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Analysis of the Adhesiveness Between the Layers of Bituminous Pavement

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***Abstract*: This study looks at the impact of tack coatings on the performance and longevity of flexible pavements, as well as the significance of layer adhesion in bituminous pavements generally. Research shows that problems like delamination, slippage, and top-down splitting can weaken pavements, therefore it's important to bond materials properly. This study compares and analyses, by experimental testing, the effectiveness of different tack coat types (CRS-1 and CMS-2) and application rates in strengthening interlayer bonding. According to the findings, CRS-1 is more effective than CMS-2, and an application rate of 0.30 kg/m^2 is recommended for achieving maximal shear strength. These findings can be used to improve pavement design and decrease the chances of early failures, which in turn increases the lifespan of roadways. The report goes on to suggest more studies to test these results in different real-world settings and environmental factors.**

***Keywords*: tack coat, performance, bond strength, shear strength, inter layers.**

1. Introduction

There is a significant relationship between the quality of adhesion between the layers of bituminous material and the performance and lifetime of flexible pavements. The efficient distribution of tension throughout the levels of multi-layered pavement systems is imperative due to the substantial traffic loads that contemporary roadway encounter. In spite of this, the structural integrity of the pavement may be jeopardized by slippage failure, top-down splitting, and surface layer delamination. These three phenomena are all possible outcomes of insufficient bonding between the layers.

The objective of this investigation is to ascertain the degree of adhesion that exists between the sections of bituminous pavement and to measure the degree of binding strength that exists at the interface between the two sections. Furthermore, the objective of the study is to determine the most efficient application rate for tack coatings in order to improve the overall performance of the pavement system and to strengthen the bonding between the layers. For this reason, the study is being conducted.

2. Background

A. Tack Coats in Pavement Construction

In the process of constructing pavement, tacking coats are an essential component because they act as a bonding agent between newly applied overlays and the layers of pavement that are already in place. It is essential for the pavement to have a tacking coating, which is commonly composed of bituminous emulsions or binders. This coating ensures that the layers of pavement cling to one another, which is necessary for the pavement to function as a cohesive unit. It is particularly crucial to consider the quality of the tack coat application in areas with high traffic volumes, as it directly affects the pavement's durability.

B. Common Problems Due to Poor Bonding

If the tack coatings are not applied properly or if they do not perform as expected, the pavement may endure a variety of different sorts of distress. This includes slippage failures, which are characterized by cracking and potholing. These failures occur when strata move over one another as a consequence of inadequate bonding. These breakdowns are most detrimental in areas that see a significant amount of automobile traffic, particularly in areas where cars often accelerate, decelerate, or turn.

C. Review of Related Literature

Previously, a comprehensive analysis was conducted to investigate the elements that influence the interlayer bonding of bituminous pavements. A previous investigation was carried out, which is the subject of this inquiry. A number of different testing methodologies, such as the Layer-Parallel Direct Shear (LPDS) device and the Ancona Shear Testing Research and Analysis (ASTRA) device, have been utilized in order to evaluate the strength of the interface bond. In the process of attaining adequate bonding, these investigations have shown that the materials used for the tack coat and the application rates at which they are applied are quite important.

This table offers a quick summary of the most important research that have been conducted on the effectiveness of various tack coatings in bituminous pavements and interlayer bonding. Specifically, it highlights the impact that different

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Table 1
Review of relevant research on interlayer bonding and the efficiency of tack coats

Author (s) and Year	**Objective**	**Tack Coat Types Tested**	**Testing Methods Used**	**Key Findings**
Doe et al., 2010	A comparison of pavement layer tack coat bonding strengths	CRS-1, SS-1h	Shear strength testing using LPDS method	CRS-1 bonded better than SS-1h at greater application rates.
Smith and Johnson, 2015	To test different tack coat materials at different temperatures.	CMS-2, CRS-2	Ancona Shear Testing Research and Analysis (ASTRA)	CRS-2 maintained shear strength better than CMS-2 at high temperatures.
Lee et al., 2018	To determine how tack coat rate affects pavement layer bonding.	CSS-1, CRS-1	Direct shear test with varying tack coat rates	A 0.30 kg/m² application rate was optimal, with CRS-1 outperforming CSS-1 in all tests.
Martinez et al., 2020	Investigating pavement system tack coat performance over time	CRS-1, CMS-2	Field testing combined with laboratory shear tests	CRS-1 improved long-term bonding, reducing slippage failures.

