INNOVATIVE SURFACING TREATMENTS DELIVERING SAFER ROADS

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ABSTRACT

A number of cost-effective, innovative surfacing treatments have been developed in New Zealand for low volume roads. This paper describes a sample of these innovative surfacing treatments from throughout New Zealand.

Significant changes to asset management models and practices during the past 15 years include increased reliance on network surveys of skid resistance and texture depth to identify sites that require treatment. All maintenance and construction on all New Zealand public roads must be contracted out. Combined with constrained budgets limiting resurfacing treatment lengths, this has encouraged substantial investment by industry in new developments and innovation, in order to extend the road maintenance budget; the innovative treatments described in detail in the paper include:

- Modern computer-controlled sprayers have been developed to apply bitumen at rates that vary transversely across the lane width and are being used when chipseal surfaces have insufficient macrotexture in the wheeltracks as well as a preventative measure for binder rise in the future
- Ultra high-pressure watercutting is being used to improve both macrotexture and microtexture of surfacings on low volume roads
- Thin and ultra thin textured gap graded hot mixes are being used in high stress high trafficked areas.

The actual performance to date of these treatments and strategies are discussed in the paper.

A new sustainable treatment is the ultra high-pressure watercutting of polished surfacings to re-texturise the surface back to that of a near new surfacing. This paper presents results from initial research results into this sustainable surfacing treatment as well as the results from up to 9 years monitoring of the other innovative sustainable treatments listed above. The monitoring of the treatments includes skid resistance, texture depth, performance, and safety.

In order to ensure the programme of treatments is always optimised, a holistic approach to solving skid and texture deficiencies on sealed roads has been developed. This holistic approach utilises the numerous innovations and developments implemented in New Zealand, and is described in the paper.

Combining the wide range of state-of-the-art surfacing treatments described in this paper with best practice in asset management in a cost effective sealing and maintenance programme has resulted in significant improvements in road safety, while also ensuring the required performance of the pavements.

INTRODUCTION

Significant changes to asset management models and practices in New Zealand and Australia during the past 15 years include increased reliance on network surveys of skid resistance and texture depth to identify sites that require treatment. With constrained budgets limiting resurfacing treatment lengths, this has encouraged substantial investment by industry in new developments and innovation, in order to extend the road maintenance budget. Some of these treatments are:

1. Variable transverse application of binder for chip seals

   The traditional technique for designing sprayed seals involves the calculation and use of an average application rate for the whole road surface which could apply too much binder in the wheel tracks and/or not enough on the shoulders, centreline and between the wheeltracks. Variable transverse application of binder for chip seals allows the binder to be applied at the required rate for each 100 mm section across the road surface and along the seal length reducing the risk of flushing and chip loss associated with the current method of binder application.

2. PAVEtex – ultra thin asphaltic surfacing

   PAVEtex is a mix developed specifically for laying in ultra thin layers (minimum 15mm) to provide surface texture, durability, and minimise the use of roading materials. PAVEtex is commonly used in areas where chipseals are failing due to shear stress, shade, and dampness.

3. Ultra high-pressure (UHP) watercutting to restore macrotexture on bitumen rich surfaces (by removing excess bitumen) and to restore microtexture to polished surfaces

   UHP watercutting was developed as a response to the growing problem of excess bitumen on the surface of New Zealand roads. Burning was the common treatment for this problem until 2000 when the burning process was banned. An added benefit of watercutting the surface is that a modification of the process significantly improves the microtexture of polished stones. Previously polished surfacings had to be resealed a wasteful use of good quality aggregate.

This paper documents the results of monitoring of the sites where these products and techniques have been used. Skid resistance and surfacing texture are a high priority for New Zealand State highways and low volume roads, in order to provide a safe driving experience for road users. The monitoring includes skid resistance, texture depth, using data from skid resistance surveys and accident monitoring from the national database.

VARIABLE TRANSVERSE APPLICATION OF BINDER

Fulton Hogan designed and built its first variable application rate bitumen sprayer in 1996, which is capable of spraying a different application rate of binder in each 100mm section across the width of the bar, as illustrated in Figure 1. The variable application rate bitumen sprayer bar was also infinitely variable in width from 100mm up to 5.0m as it was constructed with a telescopic bar.

