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Review on Effect of Anti-Stripping Agent and Cement on Indirect Tensile Strength of DBM

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Abstract: ***Due to the problems associated with cracking, the tensile properties of bituminous mix are of great concern to pavement engineers. Consequently, the tensile strength of bituminous mix is crucial for applications involving pavement. The Indirect Tensile Strength (ITS) test is used to evaluate the tensile properties of the bituminous mix. Adding cement or lime to bituminous mixtures is known to impart anti-stripping properties. For adverse conditions, however, it is advisable to use anti-stripping chemicals. It is crucial to ensure that the addition of this compound will not have a negative impact on other properties. Numerous studies on ITS have been conducted separately; however, no effect to evaluate the effect of addition of both of them has been done. In this proposal, an effort has been made to investigate the addition techniques of Anti-Stripping and Cement to DBM, both individually and in combination with the appropriate proportion.***
Keywords: Cement, ITS, Anti-Stripping Agent and DBM.

I. INTRODUCTION

The resistance of bituminous mixtures to fatigue cracking is reliant on their tensile qualities, particularly their tensile strength and extensibility characteristics. The layers of a flexible pavement structure undergo continual flexing as a result of the traffic loads they support, resulting in tensile stresses and strains at the bottom of the bituminous layers of the pavement. The size of the strain depends on the stiffness of the pavement as a whole. The indirect tensile strength test is indicative of a material's resistance to fatigue, temperature cracking, and rutting, as well as its tensile strength and adhesion. Due to the secondary stresses created by grasping a specimen in order to tear it apart, it is impossible to quantify tensile strength directly. Consequently, tensile stresses are often assessed indirectly using a splitting tensile test. In order to increase the longevity of roadways, various types of fillers are used in bituminous mixtures today. In recent years, the average annual increase in the number of vehicles has also had a negative impact on the pavement's functionality. Continuous research is conducted to improve the qualities of bitumen in order to produce innovative flexible pavements that can meet the problems of the present. Because of this, there is a big need to make improvements to bituminous pavement.

II. NEED AND SCOPE OF STUDY

The road network has expanded fast during the previous decade, and this expansion will continue in the near future. To accommodate the current demand for transportation, a new roads are constructed and existing roads are resurfaced or rectified as required. During the wet season, a significant number of flaws occur. Rock deteriorates more rapidly in regions with poor drainage, especially metropolitan areas. It is required to increase the resistance of bituminous mixtures against stripping in order to reduce drainage and associated expenses. Numerous studies are attempting to explain the utilisation of Anti-Stripping Agent, fillers, and other components. Some research has been conducted on the usage of Anti-Stripping and Cement materials, but a combination has not been attempted. This work is somewhat ahead of them in that it utilises Anti-Stripping Agent and Cement in bituminous mixtures. When Anti-Stripping Agent and Cement are added to bituminous mixtures, the performance of the mixture is likely to be affected by other parameters.

III. RESEARCH AND STUDIES ON EFFECT OF ANTI STRIPPING AGENT AND CEMENT ON INDIRECT TENSILE STRENGTH OF DBM

1) John P.Z and Geetha Srinivasan (2004) made evaluation of indirect tensile strength to identify asphalt concrete rutting potential. This prompted the National Cooperative Highway Research Program (NCHRP) to sponsor projects for the development of a simple performance test for rutting potential of asphalt mixtures. Anderson et al [2003] found that rutting potential can be evaluated using the indirect tensile strength, compaction slope measured with the Superpave Gyratory compactor and voids in mineral aggregate (VMA). In this research the main factors included in the experiment were binder type, asphalt content, sand

content, nominal maximum aggregate size, and gradation. Rutting potential was evaluated with the Asphalt Pavement Analyzer (APA). The parameters that were evaluated as independent variables include the IDT strength, volumetric parameters, compaction slope, and the compacted aggregate resistance. IDT was measured using theMarshall Stabilimeter with a split tensile head and the samples at 600 C. The analysis of variance demonstrated significant effects of all the main factors and their interactions on rutting potential

