Field Permeability Readings on MN I-35: Bituminous Construction Using Echelon Paving Method

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On August 4, 2017, MnDOT Materials and Road Research obtained field permeability and companion nuclear density meter readings on newly placed bituminous pavement located on the southbound lanes of MN I-35 between Willow River and Sturgeon Lake, Minnesota (SP 5880-180).

Equipment and Data:

"Seaman C-300 Density Meter." The method was to perform four contact density tests in the backscatter mode per test point, with the meter rotated 90 degrees after each test. Results were reported to the nearest 0.1 pound per cubic foot.

"NCAT Field Permeameter." The method was to record change in hydraulic head and time of reading. Permeameter gradation lines were marked to the nearest 0.5 cm, and time was reported to the nearest second.

- Project construction plans showed one 2-in. lift of 12.5mm nonwear followed by two 2-in. lifts of 9.5mm wear course material. SPWEA440C was specified.
- Falling-head measurements were used to calculate the coefficient of permeability (k) according to:

$$k\left(\frac{\text{cm}}{\text{s}}\right) = \frac{Area_{Top} \times Lift\ Thickness}{Area_{Base} \times \Delta_{Time}} \times \ln\left(\frac{Initial\ Head}{Final\ Head}\right)$$

- Air voids were back-calculated using the relationship for 9.5 mm gradations developed by Mallick et al: Permeability (k) = $0.3161e^{0.6306(\text{Air Voids})}$ $R2 = 0.8589$

Observations:

- Paving train consisted of:
  - Tack distributor truck
  - Haul trucks dumping material in windrows
  - Two asphalt paving machines each equipped with pickup machine. Paving machines operated in the northbound direction of the southbound lanes. The

machines were staggered so that the inside lane was paved first and the outside lane was paved seconds later.
    - Two pneumatic tire rollers (one per lane) immediately behind pavers
    - Two steel vibratory rollers (one per lane) immediately behind pneumatic
    - Finish rolling was not observed (possibly operating farther from the paving machines)
- Test points at mile 202.6 were on the final lift of wear course. At this location the cross section consisted of two southbound lanes. The echelon centerline joint at this point had an open, segregated appearance that was unlike the majority of the project. It is hereafter referred to in this report as the “poor” echelon joint.
- Test points at mile 209.5 were on the initial lift of wear course mix. At this location the cross section consisted of two southbound lanes and an acceleration lane. The echelon centerline joint at this point appeared sound, and was nearly indistinguishable from the rest of the bituminous mat. The acceleration lane joint appeared free of defects, but was presumably not paved using the echelon technique.

Results:

It should be noted that the air voids discussed in the following analysis are theoretical, back calculated air voids, and are not derived from volumetric testing of cores.

Figure 1 is a plot of averaged nuclear density readings (four per location). Note:

- The “poor” echelon-pave center joint at mile 202.6 presented the lowest density (135.9 pcf). Next highest was the non-echelon acceleration lane joint at 141.5 pcf.
- The Midlane density values averaged 147.1 pcf, and the average density for the good quality echelon center joint at mile 209.5 was 147.3 pcf.

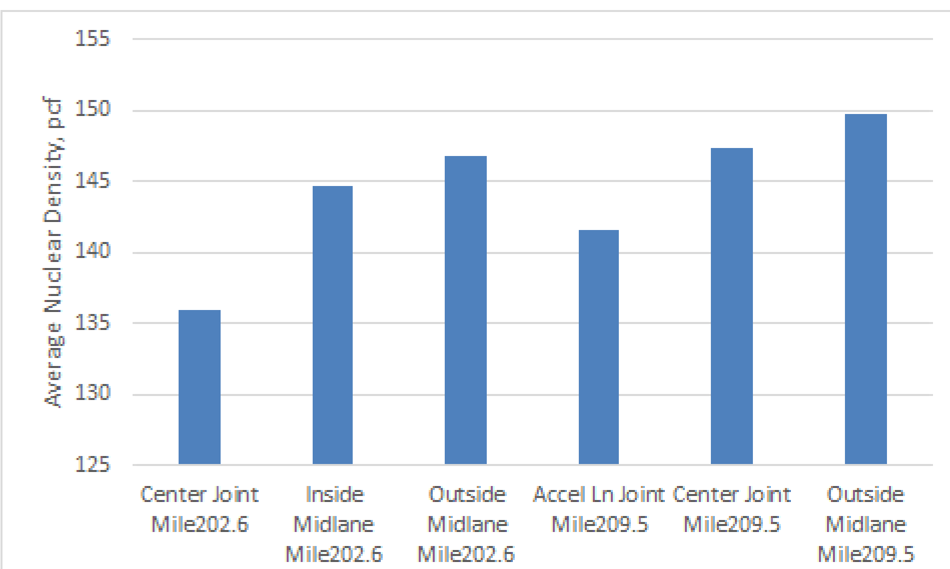

Figure 1 - Density meter results by I-35 test location.

