



Alternative Joint Construction Techniques



Longitudinal Joint Construction

Short-term Research

NRRRA Flexible Team

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LONGITUDINAL JOINT CONSTRUCTION

NRRRA State of Practice

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Summary Statement: AASHTO and the FHWA identify the most significant factor affecting the long-term durability of a longitudinal joint as the density achieved along that joint. Equally, the most difficult condition to achieve high density in HMA paving is also along a longitudinal joint in an asphalt pavement. Consequently deterioration of longitudinal joints in HMA is one of the major distresses facing agencies. This paper is a synthesis of specifications along with alternative joint construction techniques being employed by participating NRRRA states that include California, Illinois, Michigan, Minnesota, Missouri, and Wisconsin.



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1 Background

1.1 What is a longitudinal Joint?

A longitudinal joint is constructed when one lane of HMA is paved then the adjacent lane is paved next to this now cold joint. The joint formed can be along a free edge identified as unconfined or defined as confined when placed along a rigid edge such as another lane of pavement or concrete. Density at the longitudinal joint will generally not be as high as mat density even when proper construction techniques are utilized. AASHTO and other organizations identify the most significant factor affecting the long-term durability of a longitudinal joint as the density achieved along that joint. As HMA density decreases the prevalence and interconnectivity of air voids increases along with susceptibility to accelerated deterioration from moisture intrusion and freeze thaw conditions and over time these joints can ravel.

When compacting along unconfined edges the HMA material can deform laterally rather than compact. When allowed or directed, it is common to limit the drum from extending out beyond the edge of unconfined the mat, 6 inches maximum, when compacting along unconfined joints thereby allowing even compaction across the mat and maintaining roller support to avoid rolling over the edge and distorting the mat laterally; most important on the first roller pass. Tapered joint construction is considered in some states and these tapered joints are required to be compacted. Along confined joints it is suggested that good longitudinal joint construction requires a slight overlapping of the HMA which is much more observable when employing a tapered edge strategy. If the HMA along the confined edge is overlapped properly and compacted, adequate joint density can be achieved.

Agencies typically require tack coat, or other adhesive, mastic, or sealant material, be applied along the face of a longitudinal joint prior to paving the adjacent pass. The intent is to enhance bond between the surfaces and improve moisture durability. It has been shown that good relative density along joints increases durability and there is no evidence that the application of tack coat or mastic is a replacement for good density relative to joint durability.



Figure 1.1-1 – Longitudinal joint with adhesive mastic at Minnesota TH 100 during 2015 construction.



Figure 1.1-2 – Completed longitudinal joint with adhesive at Minnesota TH 100 during 2015 construction.

1.2 Why NRRRA Members Wanted This Study

1.2.1 NRRRA Members Involved

The six state agencies that are currently involved in the longitudinal joint construction technology transfer are; California DOT, Illinois DOT, Michigan DOT, Minnesota DOT, Missouri DOT, and Wisconsin DOT.

1.2.2 Why This Effort is Being Done

The purpose of this paper is to compile a synthesis of best practices and specifications being used by participating NRRRA members for HMA pavement longitudinal joint construction and identify inconsistencies or contradictions in understanding or approach that can be evaluated during the next round of investigation at MnROAD.

2 NRRRA State Member Specifications

2.1 Specifications by State

The following Table 2.1-1 provides the specification numbers by member States which govern HMA longitudinal joint construction.

Agency	California DOT	Illinois DOT	Michigan DOT	Minnesota DOT	Missouri DOT	Wisconsin DOT
Spec	39-2.01C(4)	406	501	2360.3	403	450.3.2.8

Table 2.1-1 – Longitudinal Joint Specification by State

Links to each specification and special provision

- [California – 2015 Standard Specifications](#)
- [Illinois – 2016 Standard Specifications for Road and Bridge Construction](#)
 - [Hot Mix Asphalt – Density Testing of Longitudinal Joints](#)
 - [Hot-Mix Asphalt – Longitudinal Joint Sealant \(BDE\)](#)
 - Hot Mix Asphalt – Pay for Performance
 - Hot Mix Asphalt – Quality Control for Performance
 - QCP Pay Calculation
- PFP and QCP Random Density Procedure [Michigan – 2012 Standard Specifications for Construction](#)
 - [Acceptance of Longitudinal Joint Density in Hot Mix Asphalt Pavements](#)
- [Minnesota – 2018 Standard Specifications for Construction](#)
 - [Special Provisions 2016](#)
- [Missouri – 2017 Standard Specifications for Highway Construction](#)



- [Wisconsin – 2018 Standard Specifications for Highway and Structure Construction](#)

2.2 Comparison of Design Specifications between Agencies

2.2.1 General

Participating states generally have specific specifications that address longitudinal joint construction requiring joints to be constructed in a manner that produces neat and tightly bonded seams that meet density and surface smoothness tolerances. Typical requirements are for joints to be constructed parallel to the roadway centerline and ideally located at the centerline for two-lane construction with additional joints placed at lane lines for multi lane roadway facilities. In multiple lift construction agencies generally require offsetting joints vertically between lift placements unless some type of a notched wedge joint is constructed.

