Effects of Engine Oil Residues on Asphalt Cement Quality

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ABSTRACT

This paper discusses and documents an investigation of chemical aging in asphalt cement modified with Engine Oil Residue (EOR). EOR is produced during the recycling of used motor oils collected from vehicles. It has been reported that a significant fraction of the asphalt cement used in parts of Canada is blended with EOR to meet certain low temperature Superpave™ grades. Such material can provide a low-cost method of increasing the grade span when blended with asphalt high in asphaltenes.

However, concerns exist that such modifiers may negatively affect asphalt quality in several ways. First, the paraffinic nature of the EOR and possible presence of engine detergents can reduce the adhesion to the aggregate and thereby increase moisture damage. Second, metals such as iron, copper, and chromium, abundantly present in EOR, can act as catalysts in the oxidation of asphalt cement. Finally, paraffin can precipitate asphaltenes, which may accelerate further chemical and physical hardening.

This paper presents results of aging tests on straight and EOR-modified asphalt cements. We found that EOR significantly increased oxidation rates and the tendency for asphaltenes to precipitate, leading to a less ductile material with higher stress at low temperatures, which typically results in early and increased cracking.

RÉSUMÉ

Cet article discute et documente une enquête sur le vieillissement chimique du bitume modifié avec moteur un résidu pétrolier de moteur (RPM). Le RPM est produit pendant le recyclage des huiles à moteur utilisées recueillies sur les véhicules. Il a été signalé qu'une fraction significative du bitume utilisé dans certaines régions du Canada est mélangée à du RPM pour répondre à certains grades de Superpave ™ à basse température. Ce matériel peut fournir une méthode à bas coût pour augmenter l'étendue du grade lorsque mélangé avec un bitume à forte teneur en asphaltènes.

Cependant, des préoccupations existent que de tels modificateurs peuvent nuire à la qualité du bitume de plusieurs façons. Tout d'abord, la nature du solvant du RPM et la présence éventuelle de détergents moteur peuvent réduire l'adhérence à l'agrégat et augmenter ainsi les dommages de l'humidité. Deuxièmement, les métaux comme le fer, le cuivre et le chrome, abondamment présents dans le RPM, peuvent agir comme catalyseurs dans l'oxydation du ciment bitume. Enfin, la paraffine peut précipiter les asphaltènes, ce qui peut accélérer davantage le durcissement chimique et physique.

Cet article présente les résultats de tests de vieillissement sur le bitume pur et celui modifié au RPM. Nous avons constaté que le RPM augmente significativement les taux d'oxydation et la tendance des asphaltènes à précipiter, conduisant à un matériau moins ductile avec des contraintes plus élevées à basses températures, ce qui généralement entraîne une fissuration précoce et plus grande.

1.0 INTRODUCTION

Shortly after the Superpave™ specifications were introduced, a number of low-cost asphalt modification techniques were patented and/or published in the open literature (for instance, see [1-10] and others). Nearly all of these approaches gel the asphalt cement to increase the high temperature grade without having a significant effect on the low temperature properties as measured with the Bending Beam Rheometer (BBR). It is accepted by some that a mild degree of network (gel) formation is desirable in terms of overall asphalt cement quality [11]. However, high levels can lead to phase separation, with the negative consequences of increased physical and chemical hardening reducing the ductility of the asphalt cement [12-15]. Physical hardening is especially detrimental since it can lead to high levels of retained thermal stress, with the possibility of early and excessive cracking [16]. The use of Engine Oil Residues (EOR) in asphalt cement modification is reportedly widespread in Canada, but few detailed investigative reports have appeared in the literature [17-21].

Herrington [18] studied the use of used oil distillation bottoms (EOR) as a simple extender for asphalt cement and a processing aid during the modification process of air blowing. The study concluded that the temperature susceptibility of the base asphalt was reduced when up to 10 percent oil residue was added. At moderate temperatures the oxidative hardening rates of the blends were similar to those of the base asphalt, but at high temperatures these rates typically increased. The author stated that full-scale field trials were constructed and that the details would be reported elsewhere. However, a careful search of the literature has failed to bring up further publications on the outcome of the trials.

Villanueva et al. [20] studied the addition of used lubricating oils in two different air-blown asphalts at concentrations ranging from 1 to 10 percent. With an increase in the amount of oil, the materials consistently became softer and the Superpave grade span became narrower. However, the grade span actually remained constant when a slightly different grading approach involving the direct tension test was used. The grade span improved by a significant 6°C when the used oil modified binders were compared with straight-distilled material prior to air blowing. The study therefore concluded that used lubricating oils can be used as softening additives without sacrificing the grade span. However, reiterating early concerns expressed by researchers from Quebec [19], the authors noted potential for increased moisture susceptibility associated with degraded surfactants and paraffin in the used lubricating oils as a possible downside for the use of this material in asphalt cement.

Hesp and Shurvell [21] showed that EOR was present in a majority of prematurely and excessively cracked pavement contracts in eastern and northern Ontario. The laboratory investigation linked the cracking to reduced strain tolerances as approximated by the critical Crack Tip Opening Displacement (CTOD) and increased tendencies toward physical hardening for the recovered asphalt cements, as measured with Ontario's specification tests LS-299 and LS-308 [21] and displayed in Figures 1 and 2.

2.0 OBJECTIVES

The primary objective of this study was to investigate how EOR affects the oxidative hardening tendency of straight Cold Lake asphalt cement. A secondary objective was to show if and how the current Rolling Thin Film Oven/Pressure Aging Vessel (RTFO/PAV) protocol can be improved to better capture the effects of such additives on asphalt durability. The long-term objective of this research is to aid in the development of improved asphalt cement aging and specification test methods allowing user agencies to better ensure performance.