REINTRODUCING THE INTRINSIC SELF-HEALING PROPERTIES IN RECLAIMED ASPHALT BY REJUVENATION

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ABSTRACT

Reclaimed Asphalt (RA) is one of the largest fractions of raw materials used in road construction today. Probably over 90% of the total RA in the Netherlands is being reused in new asphalt constructions. RA contains aggregates coated with very hard bitumen (penetration grade of 10-20). During service, the bituminous binder loses its flexibility and its intrinsic self-healing capability because of ageing. These parameters are critical for reconstructing new durable surface layers. Therefore it is very important to reintroduce the flexibility and the intrinsic self-healing capability of the RA. In order to achieve this goal, rejuvenation technology is developed in this paper to re-compound to the aged bitumen in the RA. A preliminary research has been conducted to evaluate the effect of different potential rejuvenators on aged bituminous binders by means of laboratory blending. Two types of laboratory aged bitumen and six types of rejuvenators were developed. The rheological properties were evaluated by using the Dynamic Shear Rheometer (DSR), and the chemical compositions were evaluated using the Infrared Spectrometry (FT-IR). The thermodynamic properties of the blended bitumen were evaluated using the Differential Scanning Calorimetry (DSC) measurements. It is shown that with the blending of the rejuvenator into the laboratory aged bitumen is a physical process, the bitumen can regain its flexibility with a lower complex shear modulus, a higher phase angle and a lower glass transition temperature. A softer rejuvenator shows a higher potential. No significant chemical change can be observed for the rejuvenated bitumen. This research is on-going to investigate the diffusion capabilities of rejuvenators on the field aged reclaimed asphalt and the fatigue and healing evaluation.

1. INTRODUCTION

Typically, RA from surface layer such as reclaimed porous asphalt (RPA) contains high quality aggregates coated with very hard bitumen (penetration grade of 10-20). In practice, the RPA is recycled into base layer with a lower penetration grade bitumen. However, it is not allowed (or very limited amount) to recycle the RA from surface layer into surface layer. One of the main concern is that the currently used technology is not able to restore the intrinsic properties (e.g. flexibility, self-healing capability, etc.) and to guarantee the durability of the recycled porous asphalt. As a result, restoring the intrinsic properties of RPA during recycling process using rejuvenators is of great interest for surface-to-surface recycling. The rejuvenator, which contains the lost light components of the aged bitumen, can be applied to penetrate and diffuse into the existing RPA to rebalance the material composition. This makes it possible for reconstructing new durable surface layers. In this paper, a preliminary research has been conducted to evaluate different potential rejuvenators on aged bituminous binders.

2. MATERIALS

Table 1 gives the information of the materials used in this paper. Two types of laboratory aged bitumen were produced namely P1 (25 pen.) and P2 (15 pen.) by using RCAT ageing device [1, 2]. A virgin bitumen with a penetration grade of 70/100 is used for comparison. Six types of rejuvenators were developed and provided by Latexfalt B.V. They are either oil type or emulsion type rejuvenators dependent on the area of final application.

3. METHODS

The aged bitumen were blended with different type of rejuvenators with certain dosages at a temperature of 150 ^{o}C for further analysis. The rheological properties were conducted using the Dynamic Shear Rheometer (DSR). The chemical compositions were evaluated using the Infrared Spectrometry (FT-IR). The thermodynamic properties of the blended bitumen were evaluated using the Differential Scanning Calorimetry (DSC).

4. RESULTS

Figure 1a gives an example of the complex modulus master curve of P1A2_20 blend (20 part of A2 mixed in 100 part of P1). A log log model was found to be applicable to estimate the rheological properties of a blend between rejuvenators and aged bitumen [3, 4] as shown in Eq. 1.

$$\log\log(|G^*|_{mix}) = a\log\log(|G^*|_a) + b\log\log(|G^*|_b) \qquad (1)$$

In order to achieve a rheological properties of a blend similar to a virgin 70/100 penetration bitumen, the amount of rejuvenators used in the blend is dependent on the viscosity of the rejuvenators. As shown in Figure 1b, rejuvenators with a lower viscosity has more potential to rejuvenate the aged bitumen than the ones with a higher viscosity.

Table 1: Materials used in this research

Name	G* @50C 10Hz [Pa]	Type	Notes
Ref	5.2E+04	Virgin bitumen	70/100 pen.
P1	2.1E+05	Aged bitumen	25 pen.
P2	9.4E+05	Aged bitumen	15 pen.
A1	6.1E+02	rejuvenator	Oil type, liquid
A2	1.3E+02	rejuvenator	Oil type, viscous
BM1	8.4E+02	rejuvenator	Emulsion type, on residual
C1	5.0E+03	rejuvenator	Oil type, viscous
CM1	6.3E+01	rejuvenator	Oil type, liquid
D	1.3E+04	rejuvenator	Soft bitumen, 160/220 pen.