There are two common joint conditions when paving HMA, confined and unconfined. A confined joint occurs when a longitudinal joint is constructed abutting up to existing HMA or PCC pavement or curb and gutter. An unconfined joint occurs when a longitudinal joint is constructed along a free edge. The conditions impact joint construction technique and a contractor's strategy to attain density.

California DOT (39-2.01C(4))

Longitudinal joints of the top lift are required to match the lane lines. In multiple-lift construction joint locations are offset at least 0.5 Ft. in lower layers. Other longitudinal joint placement patterns are allowed if authorized.

When HMA lifts thicknesses are greater than 1.8 inches in depth a 1-foot wide tapered notch wedge is required. For this construction, vertical notches are constructed to a maximum depth of 0.75 inches at the top and bottom of the paving lift with a 1-foot tapered wedge connecting the notches. The tapered wedge must be compacted to a minimum 91 percent relative density. Testing is performed by nuclear gauge and laboratory testing of cores.

Where placing HMA against the edge of existing pavement, saw cut or grind the pavement straight and vertical along the joint and remove extraneous material.

All surfaces, including vertical, to be covered require a tack coat application.

Illinois DOT (406.06(g)(2))

The longitudinal joint in all lifts shall be located at the centerline of the pavement if the roadway comprises two lanes in width, and at the lane edge if the roadway is more than two lanes in width. When stage construction prohibits the total completion of a particular lift, the longitudinal joint in one lift shall be offset from the longitudinal joint in the preceding lift by not less than 3 inches.

A notched wedge is required along all unconfined longitudinal joints where paving lifts are 2 inches or greater in depth. Vertical notches of 1 inch depth, up to 1 1/2 inches in thicker lifts, are required at the top and bottom of the paving lift with 9 to 12 inches of width between the notches.

When using a notched wedge joint, the bituminous material specified for the tack coat shall be applied at a rate of 0.05 to 0.1 gallon/square yard to the entire face of the longitudinal joint immediately prior to placing the adjacent lift of binder.



Longitudinal Joint Sealant (LJS) is now specified for centerline and lane to lane joints on all HMA pavement and HMA overlay projects as follows.

- Full-Depth HMA Pavements – under the surface lift and under the top binder lift
- Interstate HMA Overlays ≥ 3.75 in. – under both the surface and binder lifts
- Non-interstate HMA Overlays ≥ 2.25 in. – under the surface lift
- All Single-lift HMA Overlays – under the surface lift

LJS is an 18-inch-wide band (3/16-inch-thick for surface course) of highly polymerized asphalt binder that is centered under the longitudinal joint of the next lift to be placed. Placement of the HMA lift over the top of the LJS causes it to melt and migrate up into the lift 50 to 70% of the layer thickness to fill the high level of air voids associated with the unconfined edge. The LJS may be placed before or after the tack or prime coat. When placed after the tack or prime coat, the tack or prime shall be fully cured prior to placement of the LJS. The LJS application shall be centered under the joint of the HMA lift being constructed. Refer to “Special Provision for Hot-Mix Asphalt – Longitudinal Joint Sealant (BDE)” for more information.

The application of LJS typically doubles the asphalt binder content which changes the maximum theoretical gravity (G_{mm}) of the mix therefore density is not measured within 12 inches of lane-to-lane joints with LJS. Density for confined and unconfined shoulder joints, where LJS is not applied, are measured and paid for according to the PFP and QCP Special Provisions.

Michigan DOT (12SP-501Y-04(c))

In the top lift of HMA the longitudinal joint is to coincide with planned painted lane lines.

Standard specifications identify two joint construction types, Vertical Longitudinal Joint are the standard with an alternate Tapered Overlapping Longitudinal Joint. Longitudinal joints are typically defined as Type 1 or Type 2 below:

- Type 1. A longitudinal joint of new HMA that will abut up to new HMA pavement.
- Type 2. A longitudinal joint abutting up to existing HMA or PCC pavement or curb and gutter.

For Type 2 longitudinal joints abutting existing pavement, the entire mat is subject to standard HMA density specification requirements.

In lieu of Type 1 vertical joints the Engineer may allow a tapered overlapping joint constructed by tapering the HMA mat at a slope no greater than 1:12. The tapered portion shall be extended beyond the lane width and a 1/2- to 1-inch notch is constructed at the top of the taper.