2) Huang B., Shu X., & Tang Y. (2005) did the comparative study of semi-circular bending and indirect tensile strength test for hot mix asphalt. The IDT test a standard test method of AASHTO and ASTM, which is adopted by most highway agencies. Two types of aggregate are used (lime stone and gravel) and two types of asphalt binder (PG64-22) and (PG76-22) were considered. The permanent deformation under the loading strips is undesirable and in same case unbearable for the calculating of the cracking potential of asphalt mixes. Semi- 17 circular bending test could significantly reduce the loading strip-induced permanent deformation and thus is more suitable indirect tensile test for calculating tensile properties of hot mix asphalt mixtures. The results from this study indicated that semi-circular bending and indirect tensile strength test were fully comparable and convertible.

3) Chen X. & Huang B. (2008) evaluation the performance of moisture damage in hot mix asphalt (HMA) and super pave indirect tensile test. Evaluate the moisture damage of dense- graded surface HMA mixture using simple performance test (SPT) and super pave indirect tensile test (IDT). Asphalt binders (PG 64-22) with and without amine-based antistrip additive (ASA) were used to make mixtures for laboratory moisture damage evaluations. The dynamic modulus, Superpave IDT creep, resilient modulus and strength tests were performed on conditioned and unconditioned specimens. The results from this study indicated that the SPT dynamic modulus test and the Superpave IDT with F-T conditionings were effective to characterize lab-measured moisture susceptibility of HMA mixtures. Increasing F-T (freeze- thaw) cycles would increase moisture damage in HMA mixtures. Amine-based antistrip additive was effective to decrease the moisture damage in HMA mixtures. Increasing coarse aggregate angularity (CAA) levels could increase dynamic modulus; however, it seemed that CAA had no significant effects on the lab-measured moisture resistance of HMA mixtures.

4) Anurag K., Xiao F. and Amirkhanian S.N. (2009) did laboratory investigation of indirect tensile strength using roofing polyester waste fibers in hot mix asphalt. The use of these materials was proved to be economical, environmentally sound and effective in increasing the performance properties of the asphalt mixture in recent years. The primary objective of this research was to determine whether homogeneously dispersed roofing waste polyester fibers improve the indirect tensile strength (ITS) and moisture susceptibility properties of asphalt concrete mixtures containing various lengths and percentages of the fiber in various aggregate sources. The results of the experiments found that, in general, the addition of the polyester fiber was beneficial in improving the wet tensile strength and tensile strength ratio (TSR) of the modified mixture, increasing the toughness value in both dry and wet conditions, and increasing the void content, the asphalt content, the unit weight, and the Marshall stability.

5) Gandhi T., Xiao F. and Amirkhanian, S.N. (2009) estimating the indirect tensile strength of mixtures containing anti-stripping agents using on artificial neural network (ANN) models to predict the indirect tensile strength (ITS) and tensile strength ratio (TSR) of various mixtures considering five input variables such as asphalt binder source, aggregate source, anti-striping agents (ASA), conditioning duration, and asphalt binder content. The results indicate that ANN-based models are effective in predicting the ITS and TSR values of mixtures regardless 18 of the test conditions. In addition, the developed ANN models can be used to predict (or estimate) the ITS values of the mixtures used in other research projects. Furthermore, the results also show that the asphalt binder source, aggregate source, and asphalt binder content are the most important factors in the developed ANN models while the conditioning duration is relatively unimportant (i.e., it has less effect on the ITS values in comparison with other variables). In addition, the sensitivity analysis of input variables indicated that the changes of ITS values are significant as the changes of the most important independent variables.

6) N. Erarslan and D.J. Williams (2011) investigated the effect of cyclic loading on the indirect tensile strength of rocks. This paper presents the results of laboratory experiments during the investigation of the stress–strain characteristics of Brisbane tuff disc specimens under diametral compressive cyclic loading. The ITS of Brisbane tuff disc specimens was measured using the Brazilian tensile strength test. The reduction in ITS was found to be 33% with sinusoidal loading tests, whereas increasing cyclic loading caused a maximum reduction of 37%. It is believed that the fracturing under cyclic loading starts at contact points between strong grains and weak matrices and that contact points at grain boundaries are the regions of stress concentration (i.e., indenters). Trans granular cracks emanate from these regions and intergranular cracks sometimes pass

through the contact points. Once cracking begins, there is a steady progression of damage and a general 'loosening' of the rock, which is a precursor to the formation of intergranular cracks.

