New Longitudinal Joint Gets Results in Pennsylvania

Incentive/disincentive plan improves on previous practices

By Garth Bridenbaugh, P.E.; Gary Hoffman, P.E.; Jennifer Albert, Ph.D., P.E.; and Frank Colella

Joints — whether in the human body or in pavements — are vulnerable areas. An athlete with well-toned muscles can be sidelined by a mishap to the knee, and a pavement mat with years of service life remaining can be compromised by deterioration at the longitudinal joint. For pavements, achieving optimal field density at the joint is vital to long-term pavement performance, as high density is key to reducing permeability and enhancing pavement durability.

The Pennsylvania Department of Transportation (PennDOT) has achieved significant success in improving asphalt longitudinal joints using a recipe that includes incentives/disincentives and a new "percent within limits" (PWL) specification. The tapered or wedge joint has been found to provide density benefits, and there is evidence that using warm-mix asphalt (WMA) makes joints easier to compact.

PennDOT's new specification was developed in a collaborative effort between PennDOT, the Federal Highway Administration (FHWA), and the Pennsylvania Asphalt Pavement Association (PAPA).

Beginning in July 2010, PennDOT included a new longitudinal joint density specification as a special provision in a number of contracts with a goal of improving joint density and thereby enhancing joint performance.

While good mix design plays a key role in producing durable pavements, achieving optimal field density is vital to long-term pavement performance along the joint.

Pennsylvania Experience

Until recently, PennDOT had no measure of the actual densities achieved when constructing the joint. In 2006 and 2007, PennDOT and PAPA worked together to evaluate joint construction methods and began to gather data on joint density. Best practices for joint construction were developed after evaluating Michigan and Maryland practices and were distributed statewide.

Training on these was conducted at many venues across Pennsylvania.

Beginning in 2007, a joint-density baseline was established to track the progress and improvements that resulted from using these best practices and from paying closer attention to joint construction. This represented the first real data that were collected on Pennsylvania's joint densities, and this effort to obtain information continued in 2008 and 2009. The training on best practices and increased scrutiny on joint construction prior to the 2008 construction season paid off with a 1.1 percent increase in average joint density in one year (Fig. 1). However, the data showed that many projects still were not achieving optimal joint density.

For 2010, PennDOT, working with FHWA and PAPA, took a new approach toward joint construction. Instead of dictating prescriptive best practices means and methods to the contractor, the department provided a performance specification on higher volume roadways with an incentive or disincentive for the joint density.

The HMA Longitudinal Joint Density Incentive/Disincentive Specification was issued June 3, 2010. In essence, the specification allows contractors to choose their own methods to achieve performance to earn an incentive for delivering high density at the joint. Conversely, a disincentive is assessed for achieving low joint density.

Density Specification

Cutting a Density Core on a Vertical Centerline Joint

The performance specification is based on a statistical approach of calculating percent within limits (PWL) based on the average and standard deviation of the individual core specimen density test results. The lower specification limit has been set at 89 percent of maximum theoretical density, and lots with averages below 89 percent received a disincentive. As density values move further below the 89 percent limit, the disincentive grows progressively larger to a maximum of $12,000 per lot. Additionally, lots with average density lower than 88.0 percent will require a placement of a ribbon of PG binder grade asphalt cement over the joint as a remediation effort.

For densities that calculate above 89 PWL, the contractor will begin to receive an incentive payment which progressively increases as density increases, to a maximum of $5,000 per lot. The lower specification limit was set at 89 percent of maximum theoretical with the understanding that consideration would be given to raising this limit to 90 percent after a period of successful implementation.

Contractors are required to cut one core at the newly constructed longitudinal joint for every 2,500 linear feet of joint. The specification only applies to surface courses and newly constructed joints where mats on *both* sides of the joint were placed as part of the contract.

Determining Effectiveness

In order to determine the effectiveness of this new specification, PennDOT project density acceptance data was collected and a survey questionnaire was implemented by PAPA. Penn State University performed statistical evaluations on the collected data.

Forty projects were constructed by 19 different contractors during the 2011 season with the new specification and were included in the evaluation. There were a total of 137 lots among these projects, which included 676 pavement cores.

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These 137 lots represented about 320 linear miles of joints.

There was a remarkable improvement in average joint density on projects constructed with the new joint density performance specification compared to those previously constructed with the methods specification (Fig. 1). Average joint density was 91.1 percent of maximum theoretical with the performance PWL specification in 2011 compared to about 89 percent in 2008 and 2009 with the "best practices" method specification. Average roadway mat density remained consistent at around 94 percent throughout the four-year study period.

The potential for a financial incentive or disincentive drove the improved performance. Contractors received a total of $260,625 in bonuses against $99,216 in total penalties. Seventy-one percent (97 lots) received bonuses while 18 percent (25 lots) and 11 percent (15 lots) were neutral or in penalty, respectively. Only five of the 19 contractors had penalty lots.

