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Analysis of Thin Overlays Over the Bituminous Road

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***Abstract*— Thin overlays are widely used as a preventive maintenance and rehabilitation technique to enhance the performance and extend the lifespan of bituminous pavements. Applied in thicknesses typically ranging from 25 mm to 50 mm, these overlays serve to restore surface smoothness, improve skid resistance, and address minor surface distresses such as cracking, raveling, and oxidation. This study analyzes the effectiveness of thin asphalt overlays by evaluating their performance, material composition, construction practices, and long-term benefits. Emphasis is placed on their cost-efficiency, environmental advantages, and suitability for pavements that are structurally sound but exhibit surface deterioration. Field data, performance monitoring, and case studies from various transportation agencies are reviewed to assess service life and maintenance requirements. The findings indicate that when applied under appropriate conditions and with proper material selection, thin overlays can significantly delay major rehabilitation activities and reduce life-cycle costs. However, their limitations in addressing deep structural failures and susceptibility to reflective cracking must be considered. This analysis supports the role of thin overlays as a sustainable and effective pavement preservation strategy within modern asset management systems.**

***Index Terms*—Asphalt , seal coat, Aggregate.**

1. INTRODUCTION

The durability and performance of bituminous pavements are crucial for ensuring safe and efficient transportation. Over time, these pavements experience surface distresses such as cracking, raveling, oxidation, and minor rutting due to traffic loading, environmental effects, and aging of materials. While full-depth rehabilitation offers a long-term solution, it is often costly, time-consuming, and disruptive. As a result, thin asphalt overlays have emerged as a practical and cost-effective maintenance technique to extend pavement life, improve ride quality, and restore surface characteristics without significant structural intervention. Thin overlays, typically ranging from 25 mm to 50 mm in thickness, are applied over existing bituminous roads to provide a new wearing surface. These overlays are especially suitable for pavements that exhibit surface-level deterioration but remain structurally sound. Their adoption aligns with pavement preservation strategies, offering agencies a method to delay more intensive rehabilitation efforts while optimizing lifecycle costs. This analysis examines the performance, design considerations, material selection, advantages, and limitations of thin overlays, highlighting their role in sustainable pavement management systems.

2. MATERIAL

2.1 Aggregates and Binder

Class A aggregates were utilized as the coarse aggregates (material retained on the No. 8 sieve), while Class B aggregates were employed as the fine aggregates. The aggregates were predominantly dolomitic. These materials were sourced from two different locations: Capital Aggregates at the Bolm Road plant and Capital Aggregates Delta at Marble Falls. The asphalt binder used was of grade PG70-22, procured from a supplier based in Texas. For this particular task, no additives were included in any of the six asphalt mixtures.

2.2 Aggregate Gradation

As previously mentioned, six distinct asphalt mixes were developed using varying aggregate structures or gradations. The reasoning behind the selection of these six gradations was outlined in an earlier chapter and is briefly summarized below. A survey was conducted across all fifty states (Figure 3.1) to identify the aggregate gradations specified by different states that could potentially be used for an ultra-thin mix. Some states specifically defined gradations for thin overlays, while others did not have criteria for thin overlay pavements. For the latter, only gradations with a maximum aggregate size smaller than 12.5 mm (the overlay thickness) were considered. After analyzing the various gradations, it was concluded that six main categories of aggregate gradations represent the different mix types used across the country (suitable for ultra-thin mixes). A representative gradation was selected from each of these categories. Figure 3.2 illustrates the six gradations chosen for the mix design.

2.3 Bitumen

Bitumen is a black, viscous, and adhesive material derived from the distillation of crude oil. It plays a vital role in the construction and maintenance of flexible pavements, serving as a binding agent that holds aggregates together to form asphalt concrete. Due to its excellent waterproofing properties, durability, and ability to withstand varying climatic and traffic conditions, bitumen has become the most widely used material in modern road construction. Primarily used in the form of hot mix asphalt, bitumen offers flexibility, workability, and resistance to deformation under traffic loads. Its performance can be enhanced through various modifications, including the use of polymers or additives to improve resistance to rutting, cracking, and aging. Understanding the properties, types, and applications of bitumen is essential for designing long-lasting pavements and selecting appropriate maintenance strategies.