Figure 2 is a plot of average permeability and density of the MN I-35 data. It shows the expected trend of greater permeability with lower density.

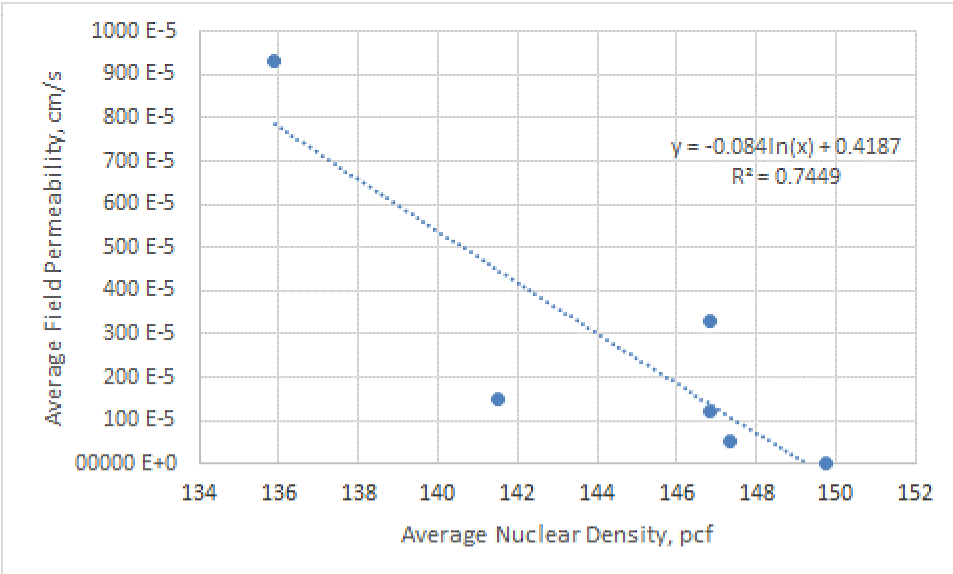

Figure 2 - Permeability versus Density, I-35 data.

Figure 3 shows the permeability data acquired from MN I-35. The data is arranged by theoretical air void levels calculated according to the relationship developed by Mallick. Note how permeability escalates near 10% air voids.

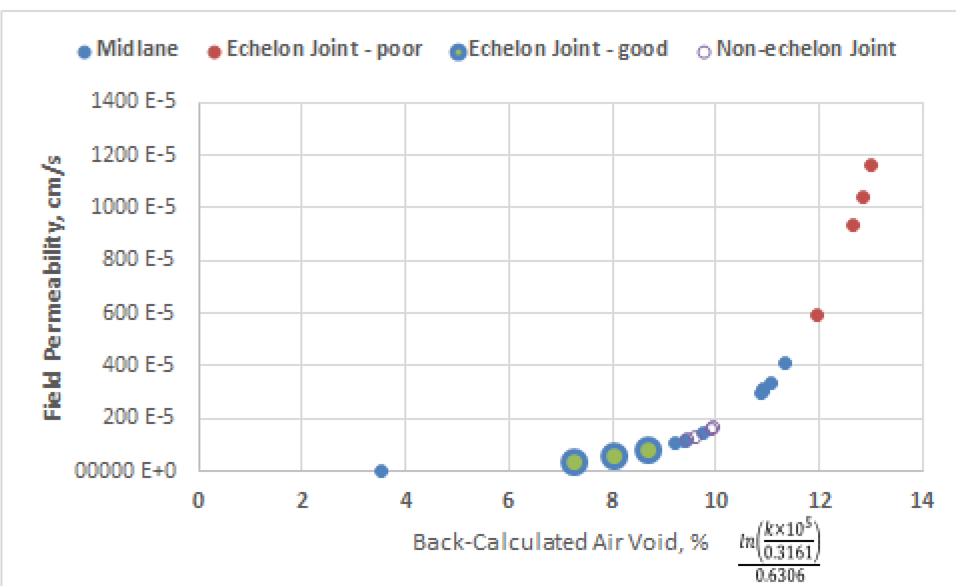

Figure 3 - Measured Permeability vs. Calculated Voids, I-35 data.

Figure 4 – Photograph of "Poor" Echelon Joint.