Construction and Building Materials 38 (2013) 423–442

Contents lists available at SciVerse ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Review

A review of state of the art on stripping phenomenon in asphalt concrete

Amir Mehrara, Ali Khodaii *

Department of Civil and Environmental Engineering, Highway and Transportation Div., Amirkabir University of Technology, Tehran, Iran

HIGHLIGHTS

- Providing a comprehensive review of researches on stripping potential of HMA.
- Classifying stripping tests on HMA according to the nature of the tests.
- Extracting some applicable stripping indicators based on previous researches.
- Highlighting recent numerical research areas on stripping potential.

ARTICLE INFO

Article history:
Received 5 April 2012
Received in revised form 28 July 2012
Accepted 11 August 2012
Available online 29 September 2012

Keywords:
Asphalt concrete
Stripping
Moisture susceptibility
Moisture damage
Computational modeling

ABSTRACT

Stripping is an important type of distress about which gaining thorough information can improve the pavements design methods. A brief review of researches on the stripping potential of asphalt mixtures over the past 40 years has been presented in this paper. The contents of the article include mechanisms of moisture damage occurrence and contributing factors, as well as an introduction to the variety of steps taken in an effort to experimentally and numerically model the moisture damage propagation. Researches on stripping have been divided into three categories of field studies, laboratory investigations, and numerical and computational analysis. Laboratory experiments are also categorized into five groups. Tests on loose mixtures, destructive mechanical tests on asphalt concrete, nondestructive mechanical tests on asphalt concrete, mechanical tests which provide a measure of cohesion in asphalt and adhesion between asphalt and aggregate, non-mechanical tests which provide a measure of cohesion and adhesion based on surface energy theories, and non-destructive non-mechanical tests. In different sections of the article, achievements including the shortcomings and blessings in each branch of researches have been discussed and finally suggestions for future investigations have been presented.

Contents

* Corresponding author. Address: Department of Civil Engineering, Amirkabir University of Technology, No. 424, Hafez Ave., Tehran 15914, Iran. Tel.: +98 021 64543000.

E-mail addresses: amir.mehrara@aut.ac.ir (A. Mehrara), khodaii@aut.ac.ir (A. Khodaii).

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http://dx.doi.org/10.1016/j.conbuildmat.2012.08.033

1. Introduction

Moisture sensitivity of an asphalt mixture, generally called stripping potential, is among the most important distresses of asphaltic pavements. Although the effect of moisture on asphalt mixtures, unlike the traffic loading and thermal stress, is not considered as a major solicitation, penetration of moisture through the asphalt mixtures can increase the pavements vulnerability to the other two solicitations [1–3]. Perhaps it has been near a century that this type of distress has been discovered. Since then, lots of researches have been conducted to understand the mechanisms of its initiation and to find remedies to control its formation in pavements. A brief look at the history of researches reveals that field investigation, laboratory experiments and analytical studies are the three major research areas around moisture damage. Before the fifties, most researches were limited to field observations, but afterwards, with the advent of laboratory test methods, researches were concentrated on laboratory studies to find a correlation between test results and field observations. From about the turn of the century, another branch of investigation has been gaining attention, in which the stripping phenomenon has been studied from a theoretical point of view, and an attempt has been made to model the coupling effects of moisture damage and traffic loading.

What is being put forth in this article is a summary of extended researches having been conducted on the reasons and causes of stripping from different researchers viewpoints during the past 40 years. Also, it is intended to take a look at studies which have been done with the aim of evaluation, estimation and preservation of stripping in asphalt concrete and asphaltic pavements considering the achievements and shortcomings of each. Finally, the new areas of research based on the improved theoretical bases of evaluation and recognition of stripping are introduced.

2. Moisture damage (definition, mechanisms, controlling factors)

Different varieties of definitions having the concept of moisture distress can be seen in the literature. According to the definitions, a separation of asphalt from aggregate or the rupture of asphalt texture in asphalt mixtures under the action of cyclic traffic load and presence of water or water vapor at the same time is named stripping. Kiggundu and Roberts gathered various definitions from a number of researchers' viewpoints such as, *Petersen*, *Kennedy* and *Tunicliff* [4]. According to the named researchers, stripping takes place due to loss of adhesion between aggregates and asphalt in the presence of water; however, Kiggundu and Roberts provided a more comprehensive definition for stripping in which both cohesive and adhesive failures were considered as the reasons of moisture damage. Although in some researches [5–7] the exertion of cyclic traffic load is taken as another cause besides moisture, some other scientists such as Birgisson et al. [8] believe that to evaluate the effect of moisture on asphalt concrete, it is better to consider the stripping affect of moisture due to its long term presence in voids of asphalt mixture without encountering the complexity of coupling of cyclic loading and moisture damage.

Apart from the definition of moisture damage and the mechanisms of its formation in asphalt concrete there are some factors related to the constitutive parts of the mixture and to the prevailing environmental conditions that can have a profound effect on expediting or impedance of moisture damage that will be discussed throughout the section.

2.1. Moisture damage mechanisms

Two mainstreams can be found in the researches that are conducted on mechanisms of stripping. These two mainstreams are studying the micro-mechanisms and macro-mechanisms of moisture damage. In other words, there are some theories that explain adhesion between asphalt and aggregate, cohesion in asphalt and the failure of these two bonds on a molecular scale, yet some other theories explain the adhesive and cohesive failure using mechanical theories on a macro-scale. However, both approaches can be seen in most of the recent researches.

2.1.1. Moisture damage micro-mechanisms

The micro-mechanism of adhesion, probably known as adhesion theories can be categorized as below according to several researchers [4,9–12].

- *Mechanical theory*: Based on this theory, the penetration of asphalt to the irregularities of the aggregate surface can produce mechanical interlocking.
- *Chemical reaction theory*: This theory attributes the adhesion between asphalt and aggregate to the chemical reactions that may exist between the aggregate particles and the adsorbed asphalt.
- *Molecular orientation theory*: According to this theory, asphalt molecules adjacent to the aggregate surface, depending on the amount of their polarity, align themselves towards the aggregate surface, so that they can satisfy the energy demand of the aggregate.
- *Surface energy theory*: This theory, which is developed based on the thermodynamic principles, assumes that adhesion has a thermodynamic nature and depends on the surface energy of the materials.