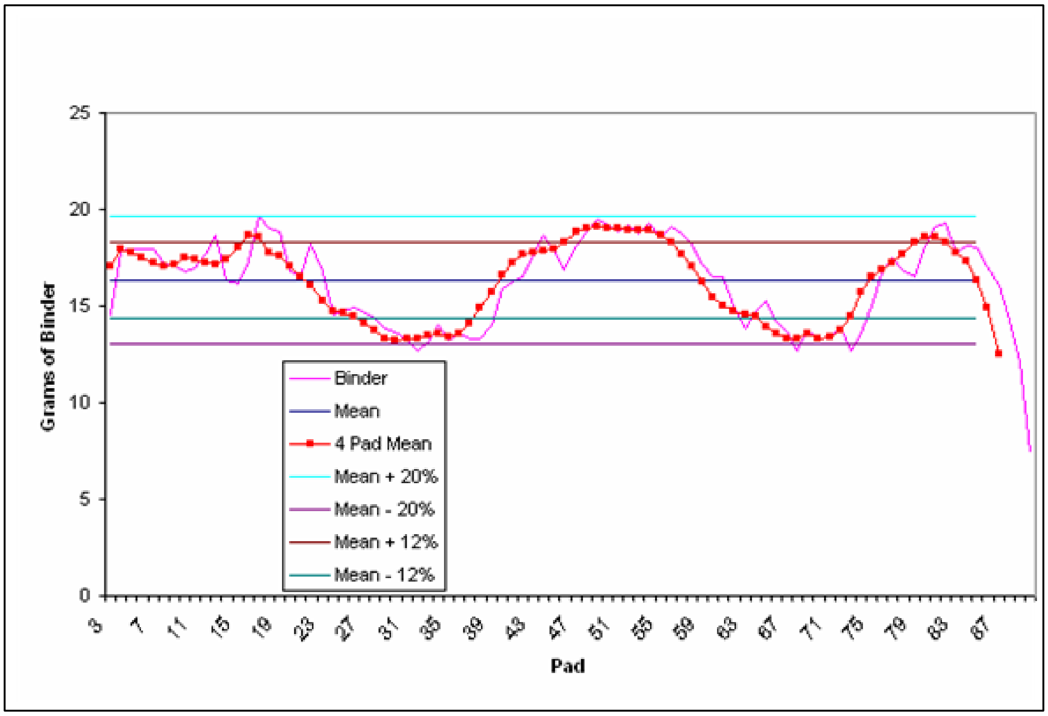

Figure 1: Tai Tapu Trial Variable Binder Application Rate – Binder Mass per Pad.

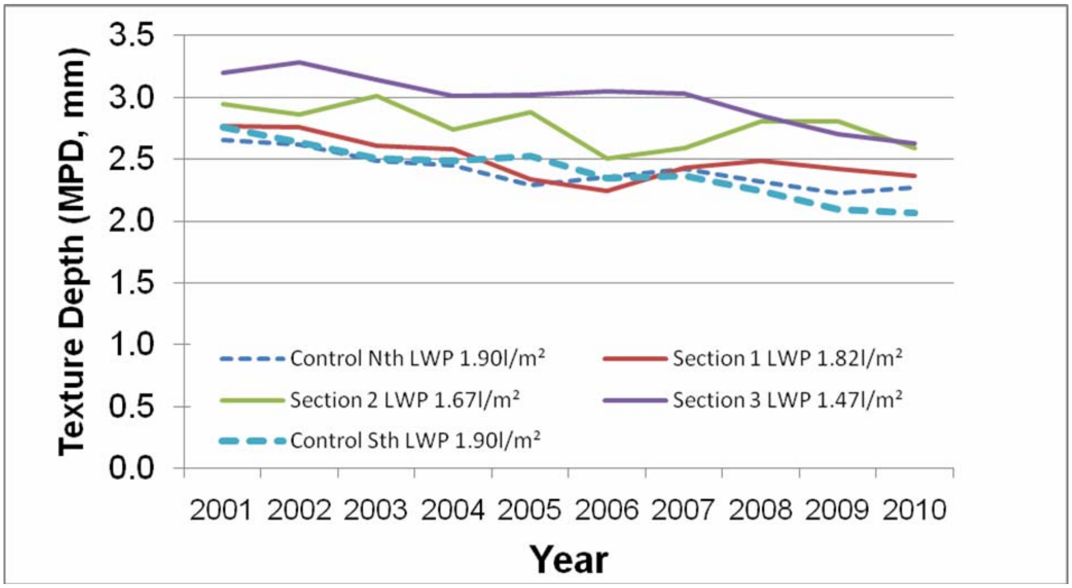

Figure 2: Tai Tapu Trial Variable Binder Application Rate - Texture Measurements.

