Laboratory Evaluation of Anti-Strip Additives in Hot Mix Asphalt

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Introduction

Some state highway departments have problems with hot mix asphalt (HMA) pavements failing prematurely due to moisture damage. Moisture damage, also referred to as stripping, occurs due to loss of adhesion between the asphalt binder and aggregate and/or loss of cohesion within the asphalt binder. Measures to prevent such failure have included the addition of anti-strip additives (ASAs) to the HMA mixtures. Examples of ASAs include hydrated lime, hydraulic cement, and several liquid ASAs.

Currently, the South Carolina Department of Transportation (SCDOT) specifies the use of hydrated lime as an ASA. This was based on research conducted in the 1980s. This research concluded that liquid ASAs were not as effective in preventing moisture damage as hydrated lime since the wet indirect tensile strengths and tensile strength ratios were lower for HMA mixtures containing liquid ASAs as compared to mixtures containing hydrated lime. Also, each particular liquid ASA was not compatible with all asphalt binder and aggregate sources used in South Carolina whereas, hydrated lime performed well with all binder and aggregate sources tested for the research project. Finally, there were storage stability problems and concerns about long-term performance of liquid ASAs that led to the decision to use hydrated lime.

In the past 20 years, new liquid ASAs have been developed that have been shown to be as effective as hydrated lime and more storage stable than earlier liquid ASAs. Due to these developments, a new evaluation of anti-strip additives was needed to determine the suitability for liquid ASA usage in South Carolina.

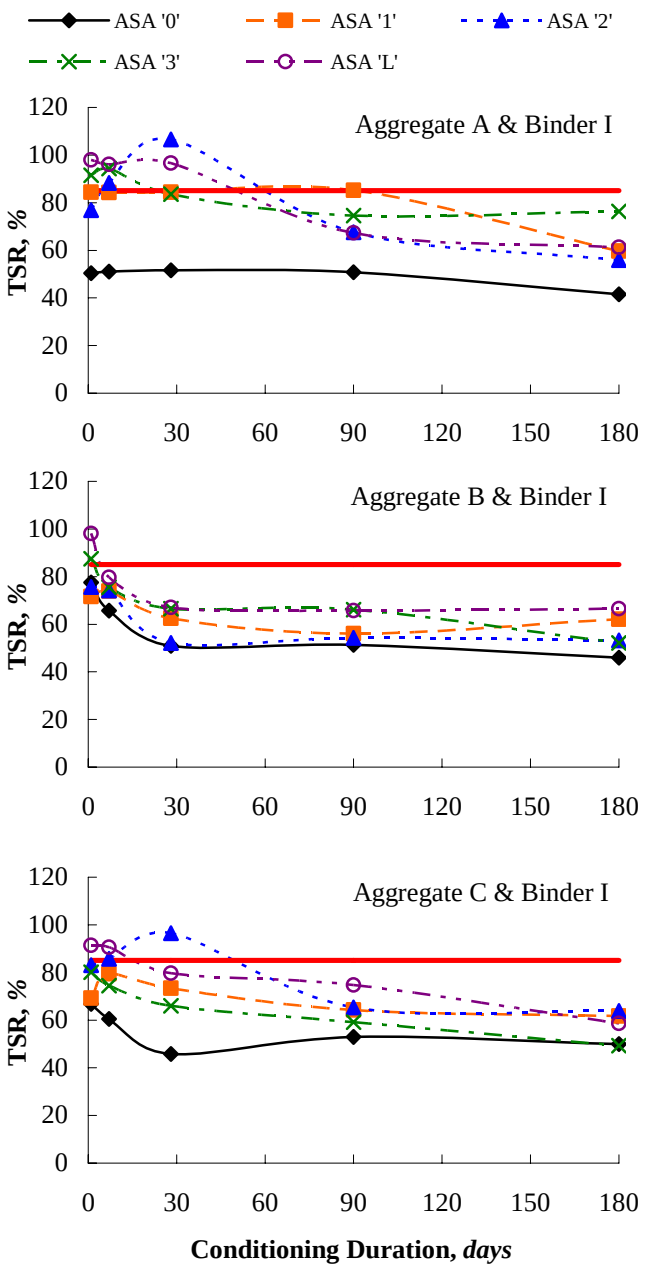
Research Objectives

The major objective of this study was to investigate the performance of ASAs in the laboratory. The specific objectives were:

1. To conduct 30 SCDOT Type B mix designs using 3 aggregate sources, 2 binder sources, and 5 ASA treatments (no ASA, 3 liquid ASAs, and hydrated lime).
2. To measure the moisture susceptibility of the 30 mixtures according to SC-T-70 (modified AASHTO T283) when exposed to extended conditioning durations (1, 7, 28, 90, and 180 days).
3. To evaluate the effects of liquid ASAs on the properties of the asphalt binders.
4. To study the heat storage stability of liquid ASAs blended with binders. Moisture susceptibility of stored binders was measured over extended conditioning durations.
5. To investigate the effects of the ASAs (liquids and hydrated lime) on the results of the asphalt ignition oven test to determine the binder content of the 30 mixes.

