Performance and behavior analysis of bond among bituminous pavement layers

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ABSTRACT

The bond of bitumen between the modern multi-layered pavements plays a very important role in the strength and long time performance of the flexible pavement. It has been scientifically observed and proved that the poor bonding between bituminous pavement layers causes to major pavement overlay distresses such as potholes, top down cracking, premature fatigue, and surface layer delamination. The other very common reason due to the poor bonding between the bituminous layers is the slippage failure, which is mainly occurs at those places where the heavy vehicles are often accelerating, decelerating, or turning. To increase the bonding strength between the layers is a tack coat which is sprayed in between the bituminous pavement layers. The tack coat is the best application of the bituminous emulsion or bituminous binder in between an existing bituminous / concrete surface and a newly constructed overlay of the bituminous. Generally, hot bituminous binders, cutback bitumen or bituminous emulsions are used as the tack coat materials.

Keywords: performance, bituminous, pavement, layers, tack.

INTRODUCTION

The modern flexible pavement is generally designed and constructed in several layers for effective stress distribution across pavement layers under the heavy traffic loads. The interlayer bonding of the multi-layered pavement system plays an important role to achieve long term performance of pavement. Adequate bond between the layers must be ensured so that multiple layers perform as a monolithic structure. To achieve good bond strength, a tack coat is usually sprayed in between the bituminous pavement layers. As a result, the applied stresses are evenly distributed in the pavement system and subsequently, reduce structural damage to the pavements. It has been observed that poor bonding between pavement layers contributes to major pavement overlay distresses. One of the most common distresses due to poor bonding between pavement layers is a slippage failure, which usually occurs where heavy vehicles are often accelerating, decelerating, or turning.

OBJECTIVES

The primary objective of this study is to fabricate a few simple testing devices for the evaluation of the bond strength offered by the tack coats at the interface between bituminous pavement layers in the laboratory scale by performing several laboratory tests with different tack coat application rates. The ideal design will be that the standard setup which produces consistent results comparable to others. A secondary goal of this study is to provide helpful information for the selection of the best type of tack coat materials and optimum application rate. An extensive laboratory testing programme was devised and the results analysed to critically assess the possible application of these materials in ground improvement.

In this work we study on the bonding between the pavement layers of bituminous for evaluation of bond between bituminous pavement layers. We study on the basis of results obtained during the analyzing of various testes which are carried out in the transportation engineering lab. Numerous studies have been performed investigating adhesive properties of the interface between layers. These studies have typically developed a unique test method or instrument for analysis of the interface bond strength. Literature on bond strength clearly indicates that shear force is mainly responsible for interface bond failure.

MATERIALS & METHODS

In this we will describes the experimental works carried out in this present investigation. This work has been deals with the experiments carried out on the materials (aggregates, bitumen, and emulsions).

Preparation of Samples

The mixes were prepared according to the Marshall procedure specified in ASTM D1559. Laboratory specimens prepared to determine interface bond strength were generally 100 mm and 150 mm in diameter and 100 mm in total height. Each specimen consisted of two layers with tack coat applied at the interface. Test variables included 100 mm and 150 mm diameter specimen and two conventional emulsions namely CMS-2 and CRS-1 as tack coats with application rates varying at 0.20 kg/m2, 0.25 kg/m2 and 0.30 kg/m2. The bottom layer consisted of a Dense Bituminous Macadam (DBM) with a VG 30 binder; the top layer was a Bituminous Concrete (BC) with a VG 30 binder. For the preparation of bottom layer, first the loose mix was compacted by giving 75 blows using Marshall Hammer and then it was allowed to cool down at room temperature.

Materials

Aggregates

For preparation of cylindrical samples composed of Dense Bituminous Macadam (DBM) and Bituminous Concrete (BC), aggregates were as per grading of Manual for Construction and Supervisions of Bituminous Works of Ministry of Road Transport and Highways (MORT&H, 2001) as given in Table.

Fig. 1

Table: 1: Adopted aggregate gradation for DBM

Property	Grading
Nominal Aggregate Size (mm)	25
IS Sieve (mm)	Percent Passing
37.5	100
26.5	95
19.0	83
13.2	68

4.75	46
2.36	35
0.300	14
0.075	5

Table: 2: Adopted aggregate gradation for BC

Property	Grading
Nominal Aggregate Size (mm)	13
IS Sieve (mm)	Percent Passing
19.0	100
13.2	89.5
9.5	79
4.75	62
2.36	50
1.18	41
0.600	32
0.300	23
0.150	16
0.075	7

RESULTS & DISCUSSION

Analyzing the results graphically, it can be concluded that specimen with CRS-1 as tack coat exhibited higher shear strength values compared to CMS-2 as tack coat at all application rates varying at 0.20 kg/m2 , 0.25 kg/m2 and 0.30 kg/m2 for all three types of shear testing devices. Also the optimum application rate was found to be 0.25 kg/m2 for the all three models.