Longitudinal Joint Data Summary			
Year	Density Lots	Average Joint Density	Average Roadway Density
2007	18	87.8%	93.9%
2008	43	88.9%	94.1%
2009	29	89.2%	94.1%
2010	No Data: Transition to PWL Specification		
2011	137	91.1%	94.1%

Fig. 1: Longitudinal Joint Density Data Summary

The data set was analyzed to consider the impact that the following variables had on average joint densities:

- type of joint (wedge or vertical),
- month of construction,
- size/type mix,
- hot mix vs. warm mix,
- PG binder type,
- amount of RAP in mix, and
- asphalt content.

One of the most evident factors that influenced the average joint density outcome was the type of joint construction. The notched wedge

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(tapered) joint averaged almost 1.5 percent higher density than the vertical (butt) joint (Figures 2 & 3). In fact, 13 of the 15 penalty lots were constructed with vertical joints.

Upon visual inspection of these out-of-tolerance cores, it was noticed that there was a void at the bottom of the paving layer on the hot side of the joint. It was speculated that this void was the result of insufficient supply of material from the paver along the joint or an inadequate rolling sequence that did not push material toward the longitudinal joint. Most contractors used vibratory compactor paver attachments to compact the tapered wedge while it was still hot to meet the new specification.

Another significant factor in lower density at the joints was the time of the year when paving was done. The preponderance of

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Breakdown by Lot Joint Style			
Lot Joint Type	Density Lots	Average Joint Density	Average Roadway Density
Notched Wedge	73	91.7%	94.1%
Vertical	55	90.3%	94.2%
Mix of Both/Other	9	90.6%	94.1%

Fig. 2: Average Joint Density by Joint Type

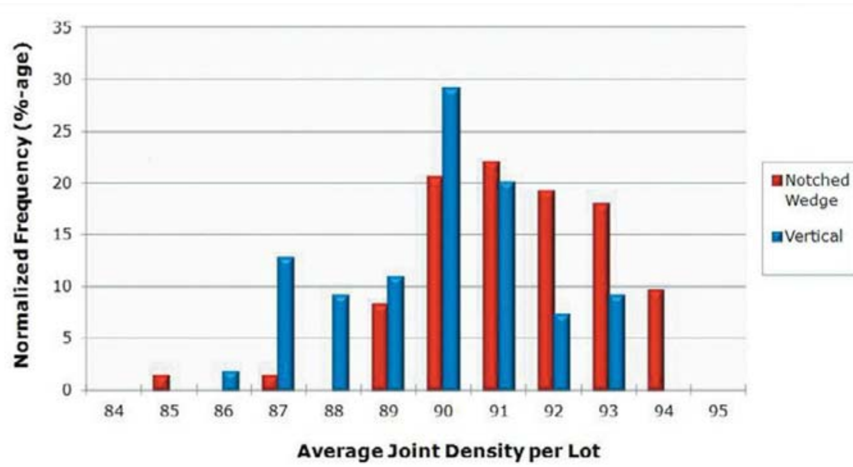

Fig. 3: Frequency Distributions of Average Joint Density per Lot by Type

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Vibratory compactor passes over an 18-inch-wide section of uncompacted material along the joint. Note that the roller pass laps over the cold mat.

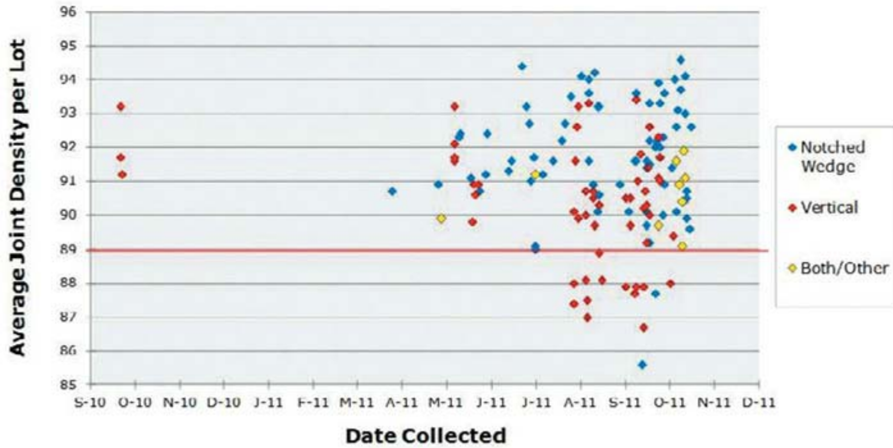

Fig. 4: Average Joint Density per Lot by Month Constructed

the out-of-tolerance core densities occurred in late August, September or October (Fig. 4).

