American Journal of Science and Learning for Development

ISSN 2835-2157
Volume 2 | No 5 | May -2023

Evaluation of Binding Properties of Bituminous Pavement Layers

[1] Ashish Kumar Jha, [2] Onkar Yadav, [3]Pappu Kumar, [4] Ajay kumar

[1]Research Scholar, Department of Civil Engineering, Sandip University, Madhubani, Bihar, India
[2,3,4]Assistant Professor, Department of Civil Engineering, Sandip University, Madhubani, Bihar, India

Abstract: *Interlayer bonding in modern multi-layer pavement systems plays a key role in achieving long-term performance of flexible pavements. Poor bonding between bituminous pavement layers has been observed to contribute to major pavement failures such as premature fatigue, top-down cracks, potholes and surface spalling. One of the most common stresses due to poor bonding between bituminous layers is slip failure, which typically occurs when a heavy vehicle accelerates, decelerates, or turns frequently. An adhesive layer is sprayed between the bitumen road layers to improve the adhesion between the layers. A bond coat is the application of a bitumen emulsion or bitumen binder between an existing bitumen/concrete surface and a newly constructed bitumen overlay. Hot bitumen binder, cut bitumen, or bitumen emulsion are commonly used as adhesives. The purpose of this study is to evaluate the adhesive strength at the interface between pavement layers by conducting laboratory tests. To achieve this goal, we used it on a Marshall load frame to evaluate the performance of a bond coat applied to the interface between layers of bituminous concrete (BC) and dense bituminous macadam (DBM) in the laboratory. Three specific attachments are manufactured for In this study, 100 mm and 150 mm diameter samples were applied from 0.20 kg/m2 to 0.25 kg using two commonly used emulsions, CMS-2 and CRS-1, as bond coats. Results were obtained for samples prepared in volume. /m2 and 0.30 kg/m2 are produced at a temperature of 250 °C.*

Keywords: *Bitumen, Pavement, Concrete, Macadam, Marshall.*

INTRODUCTION

For appropriate stress distribution between pavement layers under significant traffic loads, modern flexible pavement is typically designed and built in multiple layers. The multi-layered pavement system's interlayer bonding is crucial to the pavement's long-term performance. In order for several layers to function as a monolithic structure, enough bonding between the layers must be achieved. A tack coat is typically sprayed in between the layers of bituminous pavement to achieve strong binding strength. Because the applied stresses are spread equally across the pavement system, there is less chance of structural damage to the pavements.

2. BACKGROUND ON TACK COAT

A bond coat is the application of a bitumen emulsion or bitumen binder between an existing bitumen/concrete surface and a newly constructed bitumen overlay. Bond coats are also called bond coats because they are used to bond one paving layer to another. The bond coat acts as an adhesive or glue, so the combined paving layers act as a monolithic structure rather than individual sections. A bond coat is typically an emulsion consisting of bituminous binder particles dispersed in water with an emulsifier. Bitumen particles are suspended in water by emulsifiers, so the consistency of bitumen decreases from semi-solid to liquid at ambient temperature. This liquefied bitumen tends to spread at ambient temperatures. When this liquid bitumen is applied to a clean surface, the water evaporates

All rights reserved. © 2023
OPEN ACCESS

from the emulsion, leaving a thin layer of bitumen residue on the road surface. If a bituminous binder is used as a tack coat, it must be heated for application (Rahman, 2010). Usually hot bitumen binder, cut bitumen or bitumen emulsion is used as glue.

