Prediction of Moisture Resistance of Polymeric Asphalt Binders Through the Atomic Force Microscopy (AFM) Technique

Project Number:

22BASU02

Start Date:

04/01/2022

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Funding Source(s):

Tran-SET

Arkansas State University

Total Project Cost:

$ 119,121

Predicting moisture resitance of polymeric asphalt binders using AFM

Moisture-induced damage in asphalt concrete is a major concern to the transportation agencies. Existing moisture sensitivity tests are mostly conducted at the macro- or micro-level and focused on the qualitative measurements only. The proposed study will investigate the interaction between asphalt binder and aggregates at the interface level measuring adhesion forces between asphalt binder samples and minerals of different chemical compositions using an Atomic Force Microscope (AFM). To this end, all three Arkansas Department of Transportation (ARDOT) approved Performance Grade (PG) binders (PG 64-22, PG 70-22, and PG 76-22) from two different sources and two types of commonly used aggregates (e.g., limestone and sandstone) in Arkansas will be evaluated in the laboratory. Besides the positive impacts of a selective anti-stripping agent (Kao Gripper® X2), the effects of aging (short-term and long-term) on the stripping resistance of binders will be evaluated in the laboratory.

Problem Statement

Moisture susceptibility has been recognized as major pavement distress since the early 1990s. Great effort has been given in this field to come up with effective test methods to quantify the moisture susceptibility of asphalt concrete to take remedial action for the longevity of the structures. The most popular forms of moisture resistance tests of asphalt mixtures are the Boiling, Indirect Tensile Strength, and Hamburg Wheel test methods, which are followed by over 80% of the agencies. However, none of these techniques consider the adhesion phenomena at the interface level. Also, there does not exist an approach to predict the interfacial behavior considering the chemical composition of contact surfaces at the molecular level. However, the adhesiveness of a bitumen-aggregate system is one of the fundamental properties that affect asphalt pavements' performance; low adhesion causes bitumen detachment from the aggregate surface leading to severe distresses that include moisture damage and cracking in asphalt mixture. The proposed study will investigate the interaction between asphalt binder and aggregates at the interface level measuring adhesion forces between asphalt binder samples and minerals of different chemical compositions using an Atomic Force Microscope (AFM). The tips of the AFM will be modified with comparable aggregate minerals, thus, the adhesion force between asphalt and minerals will be measured. The adhesion force will then be used to estimate the work of adhesion between asphalt binders and materials. The findings of the proposed study are expected to give pavement professionals and researchers a better understanding of moisture-related damage in asphalts at the molecular level. Implementation of the learned knowledge will assist the transportation agencies to avoid premature pavement distresses and save taxpayers' money.

Objectives

The primary objective of this proposed research project is to estimate the interaction between bitumen and aggregates at the interface level in the form of adhesion forces between bitumen samples and minerals of different chemical compositions at a molecular level using the AFM techniques.

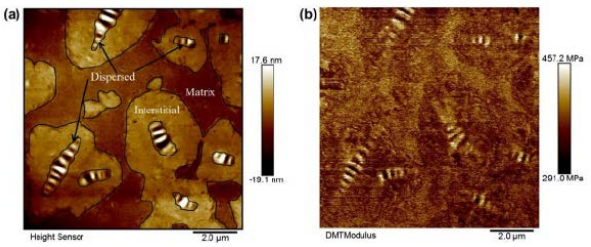

Figure 1. Typical Images of AFM Images of a Polymeric Binder: (a) Morphology Showing Three Distinct Phases and (b) DMT Modulus (Rashid et al. 2017).

Intended Implementation of Research

Workforce Development, Education, and Outreach: Research findings will be discussed among students enrolled in Advanced Civil Engineering Materials, taught by the PI. Also, a graduate student will be pursuing his/her Master's

thesis on this topic. Further, local K-12 students will be benefitted from this project through internship and hands-on creative activities. Presentations based on the findings of this study will be made at local chapter meetings of professional organizations such as ASCE. Such initiative supports the outreach activity of the Center. The proposer of this project will work with a local minority community to encourage K-8 students in STEM education. The outcomes of the research will be disseminated through a seminar, ARDOT TRC Meetings, Tran-SET Conferences, technical papers, and a final report. Technical articles will be delivered at national and local conferences and symposia such as TRB, the American Society of Civil Engineers (ASCE), and Create@STATE.

Anticipated Impacts/Benefits of Implementation

The findings of this study will help ARDOT and other industries in the region to use knowledge learned on predicting moisture resistance of asphalt binder at a molecular level using an AFM. It is expected to be a significant cost saving for these agencies in predicting moisture damage and preventing premature pavement distresses.

Web links

- Tran-SET's website https://transet.lsu.edu/research-in-progress/

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.