A bond (tack) coat is required for all joint surfaces. For Type 2 joints a double bond coat is required on the vertical face at a rate of 0.10 gallons per square yard.

Longitudinal joint density is measured in the laboratory using pavement cores. When the resulting average of the cores of a longitudinal joint section is less than 89.00 percent, the Engineer will issue a



Notice of Non-Compliance with Contract Requirements. A dispute resolution process is defined in the specifications.

Minnesota DOT

Longitudinal joints are to be constructed parallel to and at the roadway centerline or lane lines. In multiple lift construction, longitudinal joints between strips in each lift shall be constructed at least 6 inches transversely from the longitudinal joints in the previously placed lift. No joints may be located in wheel path areas of a traffic lane. Over concrete pavements longitudinal joints should be aligned directly over the concrete pavement longitudinal joints or as approved by the Engineer.

Tack coat is required on all surfaces of adjacent fixed structures and the edge of in-place mixture in all courses at transverse joints and in the wearing course at longitudinal joints. In lieu of a tack coat MnDOT projects may include a Special Provision for longitudinal joint adhesive material. Do not apply tack coat when asphalt joint adhesive is specified.

For wear courses, upper 4 inches of a mat, MnDOT requires 89.5 percent minimum density along a confined edge and 88.1 percent along an unconfined edge. For lower lifts of nonwear course material 90.5 percent minimum density is required along a confined edge and 89.1 percent is required along an unconfined edge. MnDOT allows a reduced density requirement for the first lift of material placed on aggregate base material and concrete pavement. When applied, longitudinal joint density is not evaluated.

Density is evaluated by laboratory testing of pavement cores. Incentive and disincentive payments are applied for longitudinal joint density.

Missouri DOT

Longitudinal joints in the final surface layer shall be located at the lane lines. Each side of the joint shall be flush and along true lines. Adjustments may be made so pavement markings shall not fall on a longitudinal joint. Longitudinal joints in one layer shall offset those in the layer immediately below by approximately 6 inches.

If directed by the Engineer a light coating of bituminous material shall be applied to exposed edges prior to paving along joints.

The minimum density of HMA within 6 inches of a longitudinal joint shall be no less than 2.0 percent below the specified minimum required mat density when unconfined. When confined the density along the longitudinal joint is included in the evaluation of the remainder of the mat.

Wisconsin DOT

Longitudinal joints in the final surface layer shall be located at the pavement centerline and at lane lines. Along unconfined edges of mainline paving, a notched wedge longitudinal joint is required unless the Engineer directs or allows an alternate joint ([450.3.2.8](#)). The notched wedge consists of a 1/2 to 1 inch vertical notch after compaction at the top of tapers on all lifts. Taper each layer at a slope no greater than 12:1 and extend tapers to a point that extends beyond the normal lane width or as the Engineer directs. Ensure that tapers for all layers directly overlap and slope in the same direction. Construct the tapered portion of each layer using an engineer-approved strike-off device that will provide a uniform



slope and will not restrict the main screed. Apply a weighted steel side roller wheel, as wide as the taper, to the tapered section. Compact the initial taper section to as near the final density as possible.

Where paving adjacent to existing HMA pavement, a confined joint, cut back the existing mat to form a full depth butt joint.

Apply a tack coat to the taper surface before placing the adjacent lane. Clean longitudinal joints as necessary and paint with hot asphaltic material, a cutback, or emulsified asphalt to ensure a tightly bonded, sealed joint.

Wisconsin provides a Special Provision for reheating longitudinal joints; STP-460-015 Reheating HMA Pavement Longitudinal Joints. This special provision allows for reheating an abutting edge of the previously compacted HMA layer while paving mainline asphalt pavements. The intent is to evenly reheat at least an 8-inch wide strip of the previously compacted HMA to within 60 degrees F (15 degrees C) of the mix temperature at the paver auger.

2.2.2 Density Method Direction and Payment by State:

The performance of an HMA pavement and longitudinal joints can be related to the density achieved. States with method specifications for compaction include generally provide construction direction, method specifications, along with performance requirements related to density.

Illinois DOT (406.08)

Rolling of the first lane of binder and surface course shall start longitudinally at the edge having the lower elevation (low side of transverse cross slope) and progress to the other edge, overlapping on successive trips to obtain uniform coverage. The roller shall not pass over an unprotected edge, unconfined edge) of the freshly laid HMA, unless directed by the Engineer. When directed by the Engineer, the edge shall be rolled with a pneumatic-tired roller.

When laying the HMA adjacent to a previously placed lane (confined edge), the first pass of the roller shall be along the longitudinal joint on the fresh mixture with the compression wheel not more than 6 inches from the joint. The second pass of the roller shall overlap the longitudinal joint not more than 12 inches on the previously placed lane, after which the rolling shall proceed from the low side of the transverse slope to the high side, overlapping uniformly.