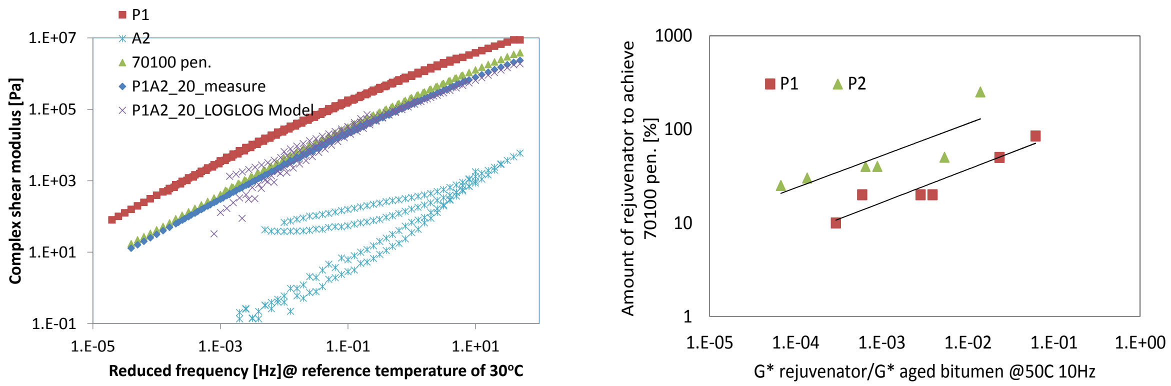

Figure 1: Rheological properties of rejuvenator-aged bitumen blends: (a) Example of master curve of P1A2_20; (b) Amount of rejuvenator to achieve the rheological properties of 70/100 pen. bitumen

Table 2: DSC results of rejuvenator-aged bitumen blends

Samples	Ref	P2	P2A1_10	P2C1_50
Tg (°C)	-22.3	-9.0	-27.0	-24.0

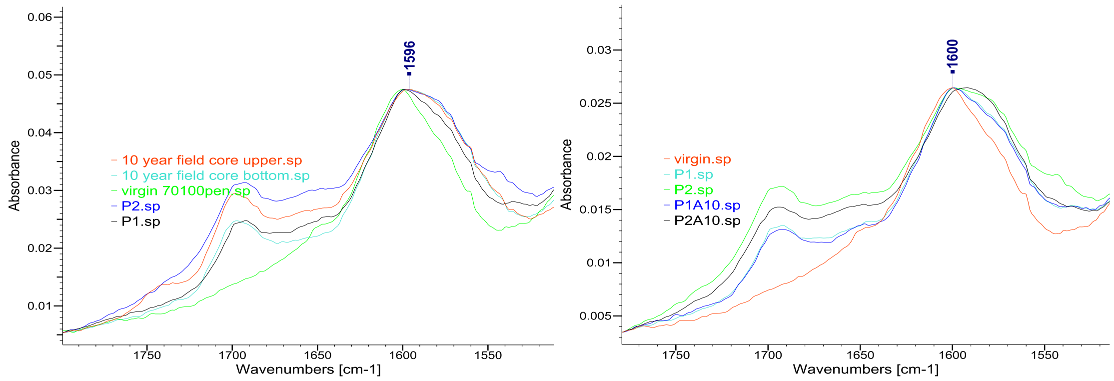

Figure 2: Example of FTIR results: (a) Aged bitumen; (b) Rejuvenator-aged bitumen blends

Table 2 shows the DSC results of the rejuvenator-aged bitumen blends. It can be observed that the lab aged bitumen increases the glass transition temperature. The blending of the rejuvenators into aged bitumen decreases the glass transition temperature to the level of the original bitumen.

As shown in Figure 2a, the FTIR was conducted on lab aged bitumen. It is shown that the lab aged bitumen P1 and P2 are comparable to bitumen extracted from the top part and the bottom part of a 10-year old porous asphalt with regard to the concentration of the carbonyl (C=O) at wavenumber of 1700 cm^{-1} [5]. This is believed to be the representative peak for ageing of bitumen. When mixing with rejuvenators as shown in Figure 2b, the amount of carbonyl in the bitumen samples does not change. This indicates that the blending of rejuvenators into aged bitumen does not alter chemical structure of the aged bitumen but only lower the complex modulus and glass transition temperature of the aged bitumen with soft components.

5. CONCLUSIONS

The blending of the rejuvenator into the laboratory aged bitumen is a physical process, the bitumen can regain its flexibility with a lower complex shear modulus, a higher phase angle and a lower glass transition temperature. A softer rejuvenator shows a higher potential. No significant chemical change can be observed for the rejuvenated bitumen. This research is on-going to investigate the diffusion capabilities of rejuvenators on the field aged reclaimed asphalt and the fatigue and healing evaluation.

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