Laboratory Investigation of Fatigue Resistance of Thin and Standard Thicknesses of Asphalt Surfaces Incorporating Fibre-Reinforced Mixes and Cape Seals Using Beam Testing

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Introduction

- The term thin asphalt could be interpreted as applicable to any bitumen surfacing designed to be placed in layers of less than 40 mm in thickness.
- There are three main types of surfaces used on New Zealand's roads and highways, these are:
  - Asphalt
  - Chip seal
  - Unsealed surfaces (NZTA, 2013).

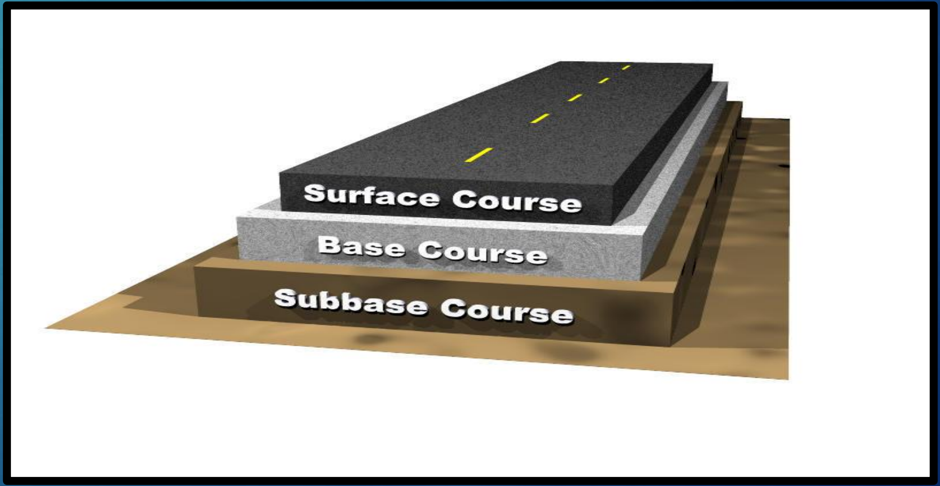
Chipseal surface

Asphalt Surface

Problem Statement

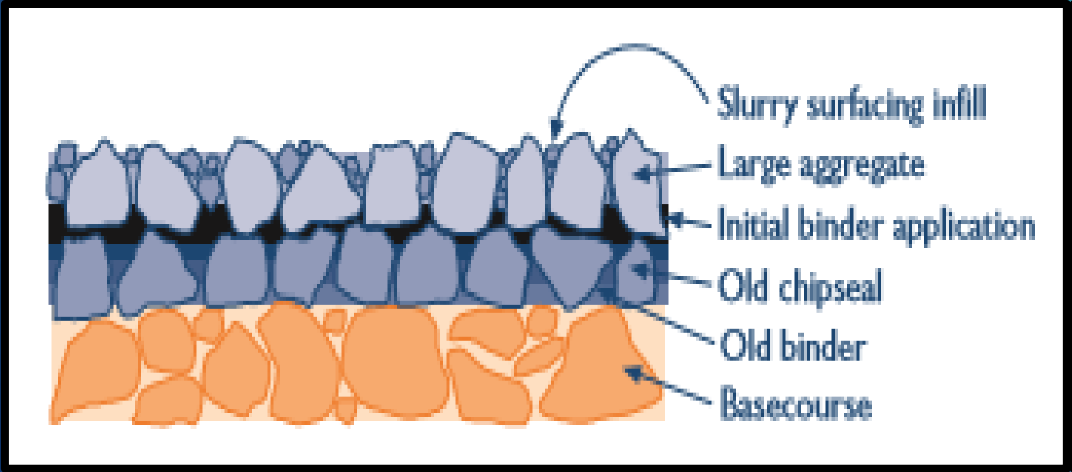
- The useful life of an asphalt surface under increasing traffic loadings is affected not only by the climatic conditions/environment under which it operates, but also by the level of structural support provided to it by the underlying pavement layers (Fletcher & Theron, 2011).

