FHWA AND AI PARTNER TO IDENTIFY BEST PRACTICES FOR LONGITUDINAL JOINTS

By Mark Buncher, Ph.D., P.E.

A long-standing challenge in keeping an asphalt pavement from reaching its potential life is its longitudinal joints. Debate, research, opinion and innovation have all had their place in getting us to where we are today.

A longitudinal joint is the interface between two adjacent and parallel asphalt mats. Premature joint failures are the result of a combination of low density, permeability, segregation and lack of adhesion at the interface.

Over the last 25 years, there have been numerous university, state department of transportation, and industry research efforts. The results show the performance of longitudinal joints is mixed. We continue to see joint deterioration as one of the highest listed reasons for premature failure of an asphalt pavement. In 2009, the Federal Highway Administration (FHWA) surveyed their Divisional Offices and found that about 50 percent reported dissatisfaction with the performance of their longitudinal joints. Improving this component of our flexible pavement systems is probably the single most important thing we can do to improve performance.

PARTNERING EFFORT

With the overall goal being to improve joint performance, the FHWA and the Asphalt Institute (AI) recently completed an effort to review past studies and research on longitudinal joints and to examine current state-of-the-practice for both specifying and constructing joints. The purpose was not to do additional research, but rather evaluate what had already been done and search for consensus on best practices in order to develop recommendations. Steps included:

- Analyze FHWA survey to their state Division Offices on specs, methods and performance.
- Review existing literature and research.
- Identify areas where there is consensus and areas where there is not.
- Conduct focused interviews with 19 recognized paving experts and contractors.
- Visit the state DOTs and their contractors that have implemented a longitudinal joint spec.

The project has been completed and a draft report has been widely circulated among industry groups for comment. The final report, titled Best Practices for Constructing and Specifying Longitudinal Joints, will be available soon through the AI or FHWA. In addition, a half-day workshop has been developed to share the findings with personnel involved in constructing and specifying asphalt pavement. These workshops are available free of charge to state agencies by contacting the FHWA Resource Center through their FHWA Division Office Pavement Engineer. A number of other marketing and communication materials are also planned in the upcoming year.

FINDING AND RECOMMENDATIONS

This project revealed there is a wide disparity among states with respect to their joint construction and specification requirements, and in many cases there are significant opportunities for improvement. The recommendations from this project cover many facets, from construction best practices to agency considerations. Improving joint performance needs to be a team effort between the agency and contractors.

CONSTRUCTION BEST PRACTICES

The following list summarizes the necessary field paving and compaction procedures to best construct a traditional (cold) longitudinal joint to optimize long-term performance. While these best practices are desired, they are not always followed, even though they generally do not require an extensive amount of additional expense or elaborate equipment.

- Follow best practices to avoid mix segregation
- Use a string-line guide for paver operator to make straight pass on first pull.
- Apply tack coat uniformly to full width of paving lane.
- Ensure vibrator screed is turned on all the time.
- Extend augers and tunnels to within 12 to 18 inches of the end gate to ensure a continual supply of fresh material is carried (not pushed) to the joint.
- Set end gate properly to firmly seat on existing pavement surface.
- Coordinate paver and auger speed to allow for a uniform head of material across the entire width of the paver. Maintain paver and auger speed.
- Use paver automation. A critical element to getting joint density is having sufficient depth of material at the longitudinal joint. A joint matcher, set immediately adjacent to the end gate, provides the best opportunity to get that sufficient depth. The use of a ski, versus the joint matcher, will normally result in a smoother pavement, but not necessarily the optimum depth of mix for the best joint. Multiple lifts offer opportunity to use ski on intermediate lifts for smoothness and a joint matcher on surface lift for good joint.
- Compact unsupported edge of mat with the first pass of vibratory roller drum extended out over the edge of the mat approximately 6 inches. An alternative method is to make the first pass of vibratory roller back 6 inches from the unsupported edge, and then extend the drum out over the unsupported edge on the second pass. With this method, watch for stress cracks that may develop parallel to the joint. This alternate method should only be used if the paving crew has experience with the specific mix and has not had a problem.
- Monitor relative density of unsupported joint using a density gauge.
- Tack the existing face of the joint with the same material (emulsion or asphalt cement) being used to tack the mat. If using an emulsion, double tack the joint face. Alternatively, consider using a proprietary joint adhesive as research indicates it improves joint performance.

- Overlap the existing lane (of a butt joint constructed with the paver, or a notched wedge joint) 1 inch +/- 0.5 inch. When the butt joint is constructed by milling or cutting back the existing lane, the overlap should be approximately ½ inch.
- Avoid luting (pushing back) the overlapped material, assuming the proper overlap was placed (see previous bullet). If the overlap exceeds 1.5 inches, carefully remove the excess with a flat-end shovel.
- Compact the supported edge of joint with the first pass of vibratory roller drum on the hot mat, but staying back from the joint 6 to 8 inches on first pass. The second pass should then overlap onto the cold mat 4 to 6 inches. With this method, watch for any stress cracks developing in the mat that are parallel and 6 to 8 inches off the joint. An alternative method is to have the first pass of the vibratory roller on the hot mat overlapping 4 to 6 inches onto the cold mat. A major concern with this method is that if an insufficient depth of HMA is placed next to the cold mat, the roller will bridge over and not compact the hot material completely.
- Encourage the use of rubber tire rollers at the confined joint. Rubber-tired rollers should not be operated close to the unsupported edge to avoid excessive lateral movement.
- Ensure when the joint is completed, that the overlap is 0.1 inch higher to ensure no bridging of the roller ever occurred.
- Monitor the relative density of the supported joint using a density gauge.
- Cut a 6-inch quality control core(s) and measure density prior to next paving day.

