Tran-SET
Transportation Consortium of South-Central States

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Use of Nanoclays as Alternatives of Polymers Toward Improving Performance of Asphalt Binders

Key Points

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17BASU01

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$35,716

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Tran-SET
Arkansas State University
Ergon, Inc.

Total Project Cost:
$71,542

Brief Project Description

The principal goal of this project is to assess the feasibility of using less expensive and naturally abundant nanoclays as an alternative modifier to sustain increased traffic loads and extreme temperature events. The proposed study will provide important laboratory data on the rheological and mechanistic properties of nanoclay-modified binders. Such data will be essential to setting the direction of future studies and eventual special provisions for incorporation of nanoclays in asphalt binder modification.

Problem Statement

Over 90% of paved roads in the U.S. are asphalt pavements. The annual expenditures for the maintenance of these pavement infrastructures exceed $100 billion (NECEPT, 2016). Hot mix asphalt (HMA) used widely in constructing roads contains about 95% crushed rocks and 5% asphalt binder. Although a small amount, asphalt binder plays a significant role in the performance of HMA pavements. For example, rheological properties and temperature susceptibility of the asphalt binder influence the pavement's performance (e.g., rutting at high temperature and cracking at low temperature). Improved mechanistic properties of the asphalt binder are important for enhancing the quality and service life of pavements. Increasing the quality and service life of pavements requires improving mechanical and rheological properties of asphalt binders as well as surface characteristics of pavements in all weather conditions.

The current practice to modify neat asphalt binders is to blend (mechanically) polymer additives such as styrene-butadiene-styrene (SBS) and styrene-butadiene-rubber (SBR), which increases the overall cost of the asphalt binder (Planco et al. 2006; Sibal et al. 2000). A significant portion of the current usages of polymer-modified binders (PMBs) can potentially be replaced by nanoclay-modified binders because nanoclay is fairly inexpensive and naturally abundant as well as has enormous surface energy. It is estimated that the cost to modify a neat PG 64-22 binder with nanoclay is about $80/ton, which is a net saving of $70/ton compared to the SBS-modified binders. Over time, the price of nanoclay is expected to go down, and so will the cost of nanoclay-modified binders. However, understanding

and controlling atomic-level interactions between asphalt binder and nanoclays are of significant interests for the development of pavements with superior load bearing capabilities.

Objective

The main objective of this project is to investigate if "nanoclay" can be used as a modifier to enhance the mechanistic performance and rheological properties of the neat asphalt binder. The specific objectives of this project are:

(1) Develop suitable protocol(s) to disperse nanoclays in asphalt binders at the nanoscopic level effectively;

(2) Investigate the effect of size, surface modification and dosages of nanoclays on critical properties of the asphalt binder;

(3) Evaluate the role of nanoclays in altering the rheological properties of the asphalt binder;

(4) Study the effect of nanoclays on aging properties of the asphalt binder;

(5) Evaluate moisture susceptibility of the modified binders;

(6) Perform chemical analysis of nanoclay-modified binders; and

(7) Conduct a life cycle cost analysis of different nanoclay-modified asphalt binders.

Intended Implementation of Research

Technology Transfer

The two main deliverables from this research project are: (1) A technical report containing the blending protocol, performance data, life cycle cost-analysis results, and recommendations and guidelines of using nanoclay-modified asphalt binders, and (2) showcase the findings of the study at AHTD Technical Research Committee (TRC) meetings at AHTD and at the Annual Research Day organized by Tran-SET. The findings from this research study will be disseminated via workshops/webinars, AHTD Transportation Research Council Meetings, Tran-SET Research Day, technical papers, quarterly and final reports, and possibly via presentations at FHWA ETG meeting.

Education, Workforce Development, and Outreach

Besides technical articles and posters, the following activities will be performed to disseminate the findings of the project:

Workshops/Webinars for DOT and Pavement Professionals: Two workshops/webinars will be conducted throughout the project duration for DOT officials and pavement professionals. The first webinar will be held at the middle of the first year, which will focus on the existing practices and planned methodology of this study. After completing the laboratory tests, the second webinar will be arranged focusing the outcomes of tests. This webinar will be held at a national level venue such as FHWA Binder or Mixture Expert Task Group Meeting.

Training High School Students: The PI will train a local high school student as part of an existing internship program with Jonesboro High School. Also, a High School Senior Preview session will be made throughout the project period. This

preview session will be helpful educating school going future citizens about the recent innovations in pavement materials, infrastructure and technologies.

Future steps: By the end of Year 1, we plan to provide DOTs with sufficient evidence (test results and benefit-cost analysis data) that they are prompted to use the proposed material as an alternative modifying agent. We will work with AHTD, County Engineers and local contractor to construct a field demonstration project to transfer the developed techniques in practice. We will work with AHTD for possible revision of AHTD's asphalt mixtures' test specifications (Article 404.04: Quality Control of Asphalt Mixtures).

Anticipated Impacts/Benefits of Implementation

The proposed research is guided by the expectation that the analysis will lead to the use of an alternative material instead of highly expensive polymers in enhancing the performance of soft binders. This will reduce the cost of asphalt mixes significantly, and thereby this will save taxpayers money. It will also help DOTs in the region to use eco-friendly and naturally abundant nanoclays in asphalt mixes that will be sustainable and preserve the environment. The findings from this research will also promote the use rejuvenating agents that can reduce pavement failures due to fatigue cracking related to brittleness of asphalt binders.

Nanoclay modifications of asphalt binders are expected to reduce the HMA production costs by $20 to $30 million annually. Nationally, the level of cost savings is expected to be hundreds of millions.

By nature, the asphalt production and paving industry is labor intensive industry. Nationally, over 330,000 people are employed by the asphalt industry. Significant savings in production costs of nanoclay-modified HMA would allow the industry as well as the transportation agencies to increase workforce. While it is difficult to estimate, the increase in workforce is expected to be in the hundreds.

Depending upon the blending protocol, some modification may be needed for effective blending of nanoclays with asphalt binders at the plant (or at refineries). We expect to have a better idea of the type of plant modifications needed, if any, in this proof-of-concept project.

Weblinks:

http://transet.lsu.edu/research/research-in-progress/

https://rip.trb.org/view/2017/P/1466538