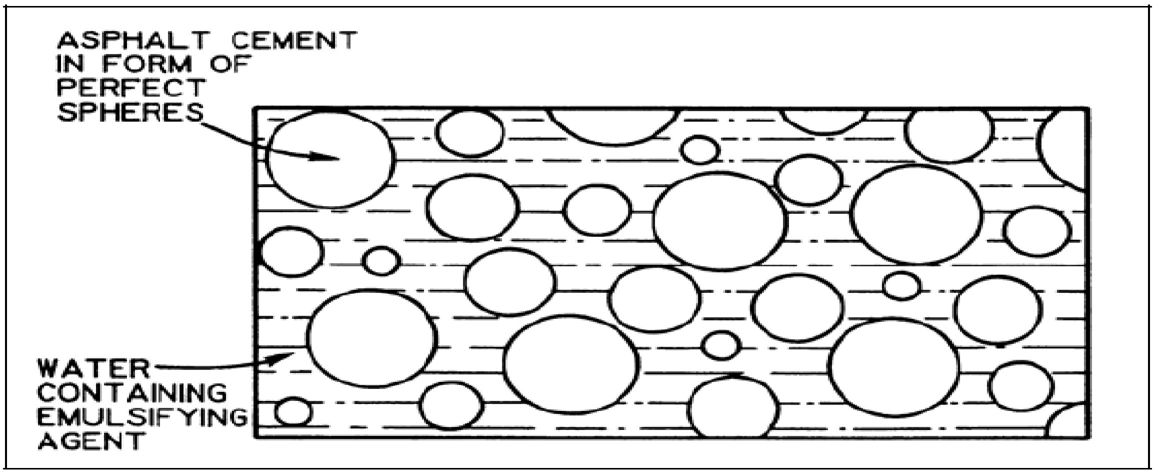

Figure 1: Composition of Bituminous Emulsion (Roberts et al., 1996)

3. RESEARCH OBJECTIVE

The main goal of this study is to create a few straightforward testing apparatuses for assessing the bond strength provided by the tack coats at the interface between bituminous pavement layers on a laboratory scale by carrying out a number of laboratory tests with various tack coat application rates. The conventional arrangement that yields reliable results on par with others will be the best design. The provision of useful information for the optimal type of tack coat material selection and ideal application rate is a secondary objective of this study.

4. LITERATURE REVIEW

Many investigations into the adhesive characteristics of the interface between layers have been conducted. For the analysis of the interface bond strength, these investigations often created a special test method or instrument. Shear force is mostly to blame for interface bond failure, according to literature on bond strength.

The following tests, among others, have been employed by various organizations and researchers to gauge the binding strength of the pavement interface:

- Layer-Parallel Direct Shear (LPDS);
- Ancona Shear Testing Research and Analysis (ASTRA);
- Superpave Shear Tester (SST), which has been recently modified by the Louisiana

Transportation Research Center by building a shear mold assembly;

- Leutner test, originally developed in Germany;
- FDOT Shear Tester;
- LCB shear test;
- Modified Marshall Test developed by the Pennsylvania Department of Transportation;
- NCAT bond strength device developed by National Center for Asphalt Technology.

The Swiss Federal Laboratories for Material Testing and Research developed a shear testing device known as the Layer-Parallel Direct Shear (LPDS). This is a modified version of the device developed by his Leutner (1979) in Germany. A modified LPDS test, as reported by Raab and Partl (2002), is used to test 150 mm diameter cylindrical specimens using the Marshall test. The bottom layer of the two-layer sample is placed on a U-bearing and the top layer is yoked at a temperature of 200°C with a constant travel speed of 50.8 mm/min.

All rights reserved. © 2023

Mohammed et al. (2002) evaluated the effects of tack coat type, application rate, and test temperature on interfacial shear strength using the Superpave Shear Tester (SST). The shearing device has her two chambers to hold the sample during testing and is mounted within the SST.

Sanjorgi et al. (2002) developed a shear test device called the Leutner test. This test equipment is standard in Austria and has also been adopted in the UK. A 150 mm He applies a normal shear load to a two-layer cylindrical specimen at 200 °C with a constant strain rate of 50 mm/min until failure. This study was examined to assess the bonding state between the surface and binder course materials, and between the binder and base course materials. Three different interfacial treatments were considered to simulate real conditions.

1) with bond coat emulsion,
2) smeared with dirt without bond coat emulsion,
3) With bond coat emulsion and thin film of dirt.

The results showed that the best adhesion was obtained with the interfacial treatment done using the emulsified adhesive coating, whereas the worst adhesion conditions were observed on the soiled surface without emulsion. As mentioned in the previous paragraph, different organizations and different researchers have developed and studied different devices to determine the bonding strength of interlayers in bitumen pavement. Some were using complex equipment, but using simpler equipment by doing a simpler setup and using the same with your existing Marshall Stability Apparatus saves time and money I decided to.

5. BASE MATERIALS

5.1. Basic materials

The basic materials which compose concrete are:

1. Aggregate (Coarse & Fine)
2. Portland slag Cement
3. Binder
4. Tack coat Materials
5. Admixture

5.2. Fabrication of laboratory test procedure to measure the interface bond strength

For the purpose of testing the shear strength offered by tack coat at the bonded interface, the following three models were fabricated:

- Model no. 1, for testing 100 mm diameter laboratory specimens based on the concept of the Layer-Parallel Direct Shear (LPDS) developed by the Swiss Federal Laboratories for Material Testing and Research.
- Model no. 2, for testing 150 mm diameter laboratory specimens based on the concept of the Layer-Parallel Direct Shear (LPDS) developed by the Swiss Federal Laboratories for Material Testing and Research.
- Model no. 3, for testing 150 mm diameter laboratory specimens based on the concept of the FDOT shear tester developed by the Florida Department of Transportation (FDOT).

