Bio-sourced asphalt from the Canadian forest industry – Final Public Report

Introduction

The goal of the project entitled "Bio-sourced asphalt from the Canadian forest industry" is to compare the constructability and performance of a lignin-asphalt pavement to that of unmodified pavements; to quantify the cost and environmental advantages of this bio-product. This project is based on open literature rather than proprietary background IP and is meant to accelerate the commercialization of a new lignin-based asphalt constructed on existing knowledge, and to demonstrate its feasibility under our Canadian conditions.

Project milestones

MS 1 – Accelerated pavement testing

In 2022, University of Laval conducted a four-part trafficking test comparing conventional and lignin-modified asphalt test pavements in their Civil Engineering laboratory using their accelerated trafficking device. The theoretical pavement damage caused by the trafficking was characterized using equivalent single axle loads over four conditions, equivalent to 3 years of total traffic impact at different temperatures.

While the rut depth and rutting rate was slightly lower for the lignin-modified asphalt, the overall rutting performance showed no significant difference versus conventional asphalt. Strain measurements found that the addition of lignin reduced longitudinal strains to a small degree and transverse strains to a moderate degree at all three test temperatures (10°C, 25°C, and 40°C). The strain reduction was more significant at higher temperatures. ULaval researchers concluded that this strain reduction should, theoretically, result in longer asphalt concrete life.

MS2 – Commercial demonstrations

A total of 6 commercial demonstrations were completed in various locations with different partners, and equipment. This shows the viability of using lignin as a partial substitute for bitumen in asphalt roads can be accomplished using existing infrastructure, i.e.

- In batch or continuous asphalt plants
- Use of dry(into aggregate) or Wet(into bitumen) mixing methods
- Use of different mix designs, including RAP addition

Road Owner (Constructor)	Asphalt Design (bitumen)	Lignin Substitution (%, by wt of bitumen)	Incorporation	Tonnes Placed	Project	Construction Date
Sturgeon County, AB (Park Paving)	HT10 RAP (PG58-31)	5%	Add to bitumen; Continuous flow plant	155	Mill & Pave	26 Aug. 2021
Thunder Bay, ON (Pioneer Construction)	HL4 (PG58-28)	5%	Add to asphalt; Batch plant	110	New Pave	20 Sept. 2021
Quebec City, QC (Eurovia)	ESG10 (PG58H-34)	10%	Add to asphalt; Batch plant	150	Mill & Pave	14 Oct. 2021
Quesnel, BC (Quesnel Paving)	16mm Class 1 Medium (PG58-28)	10%	Add to asphalt; Continuous flow plant	132	Overlay	30 Aug. 2022
Victoria, BC (City of Victoria)	100% RAP base asphalt (PEN80/100)	20% (no substitution)	Add to asphalt; Batch plant	10	5 patch sites	22 Sept. 2022
Ange-Gardien, QC (Eurovia)	ESG10 (PG 64E-28)	15%	Add to bitumen; Continuous flow plant	180	Overlay	7 Sept. 2023

Visual inspections of the Sturgeon County site were performed in May and October 2022. No degradation was observed. Lakehead University and Pioneer construction conducted inspections of the Thunder Bay demonstration in September & November 2021 and May 2022. Signs of low severity degradation were present on both the modified and conventional asphalt sections. The inspection parties concluded that the poor site drainage and the thin asphalt specification of the pavement relative to the load of the vehicles using the roadway were the contributing factors.

MS3 – Life Cycle Assessment

The Life Cycle Assessment of lignin-modified asphalt determined a 29% (188 kg CO2 eq.) reduction in GHG emissions is expected from replacing 1 tonne of bitumen with Kraft Lignin. Per 1 tonne of hot mix asphalt, this corresponds to a 0.7% reduction in GHG emissions for asphalt that contains a 5% bitumen replacement with kraft lignin. In addition to the GHG emissions reduction, the inclusion of lignin into asphalt also offers the benefit of 5.5 kgCO2 eq biogenic carbon storage per tonne of asphalt mix used.

MS4- Modified Lignin

FPInnovations developed a process to modify the properties of Kraft Lignin to be closer to bitumen by reducing the glass transition temperature (T_g) and hydroxyl group content. This process was successfully scaled up to an 18-L reactor to produce samples of four different types of lignin for bitumen application testing. The results from application testing were mixed, which suggests that the lignin properties need to be further tailored to specific bitumen applications to unlock the full potential of lignin.

MS5 – Communications

The details of the commercial demonstrations were communicated in various radio, tv and print media. Numerous presentations were made at business and technical conferences to highlight the progress of the project. The technical results of the project were published in research papers in several academic journals. Numerous dialogues occurred with Ministries of Transportation (QC, ON, BC) and bitumen producers to establish a framework around carbon in road construction to drive future policy change and determine how the supply chain will evolve. Finally, communication with lignin, bitumen and asphalt producers occurred to discuss the pathway to commercialization, including GHG reduction, packaging and storage considerations, methods for lignin addition into the asphalt making process and the equipment needed to facilitate the addition.

Conclusion

FPInnovations' project entitled Bio-sourced asphalt from the Canadian forest industry has attracted much attention across Canada and beyond. Thanks to our partners and funders, we have achieved much since its beginning in April 2020. There are three key outcomes in the project. First, the lab and accelerated pavement testing confirmed that lignin-modified asphalt mixes can meet the technical performance requirements at substitution levels up to 15%. Second, six industrial-scale field demonstrations showed the workability and performance of lignin-modified asphalt. The result was improved confidence in the industry that lignin is a viable bio-based alternative to bitumen in road construction. Lastly, the LCA has shown industry partners that the partial substitution of lignin has GHG reduction and carbon sequestration benefits that can help the industry achieve their decarbonization goals.