- Due to the lack of support from the layers below the surface layer, thin asphalt surfaces crack quickly in less than their designed life, especially because the asphalt binder is not modified (control binder is used most of the time).
- There are three options to solve the problem of the poor performance of thin asphalt surfaces in New Zealand, which are either to:
  - stabilize the underlying layers;
  - to strengthen the asphalt surface; or,
  - Use a different type of surface (e.g. Cape Seal).



Scope of Research

- This research will not solve the problem of weak underlying layers because it's very costly,
- It will rather come up with an asphalt surface mixture that is durable and cost effective with longer service life than chip seal.
- It will also investigate the effect of fibres on fatigue resistance of cape seals.



Cape Seal

Objectives

The objectives of the proposed research are to:

- Test life expectancy of enhanced AC solutions using two types of fibre.
- Validate the use of standard lab tests for testing thin asphalt surfaces.
- Investigate other surfacing options as an alternative to asphalt, such as Cape Seal, by developing tests for robust comparisons.
- Investigate the Life-cycle economic outcomes of different surface technologies and likely performance.

Methodology

Material to be Used

- Research is limited to dense graded asphalt mix which in this case is DG7 which is commonly used for thin surfacing layers in New Zealand (excludes open graded porous asphalt and stone mastic asphalt)
- Only test one performance grade binder, which is PG 64H (commonly used in Auckland)
- Cape Seal – Standard Cape Seal design using control and fibre modified slurry

Additives

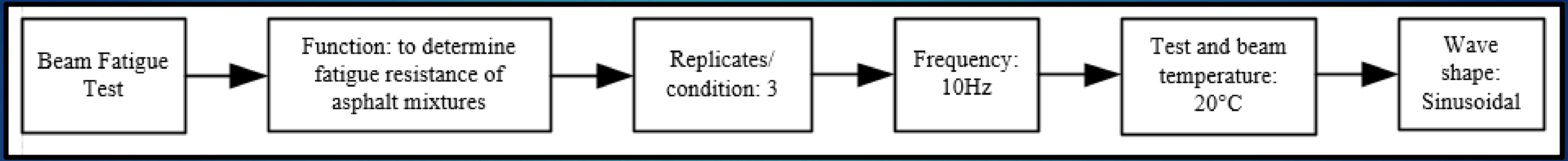
- Cellulose Fibre
- Waste textile Fibre

Methodology (Cont.)

Four Point Bending Beam Fatigue Test:

This test was performed to evaluate fatigue resistance of control and fibre modified asphalt. It was also performed to evaluate the fatigue resistance of control and fibre modified cape seal.

Four point bending beam fatigue test was performed in accordance with AGPT/T274, “Characterisation of Flexural Stiffness and Fatigue Performance of Bituminous Mixes”.