7) Al-Baiti H.K.A.(2012) study the effect of additives and other factors on tensile strength of asphalt paving mixtures. Asphalt concrete resistance to cracking is dependent upon its tensile strength and flexibility characteristic. The low tensile strength has recognized as a major contributor to other performance problem. Exponentially decreases fatigue life of mixture with decreasing the tensile strength. The main objective of this research to study the external conditions on the tensile strength and predict a model of indirect tensile strength in asphalt concrete paving materials under the local prevailing conditions and investigate the effect of percent of additives of (Polystyrene resins and Hydrated Lime) to enhance the resistance ability of asphalt concrete mixture against distresses. Main affected factors; soaking, asphalt content, compaction, aggregate maximum size and temperature, influence on the indirect tensile strength and presented through a statistics analysis model for tensile strength in asphalt mixture.

8) Navarro F. M. & Gamez M. C. R. (2012) study of the influence of crumb rubber on the indirect tensile strength and stiffness modulus of hot bituminous mixes. The mixes in the study were close graded i.e (air void percentage of 4-6%) and a continuous coarse grain maximum 19 aggregate size of 22mm and bitumen content of 3.5-5.0 % of the total weight of the mix. The use of rubber from scrap tires to modify the mechanical properties of bituminous mixes has become increasingly important in road engineering. This paper presents a study of the incorporation of crumb rubber (by the dry process and the wet process) and its effect on the bearing capacity and cohesion of bituminous mixes. The results obtained show that crumb rubber increased the stiffness and stability of mixes although it slightly reduced their indirect tensile strength. Apart from the evident environmental benefits, adding this waste to asphalt mixes improves the long-term performance of road surfaces because it reduces the effect of traffic loads on the pavement.

9) Shunyashree, B. tejas, Archana M.R. and Amarnath M.S. (2013) study of the effect of use of recycled materials on indirect tensile strength of asphalt concrete mixes. For the laboratory investigations reclaimed asphalt pavement (RAP) from NH-4 and crumb rubber modified binder (CRMB-55) was used. Foundry waste was used as a replacement to conventional filler. Laboratory tests were conducted on asphalt concrete mixes with 30, 40, 50, and 60 percent replacement with RAP. These test results were compared with conventional mixes and asphalt concrete mixes with complete binder extracted RAP aggregates. Mix design was carried out by Marshall Method. The Marshall Tests indicated highest stability values for asphalt concrete (AC) mixes with 60% RAP. The optimum binder content (OBC) decreased with increased in RAP in AC mixes. The Indirect Tensile Strength for AC mixes with RAP also was found to be higher when compared to conventional AC mixes at 30^0C.

10) Katman H.Y., Ibrahim M.R., Matori M.Y., Norhisham S. and Ismail N. (2013) study the reclaimed asphalt pavement on indirect tensile strength test of foamed asphalt mix tested in dry condition. Indirect tensile strength (ITS) test was conducted to analyses strength of the foamed asphalt mixes incorporating reclaimed asphalt pavement. Preparation of sample was followed closely to Marshall procedure in accordance with ASTN D6926 and tested with ASTM D6926-07. Samples were tested for ITS after cured in the oven at 40^OC for 72 hours. This testing condition known as dry condition or unconditioned. Laboratory results show that reclaimed asphalt pavement (RAP) contents insignificantly affect the ITS results. ITS results significantly affected by foamed bitumen contents.

11) Islam M. R., Hossain M. I. & Tarefder R. A. (2015) describe the comparison in laboratory and field aged sample to study the dynamic modulus, diametrical resilient and loss of ductility these parameters are most common to study aging by indirect tensile strength (ITS) test. The air void of the sample before conditioning ranges from 5.1% to 5.9% with an average value of 5.4%. the design binder was a performance grade binder, which was used 4.4% by 20 weight of the mixture. The maximum size of the aggregate was 19mm. In this aged in the field and laboratory and then loaded diametrically to determine indirect tensile strength value and flow number. Two types of sample compacted sample and loose mix sample performed indirect tensile strength of laboratory long term and field aged sample increase with aging period and indirect tensile strength of short-term oven aged loose sample is concave down with aging period. Sample prepared using a super pave gyratory compactor following the AAHTO T 312- 07 test protocol. Overall, the flow number will be decreases as aging intensity increases, that is the brittleness increases with aging.

