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Evaluation of Bond between Bituminous Pavement Layers

Kommu Bhagavan Das [1], Dr.B.Manoj [2]

[1,2] **1** M. Tech Scholar, b Professor
[1,2] Department of Civil Engineering
QIS COLLEGE OF ENGINEERING AND TECHNOLOGY (AUTONOMOUS)
Approved By AICTE | Permanent Affiliation: JNTU-Kakinada | UGC-Recognized
Accredited By NBA | Accredited By NAAC | ISO 9001:2015 Certified
Vengamukkapalem (V), Ongole, Prakasam dist., Andhra Pradesh -523272

ABSTRACT

The bond of pavement l ayers plays an important role to achieve good performance of a flexible pavement. It has been observed that the poor bonding b etween pavement layers causes pavement overlay distresses such as compaction difficulty, top down cracking, pot holes, premature fat igue and surface l ayer delamination. Slippage failure i s the most commonly observed problem often occurring at the locations where traffic accelerates, decelerates or turns.

In order to prevent such distresses, t ack coat will be sprayed between the pavement l ayers. A variety of Asphalt materials are used for t ack coats. A tack coat is an application of a bituminous emulsion or bituminous binder between an existing bituminous / concrete surface and a newly constructed bituminous overlay. . Normally, hot bituminous binders, cutback bitumen or bituminous emulsions are used as tack coat materials. This s tudy is aimed to evaluate the bond st rength at the interface between pavement layers by performing laboratory t ests. In this three special attachments are fabricated for use in Marshall Loading Frame to finding the performance of tack coat laid at the interface between Bituminous Concrete (BC) and Dense Bituminous Macadam (DBM) layers in the laboratory. In this study, the results of the specimens prepared with 100 mm and 150 mm diameter specime ns using two types of normally used emulsions, named CMS - 2 and CRS- 1 as tack coat of application rates varying at 0. 30 kg/ m^2 , 0. 35 kg/ m^2 and 0. 40 kg/ m^2 made at 25^0 C temperature are presented. It is observed that CRS - 1 as tack coat provides higher interface bond strength value compared to CMS -2.

Keywords: Pavement bond strength, shear strength, tack coat .

1. Introduction

The modern flexible pavement is generally designed in layers for effective stress distribution of heavy traffic loads. Now-a-days, pavements are constructing but due to heavy traffic, slippage failures are causing due to low bonding between pavement layers. Slippage failure develops when the pavement layers begin to slide on one another usually with the top layer separating from the lower layer. This is caused by a lack of bond and a high enough horizontal force to cause the two layers to begin to separate. So to prevent these slippage failure sand distresses, a tack coats named CRS-1 and CMS-2 will spray in between the layers of pavement to get the strong bond between the pavement layers. Tack coats act as adhesive. CRS-1 tack coat provides thehigher interface bond strength compared to CMS-2. So in this project, we are going to apply the tack coatsin between the layers of the pavement. Here we are preparing the specimens of 100 mm and 150 mm diameter using the emulsions of CRS-1 and CMS-2 as tack coat of application rates varying at 0.30 kg/m^2, 0.35 kg/m^2 and 0.40 kg/m^2 made at 25^{0}C temperature. By using laboratory tests, we are finding the shear strengths of different specimens.

Figure of slippage failure

2. REVIEW OF LITERATURE

Mohd Imran Kumar, Er Vikas Garg, Er Zubair, Dr. Pooja Sharma (2019) conducted a study on the modern flexible pavement is generally designed and constructed in several layers for effective stress distribution across pavement layers under heavy traffic loads. The interlayer bonding of the multi-layered pavement system plays an important role to achieve the long-term performance of the pavement. An 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.