This process allows the bituminous binder to be applied at the required rate for each 100mm section across the road surface and along the seal length reducing the risk of flushing and chip loss associated with the specified calculating method of binder application rates. The standard New Zealand design method (1) involves the calculation and use of an average application rate for the whole road surface which could apply too much binder in the wheel tracks and/or probably not enough on the shoulders, centreline and between the wheeltracks.

If sufficient binder is applied to retain the sealing chip on the shoulders and centreline so there is no chip loss, as is the case for most seals constructed in New Zealand, and if the same binder application rate is used for the wheeltracks, as is the case for most seals, then all of these seals have used more binder than required. This is a waste of a non-renewable resource (bitumen) and shortens the life of the seal (earlier loss of texture) that then requires earlier treatment that may involve the use of more binder and aggregate in another reseal.

Using the variable application rate bitumen sprayer allows the application rate to be reduced for the wheeltracks while maintaining an adequate application rate for the rest of the seal. The size of the reduction can be varied from 5% to 30% depending on the texture depth of the surface in the wheeltracks and whether there is excess bitumen present. Successful variable application chipseals have been constructed in the Canterbury region for the past ten years with no chip loss in the wheeltracks related to the binder application rate. One of the first trial sites was constructed at Tai Tapu on State Highway 75, southeast of Christchurch.

Pad tests were carried out to record the quantity of binder applied transversely across the surface; this involves weighing and laying out a set number of dry absorbent pads across the width of the lane, running the sprayer at operating speed over the pads, and removing and weighing the bitumen-soaked pads from the road, to determine the bitumen application rate. Figure 1 shows the results of one of these tests with less binder applied in the wheelpaths than elsewhere.

The texture depth was related to the reduced amount of bitumen applied to the trial sections, when compared with the control sections that were sealed with the traditional application rate that was uniform transversely. Ten years after sealing, after compaction by traffic, binder rise and reorientation of aggregate, the sections with less binder in the wheelpaths (ie test sections 2 and 3) still have greater texture than that of the control sections and test section 1, which contain substantially more bitumen in the wheelpaths.

Between 2001 and 2010, the changes in texture in the north control section, test section 1 and test section 2 have been the same (0.4 mm), but the texture depth in test section 3 (which had the least binder sprayed in the wheelpaths and the greatest texture initially) has decreased by 0.7 mm, and the texture in the south control section has decreased by 0.7 mm. This suggests that change in texture depth is independent of the initial binder application rate.

These results are validated by the large number of successful variable application seals constructed over the past eight years that have had a binder application rate reduction of 10% or more in the wheeltracks compared to the standard application rate, and have performed better than the seals constructed using transversely uniform binder application rates.

Using variable application rate sprayers is an environmentally-sustainable practice because it reduces the quantities of bitumen sprayed. Approximately 3000 km of resealing is carried out in New Zealand each year. If the average width of each wheelpath is 1 metre then each kilometre of resurfacing contains 4000m² of wheelpath that is having too much bitumen applied to it. If the average application rate is 1.5 l/m² and the application rate is reduced by 10%, 0.15 l/m² of bitumen is saved. This could equate to a reduction in waste of 1,800,000 (= 4000 x 3000 x 0.15) litres of bitumen per annum.

A number of road authorities throughout New Zealand and Australia are now requiring that binder be sprayed at appropriate rates for the traffic and texture distribution across the road surface to extend seal lives. This can be done using conventional sprayers but does create some minor problems such as increased longitudinal joints and extended time for uncovered binder while the different application runs are sprayed. The variable application rate bitumen sprayer with infinitely variable width adjustment and variable distribution produces fewer joints and the joints produced are more accurate. Binder is covered with chip as per normal seal construction methods.