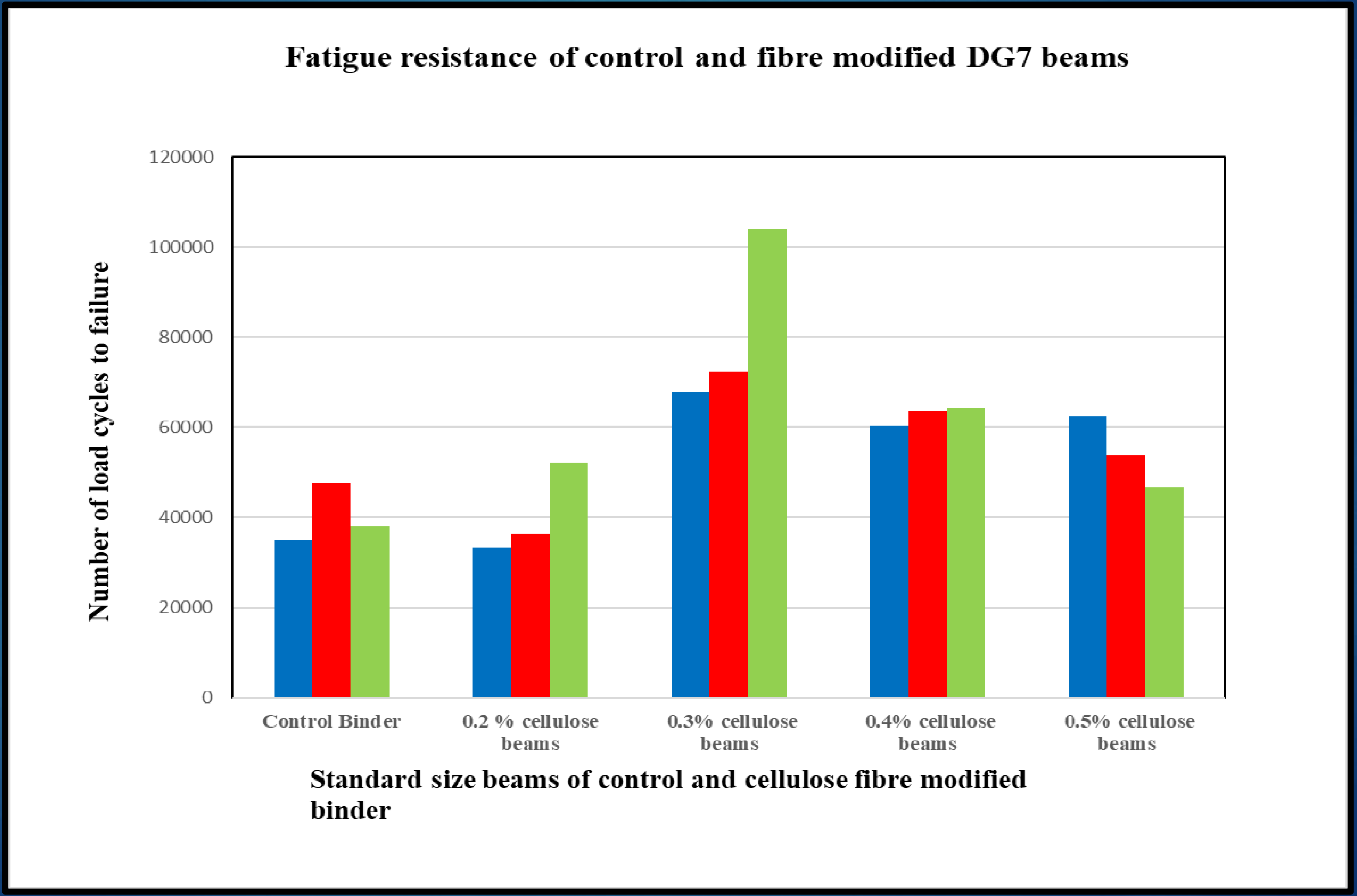


The parameters that were used in this test are as follows:

- Mode of loading: constant strain and variable stress
- Strain amplitude : 400 µm
- Initial stiffness measured at cycle no. 50
- Termination Modulous: at 50% reduction in initial stiffness
- It took 5 days to prepare and test each specimen, (Ghuzlan & Carpenter, 2000).

Methodology (mixing conditions)

Results



Fatigue resistance of control and fibre modified DG7 beams
Number of load cycles to failure
120000
100000
80000
60000
40000
20000
0
Control Binder
0.2 % cellulose beams
0.3% cellulose beams
0.4% cellulose beams
0.5% cellulose beams
Standard size beams of control and cellulose fibre modified binder

Results (Cont.)