P. Madan Mohan Reddy, S. Jyothirmayee, S. Sowjanya (2017) conducted a study This study is aimed to evaluate the bond strength at the interface between pavement layers by performing laboratory tests. To carry out this objective, three special attachments are fabricated for use in Marshall Loading Frame for finding the performance of tack coat laid at the interface between Bituminous Concrete (BC) and Dense Bituminous Macadam (DBM) layers in the laboratory. In this study, the results of the specimens prepared with 100 mm and 150 mm diameter specimens using two types of normally used emulsions, namely CMS-2 and CRS-1 as tack coat at application rates varying at 0.20 kg/ m^2 , 0.25 kg/ m^2, and 0.30 kg/ m^2 made at 25^0 C temperature are presented. It is observed that CRS - 1 as a tack coat provides a higher interface bond strength value compared to CMS - 2. Similarly, irrespective of the types of emulsions used as a tack coat, the optimum rate of application is found to be 0.25 kg/ m^2 as recommended in MORT& H's specifications.

Randy C. West, Jingna Zhang, Jason Moore (2005) conducted a study on measuring the bond strength between pavement layers. The research was also to evaluate tack coat materials and application rates for the Alabama Department of Transportation (ALDOT). The project included a laboratory phase and a field phase. For the laboratory work, the experiment included two types of emulsion (CRS - 2 and CSS-1) and a PG 64 - 22 asphalt binder that are allowed by ALDOT's specifications. Bond strengths were measured with a shear- type device at three temperatures and three normal pressure levels. Three application rates that encompassed the specification range were investigated for each tack coat. Laboratory prepared mixture samples included a coarse - graded blend and a fine - graded blend to represent two different surface textures. The effects of tack coat type, application rate, mixture type, testing temperature, and normal pressure on the bond strength were evaluated.

3.MATERIALS USED

Coarse Aggregates

Coarse aggregates are collected of size less than 25 mm IS sieve. Standard tests are conducted to determine their physical properties.

Fine Aggregates

Fine aggregates collected from a local crusher with fractions of passing 4.75 mm and retained on 0.075 mm IS sieve. Its specific gravity was found to be 2.6

Filler

Portland slag cement (Grade 43) collected of passing 0. 075 mm IS sieve is used as f i ll er material. It s specific gravity was found to be 2. 95

Binder

Bituminous binder named VG 30 bitumen collected from local source is used to prepare the samples. Tests are conducted to determine the physical properties of binders.

Tack Coat Materials

The tack coat materials are CRS- 1 and CMS- 2. Standard t ests are conducted to determine the physical properties.

4.EXPERIMENTAL INVESTIGATION

To finding the shear strengths of different specimens, three models are fabricated.

Model no. 1 is for testing 100 mm diameter laboratory specimens to find the shear strength by using thetest of Layer-Parallel Direct Shear (LPDS) developed by the Swiss Federal

Model no. 2 is for testing 150 mm diameter laboratory specimens to find the shear strength by using thetest of Layer-Parallel Direct Shear (LPDS) developed by the Swiss Federal

Model no. 3 is for testing 150 mm diameter laboratory specimens to find the shear strength by using thetest of FDOT shear tester developed by the Florida Department of Transportation (FDOT).

5.RESULTS

Shear testing model no. 1

The test was conducted on 100 mm diameter cylindrical specimens with CRS-1 and CMS-2

Table 5.1 Results of the shear strength of 100 mm diameter specimensusing Shear testing model no. 1 at 25^{0}C

Tack Coat Type	Application Rate (Kg/m 2)	Load (kN)	Shear Strength (MPa)	Average Shear Strength

				(MPa)
CMS-2	3	3.428	0.442	
CMS-2	3	3.574	0.436	0.455
CMS-2	3	4.152	0.488	
CMS-2	3.5	4.397	0.589	
CMS-2	3.5	4.397	0.581	0.596
CMS-2	3.5	4.69	0.617	
CMS-2	4	4.232	0.543	
CMS-2	4	4.351	0.581	0.574
CMS-2	4	4.397	0.599	
CRS-1	3	4.212	0.515	
CRS-1	3	3.867	0.486	0.490
CRS-1	3	3.674	0.469	
CRS-1	3.5	4.543	0.568	
CRS-1	3.5	4.79	0.597	0.593
CRS-1	3.5	5.136	0.615	
CRS-1	4	5.043	0.598	
CRS-1	4	4.597	0.579	0.598
CRS-1	4	4.817	0.617	