A lower seal frequency means less waste of non-renewable resources from the resealing and a longer pavement reconstruction life cycle, by preventing the build up of multiple seal layers that can result in an unstable mass in the wheel tracks.

PAVE*TEX* – ULTRA THIN ASPHALT – FOR THIN ASPHALTIC SURFACING

PAVEtex is a mix developed specifically for laying in ultra thin layers (minimum 15mm) to provide surface texture, durability, and minimise the use of roading materials. PAVEtex is commonly used in areas where chipseals are failing due to shear stress, shade, and dampness.

There are two different PAVEtex materials: a PAVEtex 12mm ultra thin asphalt surfacing laid to a minimum depth of 15mm and a PAVEtex 15mm ultra thin asphalt surfacing laid to a minimum depth of 20mm on higher stress sites.

The PAVEtex 12mm mix has been laid on a number of sites throughout New Zealand but mostly in the Waikato region where it was first developed in 1999.

Monitoring data from these sites show the 12mm Pavetex mix consistently maintains a texture depth 0.9 to 1.1mm over a number of years. An example of this performance is from Kirikiri on State Highway 25. The site is located in a steep sided gorge, the surface is shaded by bush and remains damp during the winter months.; the hot mix asphalt concrete (with a maximum particle size of 10 mm) was constructed in December 1998, and the adjacent Pavetex (with a maximum particle size of 12 mm) was placed in June 1999. The texture depth on both sections has been measured annually, and is shown in Figure 3. The PAVEtex UTA 12mm has performed well with the average texture of the surface remaining above 0.90 mm until 2008, with no unravelling or cracking, but there are minimal areas of pavement distress now. The 10 mm hotmix exhibited significant areas of distress, including delaminating and unravelling, that has resulted in an increase in the average texture depth for the surface in the past annual surveys since 2004.

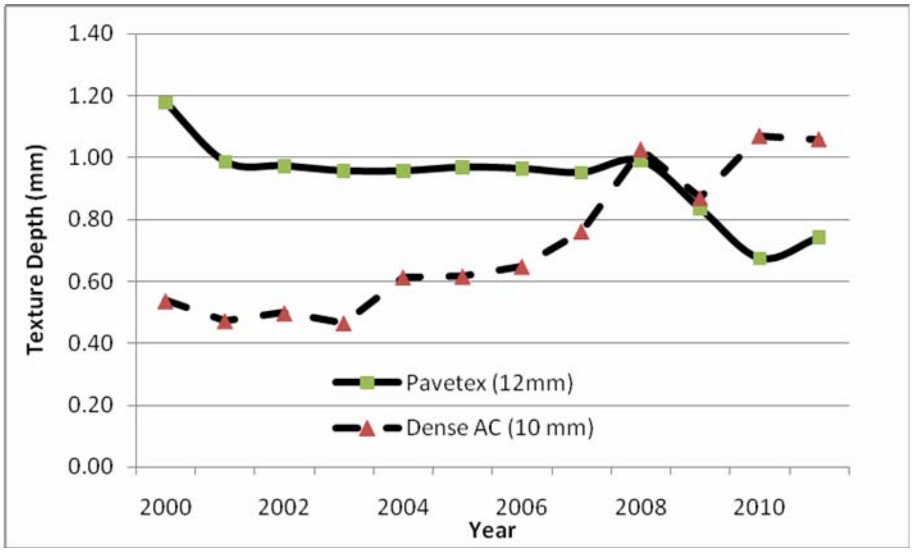

Figure 3: Texture Depth of Pavetex Compared with Dense Asphaltic Concrete.

A major advantage of PAVEtex is that the very thin layer uses a minimal quantity of non-renewable resources such as the bitumen and aggregate when compared with other thin asphaltic surfacings. This is especially important when expensive and rare high Polished Stone Value (PSV) chip is required; the cost savings in these situations is an added bonus.

In some areas crushed recycled glass is being incorporated into the mix to add further to the sustainability nature this product provides.

PAVEtex 12mm has been included in a trial on the Fairfield Motorway south of Dunedin where a range of surfacings that produce less noise under traffic have been laid to comply with the consent conditions of the project. The noise emissions from these surfacings and PAVEtex 12mm are currently being monitored under traffic. The noise emissions from PAVEtex under traffic are less than those from chipseal and asphaltic concrete but higher than those from porous asphalt (2).