Density is not measured within 12 inches of a centerline or lane-to-lane joints due to the presence of the LJS. The addition of the LJS typically doubles the asphalt binder content which changes the maximum theoretical gravity (G_{mm}) of the mix. Not accounting for the change in G_{mm} would result in erroneous density values. It has also been shown that density measurement is not critical to performance of the longitudinal joint when the LJS is used. Density for shoulder joints (where LJS is not used) confined and unconfined are measured and paid for according to the PFP and QCP special provisions and supporting documents referenced herein. Michigan DOT (501.03.F.2.b)

When compacting an unsupported (unconfined) edge of the mat, keep the roller from 3 inches to 6 inches inside the unsupported edge on the first pass; ensure the roller overhangs the unsupported edge by 3 inches to 6 inches on the second pass.



Compact the longitudinal joint by rolling from the hot side, keeping the edge of the roller approximately 6 inches to 8 inches inside the cold joint (confined joint) for the first pass. For the second pass of the roller, compact the joint from the hot side while overlapping the cold side by 6 inches to 8 inches.

Michigan DOT Special Provision (12SP-501Y-04(c))

Two joint types are identified, a Vertical Longitudinal Joint or a Tapered Overlapping Longitudinal Joint. For both joint types specifications identify compaction methods as follows:

1. For the vertical joint, when compacting an unsupported (unconfined) edge of the mat, keep the roller from 3 inches to 6 inches inside the unsupported edge on the first pass; ensure the roller overhangs the unsupported edge by 3 inches to 6 inches on the second pass. When compacting the adjoining place mixture so that the strike off shoe will produce an edge that is adjacent to or minimally overlaps the adjoining course. Compact the longitudinal joint by rolling from the hot side, keeping the edge of the roller approximately 6 inches to 8 inches inside the cold joint for the first pass. For the second pass of the roller, compact the joint from the hot side while overlapping the cold side by 6 inches to 8 inches.
2. For the tapered overlapping joint resurfacing adjacent lanes at the completion of daily paving operations is not required but is required with 24 hours, unless delayed by weather. The tapered overlapping joint is constructed by tapering the HMA at a slope no greater than 1:12. Extending the tapered portion beyond the normal lane width. Construct a ½-inch to 1-inch notch at the top of the taper.

Agency	California DOT	Illinois DOT		Michigan DOT	Minnesota DOT		Missouri DOT		Wisconsin DOT
Spec	39-2.01A(4) (i)(ii)	QCP Special Provision*		12SP-501Y-04(e)	2360.3.D.1		403.23.7.4.1		
Mixture	SP	SP	SMA	SP	3 percent air voids	4 percent air voids	SP	SMA	
Confined Edge of Mat	91.0	92.5	93.5	89.0	89.5	90.5	92.0	94.0	
Unconfined Edge of Mat		90.5	91.5		88.1	89.1	90.0	92.0	
	* See the "PFP and QCP Random Density Procedure" and the 100% Pay Factor Column in the "QCP Pay Calculation" documents linked herein.								

Table 2.2.2-1 – Longitudinal Joint Density Requirement Specifications by State

2.2.3 Quality Control/Quality Assurance (QC/QA) by State:

States typically randomly select locations to take cores and laboratory test for longitudinal joint density and/or use a nuclear gauge to perform the density testing.



California DOT (39-2.04A(4)(h)(viii))

Perform QC testing on the completed tapered notched wedge joint as follows:

Perform density tests using a calibrated nuclear gauge at a rate of 1 test for every 750-foot section along the joint. Select random locations for testing within each 750-foot section. Perform density tests at the centerline of the joint, 6 inches from the upper vertical notch, after the adjacent lane is placed and before opening pavement to traffic. Determine theoretical maximum density and percent compaction of the longitudinal joint as the ratio of the daily average density to the maximum density test results.

For a tapered notched wedge joint, take 4- or 6-inch diameter density cores 6 inches from the upper vertical notch of the completed longitudinal joint for every 3,000 feet at locations selected by the Engineer. Take cores after the adjacent lane is placed and before opening the pavement to traffic.

