South Carolina
Department of Transportation

PROJECT SUMMARY

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South Carolina
Department of Transportation
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The Evaluation and Specification Development of Alternate Modified Binders in South Carolina

Overview

The use of modified binders in hot mix asphalt (HMA) has increased steadily over the past decades around the country. Over the last three decades, many researchers have investigated the effects of these modifiers on binders and mixtures. In many states, most interstate pavements are paved using these modified mixtures. In addition, these binders are used in mixtures in many additional locations with heavy loading conditions since they provide the required strength for that loading. Most of these modified binders exhibit excellent rutting resistance properties and perform very well under severe climates (e.g., high or low temperatures).

In this research project, asphalt binders containing various polymer modifiers were investigated through examining both binder and mixture properties. Two additional topics were also investigated, including: a) the effects of liquid anti-strip additives on asphalt mixtures; and b) the effects of natural sands in asphalt mixtures.

Literature Review

Polymers that have been used to modify asphalt include styrene–butadiene–styrene (SBS), styrene–butadiene rubber (SBR), Elvaloy® (an elastomer), ground tire rubber (GTR), ethylene vinyl acetate (EVA), polyethylene, and others. Desirable characteristics of polymer-modified binders include greater elastic recovery, a higher softening point, greater viscosity, greater cohesive strength and greater ductility. Currently, in the United States, the most commonly-used polymer for asphalt modification is SBS followed by other polymers, such as GTR, SBR, EVA and polyethylene.

One of the most commonly-used anti-stripping additives (ASAs) in the United States is hydrated lime, but there are other ASAs available. Liquid ASAs in the form of cationic surface-active agents, principally amines, have been used for many years. Additionally, over the last several years, liquid ASAs have gained popularity due to advancements in available liquid ASAs as well as their cost and ease of application.

Natural sand generally has rounded particles, excessive clay and organic materials, and when it is used in hot mix asphalt (HMA), it tends to lower the pavement's resistance to rutting. As such, many highway agencies now limit the amount of natural sand in HMA for heavy-duty pavements in order to minimize rutting potential.

Results

Most of the alternate modifiers produced PG 76-22 binders when added to the virgin binders (PG 64-22) at the recommended dosage. In general ground tire rubber (GTR) binders, either lab-produced or terminally-blended (TB), produced the highest viscosity values compared to all other binders. The results indicate that the mixtures made with SBS containing hydrated lime produced the highest dry and wet ITS values. However, the mixtures containing the lab-prepared GTR and lime produced the highest TSR values. Tensile Strength Retained (TSR) values of all mixtures were greater than 80% regardless of mixture type, aggregate source, and ASA type. The modified asphalt mixtures generally produced APA and Hamburg rut depths less than 3 mm regardless of the aggregate source, modified binder and ASA type used for this research project. In addition, with the exception of one case, flow numbers for all modified asphalt mixtures were greater than 50, which is the AASHTO minimum flow number requirement for traffic loading of 3 million to less than 10 million ESAL. For the mixtures containing natural sand, flow numbers were generally greater than 30, which is the flow number requirement for mixtures that contain unmodified binders used on roads with less ADT. The increase of frequency resulted in an increase of dynamic modulus and a reduction of phase angle at the testing temperatures of 4°C and 20°C, but it caused an increase of phase angle at 45°C regardless of mixture type, aggregate source, and ASA type. The dynamic modulus values were comparable for the various mixtures. There were some differences in phase angles when tested at a higher temperature.

Summary & Conclusions

In this research project, many modified binders made with several modifiers were investigated. In addition, the properties of mixtures prepared with these binders were determined and compared to the conventional or SBS (styrene butadiene styrene) mixtures. In this research project, additional issues and topics were investigated and the results reported. These topics included the following: a) investigate the effects of liquid anti-strip additives on asphalt mixtures; and b) investigate the effects of natural sands in asphalt mixtures. The polymers used to modify the binders included two plastomers; an elastomer; PPA+SBS; terminally-blended ground tire rubber (GTR) binder; and lab-prepared GTR binder. The binder properties of all 16 binder combinations were obtained (e.g., viscosity, DSR, etc.). In addition, these modified binders were used in many mixtures containing two aggregate sources, three anti-strip additives, and different recycled asphalt pavement (RAP) contents. There were 32 different Superpave mix designs conducted for this project. Many engineering properties of the mixtures were obtained, including: indirect tensile strength; tensile strength retained; rutting (Asphalt Pavement Analyzer-APA and Hamburg Loaded Wheel Tracker); and dynamic modulus and flow (Asphalt Material Performance Tester – AMPT). The AMPT testing was conducted at different temperatures and frequencies. The results indicated that, in general, many of the alternatively-modified binders could be utilized in mixtures used in SC hot mix asphalt pavements. In addition, the use of liquid anti-strip additives tested in this research project in many cases produced moisture susceptibility values (e.g., ITS, TSR) that were compatible with the results obtained with mixtures containing hydrated lime. The results also indicated that RAP and natural sand could be utilized in limited quantities in mixtures used in South Carolina for primary and secondary roads.

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