The average shear strength of the specimens with both types of emulsions, namely CMS-2 and CRS-1 as tack coat at application rates varying at 0.20 kg/m2 , 0.25 kg/m2 and 0.30 kg/m2 considering all three models together, are calculated as shown.

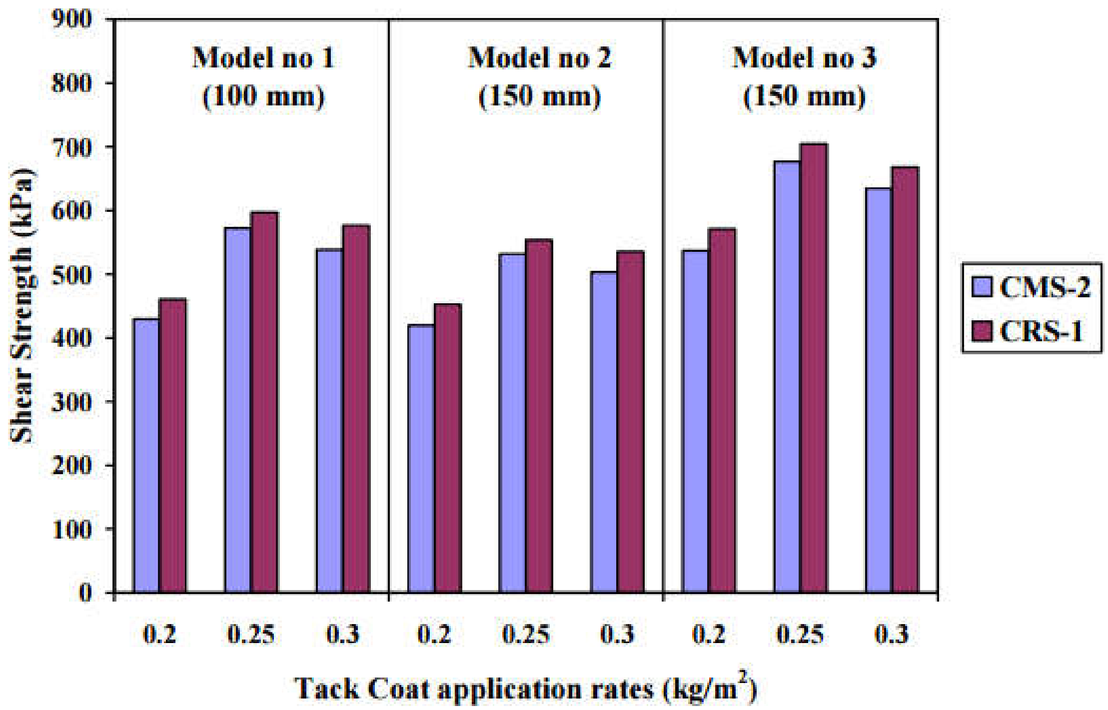

Figure 2: Comparison of Shear Strength v/s Application rates for the three models