(39-2.01A(4)(i)(ii))

If the percent of theoretical maximum density is not within the density limit, which is between 91.0 to 97.0, the Engineer may accept the joint and take a payment deduction as shown in the following table:

HMA Percent of Maximum Theoretical Density (percent)	Reduced Payment Factor	HMA Percent of Maximum Theoretical Density (percent)	Reduced Payment Factor
91.0	0.0000	97.0	0.0000
90.9	0.0125	97.1	0.0125
90.8	0.0250	97.2	0.0250
90.7	0.0375	97.3	0.0375
90.6	0.0500	97.4	0.0500
90.5	0.0625	97.5	0.0625
90.4	0.0750	97.6	0.0750
90.3	0.0875	97.7	0.0875
90.2	0.1000	97.8	0.1000
90.1	0.1125	97.9	0.1125
90.0	0.1250	98.0	0.1250
89.9	0.1375	98.1	0.1375
89.8	0.1500	98.2	0.1500
89.7	0.1625	98.3	0.1625
89.6	0.1750	98.4	0.1750
89.7	0.1875	98.5	0.1875
89.4	0.2000	98.6	0.2000
89.3	0.2125	98.7	0.2125



89.2	0.2250	98.8	0.2250
89.1	0.2375	98.9	0.2375
89.0	0.2500	99.0	0.2500
< 89.0	Remove and replace	> 99.0	Remove and replace

Table 2.2.3-1 – California DOT Payment Schedule for Percent of Maximum Theoretical Density

Illinois DOT (Hot Mix Asphalt – Pay for Performance and Hot Mix Asphalt – Quality Control for Performance special provisions and the PFP and QCP Random Density Procedure)

Longitudinal joint testing shall be located at a distance equal to the lift thickness or a minimum of 4 inches from each pavement edge.

When the longitudinal joint sealant is specified, the longitudinal joint density testing will not be required on the joint(s) with the longitudinal joint sealant.

Michigan DOT (12SP-501Y-04(d) and 12SP-501Y-05(e))

For Type 1 and Type 2 Vertical longitudinal Joints 90.5 percent density is required. Density greater than 90.5 percent is eligible for an incentive payment and when less than 90.5 percent subject to a negative quality adjustment. When longitudinal joint density is less than 86 percent the material placed is subject to removal for the full lane width constructed plus 6 inches past the longitudinal joint. Also, the Contractor may elect to over pave the joint by up to 2 inches (measured from the top of the mat) in order to cut back the vertical face of the joint.

One informational longitudinal joint core is allowed per day of production of the longitudinal joint to aid the Contractor in their control of operations. Obtain a minimum of three cores for any project having only one subsection per course of paving. Obtain a minimum of three cores, two per subsection, for any project having only two subsections per course of paving. Any additional informational cores require the approval of the Engineer. The Contractor may also take up to one random core for control for each subsection of constructed longitudinal joint.

A Longitudinal Joint Section is made up of a discrete length of Type 1 longitudinal joint and is typically made up of five Type 1 longitudinal joint subsections. A longitudinal joint subsection is a portion of a Type 1 longitudinal joint section represented by one random core every 2,000 feet. The Contractor and the Engineer may agree to reduce the typical 2,000-foot joint subsection based on project staging or other project conditions.

Ensure these cores are approximately 6 inches in diameter. Ensure cores are centered on the line where the joint between the adjacent lifts abut at the surface. For Type 1 joints in which different mix designations are used on either side of the longitudinal joint the cores will be taken 4 inches off the center of the joint on the cold side of the joint.

Where constructing a tapered overlapping joint the density acceptance requirements above do not apply to tapered notched wedge joints and Type 2 joints.



A longitudinal joint density incentive is paid for longitudinal joint density meeting or exceeding 90.50 percent on Type 1 Joints only.

(12SP-501Y-04(g))

The incentive payment will be determined based on the average QA longitudinal joint density in accordance with the following pay adjustment and QA section of the special provision.

Use the following equations to determine the quality adjustment per foot:

- EQ.1 Quality adjustment = $(0.3333 \times \text{Density}) - 30.1635$
- EQ.2 Quality adjustment = $(4.0850 \times \text{Density}) - 360.31$

Density Range (percent)	Incentive/Negative Quality Adjustment	Dollar Value	Action Required
90.50 ≥ 93.50	Incentive	\$0.00/foot - \$1.00/foot (max.) EQ. 1	N/A
88.00 – 90.49	Negative Quality Adjustment	\$0.83/foot - \$0.00/foot EQ. 1	Stop production if below 89.00 percent
86.00 – 87.99	Negative Quality Adjustment	\$9.00/foot - \$0.84/foot * EQ. 2	All joints saw or route and sealed
< 86.00			Full lane width removal plus 6 in past the longitudinal joint (s)
* Leveling and base course – \$4.00/foot (max.) - \$0.84/foot			
Leveling and base course – remove 30 in centered on the joint with saw cutting with double tack coat of vertical faces.			

Table 2.2.3-2 – Michigan DOT Payment Schedule for Longitudinal Joint Density

Any work required for over paving a joint in order to cut it back will be at the Contractor's option and the cost for cutting back the HMA and disposal of waste will be considered included in the costs of other items of work. There will be no negative adjustment in tonnage for any cut back, up to 2 inches, of HMA placed for the HMA removed as part of the cutting back.