ULTRA HIGH-PRESSURE WATERCUTTING TO RESTORE MACROTEXTURE

Ultra high pressure (UHP) watercutting was developed as a response to the growing problem of excess bitumen on the surface of New Zealand roads. Burning was the common treatment for this problem until 2000 when the burning process was banned because it pollutes the atmosphere and destroys the road surface structure.

In April 2000 the first trial of an ultra high-pressure pump with a small cutting head was carried out to remove bitumen from a flushed thin asphaltic surfacing. The results of that trial lead to the development of the UHP Watercutter machine that has been used to restore the macrotexture on flushed sites throughout New Zealand (Figure 4). The UHP watercutting process has been developed to cut the uppermost surface with fine needles of water travelling at 1800 km/h; the energy is dissipated on contact. This allows bitumen to be removed with minimal effect on waterproofness, and chip loss, and to be safely repeated a number of times without harm to the surface. The other suitable options to treat flushed sites all require surfacing using non-renewable resource to ensure the integrity of the surface.

Figure 4: Ultra High Pressure Watercutter in Operation.

The initial application had been to use the UHP watercutter solely as a maintenance treatment in replacement to the burner that had been used for so many years. Monitoring of the macrotexture and microtexture data on continuous lengths of watercut surfaces has shown that in most cases the re-texturised surface is returned to the condition of an unpolished but traffic worn surfacing.

The Northern Motorway in Christchurch was resealed in 1996. The reseal life was expected to be ten years but the first section failed (due to low skid resistance) after six years. A 300m site on the Northern Motorway was divided into three sections; one was watercut in January 2002; the third was watercut in August 2002; and the middle section left untreated. Figure 5 shows the texture and skid resistance data for this site slowly reduced over time from the refreshed levels. The entire site was resurfaced in 2010, eight years after the watercutting treatment which more than doubled the life of the seal extending it beyond the 10 year design life.. The uncut section continued to deteriorate and was left as an untreated section as a comparison however some spot treatments were carried out to keep it safe during the monitoring period. UHP watercutting extends the life of surfacings by refreshing the macrotexture when traditionally the site would be resealed. The increase in surfacing life ranges from months to years depending on the site and cause of failure. The Northern Motorway site was failing on both texture and skid resistance due to flushing in isolated areas; in the past the entire treatment length would have been resurfaced or burnt then resurfaced the following season. Watercutting was carried out only on the areas that were failing, 4% of the total area.

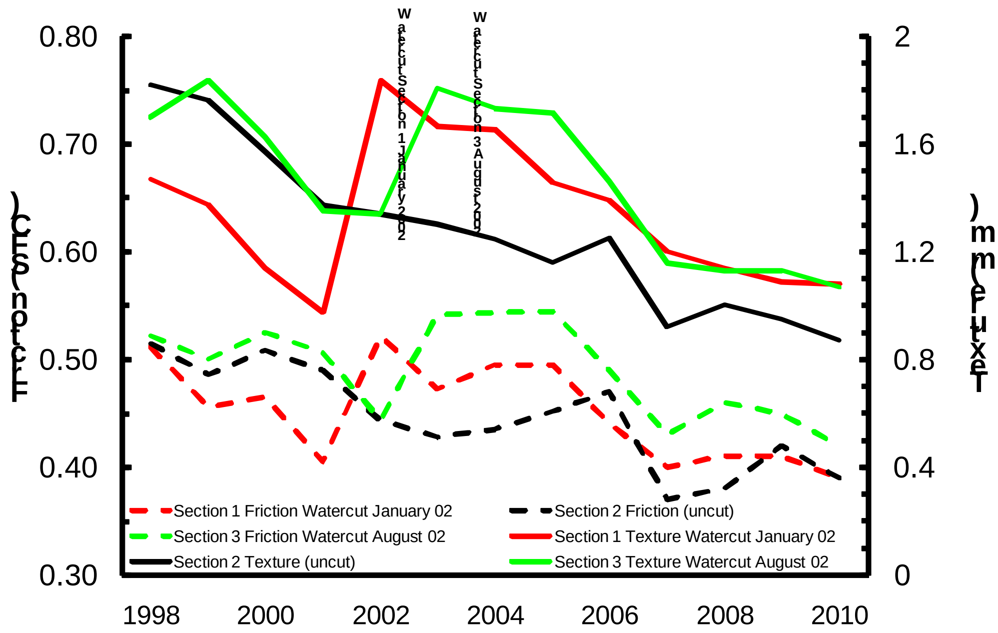

Figure 5: Comparing Performance of Re-texturised and Untreated Chipseal Test Sections.