AGENCY CONSIDERATIONS

Agencies should consider the following in terms of mix selection, project design/planning, and alternative techniques/materials to be evaluated. More details are in the report.

- Use the smallest Nominal Maximum Aggregate Size (NMAS) mix that is appropriate for the application (will not rut). Smaller size mixes are less permeable at a given in-place air void level.
- Use a gradation that favors the fine side of the .45 power curve, as finer mixes are generally easier to compact.
- Use a lift thickness that is at least 4 times the Nominal Maximum Aggregate Size for coarse gradations and 3 times the NMAS for fine gradations. Adequate lift thickness will facilitate compaction and maximize density.
- Consider using warm mix asphalt as a compaction aid, especially in late season paving.
- Consider use of the notch wedge joint (versus butt) for lift thicknesses equal to or between 1 and 3 inches. Several agencies have found the notch wedge joint tends to provide higher densities than the butt joint.
- Pay for tack as a separate bid item (as opposed to being an incidental requirement) to facilitate using the proper application rate.
- Include longitudinal joint construction as a topic for the pre-paving meeting. Plan construction sequence so that any overlap of material at the joint does not impede the flow of water.
- Offset the longitudinal joints horizontally between layers by at least 6 inches, when placing multiple lifts.
- Consider the use of infrared joint heaters, especially in cold weather paving. Recent studies have shown a marked improvement with joint density. Equipment improvements include longer and more efficient infrared heaters and automation with paver speed to minimize overheating or under-heating.
- Evaluate traffic control requirements to see if echelon paving could be utilized in any facet of project to minimize the number of traditional cold joints.
- For mill and fill jobs, evaluate traffic control requirements to require the contractor to mill and fill one lane at a time, eliminating unconfined edges.
- Assess project, traffic control and safety requirements for the practicality of evaluating the method of cutting back the joint. This method is routine on airfield projects in the U.S., and is done on roadways in the United Kingdom, with much success.
- Evaluate the use of joint adhesives (JAs), which are hot applied rubberized asphalt, to seal the face of all open unconfined joints. While not commonplace yet, use of this material appears to improve the adhesion and sealing of the joint.
- Evaluate the use of surface sealers after the joint has been constructed. Another "joint enrichment" approach is to overband the completed joint with PG binder at a width of 4 inches. >>>

SPECIFICATIONS

Research has shown there is a definite relationship between density, permeability, and pavement performance. Improper compaction, and the resulting high air void content, leads to premature pavement failure due to increased permeability and an increased rate of oxidation. Numerous studies have shown that permeability for most surface courses starts when in-place air voids reach 7 - 8%.

Current construction practices have a difficult; some say impossible, time achieving this desired air void content at the longitudinal joint. While in-place air voids for the mat typically range between 4 and 8 percent, longitudinal joint air voids tend to range between 10 – 12%. The inability to compact the longitudinal joint to 8 percent or less voids provides the explanation for why there is a significant difference in the performance of the mat versus the longitudinal joint. The saying goes, "a chain is only as strong as the weakest link." Paraphrasing that, "the performance period (and ultimately the life-cycle) of an asphalt pavement is controlled by the longitudinal joint."

States that have implemented joint density specifications have seen marked improvements. Connecticut and Pennsylvania are two recent examples of states that researched the issue, made incremental improvements in their methods and specifications over a number of years, and reported average joint densities in 2011 slightly above 91 percent theoretical maximum density (TMD) (slightly below 9 percent voids). Pennsylvania went from averaging 87.8 percent density (by cores taken directly over the joint) in 2007 to averaging 91.1 percent density in 2011 (cores over joint). Incremental steps were taken to reach such a marked improvement, from incorporating a prescriptive method spec in 2008-2009 to implementing joint density testing with an incentive/disincentive approach in 2011. Of the 131 lots sampled by PA DOT in 2011, 94 lots were paid a bonus.

Colorado implemented a minimum density joint specification in 2003, and reported average joint densities in the 90 percent range over the next five years. While this was a marked improvement, it still does not reach the necessary 8 percent or less air void level to avoid premature oxidation and permeability. That is why overbanding the joint at a width of 4-inches (or possibly some other type of joint enrichment) is recommended when the joint density falls below 92 percent. Alaska and Pennsylvania are examples of states where the practice of overbanding longitudinal joints is used. Tennessee uses joint surface sealers on joints that do not meet a minimum density.

CONCLUSION

Longitudinal joint performance is a high priority for the FHWA and many state highway agencies. Contractors, equipment manufacturers and material suppliers continue to explore new methods and materials. Ultimately, the goal is to approach the same level of compaction in the joint as in the mat. The recommendations from this effort and the subsequent training efforts will hopefully be an important step in that journey.

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The West Virginia Division of Highways (WVDOH) hosted the first offering of the "Best Practices for Constructing and Specifying Longitudinal Joints" last month in Flatwoods, WV.

The workshop brought together division employees and industry professionals to present the latest, most applicable information for both specifying and constructing longitudinal joints in asphalt pavement.

Improving the performance of the longitudinal joints in asphalt pavements is one of the top priorities for the West Virginia Division of Highways.

Feedback from both the WVDOH and industry was positive. WVDOH attendees commented that the workshop gave them an increased understanding of the things that impact performance. Industry attendees commented that the workshop had presented construction techniques that they now wished to try in order to increase density and improve performance at the joint.

The full report from the FHWA and AI is slated for release in February 2012.