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Caltrans use of scrap tires in asphalt rubber products: a comprehensive review

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Abstract: The California Department of Transportation (Caltrans) has been using scrap tire rubber in asphalt pavements since the 1970s in chip seals and the 1980s in rubberized hot mix asphalt(RHMA). Both the wet (field blend) and dry processes were used in early trials. Caltrans has also used rubber modified binders containing both crumb rubber modifier and polymer modifier that could be manufactured at a refinery facility, a terminal blend wet process. Since the beginning of this century, Caltrans increased the use of scrap tire rubber in paving projects and invested considerable resources in developing technically sound, cost effective, and environmentally friendly strategies for using scrap tire rubber in roadway applications. By the end of year 2010, approximately 31% of all hot mix asphalt (HMA) placed by Caltrans was rubberized HMA, roughly 1.2 million tons. Caltrans efforts in using asphalt rubber products were also demonstrated in its research and technology development. These included the construction of two full-scale field experiments, five warranty projects, and an accelerated pavement study using a heavy vehicle simulator. Additionally, terminal blend asphalt rubber and rubberized warm mix asphalts began to be experimented on trial basis. This paper provides a comprehensive review of Caltrans experience over four decades with asphalt rubber products. Current practices and future outlook are also discussed.

Key words: asphalt rubber; rubberized asphalt concrete; rubberized hot mix asphalt; rubber modified binder; rubber modified asphalt concrete

1 Introduction

1.1 Historical perspective

Caltrans use of scrap tire in asphalt rubber products spans nearly four decades. In the 1970s, asphalt rubber products, mainly Rubberized Asphalt Concrete (RAC, a field-blend wet process) were used in dense-graded asphalt concrete mixes on an experimental basis (Caltrans 2005; Van Kirk 1989; Shatnawi 2000). The RAC layer

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thickness was designed equal to that of conventional Dense-Graded Asphalt Concrete (DGAC) (Doty 1988).

In the 1980s, Caltrans built an experimental project (Ravendale Project) that included both RAC and DGAC overlays of several thicknesses (Doty 1988). Field performance suggested that a thickness reduction for RAC mixes was appropriate(Caltrans 1992; Van Kirk and Holleran 2000). Subsequently, several Caltrans Districts placed both dense- and open-graded RAC mixes.

In the 1990s, Caltrans continued to study rubber modified mixes through accelerated testing and field projects. The South African Heavy Vehicle Simulator (HVS) was used to evaluate rubber modified gap-graded mixes as well as conventional dense-graded mixes(Rust et al. 1993). The results of the study confirmed that asphalt rubber gap-graded mixes of reduced thickness mitigated reflection cracking. Additional studies at the University of California Berkeley confirmed this finding(Harvey and Monismith 1994; Harvey and Bejarano 2001).

By the mid-1990s, over 100 field projects, both rehabilitation and maintenance jobs, were constructed throughout the state. Two types of asphalt rubber binders (Type I and Type II) were used. Type II asphalt rubber binder requires asphalt modifier (extender oil) and high natural rubber while Type I does not. A field review of these projects in 1995 indicated that thin rubber overlays generally provided good performance when properly designed and constructed and that Type II binders performed better than Type I binders(Hildebrand and Van Kirk 1996).

As a result of these field projects, Caltrans made various accomplishments, including:

(1)Modifications to the Caltrans overlay design procedure to allow reduced thickness of rubber modified mixes, the primary benefit of which is in mitigating reflection cracking.

(2)Improvements in mix design procedures for both the gap- and open-graded mixes.

(3)Improvements in specifications and quality control for asphalt rubber mixes, including the prohibition of Type I binder, i.e., allow use of Type II binder only.

(4)Elimination of the use of dense-graded RAC mixes.

(5)Development of a modified binder specification(Reese 1995).

(6)Development of a RAC usage guide(Caltrans 2003).

In the same period Caltrans also experimented a modified binder (MB) containing both crumb rubber and a polymer modifier that could be manufactured at a terminal facility. Ten pilot projects were constructed to evaluate the performance of materials meeting the MB specification (Reese 1995). These projects were reviewed by a Caltrans-Industry group in 2002 (Caltrans 2002). Eight projects were rated as "good", and one each was rated as "fair" or "poor".

1.2 First decade of the 21 century

Since the beginning of this century, Caltrans increased the use of scrap tire rubber in paving projects and invested considerable resources in developing technically sound, cost effective, and environmentally friendly strategies for using scrap tire rubber in roadway applications. According to the 2011 Annual Report to the California Legislature and the Department of Resources and Recovery, there has been a steady increase in rubberized hot mix asphalt (RHMA) or RAC use (Caltrans 2011). By 2010, approximately 31% of all HMA placed by Caltrans was RHMA, equal to roughly 1.2 million tons. It was projected that about 2.2 million tons of RHMA would be used by the end of 2011. As illustrated in Fig.1, the RHMA usage has utilized millions of waste tires annually.

2 Applications

Asphalt rubber products have been typically used in hot mix asphalt and spread applications(Caltrans 2003). In the rewrite of the Caltrans asphalt concrete specifications, the term "rubberized asphalt concrete (RAC)" has been changed to rubberized hot mix asphalt (RHMA) (Caltrans 2011). The rest of the paper uses RAC and RH-