12) Peng Y, Wan L. & Sun L-J. (2017**)** describe the three-dimensional discrete element modelling of influence factors of indirect tensile strength of asphalt mixtures properties which contain asphalt content and three asphalt mixtures AC13, AC16 and AC20 were used in this study. AC13, AC16 and AC20 had nominal maximum aggregate size of 13.2, 16 and 19 mm, respectively. Based on this model, the effect of aggregate gradation, asphalt content and loading velocity on IDT strength were numerically

simulated. Result reveal that the IDT test at 20^0 C can be simulated. The strength of asphalt mixtures is remarkable affected by the aggregate gradation, asphalt content and loading velocity. In these experimental measurements are not too large compared to typical variation due to a number of samples is not large enough and the experimental IDT strength is low.

13) Gupta L. & Suresh G. (2018**)** evaluating the indirect tensile strength of bituminous concrete mix by using stone dust and cement as filler materials. Tensile strength of bituminous concrete mix is important in pavement applications. For the preparation of bituminous concrete mix specimens using stone dust and cement as filler materials, optimum bitumen content was determined by adopting Marshall method of bituminous mix design. Bituminous mix properties were determined at optimum bitumen content. Indirect tensile strength (ITS) and Tensile strength ratio (TSR) of bituminous concrete mix were evaluated by varying test temperatures at 15 °C, 20 °C, 25 °C, 30 °C and 35 °C. Marshall stability and optimum bitumen content as independent variable for each filler material. As the test temperature increases the ITS and TSR values of bituminous concrete mix decreases irrespective of type of filler material. Based on the analysis of data, it was observed that at any test temperature, ITS and TSR values of bituminous concrete mix prepared using cement as filler material were higher when compared to bituminous concrete mix prepared using stone dust as filler material. It may be concluded that the behavior of bituminous concrete mix prepared using cement as filler material is superior in terms of mix properties, ITS and TSR.

IV. CONCLUSIONS

From the above literature review, the following are concluded:

1) The dry ITS values of the mixtures containing fibers were lower than the control mixtures. These values were lower for 1.270 cm (1/2 in.) and 0.50% fiber mixtures. But the statistical analysis indicated that this difference was not statistically significant. The wet ITS values of the fiber induced asphalt mixtures were found to be statistically higher than the controls indicating that the use of polyester fibers decreased the moisture susceptibility of mixtures

2) The ITS response to cyclic loading was found to be different from that under static loading in terms of the lower ultimate load and different fracturing mechanisms. The reduction in ITS was found to be 33% with sinusoidal loading, whereas increasing cyclic loading caused a maximum reduction in ITS of 37%. In addition, no post-peak behaviour was observed in the load–strain plots of either the monotonic or the cyclic loading test.

3) Amine-based antistrip additive was effective to decrease the lab-measured moisture susceptibility of HMA mixtures.

4) The results from the Superpave IDT resilient modulus, creep, and strength testing indicated that the lab-measured moisture damage of mixtures include changes in multiple parameters

5) Because of the much smaller permanent deformation under the loading strip, SCB was more suitable for evaluating tensile properties of HMA mixtures at elevated temperatures (or for softer mixtures) than IDT test

6) Indirect tensile strength of asphalt mixture decreases by increase the temperature and maximum aggregate size

7) The important indices of five input variables could be calculated using the method developed by Yang and Zhang. The results show that the asphalt binder source, aggregate source, and asphalt binder content are the most important factors in the developed ANN models to predict ITS values regardless of test conditions, while anti-stripping agents is relatively unimportant in dry ITS model but is relatively important in wet ITS model. Moreover, it was found for the materials tested for this research that the conditioning duration is relatively unimportant for two types of ITS specimens as compared to the other four independent variables.