Minnesota DOT (2360.3.D.1.n and 2360.3.D.2)

Density evaluation will not include longitudinal joint density on lifts with a 1 percent reduced density requirement; when requested by the contractor for the first lift of paving on compacted aggregate grades and concrete overlays. Longitudinal joint density is evaluated in one lot per day unless the total daily weight is greater than 5,000 ton. If the total daily weight is greater than 5,000 tons, evaluate two lots per day. Within the lot to be evaluated take six cores. Take cores for longitudinal joint density with the outer edge of the core barrel within 6 in from the edge of the top of the mat from both sides of the mat. Take a companion core 1-foot longitudinally from each core. Take two cores for mat density at either 2 feet right or 2 feet left of the center of the mat the Contractor is paving, regardless of random number generation.



If using the ordinary compaction method to evaluate density, use a control strip to establish a rolling pattern. Use the rolling pattern to compact the asphalt mixture for the layer on which the control strip is constructed or until constructing a new control strip.

Incentives and disincentives are paid on a graduated scale as follows:

(2360.3.D.1.q)

Confined Edge Density (percent)	Pay Factor B Longitudinal (Confined Edge)		Unsupported Edge Density (percent)	Pay Factor C (Unsupported Edge)	
	Traffic Level 2 & 3	Traffic Level 4 & 5		Traffic Level 2 & 3	Traffic Level 4 & 5
≥ 92.1	1.02†	1.03†	≥ 91.0	1.02†	1.03†
91.6 – 92.0	1.01†	1.02†	90.1 – 90.9	1.01†	1.02†
89.5 – 91.5	1.00	1.00	88.1 – 90.0	1.00	1.00
88.5 – 89.4	0.98	0.98	87.0 – 88.0	0.98	0.98
87.7 – 88.4	0.95	0.95	86.0 – 86.9	0.95	0.95
87.0 – 87.6	0.91	0.91	85.0 – 85.9	0.91	0.91
< 87.0	0.85	0.85	< 85.0	0.85	0.85

* The Department will limit incentive payment for longitudinal joint density to lots with evaluated longitudinal joint densities.

|| Calculate the percent of maximum specific gravity to the nearest tenth.

† Payment will only apply if the day's weighted average individual production air voids fall within – 1/2 percent of the target air void value. Base the weighted average air voids on all the mixture production tests in accordance with 2360.2.G.7, —Production Tests for the corresponding day and weight by the tons the corresponding test represents.

Table 2.2.3-3 – Minnesota DOT Payment Schedule for Longitudinal Joint Density (4 percent Void)



Confined Edge Density (percent)	Pay Factor B Longitudinal (Confined Edge)		Unsupported Edge Density (percent)	Pay Factor C (Unsupported Edge)	
	Traffic Level 2 & 3	Traffic Level 4 & 5		Traffic Level 2 & 3	Traffic Level 4 & 5
≥ 93.1	1.02†	1.03†	≥ 92.0	1.02†	1.03†
92.6 – 93.0	1.01†	1.02†	91.1 – 91.9	1.01†	1.02†
90.5 – 92.5	1.00	1.00	89.1 – 91.0	1.00	1.00
89.5 – 90.4	0.98	0.98	88.0 – 89.0	0.98	0.98
88.7 – 89.4	0.95	0.95	87.0 – 87.9	0.95	0.95
88.0 – 88.6	0.91	0.91	86.0 – 86.9	0.91	0.91
< 88.0	0.85	0.85	< 86.0	0.85	0.85

* The Department will limit incentive payment for longitudinal joint density to lots with evaluated longitudinal joint densities.

|| Calculate the percent of maximum specific gravity to the nearest tenth.

† Payment will only apply if the day's weighted average individual production air voids fall within – 1/2 percent of the target air void value. Base the weighted average air voids on all the mixture production tests in accordance with 2360.2.G.7, —Production Tests for the corresponding day and weight by the tons the corresponding test represents.

Table 2.2.3-4 – Minnesota DOT Payment Schedule for Longitudinal Joint Density (3 percent Void)

Determine the pay factor in accordance with the following:

- Case 1: Total Pay Factor = (Pay Factor A) × (Pay Factor B) × (Pay Factor C)
- Case 2: Total Pay Factor = (Pay Factor A) × (Pay Factor B) × (Pay Factor B)
- Case 3: Total Pay Factor = (Pay Factor A) × (Pay Factor C) × (Pay Factor C)

Where:

- Pay Factor A = Mat density,
- Pay Factor B = Confined edge density,
- Pay Factor C = Unsupported edge density.

