

Microsurfacing Suspended Fibre Technology – Product Innovation

Laboratory Research Investigation

Howard Jeffery-Wright – Downer Infrastructure Australia

Achint Choudhary - National R & D Downer Infrastructure Australia

Hassan Akhlaghi– National R & D Downer Infrastructure Australia

Paul Price –Downer Infrastructure Australia

Abstract

Road network maintenance strategies increasingly demand more from road surfacing applications for every dollar spent. This demand requires the development of innovative ways to get more performance from our current products.

Microsurfacing offers pavement asset managers a cost effective maintenance application that can extend asset life cycles.

A well identified constraint however of a standard Microsurfacing has been its limited performance with regard to its resistance to reflective cracking from existing pavement surface cracks.

The result of an extensive research and development project spanning over 5 years Microsurfacing **SFT (Suspended Fibre Technology)**, has been developed aimed specifically at enhancing the performance of standard Microsurfacing in relation to flexibility, to resist reflective crack development and increasing modulus strength properties.

Microsurfacing SFT meets and exceeds all standard Microsurfacing specifications and is shown to increase the performance for flexibility and modulus strength up to 50% when compared to standard Microsurfacing applications, to provide a high performance, cost effective paving material.

Introduction

Increasingly road asset owners and maintainers are seeking cost effective and innovative materials to extend pavement life and maintenance intervals while decreasing expenditure budgets¹³.

Road assets in Australia are degrading to conditions that exceed the current capabilities of standard maintenance applications or beyond the expected performance achievable of standard applications¹⁴. The reliance upon standard maintenance applications to provide higher performance requirements requires innovation and development to incorporate attributes that will deliver increased lifespan and solution to increasing demands.

The development of Microsurfacing, by the introduction of polymer technology in the mid 1980's, enhanced performance allowing application at greater depth (wheel path rutting and shape correction), improved pavement flexibility, increased resistance to deformation and improved aggregate binder cohesion. This increased the range of maintenance treatments that could be offered with Microsurfacing¹⁵.

The use of fibre in construction materials to improve tensile strength characteristics has an extensive history dating back many decades. The addition of fibre increases building and construction strength in an economical and sustainable way¹⁶. The addition of fibre into microsurfacing is designed to increase the tensile strength and improve flexibility without detriment to current specified performance requirements with results similar to those found for use of fibre in asphalt materials¹⁷. This research paper details the investigation and methods undertaken to incorporate fibre into Microsurfacing mix designs and to measure the performance attributes that are gained by this.

Materials & Methods

A number fibre types were sourced to evaluate their inclusion into a standard Microsurfacing mix design; Cellulose, Synthetic, Basalt and Glass strand.

A standard Basalt 7mm microsurfacing mix design meeting the Austroads AP-T026-02¹ specification was used as a control for comparing testing results. The mix design met the following specifications; residual binder 5.84%, SBR polymer 3%, moisture 9%, filler added at 0.25%. The aggregate gradation was as follows

Sieve Size	9.50mm	6.70mm	4.75mm	2.36mm	1.18mm	600µm	300µm	150µm	75µm
% Passing	100	99	89	59	39	26	18	12	8.7

Note: Samples washed in accordance with AS1141.12² and sieved to AS1141.11.1³

The standard mix design specified performance testing is as follows

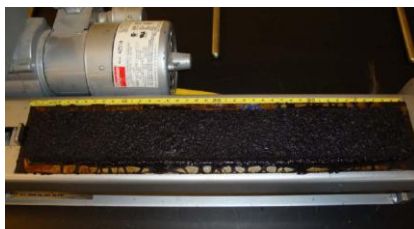
1. Cohesion using AG:PT/T271⁴ (kg.cm - 30 and 60 minutes)
2. Consistency (Flow in mm) AG:PT/T270⁵
3. Wear loss (Grams per m² - 1 hour and 6 days) AG:PT/T272⁶
4. Wet Stripping ISSA TB114⁷
5. Excess Binder content (Gram/m² - AG:PT/T273⁸)

Each fibre material was assessed by inclusion into the control design at an initial dose ratio of 0.2% by dry aggregate weight. Fibre material was mixed with the aggregate prior to addition of emulsion. Mixing was based on simulated mechanical mixing process to replicate operational field systems to ensure that fibre materials were mixed consistently through material prior to addition of binder in a similar manner to current operational machinery mixing capabilities. A stepwise assessment of each performance test (1-5) was made. If the fibre included mix design failed a particular specified test requirement then no further assessment of the material was made. Fibre included mix designs that met all the Austroads AP-T026-02 specified test methods were then further assessed for additional performance characteristics.

