Effect of Bio-oil on the Rheological Properties of Extracted Reclaimed Asphalt Pavement (RAP) Binder

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Abstract

One of the current challenges of modern pavement industry is the expensiveness and environmental effect of petroleum-based asphalt binder, searching alternative source of asphalt binder is the focus area of current pavement research.

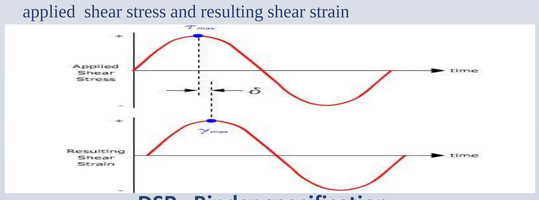
This research studies the possibility of replacing virgin petroleum asphalt binder by 100% Reclaimed asphalt Pavement (RAP) binder modified with non-petroleum bio-oils in pavement construction. After extracting 15 years old PG 58-28 reclaimed asphalt binder and modified it with 5,10 and optimum percentage of two bio-oils (waste cooking oil and soy animal supplement oil) the rheology of modified extracted reclaimed asphalt binder is tested and compared with virgin binder .A dynamic Shear rheometer (DSR) is used in this research to evaluate the rheology of modified reclaimed asphalt binder stiffness at a high, intermediate and low temperature and the result is compared with controlling virgin and 100% reclaimed Asphalt binder.

Introduction

- Asphalt road is constructed for specific service life year usually ranges from 15 to 20 years .
- At the end of the service life the top material of asphalt road composed of aggregate and binder called reclaimed asphalt pavement (RAP) is scraped and replaced by the new material as rehabilitation maintenance.
- RAP material contains stiff and aged binder and forms harsh mix when it is used in pavement as base course and surface course which is the major factor for the formation of thermal cracking.
- Bio oils are used to soften the stiff binder

Back ground

- Rheology is the study of flow and deformation of asphalt binder
- Asphalt material is visco- elastic material which means they behave partly like an elastic solid (deformation due to load is recoverable) and partly like viscous (deformation due to loading is non recoverable).
- DSR is capable of quantifying both elastic and viscus property by measuring the specimen shear modules (G*) a total resistance to deformation due to repeated shear and phase angle(δ) a gap between applied shear stress and resulting shear strain



DSR Binder specification

Material	Value	Specification	HMA Distress of Concern
Unaged binder	G*/sinδ	≥ 1.0 kPa (0.145 psi)	Rutting
RTFO residue	G*/sinδ	≥ 2.2 kPa (0.319 psi)	Rutting
PAV residue	G*sinδ	≤ 5000 kPa (725 psi)	Fatigue cracking

Basic Asphalt destresses

Distress type	Distress cause	Binder part used to prevent distress
Rutting	Traffic and high temperature	Viscus part
Thermal cracking	Very low temperature	Elastic part

Objective

- Determining the effect of bio-binders on mid-and-high temperature rheology of RAP binder.
- Determining the effect of bio-binders on low-temperature rheology of RAP binder.

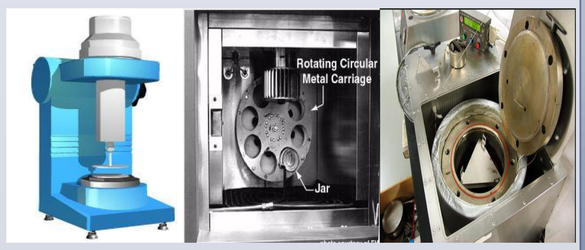
Binder extraction from RAP

- Binder is extracted using abson method of extraction with ENSolV-EX solvent chemical .

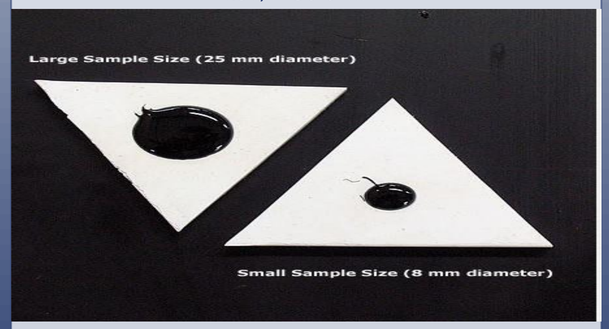
Experiment

Rheological test for unaged , RTFO(short term aged) and PAV (long term aged) is conducted using Dynamic shear rheometer (DSR) on