As shown in figure 5.1, the optimum rate of application was found to be

0.35 kg/m^2 for bothCMS-2 and CRS-1 as tack coat

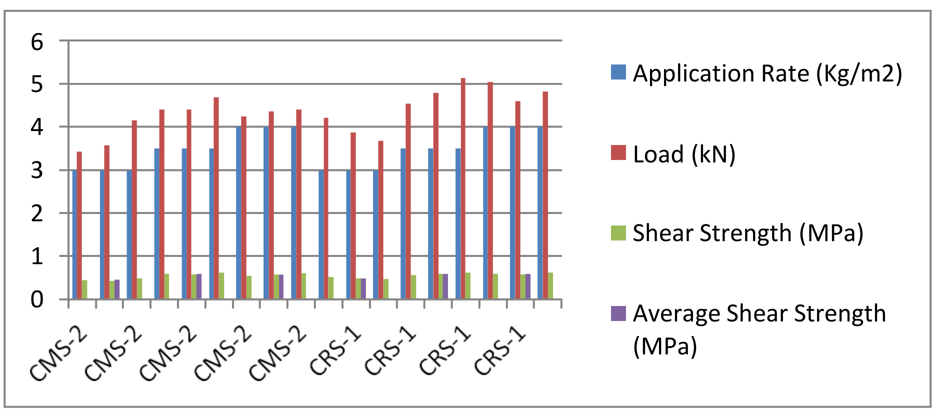


Figure 5.1: Plot of Shear Strength v/s Tack Coat application rates for100 mm diameter specimens using Sheartesting model no.1

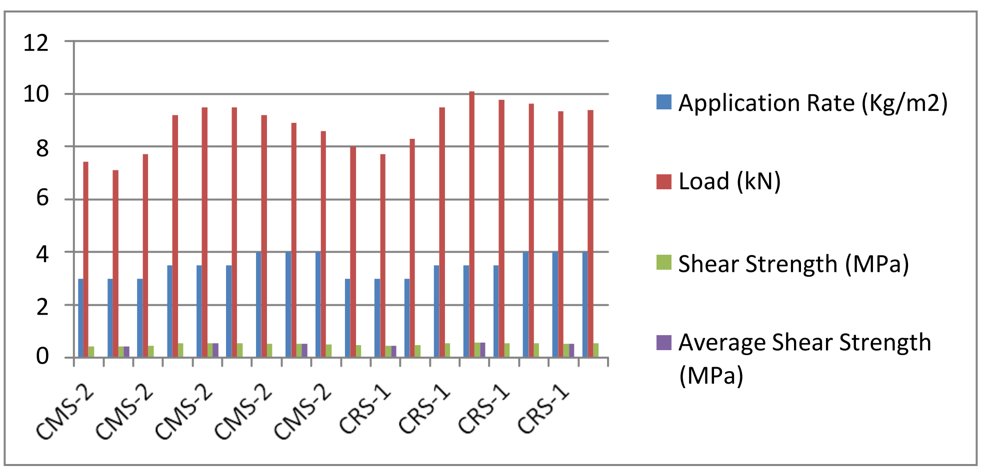
Shear testing model no. 2

The test was conducted on 150 mm diameter cylindrical specimens with CRS-1 and CMS-2

Table 5.2 Results of the shear strength of 150 mm diameter specimens using Shear testing model no. 2 at 25^0 C

Tack Coat Type	Application Rate (Kg/m2)	Load (kN)	Shear Strength (MPa)	Average Shear Strength (MPa)
CMS-2	3	7.417	0.429	
CMS-2	3	7.117	0.415	0.428
CMS-2	3	7.71	0.439	
CMS-2	3.5	9.193	0.538	
CMS-2	3.5	9.49	0.541	0.540
CMS-2	3.5	9.49	0.541	
CMS-2	4	9.193	0.526	
CMS-2	4	8.896	0.517	0.514
CMS-2	4	8.6	0.499	
CRS-1	3	8.007	0.465	
CRS-1	3	7.71	0.44	0.460
CRS-1	3	8.303	0.475	
CRS-1	3.5	9.49	0.549	
CRS-1	3.5	10.08	0.571	0.558
CRS-1	3.5	9.786	0.553	
CRS-1	4	9.638	0.539	
CRS-1	4	9.341	0.521	0.532
CRS-1	4	9.394	0.537	

As shown in figure 5.2, the optimum rate of application was found to be 0.35 kg/m^2 for both



CMS-2 and CRS-1 as tack coat.

