



Quality control/quality assurance testing for longitudinal joint density and segregation of asphalt mixtures [☆]



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HIGHLIGHTS

- Evaluate available test methods for longitudinal joint quality control.
- Develop specifications to ensure the longitudinal joint with proper performance.
- Evaluate the effect of segregation on longitudinal joint density performance.

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ABSTRACT

Longitudinal joint quality control/assurance is essential to the successful performance of asphalt pavement and it has received considerable amount of attention in recent years. Five paving projects were selected for sampling and evaluation in Iowa. For each project, joint quality is compared with regard to the “center” of the pavement mat (6' right of joint). Field densities and permeability test were made. Cores were obtained for subsequent lab permeability, density and indirect tensile (IDT) strength testing. Asphalt content and gradations were also obtained to determine the joint segregation.

In general, this study found that methods providing the most reliable measurements of joint quality are the AASHTO T166, AASHTO T331 (CoreLok) density tests and the permeability test by Karol-Warner Permeameter. The minimum required joint density for quality control should be around 90.0% and 88.5% of theoretical maximum density based on the AASHTO T166 and AASHTO T331 method respectively. Based on various mix design and longitudinal joint construction methods, the joints show differences in asphalt content and level of segregation. Results of this study indicate that poor quality of longitudinal joint should be a combination of segregation, asphalt content variation and insufficient density.

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1. Introduction

Several methods were generally used to measure and quantify the quality of longitudinal joint construction. These include the field and in-lab permeability test, nuclear/non-nuclear density test and core density test. In recent years, a number of apparatuses have been developed to measure the permeability value of an HMA mixture and among which the NCAT field Permeameter and the Karol-Warner (K-W) in-lab Permeameter are the most popular

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ones. Previous studies in Arkansas, New England and Tennessee have had similar conclusions for the use of permeability test on the longitudinal joint [1–3]. They all found that the joints have significantly higher permeability compared to adjacent mats and the use of infrared joint heater can greatly reduce the longitudinal joint permeability. Utilizing the two permeability testing devices, permeability criteria are determined based upon the percent within limit (PWL) of pavement air voids by Missouri Department of Transportation (DOT). The upper specification criteria for using the NCAT Permeameter and K-W Permeameter are 1560×10^{-5} cm/s and 530×10^{-5} cm/s, respectively [4]. In another study conducted in the National Center for Asphalt Technology (NCAT), the critical permeability infers to the point at which a pavement becomes excessively permeable [5]. However, none of a research currently has proposed quality control criteria using Permeameters for longitudinal joint construction. In addition to permeability tests, density measurement is also a key indicator used to judge the quality of a HMA pavement. The most widely used core density

testing method is the AASHTO T-166 method. An extensive review was conducted on longitudinal joint construction and specification documents proposed by various transportation agencies and the density at the joint are all generally recommended to be no more than 2–3% lower than the density specified in the lanes away from the joint [6]. Recently, another method using the CoreLok device via AASHTO T-331 method has been employed by many researchers and transportation agencies. They found that the CoreLok system tends to result in lower densities than the AASHTO T-166 method especially for lower density samples as is typical of joint cores [1]. The development of nuclear and non-nuclear density gauges offers an alternative way to measure the pavement density non-destructively. Williams and Hall [7] evaluated the effects of gauge model, temperature, gauge orientation and the present of sand using the PaveTracker and PQI non-nuclear gauges. They found that gauge orientation, moisture, sand and debris can significantly affect the reading of the two types of gauges.

To construct a sound longitudinal joint, mitigation of segregation is important. As stated by AASHTO [8] the longitudinal joint area has a higher probability of being segregated. This commonly occurs from the augers not being run at sufficient speeds on the paver, allowing the coarse aggregates to roll to the outside of the mat. In addition, in order to avoid joint segregation during the paving process the auger and tunnel should be extended within 12–18 in. of the end gate so the material can be carried, and not pushed out to the joint. Several testing methods have been generally used to detect and measure the segregation of HMA. These include permeability test and nuclear/non-nuclear density test. Williams et al. [9] found that the nuclear moisture/density gauge is capable of accurately measuring both asphalt content and density in a dry pavement condition. They also pointed out that the permeability test is only successful in detecting coarse segregation but not fine segregation. This is mainly because the permeability test depends more on the interconnected nature of void volume rather than simply the percent of voids. Fine dense-graded mixtures would have sufficiently low permeability that, even when moderately segregated, there is little to no statistical difference in permeability measurements. Larsen and Henault [10] used density profiles obtained from a PaveTracker non-nuclear density gauge to quantify the level of segregation in Connecticut. However, they found that the spatial variation in density alone from the density gauge cannot distinguish the differences in segregated and low density area. Extracted asphalt content and gradations are also commonly used as a destructive way to determine segregation. As reported by Cross and Brown [11], the pavement segregation has strong correlation with the percent passing #4 sieve, while Williams et al. [9] used the sieve size that can separate the mix gradation into approximately equal portions to define the fine and coarse segregation. However, both of the study pointed out that segregation results in significant asphalt content variation which increases from very coarse to very fine [9,11].