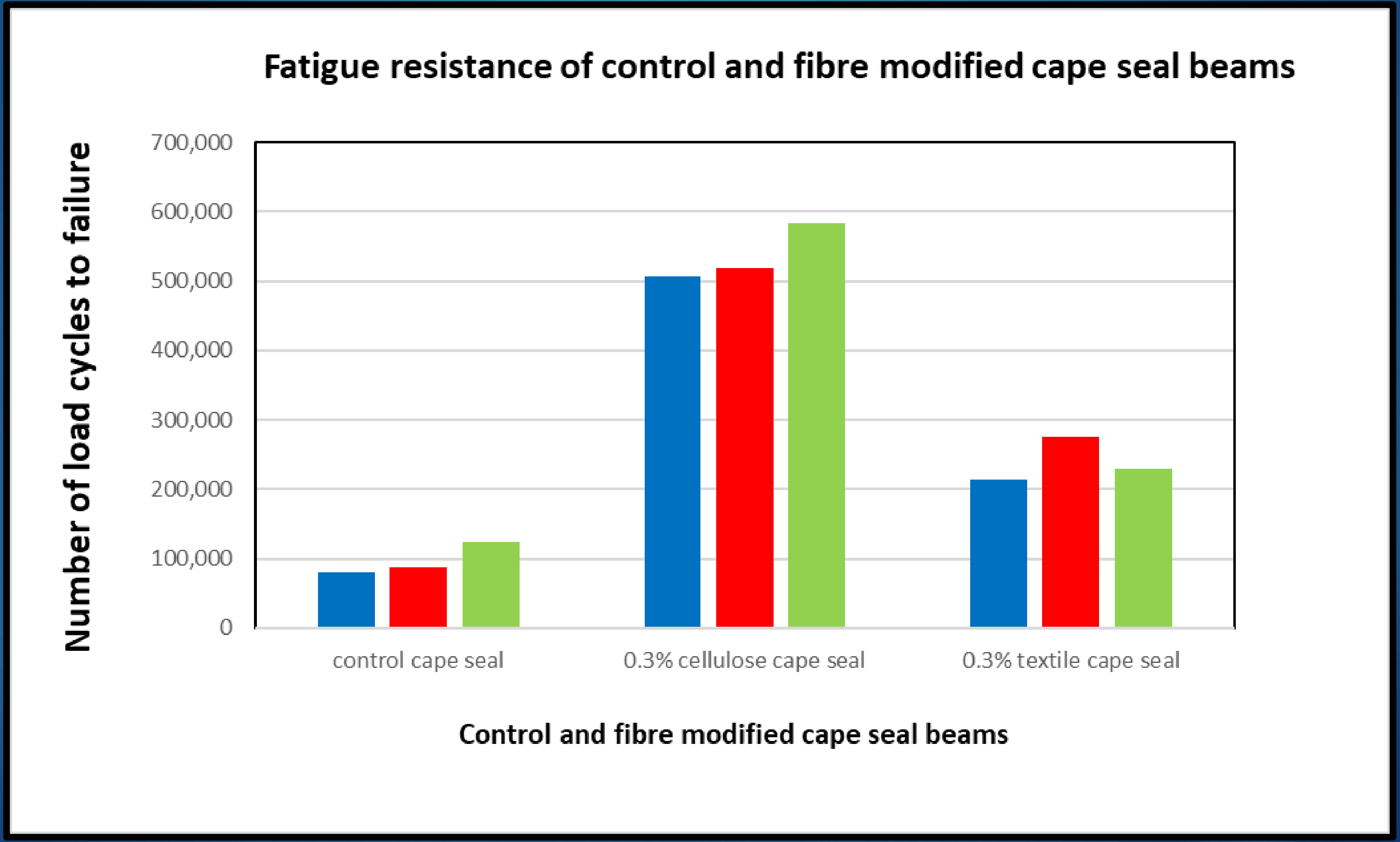
Four point bending beam fatigue test (cont.):

- 9 thin asphalt beams of 390±5 mm length, 63.5±5 mm width & 30 mm height were also prepared and tested for fatigue resistance.

3 replicates for each of the following conditions were prepared:

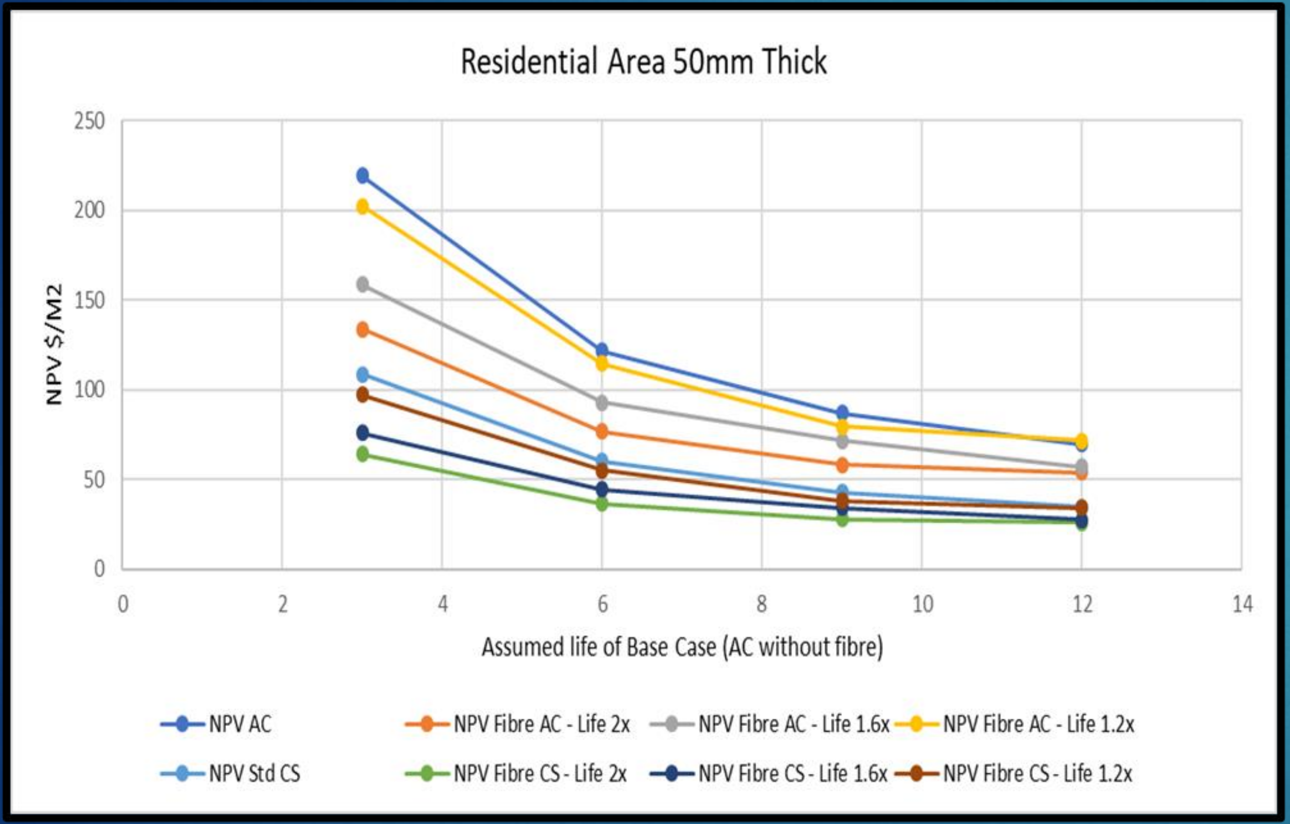
- Control binder (number of load cycles to failure were 31,274, 39,928 & 40,550 cycles)
- 0.3% cellulose fibre by mass of binder, number of load cycles to failure were (64,913 , 67,799 & 100,219 cycles)
- 0.3% textile fibre by mass of binder, number of load cycles to failure were (72,672, 75,566 &100,201 cycles)