Microsurfacing specific performance test methods for attributes of modulus, tensile and flexural properties are not currently available or specified. A number of alternative test methods were evaluated to establish their usefulness in determining performance improvement achieved by the inclusion of fibre.

ISSA TB146⁹ conducted at 18°C. Test specimens were molded onto a flexible flat steel plate. A horizontal compressive strain of $\approx 0.5\text{mm/s}$ was applied to the plate until complete cracking of the sample was observed. This test establishes the cracking resistance of a specimen when subject to a steady rate of horizontal flexural bending and enables a direct comparison of control and test mixes.

Figure 1. Flexural Tension Test



Downer UTM Modified Material Strength Test – (Load versus time) The method used, test jig and test conditions were developed during the research and development program for this project, as it was found that there had been little work in this area internationally and there were no suitable standard methods available. The test is a controlled strain vertical pull test. Samples are cast onto a split steel backing plate; dimensions 380mm X 53mm X 10mm and cured at 60°C for a minimum 16 hrs. Testing was conducted @ 30°C with a strain Rate of 0.1mm/s. The modified material strength test measures the time and force required to produce rupture / break in the Microsurfacing test specimen with an indication of post crack initiation strength. Tensile strength can be used as a potential indicator of resistance to reflective cracking in thin surfacing materials. Initial testing was carried out on samples of standard slurry and Microsurfacing gaining information on the failure mode to determine if it would be sufficiently robust to allow good comparison of materials. This sample data was then used as a control set for assessment of the SFT materials. Zero load plate lift runs were also undertaken to give a test end point determination.



AG:PT/T232¹⁰ (MOD) Test specimens were 100mm diameter x 50mm depth cores taken from a cured slab of Microsurfacing material. Slabs of each mix under investigation were cured as standard @ 60°C for 3 days in the oven before coring. Specimens were then tested at 25°C using the general procedure in the AG:PT/232 method but without a soaked set. The test is normally used to assess moisture sensitivity of asphalt through measurement of tensile splitting strength; it was used in this application to assess tensile splitting strength of the cured Microsurfacing materials.

AGPT/T233¹¹ Test specimens were cut to the dimensions specified in the standard test method from slabs of Microsurfacing which had been cured as in the modified AG:PT/T232 method. This test is generally used to assess the fatigue life of bituminous mixes subject to repeated flexural bending and determines the cycles to failure estimated as the reduction to ≈50% of initial stiffness modulus of the asphalt. The test was used to determine if the SFT had an effect on the measured fatigue life of Microsurfacing materials, against controls, thus indicating an underlying improvement in the tensile strength of the material

AS 2891.13.1¹² Test specimens were prepared from cores taken from cured slabs of Micro-surfacing complying with the dimensional requirements for the method. The method is used to measure indirect tensile stiffness modulus of materials, usually asphalt, through calculation by measurement of strain reaction under a dynamic stress; samples of Microsurfacing modified with the SFT were tested under standard conditions to determine any gains in tensile stiffness against controls which may indicate an increase in tensile strength of the modified material

Results

A number of fibre material types were assessed for compatibility and performance in a Microsurfacing system using control aggregate source, blend and emulsion formulation. The initial criteria mandated for this evaluation was that the respective fibre had to show good compatibility and dispersion characteristics in the standard system and that the system still had to be able to meet minimum specified limits of performance. Results of this initial performance testing are summarised in table 1. The only fibre assessed that met the Austroads Standard mix design criteria was a glass fibre, chopped to equal 12.5mm lengths dosed at a 0.2% by aggregate weight in the mix.

