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Original Research Paper

Characterization of recycled crumb rubber modified binders containing wax warm additives

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HIGHLIGHTS

- The wax additives in recycled crumb rubber modified (CRM) binder are effective to reduce the viscosity.
- The wax additives are still effective to improve the rutting property even though the additives experienced aging process.
- The additives are expected to have significant effect on cracking properties based upon their substantial amount.

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ABSTRACT

This paper addresses the laboratory experiment of performance properties of recycled CRM binders containing artificially aged CRM binders with wax additives. The warm CRM binders were produced using two wax additives (LEADCAP and Sasobit) and then short-term and long-term aged using the rolling thin film oven (RTFO) and pressure aging vessel (PAV) procedures. The recycled CRM binders were aged through the RTFO and PAV procedures. A set of Superpave binder tests were carried out on the binders through the rotational viscometer, the dynamic shear rheometer (DSR), and the bending beam rheometer (BBR). In general, the results of this study indicated that (1) the addition of long-term aged (LTA) CRM binder can significantly increase the viscosity of the recycled CRM binders as expected, (2) the wax additives in recycled CRM binders were still effective to improve the viscosity and rutting properties even after experiencing the aging process, (3) the CRM binders containing wax additives showed the higher rutting resistance compared to the control CRM binders, (4) the recycled CRM binder containing wax additives was found to have less resistance to fatigue and low temperature cracking, (5) wax warm additives into the recycled CRM binders seemed to have a significant role for cracking properties, based upon their substantial amount.

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1. Introduction

Approximately 300 million scrap tires are generated each year in the United States, and 95% of scrap tires is being utilized. Also, 4.3% of scrap tire is being consumed for the civil engineering applications (Rubber Manufacturers Association, 2014). The disposal of these scrap tires has become a serious issue due to many reasons such as lack of landfill space and environmental issues. Previous studies have reported that the addition of crumb rubber into asphalt binder can produce asphalt pavements that exhibit increased pavement life, decreased traffic noise, reduced maintenance costs and resistance to rutting and cracking (Huang et al., 2002; Lee, 2007; Ruth and Roque, 1995; Shen et al., 2006; Xiao, 2006; Xie et al., 2015; Xie and Shen, 2016a, b). Because of these advantages, there is an increasing interest for using crumb rubber modified (CRM) binders in hot mix asphalt (HMA) pavements in some states in the United States and other countries (Bahia and Davies, 1994; Lee et al., 2006).

Warm mix asphalt (WMA) technologies allow significant reduction of mixing and compaction temperatures of asphalt mixes using proprietary chemicals. In addition, the WMA provides better working condition based on reduction in emissions in asphalt plants and fields, and there are many other promising benefits including less fuel consumption, longer paving seasons, longer hauling distances, earlier traffic opening, reduced binder aging, and reduced cracking (Akisetty et al., 2009; Button et al., 2007; D'Angelo et al., 2008; Gandhi and Amirkhanian, 2007; Hurley and Prowell, 2005, 2006; Kim et al., 2013).

Many research projects have concluded that the use of reclaimed asphalt pavement (RAP) into HMA pavements can help offset increased initial costs, conserve natural resources, and avoid disposal problems (Hajj et al., 2009; Moghadas Nejad et al., 2014; Schvallinger, 2011). Furthermore, the properties of properly designed recycled asphalt concrete materials have been proven to be comparable to new asphalt concrete pavements (Lee, 2007; Mogawer et al., 2013; Xiao, 2006).