6. CONCLUSIONS

A laboratory study was conducted to evaluate the bond strength between layers of bituminous concrete (BC) and dense bituminous macadum (DBM), and a bond coat was sprayed on the interface. For this purpose, three simple shear test models were created and experiments were performed using them in the Marshall Stability Apparatus. In shear test model #1, laboratory tests were performed on cylindrical specimens with a diameter of 100 mm at a temperature of 250°C by applying a shear force at a constant strain rate of 50.8 mm/min. . Shear test models No. 2 and No. 3 were created to evaluate the bond strength of cylindrical specimens with a diameter of 150 mm. Samples were prepared in the laboratory by applying CMS-2 and CRS-1 as bond coats to the interface at different application rates of 0.20 kg/m2, 0.25 kg/m2, and 0.30 kg/m2. Below are certain observations drawn from the test results.

- Test results concluded that an application rate of 0.25 kg/m2 was optimal for all adhesive coatings.
- In general, as a bond coat, CRS-1 provided the best shear strength at all laydowns of 0.20 kg/m2, 0.25 kg/m2 and 0.30 kg/m2 compared to CMS-2.
- Shear strength value from shear test model number. 3 was higher than the values obtained from models #1 and #2 for all types of bond coats at all application rates. This may be due to eccentricity as shear loads were applied close to the interface. The shear strength values obtained were lower than those of model #3 where concentric shear loads were applied.
- Looking at all models together, the average shear strength values are
- 0.20 kg/m2, 0.25 kg/m2, or 0.30 kg/m2 when using CRS-1 as a bond coat at coating weights of 0.20 kg/m2, 0.25 kg/m2, and 0.30 kg/m2 The average shear strength values were 494.740, 618.424 and 592.921 kPa, respectively.

REFERENCES

1. ASTM D 88 (1994). "Standard Test Method for Saybolt Viscosity."
2. ASTM D244 (2004). "Standard Test Method for Residue by Evaporation of Emulsified Asphalt."
3. ASTM D 1559 (1989). "Test Method for Resistance of Plastic Flow of Bituminous Mixtures Using Marshall Apparatus"
4. ASTM D 4402 (2006). "Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer."
5. "Bituminous Tack Coat." Unified Facilities Guide Specification (UFGS) 02744N.
6. Chehab, G., Medeiros, M., and Solaimanian, M. (2008). "Evaluation of bond performance of FastTack Emulsion for Tack Coat applications." *Pennsylvania Depatment Of Transportation*, Report No. FHWA-PA-2008-017-PSU021, Pennsylvania Transportation Institute.
7. CPB 03-1 Paint Binder (Tack Coat) Guidelines (2003), California Department of Transportation, Construction Procedure Bulletin.
8. Cross, S. A. and P. P. Shrestha (2004). "Guidelines for Using Prime and Tack Coats." Report No. FHWA-CFL-04-001, Central Federal Lands Highway Division, FHWA, Lackwood, CO.
9. http://www.surface-engineering.net, Slippage cracking (image).
10. IS: 2386 (1963), "Methods of Test for Aggregates for Concrete (Part- I): Particle Size and Shape", *Bureau of Indian Standards, New Delhi.*
11. IS: 2386 (1963), "Methods of Test for Aggregates for Concrete (Part-III): Specific Gravity, Density, Voids, Absorption, Bulking", *Bureau of Indian Standards, New Delhi.*
12. IS: 2386 (1963), "Methods of Test for Aggregates for Concrete (Part-IV): Mechanical Properties", *Bureau of Indian Standards, New Delhi.*
13. IS: 1203 (1978), "Methods for Testing Tar and Bituminous Materials: Determination of Penetration", *Bureau of Indian Standards, New Delhi.*
14. IS: 1205 (1978), "Methods for Testing Tar and Bituminous Materials: Determination of Softening Point", *Bureau of Indian Standards, New Delhi.*
15. IS: 1208 (1978), "Methods for Testing Tar and Bituminous Materials: Determination of Ductility

