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Flexible Pavement Design by Using F-Pave

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ABSTRACT:

A bituminous pavement is a multi-layered structure generally made up of surfacing, base and sub base courses on a sub grade. An interface is said to be a boundary between any two consecutive layers. So an adequate bond between the layers at the interfaces must be ensured so that multiple layers perform as a single composite structure. In case of non-bituminous layers or bituminous-non bituminous layers, adequate bond is established as such due to the mechanical interlocking between the aggregate surfaces. However, the state of bond at the interface between any two bituminous layers has a significant influence on the stress distribution across pavement layers under traffic loads and hence on the overall performance of the pavement. To increase the adhesion or bonding between two bituminous layers, bituminous tack coats are applied prior to overlay. This study is an attempt to evaluate the interface bond strength between two types of bituminous layer combinations in the laboratory. The cylindrical specimens have been tested for bond strength at four normal service temperatures, namely 250 , 300 , 350 and 400C by applying different types of tack coat at varying application rates. The specimens have been prepared using normal Marshall Procedure first for the underlying layer, followed by application of tack coat and finally overlaying with the top layer in the same mould in an appropriate manner. Two types of layer combinations have been tried, namely (i) Bituminous Concrete (BC) layer on Dense Bituminous Macadam (DBM) samples and (ii) Semi Dense Bituminous Concrete (SDBC) layer on Bituminous Macadam (BM) samples. Similarly, different types of tack coat materials namely bitumen, Cationic Rapid Setting with low viscosity (CRS-1) and Cationic Medium Setting with high viscosity (CMS-2) emulsions have been used for the interface bond between the said bituminous layers. The samples thus prepared have then been tested on a specially fabricated attachment (named bond strength device)

fixed to the loading frame of the ii Modified Marshall Testing Apparatus. It is observed that the interlayer bond strength depends on the test temperature and this decreases with increase in test temperature. It is also observed that the bond strength depends on the type of tack coat used and conditions of the type of combinations. The optimum amount of tack coat has been found to vary for tack coat type and layer combination type.

INTRODUCTION:

Highways are considered to be the backbone of a country's growth and development. All developed as well as developing countries normally have a continuous program of sustaining and building road infrastructures or developing the existing road. To improve the existing road infrastructure in view of increased traffic is to strengthen the existing pavement layer by overlaying with another layer of appropriate material composition and thickness. The flexible pavement is generally designed and constructed in several layers for effective stress distribution across the pavement layers under the varying heavy traffic loads. The viscous nature of the flexible pavement, allows its different layers to sustain significant plastic deformation, although distresses due to repeated heavy loading over time which is the most common failure mechanism. The flexible pavement works as a single structure due to good bonding between the different layers interface of it. It is generally believed that, the pavement stress distribution is extremely influenced by the adhesion conditions at the layer interface. Poor adhesion at layer interface may cause adverse effects on the structural strength of the pavement system and form numbers of premature failures. To increase bonding between layers, bituminous tack coats are applied prior to overlay. Bituminous emulsions are normally used as tack coats. In spite of their extensive application, the thoughts among pavement engineers differ regarding the effectiveness of tack coat in enhancing the adhesion between the two layers. This tack coat also made of a thin layer of bitumen residue and its objective is to provide adequate adherence between the layers. If the quantity of bituminous emulsions used is in excess or less than the required one, the interface bonding will not be satisfactory

1.2 Failures arise due to inadequate bond

A Number of premature pavement failures can be attributed due to loss of bond between two layers of hot mix asphalt

(HMA). It has been generally observed that poor adhesion between pavement layers contributes to major pavement overlay distresses and numbers of premature failures. Such are Slippage failure and Surface layer Delamination. Slippage failure grows when the pavement layers begin to slide on one another and generally the top layer separating from the lower layer. This type of failure develops due to lack of bond between two top important pavement layers and it's mainly seen at high horizontal force at points where traffic is accelerating or decelerating, such as at traffic signals and within horizontal curves.

1.3 Background of Tack coat The word tack relates to a sort of stickiness. The coat is a small thickness of layer. So tack coat is a light application of a bituminous emulsion between pavement layers, most probably applied in a thin layer between an existing and a newly constructed bituminous surface. The importance of glue or sticky material like tack coat is to provide appropriate adhesive interlock between paving layers so that they react as a monolithic structure. Emulsified bitumen is a mixture of bituminous binder, water and emulsifying agent. The emulsifying agent might be soap, dust or colloidal clays. The structural view as reported by Roberts et al. (1996) is shown in figure1.3. Bituminous particles are kept in suspension in the water by the emulsifying agent and thus bitumen consistency is reduced at ambient temperature from a semi-solid to an applicable liquid form. So this liquefied bitumen is easier to distribute over a surface at ambient temperatures. When this liquid bitumen is applied to a clean bitumen surface, the water evaporates from the emulsion and leaving behind a thin layer of residual bituminous on the pavement surface. Usually, hot bituminous binder, cutback bitumen or bituminous emulsions are used as tack coat materials for construction purpose. The use of bituminous emulsions as a tack coat material is escalating instead of cutback asphalt or hot bituminous binder.