The recycling of CRM binder was already introduced by several studies (Lee et al., 2008; Shen et al., 2006, 2007). According to the research results, the use of CRM RAP into virgin binder satisfied the requirements used in the field. In addition, the CRM binder containing warm additive technology was mentioned by previous researches (Akisetty et al., 2009). The addition of warm

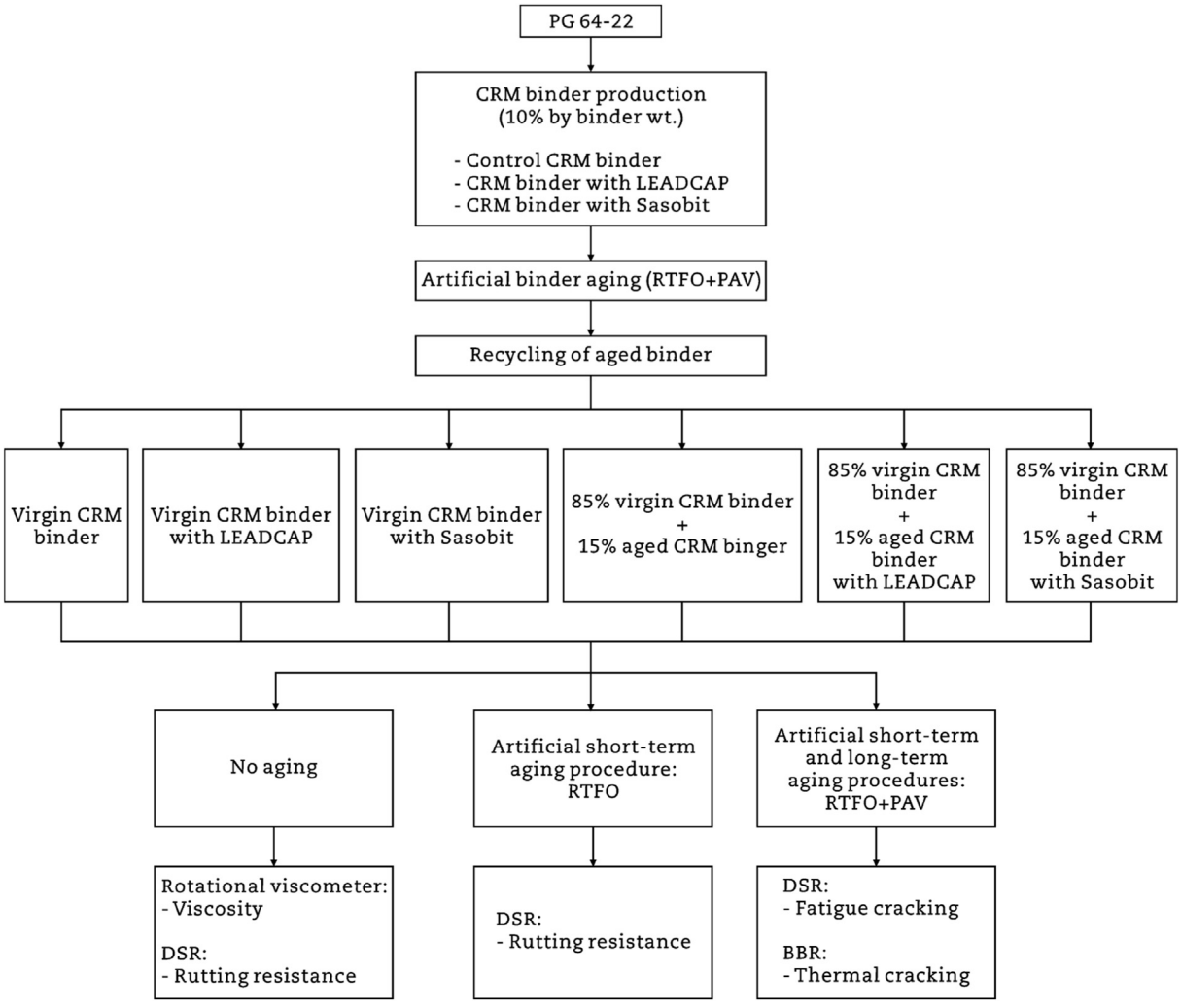

Fig. 1 – Flow chart of experimental design procedures.