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Tensile Strength of Asphalt Concrete due to Moisture Conditioning

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***Abstract*—**This study investigates the effect of moisture conditioning on the Indirect Tensile Strength (ITS) of asphalt concrete. As a first step, cylindrical samples of 100 mm diameter and 50 mm thick were prepared using a Superpave gyratory compactor. Next, the samples were conditioned using Moisture Induced Susceptibility Test (MIST) device at different numbers of moisture conditioning cycles. In the MIST device, samples are subjected water pressure through the sample pores cyclically. The MIST conditioned samples were tested for ITS. Results show that the ITS does not change significantly with MIST conditioning at the specific pressure and cycles adopted in this study.

***Keywords*—**Asphalt concrete, tensile strength, moisture, laboratory test.

I. Introduction

RESEARCHERS have studied the moisture susceptibility of Asphalt Concrete (AC) in the past. The effects of moisture conditioning on the fatigue and rutting performance of AC were found to be detrimental to pavement [1]-[3]. The change in stiffness of AC due to moisture conditioning has been intensively examined in the literature [4], [5]. To this day, the effect of moisture on the ITS of AC has been studied by researchers using AASHTO T 283, in which moisture conditioning is done by one cycle of saturation and then, freezing and thawing, which does not reflect field condition [6].

In field, an AC pavement is subjected to increase and decrease in pore pressure when saturated. When a vehicle passes on the road surface, the saturated pavement beneath that vehicle tire is pressurized by water, that is, water enters the pores of the asphalt concrete due to wheel weight. As the wheel moves away, the pore pressure is released. The same phenomenon is simulated by the Moisture Induced Susceptibility Test (MIST) device in the laboratory. This study examines whether this MIST conditioning has any effect on the Indirect Tensile Strength (ITS). If it does not affect, then we cannot say that moisture damage is not happening inside the AC sample by MIST conditioning. Rather, we would consider that moisture damage cannot be captured with the macroscopic ITS test method. Also, it is possible that the combination of the number of MIST conditioning cycle and the magnitude of applied pore water pressure selected for this study does not cause moisture damage nor any change in ITS value.

Moisture susceptibility tests are generally categorized into two classes: qualitative test, and quantitative test. The qualitative tests are only be used for the initial screening but is not used for detailed analysis. Tunnicliff and Root [7] and the AASHTO T 283 [8] are two popular quantitative tests methods typically found in asphalt literature to evaluate the moisture susceptibility. According to the Tunnicliff and Root [7] and the AASHTO T 283 [8] test methods, ITS values of samples are determined before and after moisture conditioning. According to the Tunnicliff and Root [7] method, moisture conditioning is performed by submerging asphalt samples under water and subjecting them to a vacuum of 137.9 kPa (20 psi) for 5 minutes. The specimens are then soaked in a water bath for 24 hour at 60˚C and subsequently cooled in another water bath at 25˚C for 1 hour. According to the AASHTO T 283 [8], moisture conditioning is done by subjecting an asphalt sample to vacuum saturation and then to a freeze cycle at -18˚C for minimum of 16 hours followed by soaking in water at 60˚C for 24 hours.

Fwa and Oh [9] studied the effect of moisture content on properties of asphalt mixes by both Tunnicliff and Root [7] and the AASHTO T 283. The researchers reported that ITS of AC were affected by saturation levels. No statistically significant difference in result was found between the Tunnicliff and Root [7] and the AASHTO T 283 [8] conditioned samples at the 95% Confidence Interval (CI). Ping and Gun [10] evaluated the effect of moisture content on ITS using Tunnicliff and Root [7] method. Ping and Gun [10] found that ITS of foamed AC decreased with moisture conditioning.

The above mentioned moisture conditioning procedures have some drawbacks. It has been argued that the AASHTO T 283 procedure is too severe because the warm water soaking of the vacuum saturated and frozen specimen can damage the mastic or binder film severely, which do not simulate field moisture conditions [11], [12].

II. Objective

The objective of this study is to determine the change in ITS value of the laboratory prepared AC sample due to MIST moisture conditioning. The moisture conditioning has been conducted for different number of cycles. The ITS of the moisture conditioned sample has been determined applying diametrical compressive load until failure. The ITS of moisture conditioned sample has been compared with that of control sample.

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III. Laboratory Testing

A. Materials and Sample Preparation

Cylindrical samples of 150 mm diameter and 170 mm height were prepared using a Superpave gyratory compactor following the AASHTO T 312-06 test protocol [13], as shown in Fig. 1. Next, the samples were cut into 100 mm diameter and 50mm thick using a laboratory saw (Fig. 2). These samples are then ready for MIST conditioning and are shown in Fig. 3. The bulk densities of the samples were determined following the AASHTO T 166-07 [14]. The air voids of the samples are calculated using the maximum densities measured by the AASHTO T 209-05 test [15]. The air voids of the sample ranges from 5.1% to 5.8% with an average value of 5.4%.