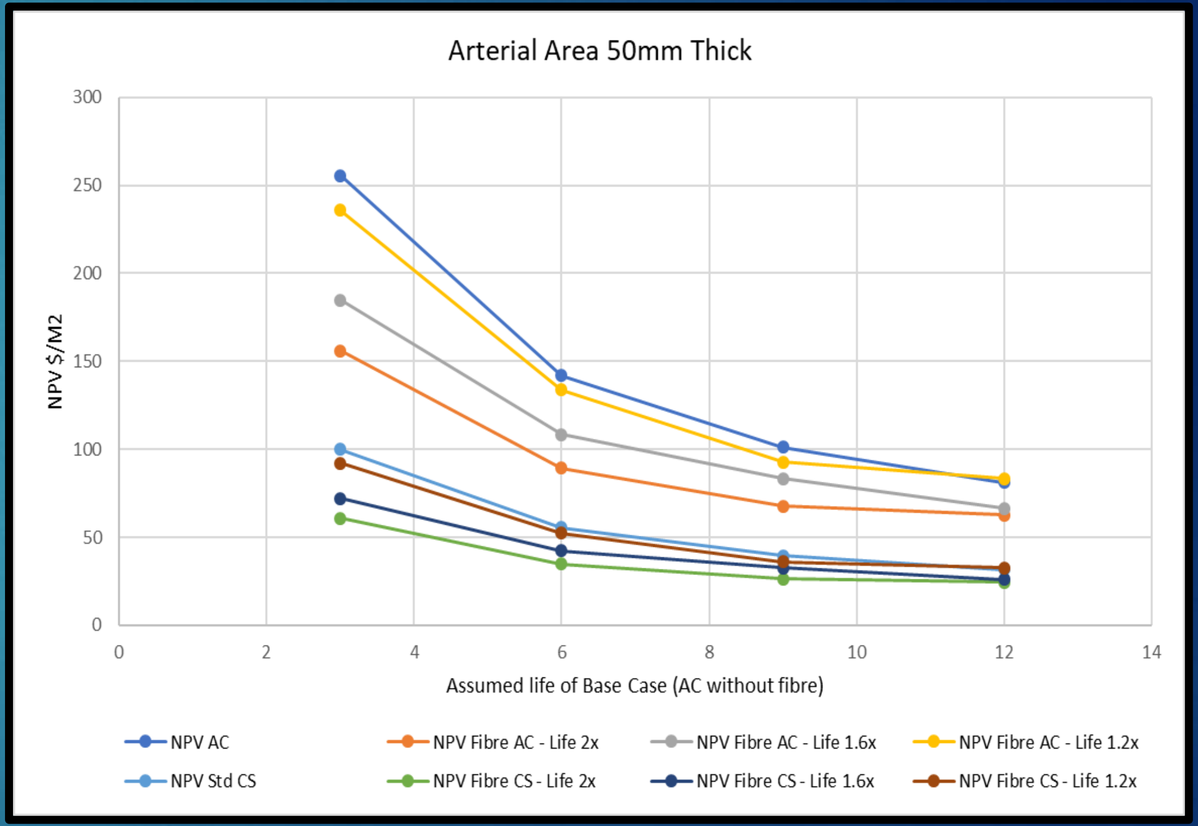
Results (Cont.)



Results (Cont.)

Net Present Value





Conclusion

- In New Zealand, thin asphalt surfaces have lower service life than designed which is not economical.
- Strengthening under-lying pavement layers is not always affordable, and the only other alternative would be to enhance the service life of the surface layer. This research investigated the effect of cellulose and textile fibres on fatigue resistance of asphalt and cape seal mixtures.
- The fibres yielded much-enhanced fatigue lives, suggesting a resistance improvement between 20% and 100%. The two tested fibres, the cellulose fibre and the waste textile fibre have similar performance when mixed with asphalt.
- The use of the standard four point bending beam fatigue test was validated for testing thin beams in a laboratory setting.
- Thin asphalt beams and standard size asphalt beams made of the same materials showed similar fatigue resistance when tested by four point bending beam fatigue test.

Conclusion

- Cape Seal in both conditions (control and fibre modified) performed more favourably than asphalt. The Cape Seal that contained cellulose fibre performed significantly better than Cape Seal containing waste textile fibre.

- NPV method was used to economically evaluate the different surface technologies which are asphalt and Cape Seal. The results demonstrated that fibre AC is more cost effective than control AC when the service life of fibre AC was 60% and/or 100% more than the life of control AC. The fibre AC was deemed not economical when its life is only 20% more than the life of control AC.

- Similar results were noted using fibre Cape Seal, and demonstrated that fibre Cape Seal is also more cost effective when the increase in service life is 60% and/or 100% compared to the service life of control Cape Seal. The fibre Cape Seal is not economical when there is only 20% improvement in its service life compared to the life of the control Cape Seal.

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Thank You