Table 2
Shear strength of bituminous pavement layers at various tack coat application rates

Application Rate (kg/m^2)	**Model 1 (Shear Strength in kPa)**	**Model 2 (Shear Strength in kPa)**	**Model 3 (Shear Strength in kPa)**
0.25	400	450	520
0.3	560	590	670
0.35	530	570	630

types of tacking coats and application conditions have on bonding strength, and it provides a complete summary of the objectives, testing methodology, and principal conclusions of each individually conducted study.

3. Research Methodology

A. Experimental Design

The experimental part of this inquiry consisted of the preparation of cylindrical specimens of Bituminous Concrete (BC) and Dense Bituminous Macadam (DBM) with diameters of 100 mm and 150 mm, respectively. The CMS-2 and CRS-1 bond coat emulsions were the two most widely used bond coats because they were the primary focus of the testing. In order to determine whether or not these materials were effective in enhancing the bonding strength between the layers of pavement, they were applied at a variety of different rates.

B. Sample Preparation

In the beginning, the specimens were prepared by applying the tack coatings at precise rates, which were determined by the surface area of the specimen they were being applied to. Ensuring that the water in the emulsion evaporated and producing a thin layer of bituminous material was accomplished by allowing the tack coat to dry for a period of time. In order to compress the top layer into the tack-coated bottom layer, the Marshall Hammer was utilized. Subsequently, the specimens were permitted to cure at room temperature prior to examination.

C. Testing Procedure

This was accomplished by using three different shear testing models in order to quantify the strength of the interface connection. Model No. 1 was meant to accommodate specimens with a diameter of 100 millimeters, whilst Models No. 2 and No. 3 were produced with the intention of accommodating specimens with a diameter of 150 millimeters. The shear strength was defined by the maximal load that was delivered to the interface, and each model applied a shear force to the contact at a constant rate of deformation.

4. Results and Discussion

A. Analysis of Shear Strength

For all application rates, the results of the shear strength trials showed that CRS-1 performed significantly better than CMS-2. According to the findings, the shear strength values were at their highest when the best application rate for both types of tack coatings was determined to be 0.30 kg/m^2. In comparison to the other three models that were assessed, the shear strength values of Model No. 3, which was exposed to a concentric shear stress, were the greatest.

In the table 2, the shear strength (in kPa) has been determined for three different types of bituminous pavement layers at different tack coat application rates (0.25, 0.30, and 0.35 kg/m^2). The results of these measurements are shown together. The findings demonstrate that each model is more effective than the others in maintaining the strength of the interlayer bonding.

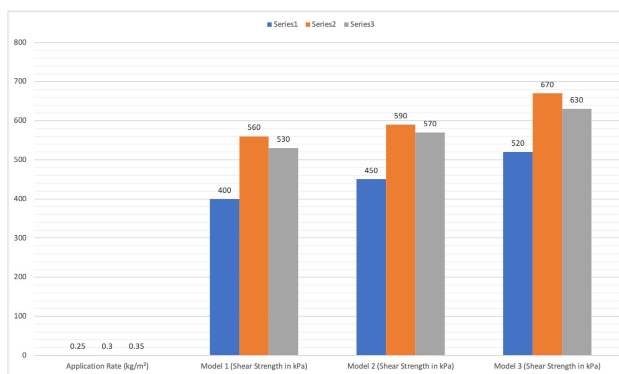

Fig. 1. Shear strength vs. Tack coat application rate for different pavement models

Within the context of three different models, this figure illustrates the relationship between the tensile strength of the pavement layers and the rate at which the tack coat is applied. A visual comparison of the performance of the models is presented in the chart, with an emphasis on the ideal application rate for achieving maximum shear strength levels.