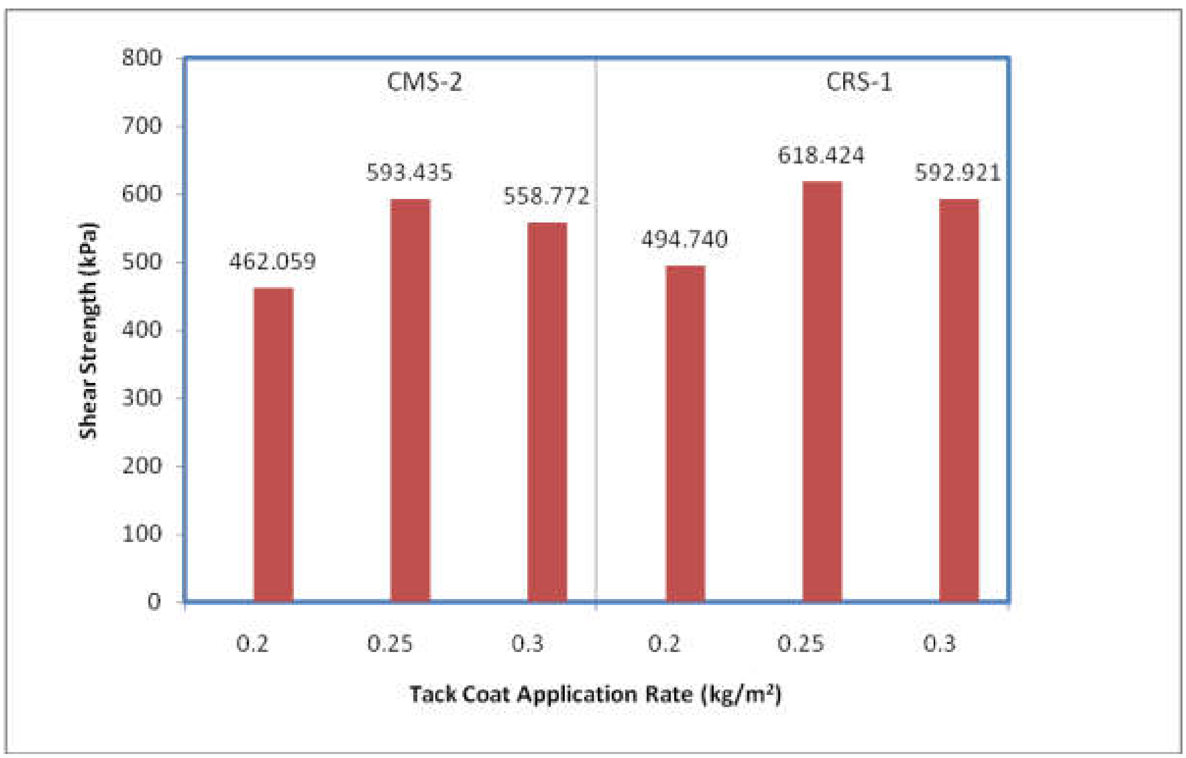

Figure 3: Average Shear Strength v/s Application rates for the three models.

The average maximum shear strength was observed on specimens with CRS-1 as tack coat at an application rate of 0.25 kg/m^2 while the specimens with CMS-2 at an application rate of 0.20 kg/m^2 showed the average minimum shear strength as shown in figure 2. Using CMS- 2 as tack coat the average shear strength values were obtained as 462.059, 593.435 and 558.772 kPa at application rates of 0.20 kg/m^2, 0.25 kg/m2 and 0.30 kg/m^2 respectively. Similarly using CRS-1 as tack coat at application rates of 0.20 kg/m^2, 0.25 kg/m2 and 0.30 kg/m^2 the average shear strength values obtained were 494.740, 618.424 and 592.921 kPa respectively.

CONCLUSIONS

A laboratory study was conducted to evaluate the bond strength between the Bituminous Concrete (BC) and Dense Bituminous Macadam (DBM) layers with tack coat sprayed at the interface. For this purpose three simple shear testing models were fabricated and experiments were conducted using the same in a Marshall Stability Apparatus. For shear testing model no 1, laboratory tests were conducted on 100 mm diameter cylindrical specimens at a temperature of 25^{0}C by applying a shear force of constant deformation rate of 50.8 mm/min. While the shear testing model no. 2 and 3 were fabricated to evaluate the bond strength of 150 mm diameter cylindrical specimens. The samples were prepared in laboratory by applying CMS-2 and CRS-1 as tack coat at interface at application rates varying at 0.20 kg/m^2, 0.25 kg/m^2 and 0.30 kg/m^2.

The following are specific observations drawn from the test results.

1. The test results concluded the application rate of 0.25 kg/m ^{2} as the optimum one for all the tack coats.
2. Generally, CRS-1 as tack coat provided the highest shear strength at all application rates, 0.20 kg/m ^{2}, 0.25 kg/m^2 and 0.30 kg/m^2 as compared to CMS-2.
3. The shear strength values obtained from shear testing model no. 3 were higher than those obtained from model no.1 and 2 for all types of tack coat at all application rates. This might be due to eccentricity as the shear load was applied near the interface therefore; the shear strength values obtained were lower than those obtained from model no. 3 where a concentric shear load was applied.
4. Considering all models together, average shear strength values were found to be as 462.059, 593.435 and 558.772 kPa using CMS-2 as tack coat at application rates of 0.20 kg/m^2, 0.25 kg/m^2 and 0.30 kg/m^2 respectively while using CRS-1 as tack coat at application rates of 0.20 kg/m^2, 0.25 kg/m^2 and 0.30 kg/m^2 the average shear strength values obtained were 494.740, 618.424 and 592.921 kPa respectively.

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