ULTRA HIGH-PRESSURE WATERCUTTING TO RESTORE MICROTEXTURE

The monitoring of sites like the northern motorway site indicated that the watercutting process may be refreshing the microtexture on the surface of the aggregate, and that the deterioration in texture of a re-texturised seal may be comparable to that of an untreated seal (Figure 6). After small scale experiments were carried out to demonstrate that the watercutter did refresh the microtexture, field trials using sites with polished aggregate, but good macrotexture, were conducted.

Figure 6: Polished Aggregate before (on left) and after (on right) Ultra High Pressure Watercutting.

After a series of experiments, a process to refresh microtexture using the ultra high-pressure watercutter was established. However, there is no data on which to base a lifecycle, so trial sites had to be established and monitored.

A research project comparing the life cycle costing of water cutter rejuvenation of low PSV aggregates versus using high PSV aggregate surfacings on high stress high-risk sites started in 2003 and continued for the next two years (3). Ten trial sites, covering a range of surfacing types, aggregate types, traffic counts, climate and road geometry, were selected on the basis of having low skid resistance but adequate macrotexture (ie the sites contained aggregate that was polished, but there was no flushing or excess bitumen). A large portion of each of the sites was resurfaced leaving a section to be watercut as soon as possible afterward. The sites were being monitored for skid resistance, texture, accidents, climate and performance.

The skid resistance of the polished sites was improved, but the length of time the improvement in skid resistance (created by UHP watercutting) lasted varied significantly depending on the original surface treatment and other factors. Due to the large number and varied nature of these factors, which would require a relatively expensive and extensive research programme to resolve, there is no further research envisaged to establish the conditions under which water cut sites do not maintain the initial gains. That decision is left to experience and engineering judgement.

Prior to this process, the only treatment for a polished chipseal or asphalt surface was to resurface it. Normally this required resurfacing of the whole treatment length to ensure that the site surface was kept consistent. A polished surface means the aggregate had failed to provide the required skid resistance for the site, so an aggregate with a higher PSV would normally be used to reduce the rate of polishing of the surface. However if the correct PSV aggregate has been used the polishing will be restricted to the areas with the highest stress or traffic scrub on the site, this is normally only a small portion of the site which can be treated with the watercutter.

Watercutting polished surfaces extends reseal lives, reduces the requirement for high PSV aggregate, reduces the incidence of resealing because of polishing, and leaves roadmarking untouched, thereby reducing the waste of non-renewable resources such as high PSV chip, binder and paint.

CONCLUSIONS

This paper described a number of innovative technologies developed in New Zealand, that aid in achieving better performance while also being environmentally sustainable:

1. Variable transverse application of binder for reseals extends seal lives and reduces the waste of non-renewable resources.
2. PAVE*tex* – ultra thin asphalt surfacing is a suitable surfacing treatment for providing texture in high stress, high-speed environments where chipseals cannot sustain the stresses.
3. Ultra High Pressure Watercutting is a suitable re-texturising treatment for situations where the current surfacing has failed because of an excess of bitumen on the road surface.
4. Ultra High Pressure Watercutting is a suitable resurfacing treatment for situations where the current surfacing has failed because the surface aggregate has polished to an unsafe level. Functional seal lives have been extended by up to 50%.

ACKNOWLEDGMENT

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Gerard Killick is the Spray and Blending Divisional Manager, based in South Australia. Gerard started his career with Fulton Hogan in Christchurch working in various roading crews while completing a Civil Engineering Degree at the University of Canterbury in 1992. Gerard was heavily involved in the testing and certification of the first Variable Application Sprayer built by Fulton Hogan and has specialised in Sprayed Seals and Project Management in both New Zealand and Australia.