Fig. 1 Gyratory compactor

Fig. 2 Cutting a sample using a laboratory saw

Dense graded Superpave (SP) mix, type SP-III is used for compacting gyratory samples. This mix contains 35% Reclaimed Asphalt Pavement (RAP) materials and 65% virgin crushed basalt aggregate. The design binder is a Performance Grade (PG) binder, PG 76-22, which is used 4.4% by the weight of mixture. The nominal maximum aggregate size is 19 mm. About 5% of the materials passes through a number 200 sieve (0.075 mm).

B. Conditioning and Testing

The moisture conditioning is performed using the MIST device shown in Fig. 4. In this study, a total of 3500, 7000 and 10500 cycles of water pressure at 40 psi are applied at a temperature of 60°C. Damage is expected to occur inside the AC samples in the form of washing out of binders, loosening the bond between aggregate and binder due to the cyclic water pressure.

Fig. 3 Some prepared samples

Fig. 4 MIST moisture conditioning device

The ITS values of the MIST conditioned samples are determined using Indirect Tensile (IDT) test device in an environmental chamber as shown in Fig. 5. Samples were subjected to a vertical deformation of 50 mm per minute at 20°C until failure. The peak failure load is considered as the ITS value of an asphalt sample.

Fig. 5 IDT test setup

Fig. 6 shows few failed samples. The failure was brittle in nature and separated into two parts. However, the control sample did not crush into parts.

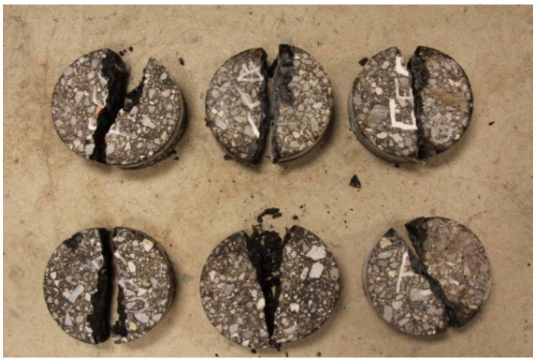

Fig. 6 Failed samples

IV. Results and Discussion

The ITS values of the moisture conditioned samples are shown in Fig. 7. A total of ten samples were tested for each category. The standard deviation of the each category is shown on top of each bar. The ITS value of the control sample, that was not subjected to MIST conditioning, is found to be 1.25 MPa. The ITS values of 3500, 7000 and 10500 cycles of MIST conditioned samples are shown to be 1.24 MPa, 1.27 MPa and 1.25 MPa, respectively. It can be seen that the ITS values of and the moisture conditioned samples do not vary significantly from the ITS value of the controlled sample. Any real reason could not be found from this study. Several speculations can be made. We believe that asphalt binder used in this study is a hydrophilic material. As such, it swelled and filled the voids inside the sample during initial cycles, which has resulted in reduced water intrusion inside the pores due to pore clogging instead of pore opening. This might have prevented moisture damage as the cycle number increases. Statistical test is needed to evaluate the changes in ITS values of the control and moisture conditioned samples.

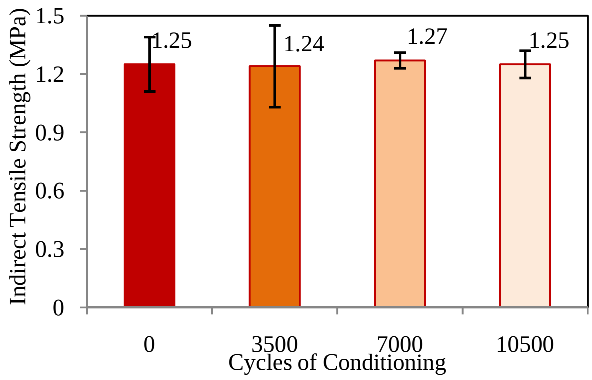

Fig. 7 Tensile strengths of virgin and moisture-conditioned samples

One Way Analysis of Variance (ANOVA) test is employed to evaluate ITSs of control and moisture-conditioned samples. The null hypothesis is that the average values are equal and the alternative hypothesis is that the average values are not equal. The *p*-value (probability of null hypothesis to be true) of the test is found to be 0.41. As the *p*-value is greater than 0.05 (5%), the null hypothesis is true. That is, ITS value of the control and moisture conditioned samples are statistically equal at 95% Confidence Interval (CI). Therefore, it can be said that MIST conditioning at 3500-10500 cycles at 40 psi pressure is not enough to cause moisture damage that can be captured by the indirect tensile strength test. A new test procedure needs to be developed or further investigation is needed.

V. Conclusion

This study investigates the effect of moisture conditioning on the ITS of laboratory prepared asphalt samples. Based on the finding of the study, it can be concluded that the ITS value of laboratory prepared AC sample does not change due to moisture conditioning by MIST device.

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