8) The ITS values of the laboratory long-term and field aged samples increase with the aging period.

9) The ITS of the short-term oven aged loose samples increases with the conditioning period; it reaches a peak and then decreases with the conditioning period.

10) The flow number decreases (brittleness increases) with the conditioning period under all kinds of aging modes.

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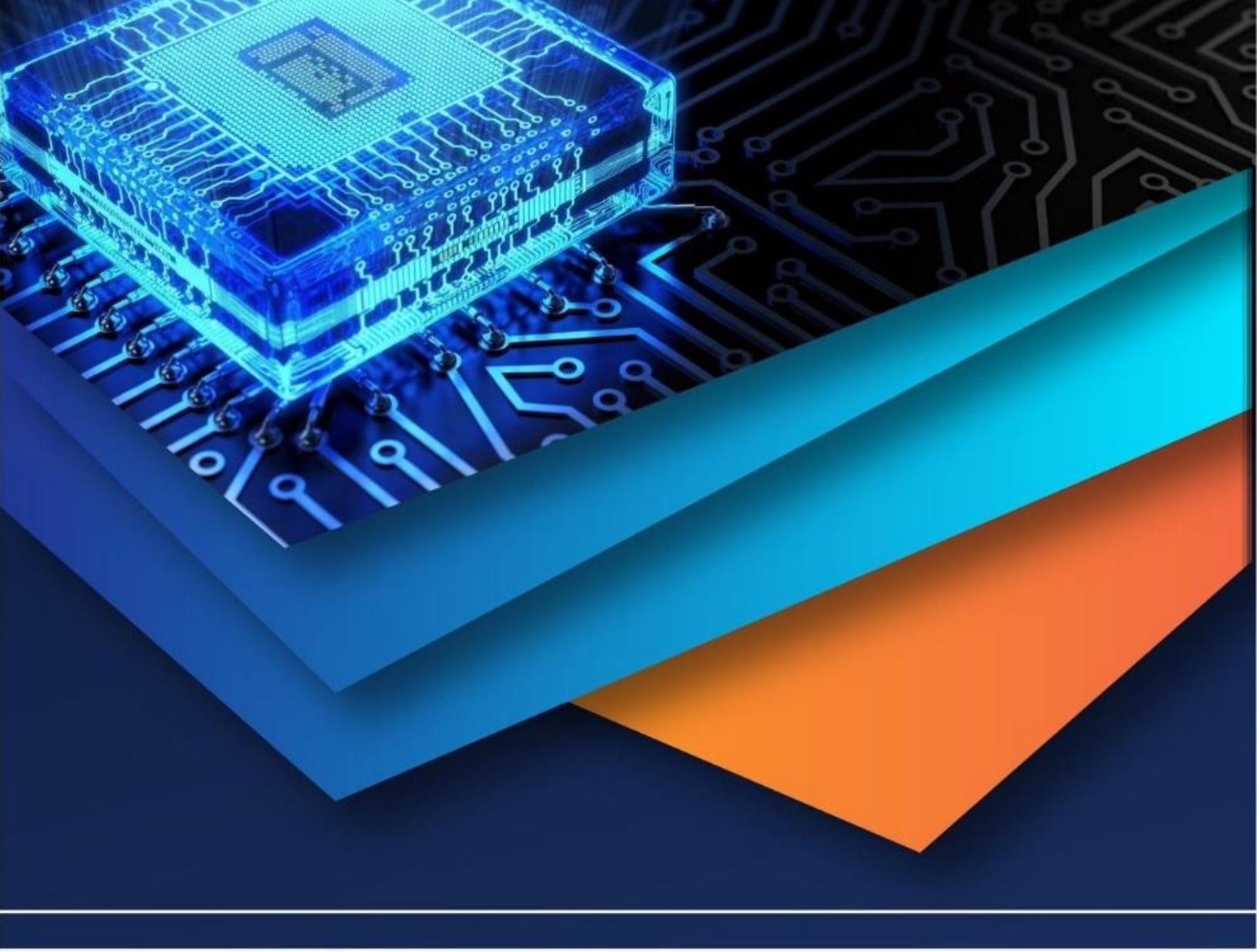

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