Figure 5.2: Plot of Shear Strength v/s Tack Coat application rates for 150 mm diameter specimens using Sheartesting model no. 2

Shear testing model no. 3

The test was conducted on 150 mm diameter cylindrical specimens with CRS-1 and CMS-2

Table 5.3 Results of the shear strength of 150 mm diameter specimens using Shear testing model no. 3 at 25^{0}C

Tack Coat Type	Application Rate (Kg/m2)	Load (kN)	Shear Strength (kPa)	Average Shear Strength (kPa)
CMS-2	0.3	9.193	520.566	
CMS-2	0.3	9.786	563.873	547.371
CMS-2	0.3	9.49	557.673	
CMS-2	0.35	11.56	664.341	
CMS-2	0.35	12.45	704.524	680.001
CMS-2	0.35	11.86	671.137	
CMS-2	0.4	11.414	645.899	
CMS-2	0.4	10.97	635.774	639.732
CMS-2	0.4	11.266	637.524	
CRS-1	0.3	9.786	573.773	
CRS-1	0.3	10.082	570.523	577.190
CRS-1	0.3	10.378	587.273	
CRS-1	0.35	12.45	704.524	
CRS-1	0.35	12.15	697.548	713.430
CRS-1	0.35	12.745	738.218	
CRS-1	0.4	11.71	652.649	
CRS-1	0.4	11.857	682.573	672.598
CRS-1	0.4	11.857	682.573	

As shown in figure 5.3, the optimum rate of application was found to be 0.35 kg/m^2 for both

CMS-2 and CRS-1 as tack coat

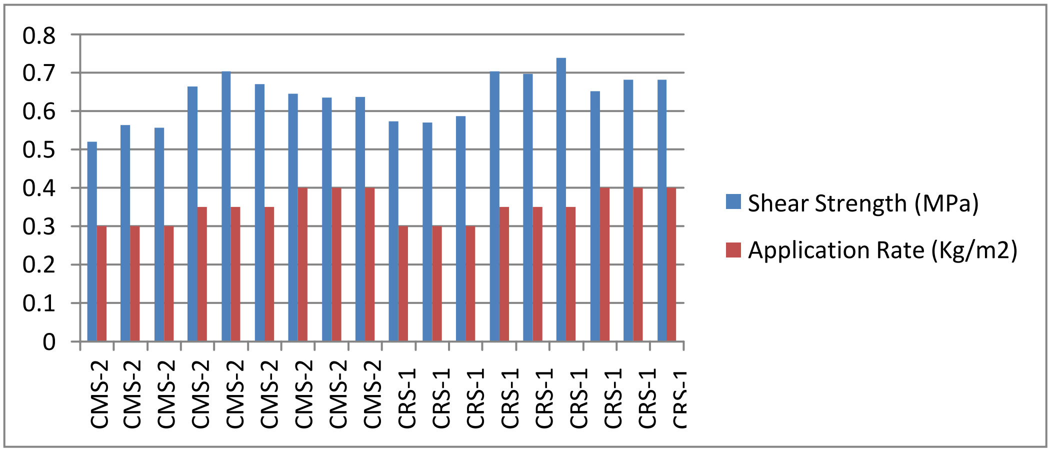


Figure 5.3: Comparison of Shear Strength v/s Application rates for the three models.