Table 1: Summary of Austroads Mix Design Performance Tests for Fibre Inclusion

	Cohesion (30 mins) (≥12)	Cohesion (60 Mins) (≥20)	Consistency (25 - 35)	Wear loss (1 hour) (<540)	Wear loss (6 Day) (<800)	Wet stripping -	Excess Binder -	Observation or comment
Standard Micro Mix (Control)	12	21	27	525	210	97	390	
Cellulose	11	21	27	850				Evaluation discontinued due to failure to meet specification for wear loss
Synthetic	DNC*							Evaluation discontinued as material was found to be moisture sensitive and this affected standard performance.
Basalt	8	16	26	2450				Evaluation discontinued as the material visibly degraded during initial mixing
Milled glass	12	21	27	500	DNC*			Evaluation discontinued due to failure to meet specification for wear loss
Glass	12	22	27	350	385	98	350	Met all standard criteria

*DNC – Did not conform to Performance Test

The performance attributes of the glass fibre included mix design were then assessed using the performance test methods.

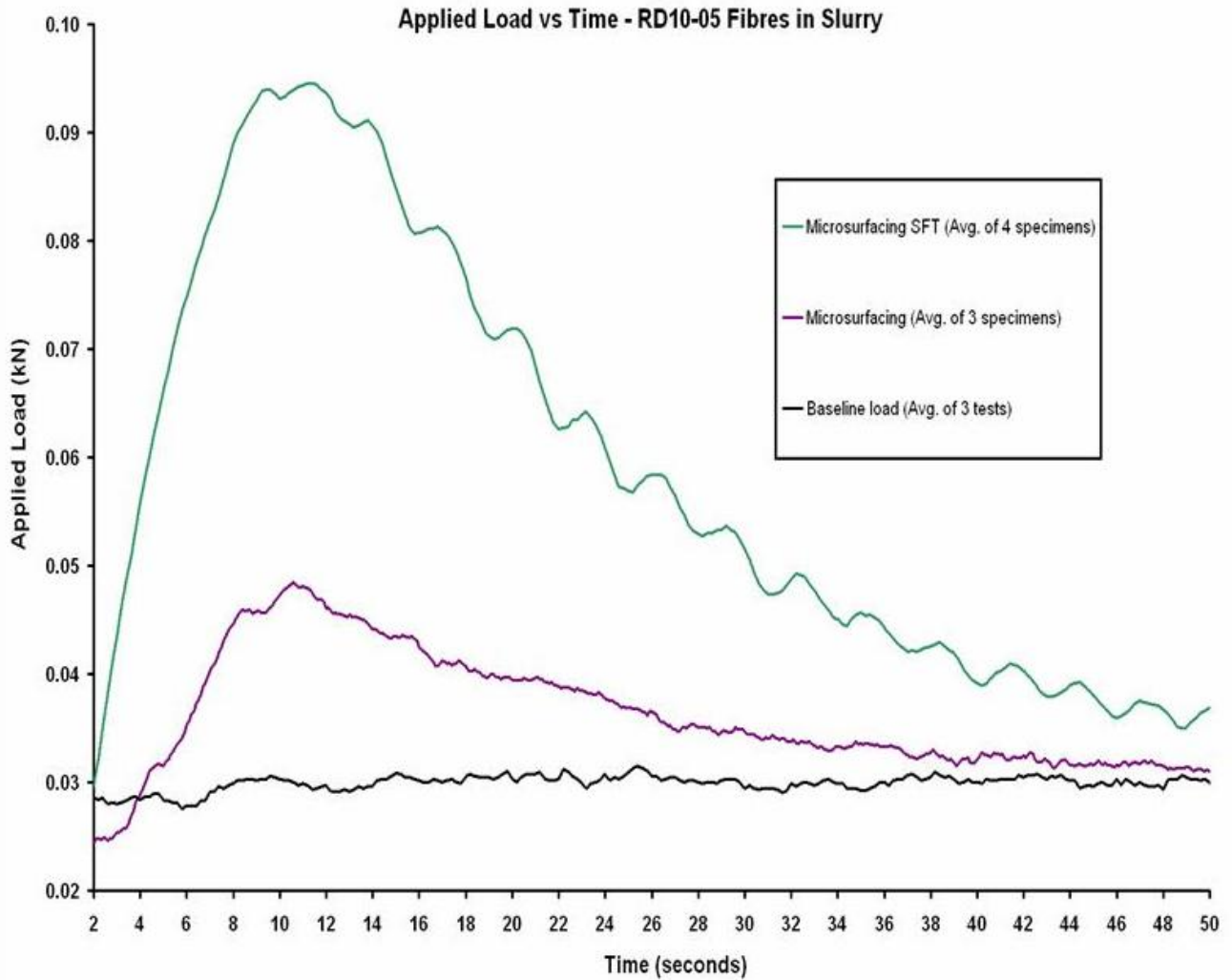
ISSA-TB 146 Microsurfacing inclusive of fibre demonstrated better resistance to cracking under flexural tension than Microsurfacing without fibre (Table 2).

