

Evaluation of Nanoclay Additives for Improving Resistance to Moisture Damage in Hot Mix

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Introduction

Departments of Transportation throughout the U.S. invest hundreds of millions of taxpayer dollars on maintaining and managing pavement infrastructures. For example, in California alone, Caltrans invests between \$500 million and \$600 million annually for the maintenance of approximately 50,000 lane-miles of paved highways. One of the most common issues that trigger the need for pavement maintenance is moisture-induced asphalt damage. Finding a cost-effective modifier to the asphalt binder to resist moisture-related damage will significantly increase the service life of the pavement and, thus, reduce the frequency and cost of pavement maintenance.

In previous research, nanomaterials showed promise in enhancing pavement properties including moisture resistance. However, these studies did not compare the nanomaterial's performance to the other asphalt binder modifiers commonly used in California. Thus, this

research was conducted to: (a) evaluate the effectiveness of nanoclay for enhancing the asphalt binder's resistance to moisture induced damage, (b) compare the performance of nanoclay to the standard modifiers used by Caltrans for reducing moisture sensitivity of hot mix asphalt (HMA), and (c) rank the binder additives studied in the literature based on multi-criteria to identify and inform decisions on the feasibility of using nanoclays for reducing moisture sensitivity of HMA.

Study Methods

The physical and mechanical properties of aggregates and asphalt binders used in the study were evaluated in accordance with standard specifications. The study tested five additives for enhancing moisture resistance of HMA: (a) two types of surface-modified nanoclays, (b) lime-treated aggregate, and (c) amine-based liquid anti-stripping chemicals (HP+ and LOF 6500). The asphalt binder was combined with varying concentrations of

each of the additives and tested using a Dynamic Shear Rheometer (DSR) before and after being aged in a Rolling Thin Film Oven (RTFO). Aggregate gradation curves were established for the mix design following Caltrans standards, and an optimum binder content was determined to be 5.75% using the Superpave mix design method. Using this mix design, the research team introduced varying amounts of each additive to the mix. Finally, the team tested the specimens for indirect tensile strength before and after being conditioned to evaluate potential enhancement in moisture resistance.

Nanoclay improves resistance to moisture-induced damage in HMA; however, antistripping liquids are more cost-effective alternatives.

Findings

Based on the DSR and RTFO tests, the two nanoclays had a stiffening effect on the binder. On the other hand, both liquid antistripping agents (HP+ and LOF 6500) had the opposite effect on the asphalt binder, decreasing both the elastic and complex modulus of the binder. After RTFO aging, similar trends for the additives were observed, except the binder had become much stiffer in all cases, which is typical for this test. The phase angle also decreased for most additive concentrations, making the binder more elastic in nature.

Compacted specimens were molded and tested using the AASHTO T 283 indirect tensile test. Specimens were compared on the basis of unconditioned tensile strength, conditioned (after moisture damage) tensile strength, and tensile strength ratios. Dry tensile strength results for the two nanoclay types and LOF 6500 modified mixes were higher than that for the control mix. However, all modified mixes resulted in wet tensile strengths that were higher than those for the control mix. TSRs for all modified mixes were higher than for the control mix and also exceeded the Superpave mix design method minimum of 0.80. The liquid antistripping agents tested herein were the least costly additive at an approximately \$2.0/ton added cost.

Policy Recommendations

The following professional practice recommendations stem directly from the research findings:

- Hydrated lime is currently being used in asphalt pavements on the central coast; however, liquid antistripping and nanoclays enhanced the resistance to moisture damage and could be tested in the field.
- Tests were only conducted on one mix design, one type of aggregate, and one type of binder. Varying any of these parameters can impact the performance of anti-stripping additives and thus, more testing is recommended.
- Development of a testing standard or case studies to evaluate the performance of these additives in the field would further benefit the asphalt pavement research.

About the Authors

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To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2151



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