Mix Types

The 40 projects included three size/type mixes with both hot-mix and warm-mix construction. Most of the wearing courses were 9.5-mm mixes, but there were also some 12.5-mm and stone-matrix asphalt (SMA) mixes. Fig. 5 indicates that the finer 9.5-mm mixes had lower total average densities than those of the coarser 12.5-mm and SMA mixes. This is contrary to what was expected, and it is believed that the negative influence of the penalized butt joint lots lowered the total average of the 9.5-mm wearing courses.

A comparison of average joint density between HMA and WMA mixes of the same size (Fig. 6) indicated that there was virtually no difference in the density. Anecdotal comments from contractors tended toward a greater ease in achieving compaction with the use of warm-mix technologies.

The bulk of the mixes on these 40 projects used PG 64-22 and PG 76-22 grades of liquid asphalts. Softer PG 58-22 binder was used in only seven of the 137 lots. Average joint and mat densities were relatively similar for the three different binder grades.

Breakdown by Lot Mix Size			
Lot Mix Size	Density Lots	Average Joint Density	Average Roadway Density
9.5 mm	93	90.7%	93.8%
12.5 mm	19	91.8%	94.1%
SMA	23	91.9%	94.9%

Fig. 5: Average Joint Density for Lots by Size and Type of Mix

Breakdown by Lot Mix Size and Type			
Mix Size and Type	# of Lots	Avg. Density per Lot	Standard Deviation
9.5 mm HMA	45	90.62%	1.68%
9.5 mm WMA	48	90.84%	1.67%
9.5 mm SMA	25	91.90%	1.22%
12.5 mm HMA	15	91.86%	1.49%
12.5 mm WMA	4	91.68%	1.69%
∑ = 137			

Fig. 6: Average Joint Density for HMA vs. WMA Mixes

Lastly, a comparison of average joint densities per lot was done for mixes with various percentages by weight of total mix of reclaimed asphalt pavement (RAP). Fig. 7 shows that the average and spread of lot densities at the 15 percent RAP level was very similar to that of 100 percent virgin material mixes. Mixes at the 25 percent RAP level appear to have a somewhat lower average, but there are too few data points at this level to draw conclusions.

Bottom Line

Contractor responses to the survey questionnaire provided some important comments. Sixteen of the 19 contractors purchased special equipment to densify the tapered or wedge joint. Numerous contractors added personnel to the paving crew

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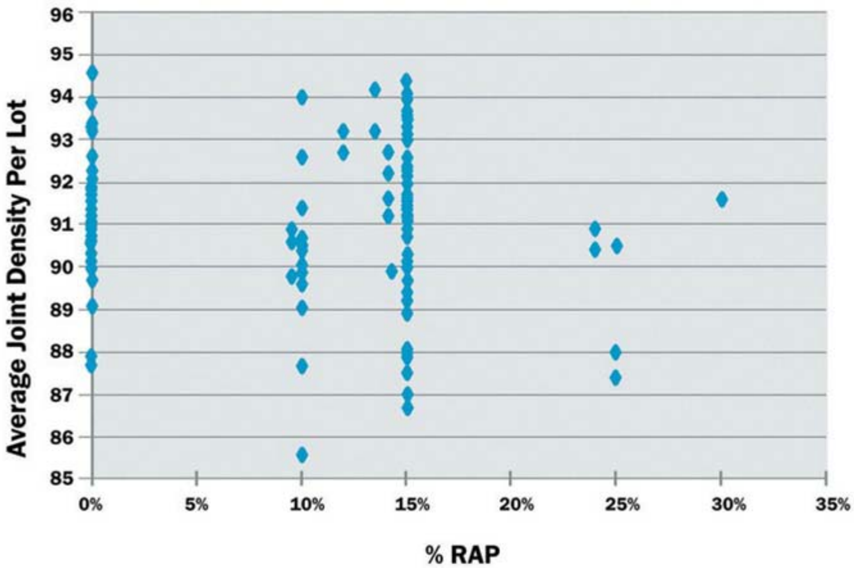

Fig. 7: Average Joint Density per Lot by Percent of RAP in the Mix

to meet the new specification. Many of the contractors indicated that the mix with the warm-mix technology was easier to compact.

Also in the survey, concern was expressed for the safety of workers along the centerline joint with traffic in the adjacent lane. Adjustments in traffic control plans have been suggested and implemented.

The bottom line is that contractors wanted to maintain the incentive/disincentive pay adjustments in the specification, although they recommended that incentive and disincentive should be equal. There was a general belief that the new specification and the resultant improved joint density would provide longer pavement performance.

Based on the successful implementation of this specification, PennDOT proposes to increase the lower PWL density limit from 89 percent to 90 percent as a quality improvement initiative for the 2013 construction season. The industry will respond accordingly to provide longer-lived asphalt pavements in Pennsylvania. AP

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A vibratory plate attachment compacts the taper in a notched-wedge joint.