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Recycling Chip Seal Road Surfacings

WSP 2/Round 1 Hoe ki angitū Innovation Fund

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Executive Summary

Introduction

This report covers research undertaken by WSP NZ Ltd on the feasibility of recovering and recycling chip seal road materials. The work was funded through the 2022, Waka Kotahi Hoe ki angitū Innovation Fund, responding to the Round 1 first challenge, "Accelerating the use of recycled materials and sustainable practices".

The chip seal road network in New Zealand holds over an estimated 1 million tonnes of bitumen and many millions of tonnes of good quality aggregate which could be recycled back into road surfacings reducing the need for virgin materials.

Recycling of chip seals provides three main benefits:

- *Efficient use of non-renewable resources.*

  The very large-scale of the resource offers the potential for a very significant step towards the goal of a sustainable road network through the recycling of non-renewable and, in the case of aggregate, a resource that is also scarce in some regions, necessitating significant freight movements around the country.

- *Helping to reduce the carbon footprint of the New Zealand road transport infrastructure.*

  A more circular process will be created in which the embodied carbon of the current chipseal remains in use, rather than being simply buried or moved from the network and sent to clean fill sites.

- *Sustainable and secure bitumen supply.*

  All bitumen is imported to New Zealand. The cost of bitumen is predicted to escalate in the future as the demand for crude oil decreases. The physical supply security of suitable bitumen when needed is also a potential risk. Bitumen recycling process will help reduce both cost and supply issues.

Recycling of chip seal materials will directly benefit Waka Kotahi and local authorities, who are the principal purchasers of bitumen in New Zealand, to help meet the Governments carbon reduction targets.

Research concept and objectives

Solvent extraction could potentially be used to separate bitumen and aggregate from chip seal millings. In such a process the solvent would be recycled and reused. To reduce the environmental impact from the process and produce a very low carbon footprint recycled bitumen, the use of solvents derived from renewable biomass feedstocks was investigated.

The main objectives of the research were to:

- Undertake a review of technologies used to extract bitumen from oil-sands for potential application to chip seal materials recovery.
- Identify potential renewable solvents.
- Measure the bitumen solubility and solvent extraction efficiency of potential candidate solvents.

Key Findings

- The possibility of adapting hot water-based methods commonly used to extract oil sands in Canada and the US was discounted, partly for the environmental problems associated with the large volumes of contaminated wastewater produced, but also for technical reasons.
- Based on their chemical structural similarity to known good bitumen solvents, numerous biomass derived solvents were assessed on their likely ability to dissolve bitumen and for future practical purposes, their potential availability in bulk. Three solvents from renewable resources were selected for further assessment (solvents A, B and C) and their physical properties compared to known good petrochemical solvents for bitumen. The latter included cyclohexane, dichloromethane, toluene and tetrachloroethene. In particular the heat of vaporization and heat capacity were compared as these are key properties determining the energy required to recover and recycle the solvent.
- The extraction efficiency of the renewable solvents was compared to that of the petrochemical derived solvents. Initially the solubility in the solvents of a hard bitumen (meeting the NZTA M01 40-50 penetration grade) was measured using a minor modification to ASTM method D2042 at a high solvent to bitumen ratio and a 2 hour soaking period. Solubility in solvents A and B was poor (about 70-80%) whilst that in solvent C was effectively 100% - the same as dichloromethane and tetrachloroethene and better than toluene and cyclohexane.
- In chip seal millings the bitumen will be coated and chemically adsorbed onto aggregate surfaces. A method was developed in which the solvents were used to extract bitumens meeting the NZTA M01 40-50 and 80-100 penetration grades from fine aggregate. To assess the relative extraction rate, a one minute extraction time at room temperature and reduced (10:1) solvent to bitumen ratio was used. The method was further modified to oxidize the bitumen to simulate field aging. The aging conditions were established by an analysis of existing published data and infrared spectroscopic measurements.
- Solvents A and B performed satisfactorily with unaged bitumen, but only solvent C efficiently extracted the oxidized bitumen and was in fact as good as dichloromethane and tetrachloroethene in this respect (both are very good bitumen solvents).
- Solvent C is a promising candidate for further investigation into the practical feasibility of a low carbon, sustainable solvent based bitumen recovery process. A desk top study based around such a process using solvent C would allow an estimate of potential cost and energy requirements for a range of practical scenarios.

Outcomes

Support from the Hoe ki angitū Innovation Fund has enabled this successful preliminary investigation into the concept of an environmentally friendly solvent recovery process for chip seal materials. A methodology to measure solvent efficiency in recovery of oxidised bitumen from an aggregate matrix was developed and was used to compare various solvents and can be used in subsequent studies. The research was successful in identifying a suitable renewably sourced solvent which is commercially available at large scale and at a realistic price point. The

research has also highlighted areas where more detailed information is needed to determine the practicality and economics of the proposed recovery process.

Next steps

The project has highlighted the absence of data on the properties of aged bitumen in chip seals. Work needs to be undertaken to obtain more information about bitumen quality (physical properties and chemical composition) and consistency to understand how the recovered bitumen could best be used. Additionally information about the current volumes of millings potentially available for recycling annually in each region is needed to understand the scale and location of the resource as it currently stands.

A basic plant-concept design for a large bitumen recovery process needs to be developed, based around the use of the renewable solvent and the solubility data in this report. A high-level desk study can then be undertaken to estimate the economics, health and safety implications and environmental aspects of the extraction and recovery process using the solvent. Such a study would provide information on the potential economics and CO_2 emission savings by modelling different scenarios to understand the effects of scale and the throughput of recovered bitumen.

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