Use a pay factor of 1.00 for Pay Factor B, Pay Factor C, or both in lots where no cores are taken at the longitudinal joint.

Missouri DOT (403.23.7.1.5)

All mixture placed on the roadway shall be subject to random testing, except mixture placed within 6 inches of an unconfined longitudinal joint shall not be subject to evaluation. Random samples taken in the same day may be separated by 200 tons.



(403.23.7.4.1(b))

Pay adjustments due to longitudinal joint density will apply to the full width of the lane paved.

SP Mixture Density (percent)			SMA Mixture Density (percent)	Pay Factor (percent of Contract Unit Price)
		92.0 to 97.0 inclusive	> 94.0	100
97.1 to 97.5	or	91.5 to 91.9 inclusive	93.5 to 93.9 inclusive	90
	or	91.0 to 91.4 inclusive	93.0 to 93.4 inclusive	85
97.6 to 98.0	or	90.5 to 90.9 inclusive	92.5 to 92.9 inclusive	80
	or	90.0 to 90.4 inclusive	92.0 to 92.4 inclusive	75
Above 98.0	or	Below 90.0	Below 92.0	Remove and replace

Table 2.2.3-5 – Missouri DOT Pay Schedule for Longitudinal Joint Density

2.2.4 Corrective Action

Some states require the removal and replacement of joint with acceptable material from the Contractor if the joint density exceeds the control limit as follows:

Agency	California DOT	Illinois DOT	Michigan DOT	Minnesota DOT		Missouri DOT		Wisconsin DOT
Spec	39-2.01A(4)(i)(ii)	1030.05(d)(7)	12SP-501Y-04(e.2.C)	2360.3.D.1.q		403.23.7.4.1		
Mixture	SP	SP	SP	3% air voids	4% air voids	SP	SMA	
Less than	89.0	-	86.0	-	-	90.0	92.0	
Greater than	99.0	-	-	-	-	98.0	-	

Table 2.2.4-1 – Longitudinal Joint Density Requirement (%) by State

No additional payment will be made for such removal and replacement.

Michigan DOT requires that any longitudinal joint in place with a joint subsection density less than 88.00 percent will require saw or route and seal.

3 NRRRA Summary of the State of Practice

The performance of an HMA pavement can be related to the performance of longitudinal joints. Deteriorated longitudinal joints are a safety hazard for vehicles with narrow tires particularly motorcycles. Items to consider in proper joint construction are:

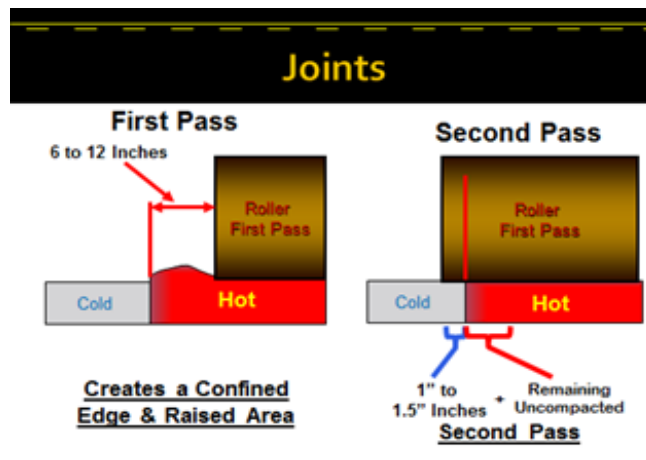


- 1) Paver reference line: A major element to success in paving is the first pass should be straight and where following a curved alignment the curve should be smooth, this too is related to safety. When striping is faint, paving seams are often visible, which can create driver confusion when not straight and along lane lines. Pavement markings are typically placed alongside the longitudinal joints, not over the top or crossing. The best paving reference can be established by following a stringline.
- 2) The type and arrangement of rollers selected as well as arrangement is important to ensure proper densification of the longitudinal joint. A steel wheel roller rolling from the hot side of the mat with approximately 6 inches overhanging the edge of the mat is generally thought to provide the greatest compactive effort. A pneumatic tired roller should not be used within 6 inches of the unconfined edge as the mixture will tend to push sideways.



- 3) Screed placement on an adjacent paver pass ensuring the end gate of the screed is placed with an overlap of 1 to 1.5 inches on the cold mat is very important to constructing a durable longitudinal joint. The overlap should be about 1/4 inch higher than the adjacent mat to allow for consolidation. The rule of thumb is the mix will consolidate approximately 1/4 inch for every inch of material placed.
- 4) Two methods are typically followed for compacting the confined longitudinal joint. One approach, pinching, places the first pass of the roller about 6 inches away, on the hot side with a second pass placed over the joint compacting any overlapped and raised material.

