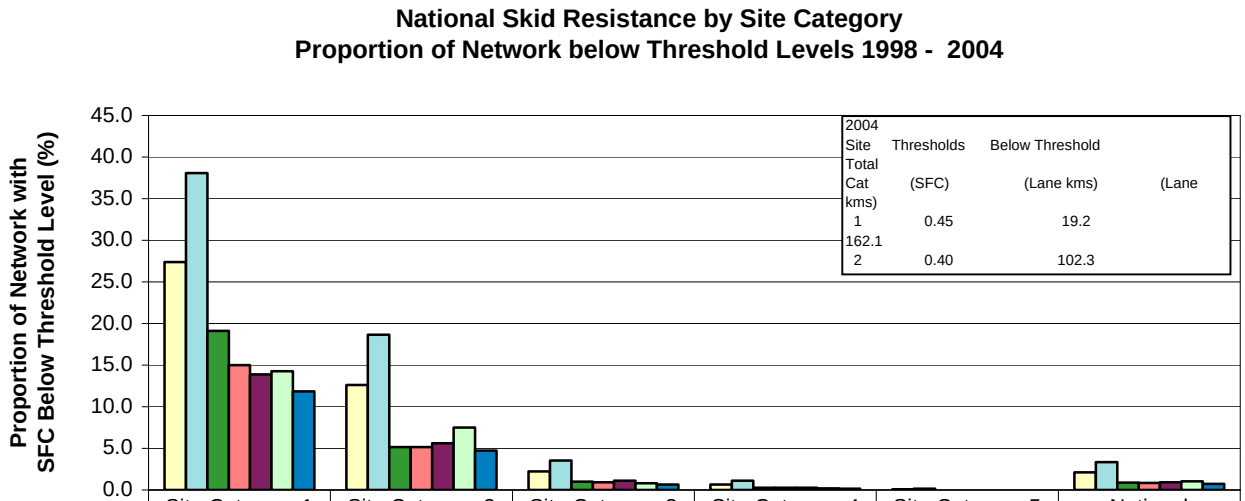
- various technical workshops around New Zealand,
- a full set of technical notes were produced for presenting at these workshops,
- conference papers,
- explanatory guidelines/memos,
- a polish stone value chart was produced to help practitioners determine where these higher PSV aggregates could be sourced from Quarry locations; and
- that Transit would continue to carry out annual surveys of the entire state highway network, measuring in both wheel paths and both directions and on multi-lane roads in the heavily trafficked left-hand lane.

Current

Transit New Zealand continues to carry out annual network surveys. Transit New Zealand together with WDM (UK) Ltd have initiated various improvements to the SCRIM survey vehicle, which is now called the SCRIM+, denoting the fact that it has various innovative technologies on board and is one of the most unique and technically advanced network surveys vehicle in the world at this point in time.

As network survey is undertaken each summer, exception reports are produced using raw data and these are supported with photos for sites that are shown to be dramatically below the Investigatory Levels. These reports are delivered as each network management area has been surveyed and allows the road manager to promptly inspect these sites and determine if urgent treatment is required.

Given that surveys have been happening continuously since 1997, Transit New Zealand has been able to review the results over a number of years, develop trends and monitor changes in average skid resistance across the whole network year-on-year – refer to Figure 1. Current research initiatives include the investigation and analysis of the minor inconsistencies that arise during a full network survey and some of the changes in network results from year-to-year. Two years ago Transit New Zealand implemented a factor for correcting the survey results called Equilibrium SCRIM Coefficient (ESC). This factor enables the annual results to be adjusted to take account for some of the average variations that are evident from year-on-year comparisons and help reduce sudden swings in annual data.



	Site Category 1	Site Category 2	Site Category 3	Site Category 4	Site Category 5	National
1998	27.38	12.60	2.23	0.67	0.06	2.12
1999	38.07	18.64	3.54	1.12	0.15	3.33
2000	19.13	5.16	0.99	0.26	0.01	0.90
2001	15.02	5.15	0.93	0.26	0.00	0.85
2002	13.88	5.60	1.12	0.26	0.01	0.92
2003	14.27	7.49	0.80	0.19	0.01	1.03
2004	11.84	4.74	0.66	0.15	0.00	0.72

Figure 1 - Source: Transit New Zealand SH National Pavement Condition Report 2004

Issues

One of the main challenges in undertaking a network survey is using the results for network analysis versus assessment of the data at a project specific level. As results are taken every 10 metres, project specific information can be investigated on site but due to the fact that 22,000 lane kilometres is measured in a short period of time, there is always going to be inconsistencies at the upper and lower limits. There will always be a constraint in project specific accuracy requirements versus cost/time/volume of data for network type analysis.

Another important consideration is the timely and appropriate treatment once the results have been analysed. The initial survey in 1997 identified many sites that required treatment. This then results in some overhasty resurfacing to be undertaken, which interrupted the traditional reseal cycles and in some cases this caused an imbalance through over-zealous resurfacing with a total focus on addressing the skid resistance issues yet jeopardising appropriate resurfacing techniques. The result is which we have sometimes ended up with inappropriate seals being put down that have subsequently resulted in premature flushing and bleeding, thus compounding to the skid resistance problems.

