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Tack coats for asphalt paving

N.F. Ghaly, I.M. Ibrahim *, E.M. Noamy

Egyptian Petroleum Research Institute (EPRI), Nasr City, Cairo, Egypt

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Abstract Poor bonding between two layers of hot mix asphalt (HMA) is the cause of many highway pavement problems. Normally, hot asphalt cements, emulsified asphalts or cutback asphalts are used as tack coat. The objective of this study was to evaluate the practice of using tack coat through controlled laboratory simple shear tests and determine the optimum application rate. The influences of tack coat types, application rates, viscosity and temperatures on the interface shear strength were examined. Test results indicated that latex modified asphalt emulsion has the highest interface bond strength. It was also found that applying low viscosity tack coat asphalt emulsion at two layers is more effective than a tack coat asphalt emulsion high viscosity one layer coat.

1. Introduction

Asphalt pavements are usually constructed in several layers and proper bonding between adjacent layers is required to ensure good performance [1]. The loss or the poor bonding between layers can result in several types of pavement distress, such as slippage cracking, compaction difficulty, premature fatigue and top down cracking [2–4]. So the importance of achieving the best tack coat type and application rate is an essential part to get long term performance of a flexible pavement. According to ASTM tack coat can be defined as an application of bituminous material to an existing relatively nonabsorptive surface to provide a thorough bond between old and new surfacing [5]. Normally, hot bituminous binders, cutback bitumens (bitumen–solvent base) and/or bitumen emulsions (bitumen–water base) are used as tack coat materials. Asphalt emulsions are the most widely used materials for tack coats instead of cutback asphalt or hot bituminous binders due to the fact that: (a) they can be applied at lower temperatures compared to cutback asphalt or hot bituminous binder, (b) they are environmentally friendly as they do not contain harmful volatile solvents and (c) they are safer to use as they are not flammable and pose a health risk to workers [6,7]. Tack coats are sprayed in a thin film on the existing layer surface before the construction of the next pavement layer. After the tack coat wets the surface of the old pavement and fills the tiny pores, it solidifies and develops what is called interlocking. This interlocking is strongly affected by the liquid's viscosity at installation. Low viscosity tack coat can penetrate and follow the surface irregularities better than the high viscosity tack coat and, hence results in a better interlocking [8,9]. There are many other factors affecting tack coat performance and interlayer bond strength including: tack coat type, application rate, temperature, normal pressure,

* Corresponding author.
E-mail address: dr_ismailmohamed@yahoo.com (I.M. Ibrahim).

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application methods and surface roughness. A bond strength study in Louisiana showed that, interlayer bond strength was 2.3 times greater at 50 °F compared to 77 °F. This study showed also that, at higher temperatures the tack coat adhesion becomes relatively insignificant and most measured shear resistance comes from layer surface roughness and higher normal stress, which increases resistance to slippage failure [10].

2. Materials and experimental procedures

This study was aimed at evaluating the influence of modified and unmodified cutback asphalts types (cutback asphalt and tack coat asphalt emulsion). The residual application rates (0.05, 0.15, 0.25 and 0.35 l/m^2), two different temperatures (25 and 60 °C) on the interface bonding strength, and two different modified cutback and tack coat viscosity (high viscosity at 50% active material and low viscosity at 30% active material). A 12.5 mm asphalt concrete mixture was used for the preparation of test specimens. Triplicate samples were tested at each of the above-mentioned combinations of tack coat types, application rates, viscosity and temperature, after completing all the shearing strength tests of the factorial, statistical analysis on the shearing strengths.

2.1. Materials

Asphalt: local asphalt penetration grade 60/70 (Penetration 60, Kinematics viscosity at 135 °C is 346 C.st, Softening point is 52 °C) used to produce cutback asphalt and tack coat asphalt emulsion.

Latex emulsion: Latex emulsion used in this work, (solids content of 69%, Brookfield viscosity 700 cp/s and styrene butadiene ratio is 24/76) was used to produce modified asphalt binder or modified asphalt emulsion.

Aggregates: the aggregates used in all hot asphalt concrete mixtures are crushed dolomite.

2.2. Methods of preparation

2.2.1. Preparation of modified asphalt binders

The required amount of the base asphalt was heated to 140 °C and stirred for about 5 min, and then latex emulsion (1.5% by weight of asphalt) was added slowly to the base asphalt while stirring. The temperature was raised to 170 °C. Stirring was continued at this fixed temperature for two hours until achievement of a completely homogenous asphalt.

2.2.2. Preparation of cutback and modified cutback asphalt binders

The required amount of the asphalt (unmodified asphalt and/or modified asphalt) was heated to 140 °C and stirred for about 5 min. Xylene solvent was added slowly to the asphalt while stirring to produce cutback asphalt and modified cutback asphalt binders (asphalt solvent ratio 1:1).

2.2.3. Preparation of tack coat asphalt emulsion

Emulsions are manufactured by passing hot asphalt and water containing emulsifying agents through a colloid mill under high pressure. The colloid mill produces extremely small (less than 5–10 μ) globules of asphalt, which are suspended in water.

2.2.4. Preparation of modified tack coat asphalt emulsion

Asphalt emulsion was flipping for about 2 min and 1.5% latex emulsion (by weight of asphalt emulsion) was added slowly to the asphalt emulsion while flipping for 30 min to produce modified tack coat asphalt emulsion.

2.3. Mixture design

Asphalt mixtures were obtained with a 12.5 mm gradation. dolomite coarse aggregate and fine aggregate (bulk specific gravity of 2.96 and 2.94 g/cm^3, respectively, water absorption of 1.3% and 1.8%, respectively) were used in the specimens preparation, dolomite was used as a mineral filler. The design asphalt content of 5.5 percent was selected at 3.6% air void, 10,390 N stability and 2.9 mm flow (according to Marshal Test).

2.3.1. Preparation of specimen

A complete specimen consisted of two hot mix asphalt layers with and without coat types at the interface of these layers and a diameter of 150 mm. The bottom half of each specimen was prepared by compacting asphalt mix to a height of 50 mm at 160 °C. The compacted specimen was then allowed to cool down to room temperature. The bottom halves were allowed to dry out at room temperature for at least four days before preparing complete specimens to allow drainage of any trapped water. The bottom half of the specimen was placed on an electronic scale, which was set to zero. The calculated amount of coat was then applied on one face of the sample by using a paintbrush. Once the application and curing of the coat were complete, the top half of the sample was compacted by placing the bottom half in a compaction mold and compacting loose mix on top of coated bottom.

2.3.2. Condition specimen

Tests were conducted at two temperatures, 25 and 60 °C within a few days after sample fabrication, to determine the shearing strength of the interface layer of a complete specimen. For the tests conducted at 60 °C, specimens were conditioned in an oven for at least two hours before fitting them in the shearing mold. The shearing mold assembly was then placed in the Shimadzu Universal Tester (SUT) with computer controlled hydraulic servo system and a velocity of 20 mm/min. Since the shearing mold assembly's temperature decreases during its placement in the (SUT), it was conditioned for an additional half hour at 60 °C inside the machine before conducting the test. No oven conditioning was required for the 25 °C tests, since room temperature was controlled at 25 °C.

2.3.3. Shearing device

A shearing mold was specifically designed for the shear strength test in this study. The mold consists of two parts. Each part has a 150 mm diameter and 50 mm deep cylindrical groove in it, so that the mold can hold the specimens during testing. Fig. 1 shows the parts of the designed shearing mold.