Table 2 ISSA TB146 Microsurfacing v Microsurfacing SFT

Test Sample	Average flexural Bend (mm)	Range (mm)
Microsurfacing	9	5-15
Microsurfacing SFT	54.5	34-95

Downer UTM Modified Material Strength Test Standard slurry (excluding use of SBR polymer), Microsurfacing and Microsurfacing with fibre results were graphed using averaging to smooth the data points and then assessed. The graphed test data indicated there was an increase in the initial break/crack initiation load of the fibre incorporated specimens; additionally a longer load decay time to a test end point on the fibre inclusive specimens was observed. These results indicate an increased tensile strength of the Microsurfacing with fibre when compared to unmodified material and the increased time to endpoint load also indicates that the fibres are providing resistance to crack growth after initiation.

Figure 1 UTM Tensile Strength Test Applied Load v Time: Microsurfacing with fibre v Microsurfacing.



AG:PT/T232 (Mod), AG:PT/T233 and AS2891.13.1 The results for each of these test methods for Microsurfacing v Microsurfacing SFT are summarized in Table 3.

Table 3 Summary AGPT/T232, AG:PT/T233 and AS2891.13.1 Results Microsurfacing V Microsurfacing including Fibre.

Test Sample	AG:PT / T232 Load (Kn)	AG:PT/T233 Cycles to failure	AS 2891.13.1 MPa
Microsurfacing	9.1	202870	1120
Microsurfacing SFT	11.2	641190	1390

There was a 23% improvement in tensile splitting strength (AG:PT/T232), a 24% improvement in indirect tensile stiffness modulus (AS2891.13.1) and fatigue beam testing (AG:PT/T233) showed a 200% improvement in lifecycles for Microsurfacing SFT v a Standard Microsurfacing Mix.

Discussion

The desire for all bituminous surfacing materials is to achieve a combination of flexibility and strength characteristics to provide the highest performance in application. Microsurfacing is designed as a maintenance application used to prolong the lifespan of existing sound pavements but as a thin applied treatment has a limited capability to treat existing pavement cracking. Financial considerations plus ageing infrastructure are requiring much higher performance from all surfacing applications and the innovation of existing products potentially provides asset managers a cost effective method of achieving more for less.

Performances for Microsurfacing flexibility and strength have not been attributes that have historically been measured or specified but the inclusion of fibre has now provided new potential in terms of these attributes and the potential ability to measure and specify these attributes.

The test methods adopted from asphalt testing (AG:PT/T232 (Mod), AG:PT/T233 and AS2891.13.1) were carried out to assess their applicability to the testing of the Microsurfacing SFT materials; they generally give a proxy indication of an increased tensile strength in the SFT materials as they all rely on measurement of some form of tensile stress / strain function within the materials. Test methods adopted and used for this study have demonstrated their potential use as evaluation tools for the comparison of microsurfacing mix designs however further evaluation and refinement of the specific test methods and equipment are ongoing. Of particular interest is the development of a test that will allow the evaluation of performance measures, such as toughness of material calculated on a load versus time basis. Additional research will continue with the further development of the modified material strength test as it is anticipated this will reflect better the performance attributes that are being assessed based upon the application scope of the material as a thin surfacing treatment.