A Results of the average shear strength using CMS-2 as tack coatfor all three models at 25^0 C

Table 5.4: Results of the average shear strength using CMS-2 as tack coatfor all three models at 25^0 C

Model No	Rate of Application (Kg/m2)	Specimen No	Shear Strength(Mpa)	Average Shear Strength(Mpa)
	0.3	1	0.442	
1	0.3	2	0.436	
	0.3	3	0.488	
	0.3	1	0.429	
2	0.3	2	0.415	0.476
	0.3	3	0.439	
	0.3	1	0.52	
3	0.3	2	0.563	
	0.3	3	0.557	
	0.35	1	0.589	
1	0.35	2	0.581	
	0.35	3	0.617	
	0.35	1	0.538	
2	0.35	2	0.541	0.605
	0.35	3	0.541	
	0.35	1	0.664	
3	0.35	2	0.704	
	0.35	3	0.671	
	0.4	1	0.543	
1	0.4	2	0.581	
	0.4	3	0.599	
	0.4	1	0.526	
2	0.4	2	0.517	0.575
	0.4	3	0.499	
	0.4	1	0.645	
3	0.4	2	0.635	
	0.4	3	0.637	

Table 5 .4: Results of the average shear s trength using CRS -1 as tack coatfor all three models at 25^{0} C

Mod elNo	Rate of Applicati on(Kg/m 2)	Specime nNo	Shear Strength(Mpa)	Average Shear Strength(Mpa)
	0.3	1	0.515	
1	0.3	2	0.486	
	0.3	3	0.469	
	0.3	1	0.465	
2	0.3	2	0.44	0.508889
	0.3	3	0.475	
	0.3	1	0.573	
3	0.3	2	0.57	
	0.3	3	0.587	
	0.35	1	0.568	
1	0.35	2	0.597	
	0.35	3	0.615	
	0.35	1	0.549	
2	0.35	2	0.571	0.621333
	0.35	3	0.553	
	0.35	1	0.704	
3	0.35	2	0.697	
	0.35	3	0.738	
	0.4	1	0.598	
1	0.4	2	0.579	
	0.4	3	0.617	
	0.4	1	0.539	
2	0.4	2	0.521	0.600778
	0.4	3	0.537	
	0.4	1	0.652	
3	0.4	2	0.682	
	0.4	3	0.682	

5.5 Overall Performance of tack coat

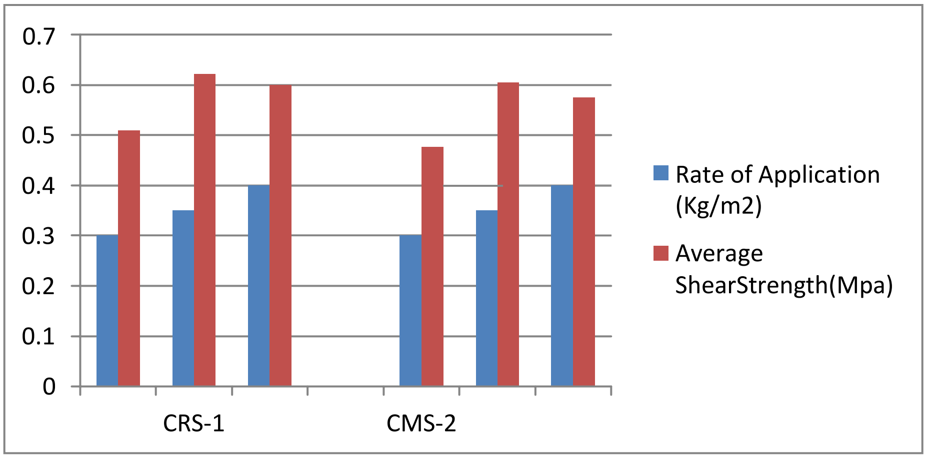


Figure 5.5: Average Shear Strength v/s Application rates for the three models.

CONCLUSION

The average maximum shear strength was observed on specimens with CRS -1 as tack coat at an application rate of 0.35 kg/m ^{2} while the specimens with CMS - 2 at an application rate of 0.30 kg/m ^{2} showed the average minimum shear strength as shown in figure 4.5. Using CMS -2 as tack coat the average shear strength values were obtained as 476.059, 605.435 and 575.772 KPa at application rates of 0.30 kg/m ^{2}, 0.35 kg/m ^{2} and 0.40 kg/m ^{2} respectively. Similarly using CRS - 1 as tack coat at application rates of 0.30 kg/m ^{2}, 0.35 kg/m ^{2} and 0.40 kg/m ^{2} the average shear strength values obtained were 508.889, 621.333 and 600.778 KPa respectively.

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