REVIEW:

Past Studies on Evaluation of Pavement Interlayer Bond Strength Bituminous pavements are generally constructed in several layers and proper bonding between adjacent layers is required to ensure good performance. But, this is not always achieved and a number of premature pavement failures have been developed due to poor bonding condition. The interface bond failure paving layers is due to mainly shear force only. In the recent past, interlayer shear performance has been broadly investigated. These studies have typically developed a unique test method or instrument for analysis of the interface bond strength. Various organizations and numbers of researchers have used various test methods for observing the pavement interlayer bond strength performance. Uzan et al. (1978) used a direct shear test device to test with a 60-70 penetration asphalt binder as a tack coat at five different application rates. The tests were conducted in two different temperature 77 and 1310 F (25 and 550C). The tack coat was applied on the bottom layer and 3cm (1.8inch) of mix compacted on top. The direct shear device was developed considering the specimen size with a constant displacement rate of 2.5 mm/min (0.098 in/min). The shear strength was evaluated at five different normal loading pressures of 0.05, 0.5, 1.0, 2.5 and 5 Kg/cm2 . The shear strength increased when the test temperature decreases and the normal pressure increases. The observed optimum tack coat application rate for this studied was 1.0 Kg/m2 at 250C. In Delft University of Technology Molenaar et al. (1986) used a shear test device to determine the shear resistance of the tack coat at the interface of the asphalt layers. The device was mounted on a standard Marshall Stability loading press for applied a load at a rate of 0.85 mm/Sec. This device held bottom part of the compacted cylindrical specimens and shear load was applied perpendicular to the axis of the specimens of the top layer. In Canada, Mrawira and Damude (1999) observed the bond strength of the interface by direct shear test. The specimens were collected as field cores from in-service pavements. Cores were assembled in six subsets varying with pavement age. All specimens were the same type of mix and the same type of materials used. The cores were trimmed to a height of 8cm (3.15 inch) and at the top surface of the layer 0.2 to 0.3 L/m2 of SS1 emulsion was applied with set times left less than one hour. When the tack coat cured, 16mm nominal maximum aggregate size compacted on the core in two lifts with 75 Marshall blows per lift as a overlays. The specimen were left to cure for two weeks at room temperature, then cut into rectangular size and placed in a water bath at 220C (750 F) for thirty minutes. The specimens were sheared on a guillotine style machine at a constant displacement rate of 1 mm/min. Mohammad et al. (2002) evaluated the bond strength of tack coat used in the interface of the bituminous paving layers by using the

Superpave shear tester shown in figure 2.2, which consists of a shear box set up for 150 mm (6 inch) diameter specimens. The specimens were compacted up to 50 mm and tack coat applied in five different application rates (0.0 to 0.9 L/m2), the samples were allowed to cure and second lift is placed on top and compacted.

Conclusions A study has been made in this project to evaluate the interlayer bond strength in the laboratory for different types of tack coat using laboratory prepared samples for DBM/BC and BM/SDBC layer combinations. A special device has been designed and fabricated, which can be fitted to the loading frame of the Modified Marshall Test apparatus to determine the interlayer bond strength of two-layered bituminous specimens. The specimens have been tested at four different test temperatures, namely 250 , 300 , 350 and 400C, which are very common in our country. A specimen basically consists of two bituminous layers, bonded together by emulsion or bitumen. The upper and lower layer combination is either DBM or BC or BM and SDBC respectively. Various application rates have been tried and in case of emulsion, different setting times have been tried. All such variations in materials and sample casting methods have been attempted to explore the optimum condition for appropriate bond strength in a particular situation. The following conclusions are drawn from the results of the tests conducted. DBM/BC Combination It is observed that for CRS-1, maximum interlayer bond strength results at 0.25 Kg/m2ϖ application rate in all test temperature conditions used and for CMS-2, at 0.15 Kg/m2 application rate irrespective of different test temperatures. These optimum application rates are also found for all setting times considered for both types of emulsions. In the cationic medium setting type of emulsion used as tack coat, the maximumϖ interlayer bond strength was found when setting time was at 9 hours and in the cationic rapid setting type of emulsion, maximum interlayer strength was observed when setting was at 1 an hour. When conventional VG 30 bitumen is used as a tack coat, the maximum interlayer bondϖ strength is observed at 0.2 Kg/m2 application rate when setting time was at 0.5 hours in all test temperatures used. When no tack coat is used, maximum bond strength at the interface available when theϖ upper layer mix is laid and compacted immediately after the lower layer compaction was completed. If the duration of compaction increased between two layers, the interlayer bond strength decreased. At a test temperature 250C, all types of tack coat used and other considerations taken ϖ for observing the interlayer bond strength have been found maximum value as compared to other test temperatures. BM/SDBC Combination It is determined that for CRS-1, maximum interlayer bond strength results at a 0.15ϖ Kg/m2 application rate in all test temperature conditions used and for CMS-2, at the 0.15 Kg/m2 application rate irrespective of different test temperatures. The interlayer bond strength is decreased when the test temperature increased for bothϖ types of tack coat used.

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