3.Mix Design Procedure

In order to avoid raveling and bleeding in the field, it is crucial to use the optimum binder content in an asphalt mixture. As per Tx DOT 2014 Specifications, Item 347 specifies the criteria to determine the optimum asphalt binder content. For this task, the optimum asphalt binder content was determined using the aforementioned specification. The procedure used to determine the optimum binder content is briefly described below'

The asphalt binder was heated inside the oven at 150 ◦C. The binder was heated until the binder was workable and of consistent viscosity throughout the container. The temperature was based on the PG of the asphalt binder (TxDOT Tex-241-F), which was PG70-22 in this case.

3.3 Calculation % Volume of bitumen (Vb)

Volume of Bitumen (Vb) refers to the percentage of the total volume of a compacted bituminous mixture that is occupied by bitumen (binder).

$$Vb = \frac{\frac{Wb}{Gb}}{\frac{W1+W2+W3+Wb}{Gm}}$$

$$Vb = \frac{\frac{60}{0.99}}{\frac{456+672+100+60}{2.012}}$$

The aggregates sampled from the field were from different stock piles. For this task, researchers did not use the stock pile gradations to prepare aggregate blends. Instead, aggregates from each stock pile were sieved into different size fractions and recombined later. Also, aggregate samples obtained from the field had a high dust content. All aggregates were washed and then used in the mixture design.

3.1 Calculate The Specific gravity

Specific gravity is defined as the ratio of the density of a substance to the density of a reference substance, usually water for liquids and solids, and air or hydrogen for gases.

Specific Gravity of specimen\Bulk density (Gm)

$$Gm = \frac{Wa}{Wa - Ww}$$

$$Gm = \frac{1258}{1258 - 632.8} = 2.012$$

Theoretical Specific Gravity without considering the air void (Gt)

$$Gt = \frac{W1 + W2 + W3 + Wb}{\frac{W1}{G1} + \frac{W2}{G2} + \frac{W3}{G3} + \frac{Wb}{Gb}}$$

$$Gt = \frac{456 + 672 + 60 + 100}{\frac{456}{2.6} + \frac{672}{2.03} + \frac{100}{1.78} + \frac{60}{0.99}} = 2.066$$

3.2 Calculate The Air Voids Ratio

To calculate air voids in a compacted material like asphalt or soil, you can use the following formula

Air Voids %(Vv)

$$Vv = \frac{\mathrm{Gt} - \mathrm{Gm}}{\mathrm{Gt}}$$

$$Vv = \frac{2.066 - 2.012}{2.066} \times 100 = 2.6\%$$

3.4 Calculation of Voids in Mineral Aggegates

$$VMA = Vv + Vb$$

$$VMA = 2.6 + 9.46 = 12.06$$

. 3.5 Calculation of Air Voids

$$VFB = \frac{Vb \times 100}{VMA}$$

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$$VFB = \frac{9.46 \times 100}{12.06} = 78.44$$

5. Result and Discussion

Table 5.1 lists the different mixes that were evaluated using the a forementioned tests for their performance abinder contents that are slightly higher and lower than the optimum binder content