The ability to integrate fibre into standard microsurfacing mix designs has been achieved with minimal variance to standard mix designs or detriment to standard specified performance criteria. Critical components of the standard designs such as binder content are highly influential in the overall material cost and the ability to incorporate fibre without variance to such components allows for heightened material attributes with minimal cost increases to the material. The inclusion of fibre into standard microsurfacing mix designs has also shown some improvement to standard specified test methods (such as cohesion and wear loss) when compared to standard microsurfacing. These benefits effectively improve the standard material characteristics in addition to the desired outcomes of the material at minimal additional costs to the user.

Future Work; This laboratory investigation has shown measurable flexibility and strength increases in Microsurfacing are achieved via the incorporation of fibre into the mix. Field-testing of fibre incorporated microsurfacing has commenced to evaluate the performance of the material under Australian road conditions with trial sites applied in various applications to allow ongoing evaluation. Trial sites completed to date have exhibited no discernable change in material workability or application in use across a variety of aggregate sources and climatic conditions. Final surface attributes for texture depth and skid resistance have shown no detriment when compared to standard applications applied on similar sites.

The research completed to date has focused on a standard dose and length of fibre. Further research to evaluate the optimal fibre dose rates and fibre length under Australian conditions is ongoing along with evaluation of the appropriate method to test and measure performance criteria.

References

- (1) Austroads (2003) AP-T26-03 Guidelines and Specification for Bituminous Slurry Surfacing
- (2) Standards Australia (1996) Australian Standard 1141.12: Methods for sampling and testing of aggregates - Materials finer than 75 micrometre in aggregates (by washing)
- (3) Standards Australia (2009) Australian Standard 1141.11.1: Methods for sampling and testing aggregates - Particle size distribution - Sieving method
- (4) Austroads (2007) AG:PT/T271 Determination of Set and Cure for Bituminous Slurry (Cohesion Test) pp1-8
- (5) Austroads (2005) AG:PT/T270 Consistency of Bituminous Slurry pp1-5
- (6) Austroads (2005) AG:PT/T272 Determination of Abrasion Loss of Bituminous Slurry pp1-6
- (7) ISSA (2007) TB-114 Wet Stripping Test for Cured Slurry Seal Mix
- (8) Austroads (2005) AG:PT/T273 Determination of Excess Binder in Bituminous Slurry pp1-6
- (9) ISSA (1989) TB 146 Flexural Tension Test Method for Determination of Cracking Resistance of Slurry Mixes pp1
- (10) Austroads (2007) AG:PT /T232 Stripping Potential of Asphalt – Tensile Strength Ratio pp1-10
- (11) Austroads (2006) AG:PT/T233 Fatigue Life of Compacted Bituminous Mixes subject to repeated flexural bending pp1-17
- (12) Austroads (2006) AG:PT/T233 Fatigue Life of Compacted Bituminous Mixes subject to repeated flexural bending pp1-17
- (13) South Burnett News - May 2,2013 – Council Faces “Tough Decisions” on Funding for Roads repairs downloaded from <http://southburnett.com.au/news2/2013/05/council-faces-tough-decisions-on-funding-for-road-repairs/>
- (14) Australian Rural Road Group (ARRG) – “Going Nowhere” November 2010 , p18 – downloaded from http://www.infrastructureaustralia.gov.au/publications/files/Australian_Rural_Roads_Group_Report.pdf
- (15) Ben Broughton, Soon-Jae Lee, and Yoo-Jae Kim, “30 Years of Microsurfacing: A Review,” *ISRN Civil Engineering*, vol. 2012, Article ID 279643, 7 pages, 2012. doi:10.5402/2012/279643
- (16) International Glassfibre Reinforced Concrete Association – “40+ years of GRC” – downloaded from <http://www.grca.org.uk/projects/project4.asp>
- (17) Xu Q, Chen H, Prozzi JA (2010) Performance of fiber reinforced asphalt concrete under environmental temperature and water effects. *Construction and Building materials*. 24, (10), pp 2003 -2010 <http://dx.doi.org/10.1016/j.conbuildmat.2010.03.012>