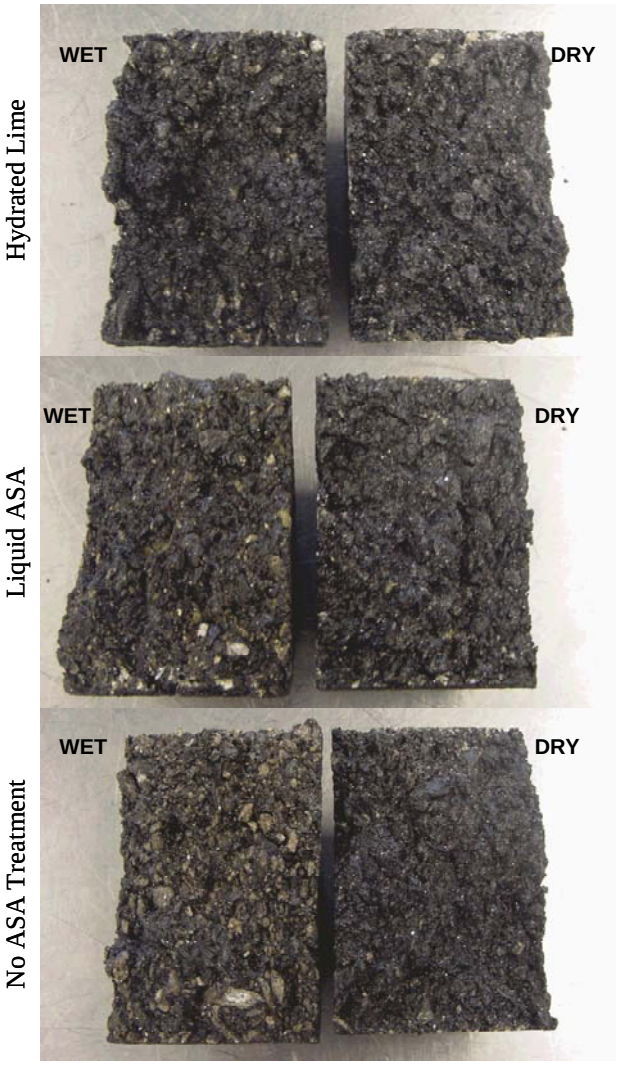
Results

The following figures summarize the results of the moisture susceptibility testing of mixtures containing the different ASAs with the three aggregates and one of the binders. The tensile strength ratio (TSR) is plotted against conditioning duration. The solid red line at a TSR of 85% is the SCDOT minimum value for TSR.



The photographs below indicate the degree of stripping that was visible on the samples that were wet conditioned. The visual results showed that the hydrated lime was most effective at preventing stripping while the mixtures containing no ASA showed higher potential for stripping. The specimens containing

liquid ASAs showed some discoloration, but not as severe as those containing no ASA treatment.



Conclusions

Based on the results of this study, the following conclusions were made regarding the use of anti-strip additives (ASAs) in hot mix asphalt (HMA) mixtures used for this research project:

- ✓ All of the ASAs (liquid ASA and hydrated lime) evaluated in this study improved the moisture susceptibility over the control mixes containing no ASA. However, hydrated lime was the most effective in raising the TSR of the mixes above the SCDOT minimum value of 85% for the ASA percentages evaluated in this study.
- ✓ All of the ASAs were effective in producing mixtures with wet ITS values above the SCDOT minimum value of 65 psi. This was not always the case with the control mixes.
- ✓ The aggregate and binder sources have an effect on the effectiveness of a particular ASA treatment.
- ✓ No particular trend regarding the effectiveness of the different ASAs over extended conditioning durations could be identified. All of the mixes had lower wet ITS and TSR values as the conditioning duration increased.
- ✓ The effect of storing binders containing liquid ASAs did have an effect on the moisture susceptibility of the mixes, but all of the mixes performed similarly. Additionally, the mixtures containing stored binder with hydrated lime also had increased moisture susceptibility.
- ✓ The effect of the liquid ASAs on the properties of the asphalt binders was not significant in either the fresh or stored conditions. All binders met the criteria of a PG 64-22 in accordance to AASHTO M320.
- ✓ The boil test proved to be ineffective to identify stripping in all cases, when compared to SC-T-70.

Recommendations

Based on the results and conclusions of this study, the authors recommend two possible courses of action for the SCDOT regarding the use of liquid ASAs: field implementation and future considerations.

Field Implementation

Based on the findings of this study, it is recommended that the SCDOT conduct some field investigations incorporating liquid ASAs in the mix designs. In doing so, the following should be considered:

- ✓ Conduct the field evaluations on lower volume routes to develop a "comfort level" when using these products.
- ✓ The effectiveness of many liquid ASAs is dependent upon the binder/aggregate combination. Additional testing may have to be performed during mix design to determine the proper dosage of liquid ASA to achieve the minimum wet ITS and TSR.
- ✓ Field TSR testing should be conducted to assure that the wet ITS and TSR requirements are being met.

Future Considerations

Based on the findings of this study, the following are recommended to the SCDOT for consideration:

- ✓ Future research to determine the fatigue performance of HMA containing different ASAs exposed to similar conditioning evaluated in this study.
- ✓ Re-evaluate the TSR requirement of 85% for all situations. In some cases, a mixture having a TSR of 80% and a wet ITS of 120 psi. may perform better than a mix having a TSR of 85% and a wet ITS of 65 psi.
- ✓ Evaluate the effect on the life-cycle cost of pavements constructed with HMA containing liquid ASAs compared to hydrated lime.

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