B. Optimal Application Rates

During the course of the research, it was found that 0.30 kg/m^2 was the most efficient application rate for maximizing

Table 3
Cross-model comparison of the optimal tack coat application rate and corresponding shear strength

Tack Coat Type	Application Rate (kg/m²)	Model 1 (Shear Strength in kPa)	Model 2 (Shear Strength in kPa)	Model 3 (Shear Strength in kPa)	Average Shear Strength (kPa)
CRS-1	0.3	560	590	670	606.67
CMS-2	0.3	530	570	630	576.67

shear strength. With this pace, the best balance was achieved between limiting excessive material application, which could lead to slippage at the interface, and guaranteeing adequate bonding among the materials. When compared to CMS-2, CRS-1 had considerably better bonding capabilities.

It is provided in this table that the shear strength values (in kPa) for three different pavement models, as well as the optimal tack coat application rate (0.30 kg/m^2) for two different types of tack coats (CRS-1 and CMS-2), are presented. A further result of this computation is the determination of the average shear strength of the models, which highlights the effectiveness of each adhesive coat when applied at the ideal rate.

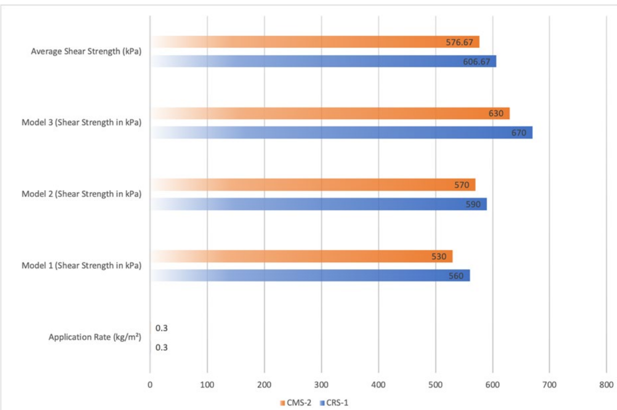

Fig. 2. Bar graph of shear strength at the best rate for applying tack coat (0.30 kg/m²)

A comparison of the shear strength (in kPa) of three different pavement models at the ideal tack coat application rate of 0.30 kg/m^2 is shown in this image. The two different sorts of tack coats, CRS-1 and CMS-2, are compared to one another. In contrast to CMS-2, the diagram underscores the superior bonding performance of CRS-1, as evidenced by the increased shear strength values observed in all models.

C. *Implications for Pavement Design*

The design and construction of bituminous pavements are greatly impacted as a result of these discoveries. The longevity and performance of pavement constructions can be improved by engineers by selecting the appropriate material and increasing the application rate of tack coatings. This will result in a reduction in the likelihood of early failures occurring.

5. Conclusions and Recommendations

A. *Summary of Key Findings*

The research proved that tack coating type and application rate substantially affect interlayer bonding strength. The ideal application rate to produce the maximum shear strength was found to be 0.30 kg/m^2, with CRS-1 proving to be more effective than CMS-2.

B. *Recommendations for Practice*

It is recommended that professionals working in the field of pavement construction take into consideration the utilization of CRS-1 at an application rate of 0.30 kg/m^2 in order to guarantee robust interlayer bonding. This method will assist prevent typical difficulties such as slippage failure and surface layer delamination, which will ultimately result in the pavement having a longer lifespan.

6. Future Research Directions

Additional study is recommended in order to validate the results by comparing the findings from the laboratory with data collected from the field. In addition, the investigation of the impact of various environmental circumstances, such as variations in temperature and normal pressure, on the performance of tack coats will reveal even more profound insights into the optimization of pavement design.

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