LONGITUDINAL JOINT DENSITY AND PERMEABILITY IN ASPHALT CONCRETE

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Problem Statement

Low longitudinal joint density has been identified as one of the major issues relating to poor asphalt pavement performance. Low longitudinal joint density can lead to premature raveling of the joint and the lower density results in increased permeability of the pavement. Increased permeability allows water to easily enter the pavement resulting in increased susceptibility to moisture induced damage or stripping.

Rather than specify a method of longitudinal joint construction, most owner agencies prefer to specify a final product and let the contractor determine the methods and/or equipment. However, due to the steep density gradient that exists at longitudinal joints it is recommended that DOTs spell out exactly where and how to test joint density.

Pavement cores have traditionally been used to evaluate pavement density or compaction. Nuclear and non nuclear gauges have been utilized as well but both require correlation to densities obtained from cores. The reported drawback to using gauges to measure longitudinal joint density is the inability of the gauge to seat firmly on the joint, making it impossible to get an accurate reading directly at the joint. Cores can directly measure joint density; however, density results are not immediately available and patching of the hole is required which can lead to water infiltration.

Field permeameters have recently been developed that can readily measure HMA permeability. If a correlation can be obtained between longitudinal joint density and field permeability then a simple direct method would be available to control longitudinal joint permeability and indirectly control longitudinal joint density.

Proposed Research

The Oklahoma Department of Transportation (ODOT) does not currently have a test method or specification that addresses the problem of low longitudinal joint density. The objective of this study was to obtain the necessary field and laboratory test data to provide information around which a test method and/or specification for control of longitudinal joint density could be written.

Scope

Three recently constructed pavements were selected for field testing. One pavement was on a county road and the other two pavements were ODOT construction projects. Two or three locations from each project were sampled and tested for a total of seven test sites. Field testing at each site consisted of measuring in-place permeability, measuring pavement density using an electromagnetic device (OHD L-14 Alternate Method B) and obtaining pavement cores at five locations at each test site. Field permeameters used included an NCAT permeameter, a Kentucky air induced permeameter (AIP) and a Romus air permeameter. Laboratory permeability (OHD L-44) was determined on the pavement cores.

The results from the pavement density testing, core density testing, field permeability testing and laboratory permeability testing were analyzed to determine relationships between field permeability, pavement density and laboratory permeability. The suitability of using field permeability at longitudinal joints for control of longitudinal joint density and permeability was evaluated.

Sampling and Testing

Field sampling and testing consisted of obtaining density measurements, field permeability measurements and obtaining pavement cores from five locations at each test site. Test locations were on the longitudinal joint (location C) adjacent and on both sides of the longitudinal joint (locations B & D) and 1-2 feet away from the longitudinal joint in both adjacent lanes (locations A & E).

Density measurements can be affected by water; therefore, they were performed first at each location. The density was obtained in accordance with OHD L-14, Alternate Method B as shown in figure 1.

Figure 1 Electromagnetic gauge.

Next, field permeability at each location was determined using the Romus air permeameter (fig.2), followed by the AIP (fig. 3) and the NCAT permeameter (fig 4).

Figure 2 Romus air permeameter.

Figure 3 Kentucky AIP.

Figure 4 NCAT permeameter.

After field permeameter testing was completed, a 6-inch diameter core was obtained directly over the spot where the previous testing was performed.

Cores were tested for bulk specific gravity in accordance with OHD L-14 Method A. If water absorption exceeded two percent by volume, the bulk specific gravity was determined in accordance with OHD L-45 (CoreLok™ procedure). Dry mass was determined in accordance with ASTM D 7227-06 (CoreDry™ apparatus). After bulk specific gravity testing, laboratory permeability of the surface mix of each core was determined in accordance with OHD L-44.

After permeability testing, cores A and E were tested for theoretical maximum specific gravity (Gmm) in accordance with AASHTO T 209. The Gmm from core A was used in subsequent voids calculations for locations A and B. The Gmm from core E was used in subsequent voids calculations for locations D and E. The average Gmm from location A and E was used for voids calculations for location C, the longitudinal joint.

Conclusions

1. The Romus air permeameter was the easiest of the three field permeameters to use; however, as delivered the permeameter would not seal to the pavement surface.
2. The AIP tends to seals itself to the pavement surface but requires an air compressor, either a gas powered air compressor or an electric air compressor and generator.
3. The NCAT permeameter is easy to use but requires care to obtain a proper seal.
4. The Romus air permeameter gave the highest permeability, followed by the NCAT permeameter, the AIP and OHD L-44. The statistical analysis indicated no statistically significant difference between the NCAT permeameter, AIP and OHD L-44. The equivalent water permeability for the Romas air permeameter was an order of magnitude larger than the other three permeameters evaluated.
5. There was a good relationship between in-place voids and permeability measured using OHD L-44, the NCAT permeameter and the Romus air permeameter.
6. There were good correlations between the NCAT permeameter and OHD L-44 and between the NCAT permeameter and the Romus air permeameter.
7. The AIP did not correlate with any of the other permeameters. The AIP does not measure permeability but was correlated to the NCAT permeameter for Kentucky mixtures. A good correlation was found between AIP vacuum pressure and NCAT permeability for Oklahoma mixtures.
8. Permeability starts to increase when in-place voids exceed 8 percent. A critical void content for field and laboratory permeability was found between 10 and 12 percent voids.
9. Joint permeability was more closely related to mix properties on the cold side of the joint rather than the hot side of the joint. The cut-off wheel might be the best method to avoid longitudinal joint permeability issues.
10. There was no good relationship found between difference in core voids (or compaction) from the mat and adjacent to the longitudinal joint and joint permeability.
11. For the cold side of the longitudinal joint, high joint permeability was

related to a difference in voids of greater than 2.5 percent.

12. A fair correlation was found between difference in mat density between the mat and adjacent to the longitudinal joint and change in NCAT permeability. A critical difference in mat density was found between 6 and 7 pcf.
13. There were no strong correlations found between the differences in mat density between the mat and adjacent to the longitudinal joint, and joint permeability.
14. For the cold side of the longitudinal joint, a difference in mat density between the mat and adjacent to the joint of greater than 6.5 and 4.5 pcf was related to high OHD L-44 and NCAT joint permeability, respectively.
15. For the hot side of the joint, a difference in mat density between the mat and adjacent to the joint of greater than 4.0 pcf was related to high OHD L-44 and NCAT joint permeability.

Recommendations

There are several ways a specification could be written to help control longitudinal joint density. There were good relationships found between in-place voids (compaction) and permeability and the difference in voids (compaction) and unit weight and permeability. To control permeability and longitudinal joint permeability the following recommendations for consideration as a specification are made.

1. In-place air voids or percent compaction of the mat should not be allowed to drop below 10 percent or 90 percent, respectively.
2. A difference in air voids or percent compaction between the mat and adjacent to the longitudinal joint on the cold side of the mat of greater than 2.5 percent was related to high longitudinal joint permeability.
3. A difference in unit weight between the mat and adjacent to the mat on either side of the longitudinal joint of greater than 4.5 pcf was related to high joint permeability.

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