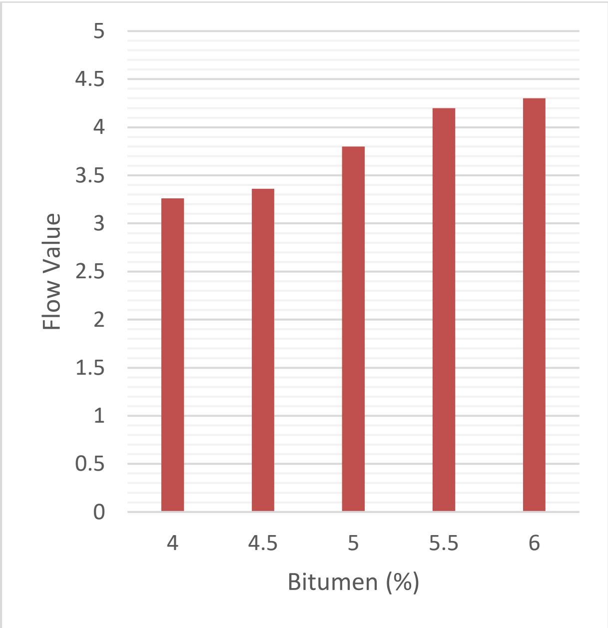

Figure no 5.1:- Marshall stability Curve

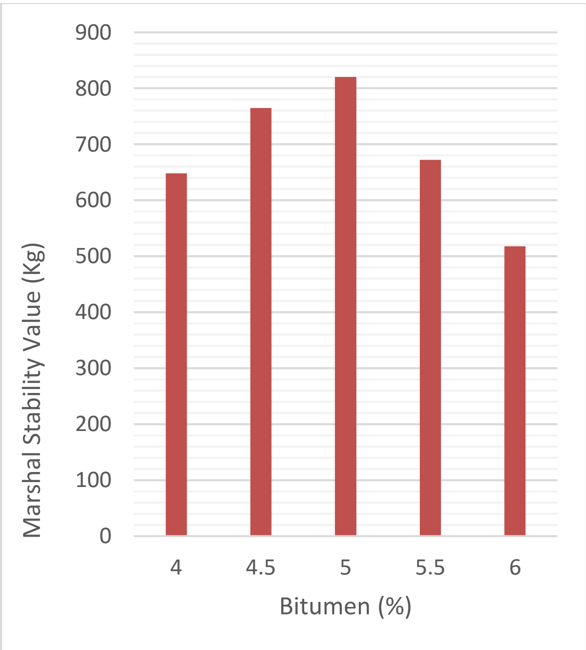

Figure no 5.2:- Flow Curve

1	Weight of sample in air (W_a)	1258g
2	Weight of sample in water (W_w)	632.8g
3	Weight of coarse aggregates (W_1)	456g
4	Weight of fine aggregate (W_2)	672g
5	Weight of filler materials (W_3)	100g
6	Weight of bitumen (W_b)	60g
7	Specific gravity of coarse aggregate(G_1)	2.6g
8	Specific gravity of fine aggregate(G_2)	2.03g
9	Specific gravity of filler materials (G_3)	1.78g
10	Specific gravity of	0.99g

Table no.5.1:- Calculation for 5% of Bituminous Content

SI. No.	Description	Requirement
1.	Marshall stability (ASTM Designation: D-1559 determined on Marshall Specimens compacted by 75 compaction blows on each end	820 kg (1800 Ib.) Mnimum
2.	Marshall flow (mm)	2-4
3.	Per cent voids in mix	3-5

4.	Per cent voids in mineral aggregates	Minimum 11-13 per
5.	Per cent voids in Mineral aggregates filled by bitumen (VFB)	65-75
6.	Binder content, per cent by weight of total Mix	Minimum 4.5

Table no.5.2:- Recommendation of Marshal Value and Flow Value as per IRC

6. Conclusion

The main goals of this study were to: (i) explore the different possible aggregate structures that could be used to design a mix for application as an ultra thin overlay, (ii) identify and validate a volumetric mix design criterion to design such mixes using laboratory based performance indicators, (iii) identify requirements for the tack coat to be used with such mixes and ultra thin overlays, and (iv) demonstrate the life-cycle cost for such overlays compared to chip seals. strength requirements, builders and contractors can employ this blend confidently.
In order to achieve the aforementioned goals, a nationwide survey of aggregate struc- tures that could potentially be used as an ultra thin overlay was conducted. Six different aggregate structures were identified and used in the remainder of this study. These mixes were used with a volumetric mix design criterion to determine the optimum binder con- tent. Mixture specimens were prepared and performance tests at the optimum, as well as above and below this optimum content for each mix were conducted. These performance tests included Hamburg Wheel Tracking Device or HWTD, Modified Specimen HWTD, Overlay Tester, and Three Wheel Polishing Device – DirectFriction Tester or TWPD-DFT combination. Performance metrics included resistance to rutting, cracking, bleeding, and raveling while also maintaining a desirable level of skid resistance. In addition, four differ- ent field mixes were also used to benchmark the results from the performance tests. Skid resistance results from the mixes were compared to skid resistance of chip seals using data and correlations available from the existing literature for the latter.

Three of the six candidate aggregate structures were ultimately deemed vi- able for use as an ultra thin overlay. Measurements of skid resistance show that mixes designed for ultra thin overlays had comparable, and in most cases better, performance when compared to equivalent DFT friction values obtained on seal coats from other stud- ies.

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