While the SCRIM survey is predominantly focussed on microtexture, surface texture or macrotexture is also measured concurrently and is analysed alongside the skid resistance results. More recently there has been a stronger focus on minimum macrotexture requirements and this has been compounded by the challenges faced in trying to achieve quieter surfaces, yet provide adequate macrotexture to reduce the risk of vehicles aquaplaning. With the stronger focus on macrotexture this has been difficult to achieve and is contrary to the general move to quieter road surfacings. There are also compounded

social and environmental conflicts recently experienced through the banning of road burning, the challenges over road surface noise constraints in built-up areas, and traffic delays when traditional resurfacing is undertaken on highly trafficked roads.

Transit New Zealand is also experiencing a stronger cycling lobby and their views to have smoother, faster road surfaces with the minimal friction, particularly from competitive cyclists training and travelling at very high speeds on the highway network.

On the premium or high friction surfacings (typically defined as having PSV requirements <65, which naturally occurring aggregates cannot provide there are issues from surface delamination. Typically at these high friction sites, due to the increased tyre/surface stresses through increased tyre grip, in some situations this can result in the top surface breaking away from the underlying pavement layer. There is also some risk of higher vehicle speeds through these high friction sites, especially on tight corners, which in turn can lead to the transfer of crashes to the next corner, where the surfacing or friction may not be as high.

Transit New Zealand is also planning to review the current polished stone value policy. The PSV is a predictor of the ultimate state of stone polishing and is used to compare various aggregates sources. Typically, it is not necessarily a direct predictor of in situ polishing or performance of the stone, particularly in multiple event areas. While the T/10 specification does allow for the investigatory levels to be modified in the multiple event areas, there are some areas and challenges in determining an appropriate PSV aggregate, that will last for the life of the surfacing. The larger vehicles are predominantly the primary cause of stone polishing and with the significant increases in heavy commercial vehicles on the state highway network, if these increases are not forecast, premature polishing of the surface occurs. The loss of one or two years predicted life of a road surface has significant financial implications.

The SCRIM survey is a snapshot in time and identifies all deficiencies on the road network, whether permanent or temporal. For example, where we may have a flushed pavement repair and subsequent binder carryover or bleeding, will track over a significant length of road. While this binder carry over is present it masks the microtexture of the surface aggregate causing a temporal loss in surface friction. This binder carryover will typically wear off during the winter months causing the road surface friction levels to revert that provided by the aggregate. The challenge is to prevent the bleeding occurring and thereby reduce any potential short-term risks to motorists.

Into the Future

Given some of the issues that we face, Transit New Zealand is looking at a range of actions to address these challenges and lead the charge in a proactive approach to skid resistance into the 21st century and beyond. The following are some of the areas that Transit New Zealand, together with a range of supplier expertise, is exploring with a view to continuous improvement and hopefully make the driving experience safer and more pleasurable for our customer - the road users.

We are going to undertake a full review of the Investigatory Levels as seen in T/10 specification. Currently, where a tight curve, which is a site category 2, straightens out and becomes a site category 4, this sudden category change can cause a significant change in the skid resistance value as specified in T/10. We are looking at a more integrated approach adopting what has been utilised in the UK for the Welsh Assembly and the Scottish Executive.

Research in the United Kingdom has suggested that a move to provide a range of Investigatory Levels for each category type. The advantage of this approach is that sites that are considered to be lower in risk and found not to justify treatment, can have the Investigatory Levels reduced. They may then comply with the revised skid resistance Investigatory Level requirements. This means that these investigated sites can then be removed from the pool of sites identified for investigation each year, allowing effort to be concentrated on those sites where improvements are required. Alternatively, certain sites presenting a greater risk of skidding accident than would be expected for the particular site would justify a higher IL. A similar study for Transit New Zealand using State Highway data has recommended that a similar approach might be beneficial for use in New Zealand[1].

The implementation of this approach will allow some flexibility in assigning skid resistance values to the network and the adoption of a more appropriate use of the risk-based analysis for determining the appropriate investigatory level. The current trigger levels, which sit at 0.1 below the investigatory levels where action is required, is defined as Transit New Zealand's current level of intervention. This will also be reviewed as part of our ongoing refinement of the level of service provided.

Seasonal variations that affect the SCRIM survey results, require factors to be applied to the survey results that may adjust the survey readings and are largely dependant upon the weather immediately prior to the survey. A research project is proposed to look at how these seasonal corrections are derived and to what area the benchmark's sites which are measured before, during and after the full survey, apply to the results, and the area to which these adjustment factors are applied.

Transit New Zealand is reviewing the contractual procurement for the network condition survey. Given the specialised equipment used to measure the network, and the expertise required to capture, analyse and report this data, Transit New Zealand is keen to ensure that this expertise is maintained at reasonable cost. History has shown that changing suppliers can influence the results with shifts in the overall data as seen in the past swinging in the order +/- <10%. Given the importance on this data and programme of work that it drives, it is important that the highest calibre of equipment and personnel to carry out this network survey is acquired. With the shift in the competitive pricing and procurement options, Transit New Zealand is looking at all options, to ensure we obtain the best supplier with the most current international leading edge expertise.