(First Revision)", *Bureau of Indian Standards, New Delhi.*

16. IS: 8887 (2004), "Bitumen Emulsion for Roads (Cationic Type) - Specification (Second Revision)", *Bureau of Indian Standards, New Delhi.*
17. Kucharek,T., Esenwa, M. and Davidson, J.K. (2011). "Determination of factors affecting shear testing performance of bituminous emulsion tack coats." *7e congrès annuel de Bitume Québec,* Saint-Hyacinthe, Canada.
18. Lavin, Patric G. (2003) *Asphalt Pavements*. Spon Press, New York, NY.
19. Ministry of Road Transport and Highways (2001), *''Manual for Construction and Supervision of Bituminous Works'', New Delhi.*
20. Miro, R. R.; Perez-Jimenez, F.; Borras, G.; and Juan, M. (2003). "Evaluation of the effect of tack coats. LCB shear tests," *6th RILEM Symposium PTEBM'03,* Zurich, pp. 550-556.
21. Mohammad, L.N., Raqib, M.A., and Huang, B. (2002). "Influence of Bituminous Tack Coat Materials on Interface Shear Strength," *Transportation Research Record: Journal of the Transportation Research Board*, No. 1789, pp. 56-65, Washington, D.C., Transportation Research Board of the National Academies.
22. Mohammad, L. N., Bae, A., Elseifi, M.A., Button, J., and Scherocman, J.A. (2009). "Interface Shear Strength Characteristics of Emulsified Tack Coats." *Journal of the Association of Bituminous Paving Technologists*, Vol. 78.
23. Paul, H. R. and Scherocman, J. A. (1998). "Friction Testing of Tack Coat Surfaces," *Transportation Research Record 1616,* Transportation Research Board, National Research Council, Washington, DC; pp. 6–12.
24. Patel, N. B. (2010). "Factors affecting the interface shear strength of pavement layers". Master's Thesis, Department of Civil and Environmental Engineering, *The Louisiana State University and Agricultural and Mechanical College*.
25. "Proper Tack Coat Application (2001)." *Technical Bulletin*, Flexible Pavement of Ohio, Columbus, OH.
26. Rahman, F. (2010). "Performance evaluation of 4.75 mm NMAS superpave mixture". PHD's Thesis, Department of Civil Engineering, *The Kansas State University*.
27. Raab, C. and Partl, M. (2004). "Interlayer Shear Performance: Experience with Different Pavement Structures." *3rd EurBituminous & Eurobitumen Congress*, Vienna.
28. Roffe, J.-C. And F. Chaignon. (2002) "Characterization Tests on Bond Coats: Worldwide Study, Impact, Tests, Recommendations," *3rd International Conference on Bituminous Mixtures and Pavements,* Thessaloniki, Greece, pp. 315.
29. Roberts, F.L., Kandhal, P.S., Brown, E.R., Lee, D., and Kennedy, T.W. (1996). *Hot Mix Bituminous Materials, Mixture Design, Construction*, 2nd Edition, Lanham, Maryland, National Bituminous Pavement Association and Research Education Foundation.
30. Sangiorgi C., Collop, A.C., and Thom, N.H. (2002). "Laboratory Assessment of Bond Condition using the Leutner Shear Test." Proceeding of *3rd International Conference on Bituminous Mixtures and Pavements,*, pp 315-324, Thessaloniki, Greece.
31. Santagata, E., and Canestari, F. (1994). "Tensile and Shear tests of Interfaces in Asphalt Mixtures: a New Perspective on Their Failure Criteria," Proceedings of the *2nd International of Symposium on Highway Surfacing, Ulster, Ireland.*
32. Santagata, E., and Canestari, F. (2005). "Temperature effects on the Shear Behaviour of tack Coat Emulsion used in flexible Pavements." *International Journal of Pavement Engineering*, Volume 6, Issue 1, pp 39-46.

33. Sholar, G.A., Page, G.C., Musselman, J.A., Upshaw, P.B., and Moseley, H. (2004) "Preliminary Investigation of a Test Method to Evaluate Bond Strength of Bituminous Tack Coats." *Journal of the Association of Bituminous Paving Technologists*, Vol. 73.

34. Tashman, L., Nam, K., and Papagiannakis., T. (2006). "Evaluation of the Influence of Tack Coat Construction Factors on the Bond Strength Between Pavement Layers." *Washington Center for Bituminous Technology*, Report No. WCAT 06-002, Washington State University.

35. *The Asphalt Handbook (*1989) Manual Series No. 4 (MS-4). The Asphalt Institute, Lexington, KY.

36. *The Hot-Mix Asphalt Paving Handbook (2000)*. AC 150/5370-14A, U.S. Army Corps of Engineers, Washington D.C.

37. West, R.C., J. Zhang, and J. Moore. (2005). "Evaluation of Bond Strength Between Pavement Layers." NCAT Report No. 05-08, National Center for Asphalt Technology, Auburn, AL.