- 5%, 10% and optimum percentage of soy oil modified extracted RAP binder and 5% ,10% and optimum percentage (16.5%) of waste cooking oil modified extracted RAP binder
- The result is compared with virgin PG58-28 ,Pg64-28 and 100%extreacted RAP binder
- 5% each (soy oil and waste cooking oil) modified extract RAP binder is also tested to analyze the effect of bio binders on each other



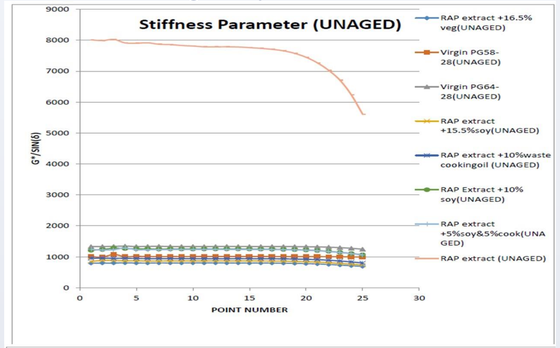
DSR ,RTFO and PAV

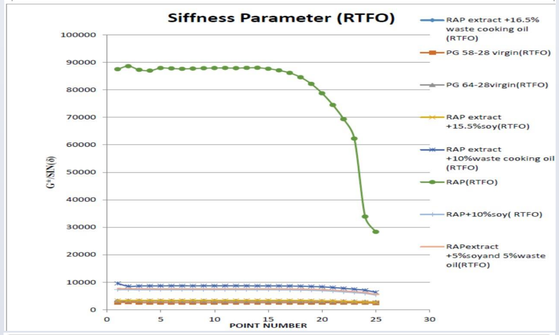


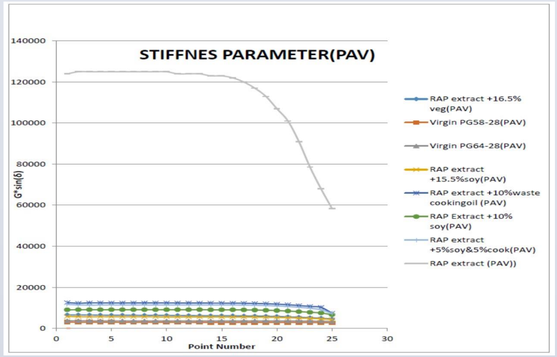
PG58-28 and PG64-28 binder

RESULT

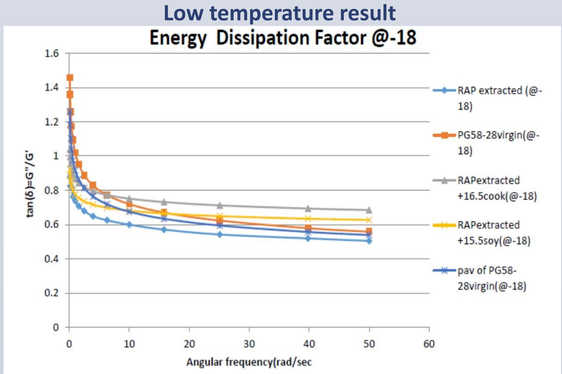
High temperature result







Low temperature result



Conclusion

- Both bio-oils ,waste cooking oil and soy oil have the tendency to decrease the stiffness of RAP binder.
- Soy oil has better high temperature stiffness reduction potential than waste cooking oil whereas waste cooking oil exhibited better elastic (energy dissipation) property at low- temperature.
- With the addition of 15.5% soy oil and 16.5% waste cooking oil, the stiffness of modified RAP binder is close to PG 58-28, which is the original grade of virgin binder in RAP.
- Effectiveness of bio-binders in reducing RAP binder stiffness decreases with aging .

Generally super pave specification are satisfied for Both bio-oil modified RAP binders

Type	unaged G*/sin(δ)Pa	RTFO G*/sin(δ)pa	PAV G*sin(δ)pa
RAP+15.5%soyoil	1051	4569	4627
RAP+16.5wwaste cooking oil	783	2962	6031

Recommendation

- Further validation on the performance of bio - oil modified RAP binder mix need to be investigated
- The Effect of bio oil on wide ranges of PG grade bitumen need to be investigated
- More bio oil need to be included to determine there effect and determined the best bio binder

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