2. Test plan and procedure

Five projects are selected for sampling and evaluation in this project study with each one represents a typical longitudinal joint construction technique as shown in Table 1. All five construction techniques are commonly used in Iowa. A summary of the five projects location, longitudinal joint construction type, lift thickness, surface mix type, and mix design are all listed out in Table 1. The route numbers for the five projects are designated as the project names in this study for simplicity. Brief discussions for each construction method are as follows:

The butt joint applies the first roller pass with the wheel on the hot lane and overlapped onto the cold lane by about a 150 mm

(6 in.), while the modified butt joint (hot pinch) applies the first roller pass with the wheel on the hot lane and about 150 mm (6 in.) away from the joint. The hot pinch has the potential to push HMA in the hot lane towards the joint during the initial roller pass. Milling and filling joint construction method include first milling a single lane, overlay that lane, and then mill the adjacent lane. Confinement can be formed during both the paving process of the cold and hot lanes by the milling and filling method. Temperature is always considered as the key in pavement construction. It is generally believed that higher compaction temperature can help increase compaction of the mix at the joint and improve the bond between the cold lane and hot lane. Higher temperature can also increase the flow ability of the mix and reduce segregation. The infrared joint heater by reheating the joint to around 230 °F before compaction is reported to be very effective [3,12] and more detailed temperature and thermal conductivity analysis for infrared joint heater can be found in the literature [12]. With the same idea, longitudinal joint paved in WMA is believed to have a tight and better compaction than HMA [13].

The test plan contains two parts: field testing and laboratory testing. Field testing and sampling consisted of obtaining pavement density by the PaveTracker non-nuclear gauge, field permeability measurements using the NCAT Permeameter and extracting pavement cores from six random locations for each project. In each random selected test location, field tests were done on both the pavement longitudinal joint and the mid-section of the hot lane (about 6' right of longitudinal joint). Therefore, this results in testing a total number of 12 field locations and corresponding 12 core extractions from each project. Field density measurements using PaveTracker non-nuclear gauge can be greatly affected by water; therefore, they were performed firstly at each location. Once the PaveTracker density measurements were completed, NCAT permeability tests were made at the same location. After the pavement surface course is totally cooling down, core samples were taken at the same places where the field tests were performed. The core samples are from 4 to 6 in. in diameter and the thickness equals to the lift thickness of the surface course. Finally, these cores were transported to the Bituminous Materials Laboratory at the Iowa State University for further testing.

The following tests were performed on each field core samples in the laboratory: (1) voids analysis, (2) in-lab permeability, (3) indirect tensile strength and (4) determination of asphalt content and gradation. The void analysis includes the bulk specific gravity tests in accordance with AASHTO-T166 and the AASHTO T-331 method by the CoreLok® system. Karol-Warner (K-W) Permeameter was used for the in-lab permeability test based on the ASTM PS129 method. Upon completion of the laboratory density tests, core samples were tested for IDT strength following the AASHTO T-322 procedure. The joint core samples are loaded along the direction of the longitudinal joint so that failure could occur along the joint and the IDT strength at the joint can be obtained. Finally, the broken core samples were used to determine the asphalt content and gradation by the ignition method according to the AASHTO T-308 and AASHTO T-30 procedures respectively. Calibration factors were used in the ignition method from the cold-feed gradations to provide acceptable results.

3. Test results and analysis

For each test method, the test results were firstly compared to see whether they are capable of detecting the density, permeability and tensile strength differences on longitudinal joint and 6' right of the pavement joint (on pavement mat). Graphical comparisons for all projects are shown in Figs. 1–3.

On the basis of the results comparison, the following conclusions are drawn:

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