Transit New Zealand will continue to monitor the crash rate on our highway network, to ensure that our skid resistance policies are delivering an effective result in reducing wet road crashes. The most recent analysis shows that the wet-road crash rate is still declining, which is very pleasing to note, confirming that the Transit New Zealand policy is continuing to target wet-road accidents, where vehicles braking in wet conditions are most vulnerable – refer to Figure 2.

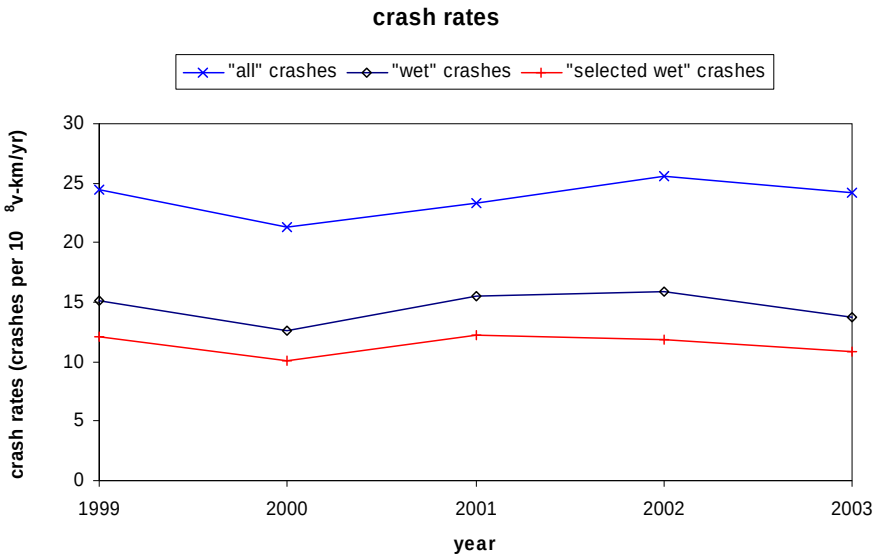


Figure 2 – Source: Opus report "Statistical Analyses of SH Crash & Skid Resistance Data: 1999-2003"

Transit New Zealand also propose to review the current polished stone value policy. High PSV aggregate is a limited resource and with Transit New Zealand's new strategic plan focussed on recycling and sustainability we want to ensure that we target the use of this limited and valuable resource in the most high-risk, high-value areas.

Given the drive towards sustainability, waste minimisation and recycling of existing materials, options such as rejuvenation of existing material and looking at alternative materials that provide adequate levels of skid resistance are something that we hope to pursue in conjunction with our key suppliers and stakeholders. Transit New Zealand will also be focussing on our contractual performance measures to ensure that these deliver value for money and that we target the highest risk areas. We will also be targeting our site category 1 and 2 and our urban network which currently still have the highest percentage of sites that require treatment.

As technology advances we will be looking at how we accurately locate the survey results on the network and ensure that the site categories apply exactly to the corresponding areas on the network. With the technology of our spatial centre line and more accurate GPS readings, this will allow us to more accurately locate the site category locations and ensure that results year-on-year have even greater consistency.

Summary

Transit New Zealand is currently at the leading edge internationally in terms of its skid resistance policies and initiatives. Our annual survey of the state highway network has bought about change in places like the UK where traditionally they measured one-third of the network every three years. In conjunction with WDM (UK) Ltd, who have adopted new technology through a fully integrated survey vehicle, thus enabling the various network condition characteristics to be measured all at one time and provide a consistent set of survey results. These innovations are seen internationally as being at the cutting edge of network condition measurement.

Transit New Zealand and WDM have worked together to bring about these improvements and ensure that the results from the survey are accurate and applicable to New Zealand road conditions. This is extremely important as we see these results from the survey are

used to trigger treatments and investments in road surfacings and more importantly, are used in Court to defend Transit New Zealand's position in providing adequate skid resistance when there has been a crash, where loss of skid resistance has been one of the alleged causal factors.

Our dramatic impact on reducing the initial 25% deficiency in skid resistance identified in the early 90's, has bought about a significant improvement in the overall network skid resistance, and are well within the targets set in Transit New Zealand's Statement of Intent.

Transit New Zealand has made huge inroads in lifting the skill set in terms of people's knowledge and understanding on this challenging and technical network pavement condition measurement. The investment that Transit New Zealand has made over the last 10 years has been especially rewarding through the dramatic reduction in wet road crash rate. All those who have worked together to develop and implement this policy should be proud of the achievements they have made in ensuring that our state highway road network is safe.

Reference [1]: Cook. D; Donbavand. J; Kennedy. C. **A Review of Skid Resistance Investigatory Levels for New Zealand,** Towards Sustainable Land Transport Conference, Wellington New Zealand 21 – 24 November 2004