A second approach places the first pass of the steel wheel roller 6 inches over the joint from the hot side.



- 5) For unconfined joints 4 member States require or have a notched and tapered design wedge alternative described by specification. Minnesota and Missouri do not include notched wedge alternatives. The notched wedge approach is thought to provide improved joint density for a more durable joint structure.

The notched wedge is slightly different in each specification but in general a notch 1 to 1-1/2 inch depth is required at the top, sometimes the bottom of the new mat also, then a taper is constructed about 12 inches in width to the top of an existing mat or another notch. Construction of a notched wedge joint requires a form to be placed on the paver, just even with the end gate, for shaping of the notches and wedge if required. The formed wedge is compacted with a small roller. Issues that can occur include maintaining the required notches due to compaction or raveling of the thinner portions of the wedge

Notched Wedge



All States in general require the application of a tack coat with some allowed exclusions. Minnesota maintains a special provision for application of a joint adhesive material in lieu of tack and Wisconsin maintains a special provision for reheating a longitudinal joint immediately in front of a paver.

Illinois utilizes Longitudinal Joint Seal (LJS) without a density specification to mitigate centerline joint distresses and extend the life of the pavement. LJS is placed before paving the HMA layer to be joint sealed. Placement of the HMA lift over the top of the LJS causes it to melt and migrate up into the lift to fill the high level of air voids associated with the unconfined edge.



All States maintain a density specification. The specifications tend to provide some direction for contractor's compacting process but ultimately use performance, measured density, for acceptance.

Illinois, Michigan, Minnesota, and Missouri have specific longitudinal joint density specifications with payment schedules that include incentives for enhanced density and disincentives for lower density.

4 Future Research

4.1 Rolling Density Meter

A Rolling Density Meter is a GPR device that is a product from the SHRP2 R06C study.

It provides a way to easily test the entire, newly paved road to help ensure its uniformity and also that layer compaction is within limits set by the DOT. Texas A&M Transportation Institute (TTI) researchers teamed with a manufacturer of ground penetrating radar to tailor a system for asphalt mixture evaluation. The manufacturer developed a device, dubbed the rolling density meter, which can be rolled over the roadway.

The meter includes an onboard radar that transmits an electrical magnetic pulse into the pavement. The reflections from the pavement surface are readily correlated to surface layer density, which allows the operator to monitor in real time the mix densities in a continuous one-step process. Currently, the radar is part of a four-wheeled device pushed over the pavement. Researchers anticipate that multiple rolling density meters can be mounted transversely onto a vehicle to provide close to 100 percent coverage of the new surface layer being placed.

5 Innovation

Longitudinal Joint Sealant

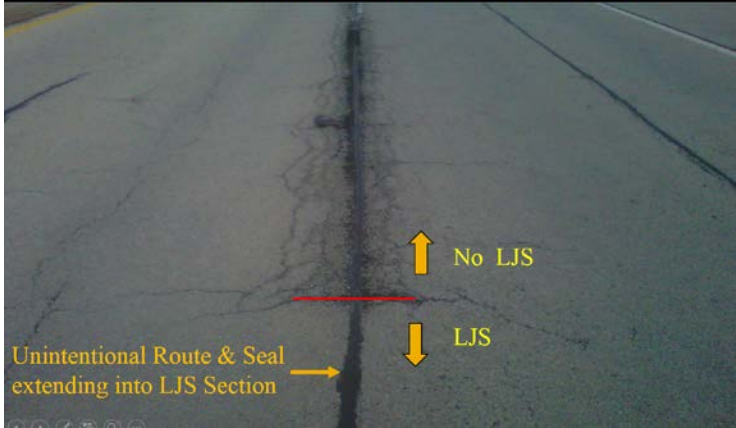
In 2001 Illinois began efforts to develop the concept of sealing the high air void region of longitudinal joints associated with unconfined edges from the bottom up of a paved layer of HMA. Illinois Dept. of Transportation (IDOT) reached out to two companies to begin development of an asphalt binder material (Longitudinal Joint Seal (LJS)) that would be stout enough to resist pickup of construction traffic, and to be placed 18 inches wide and a thickness of 3/16-inch without flowing wider. At the same time, the LJS had to be soft enough to melt and migrate at least 50% of the way up into the layer of HMA paved over the top of it. IDOT proceeded to construct experimental test sections using both of the LJS products on paving projects in several Illinois districts in 2002 and 2003. One supplier provided their "Quick Seam" LJS material in the form of a roll-out tape, another supplied their "J-Band" LJS material in liquid form and placed it using a drag box pulled manually down the longitudinal joint. Two reports documenting these efforts are available upon request at the IDOT Central Bureau of Materials. The following are photos illustrating the performance of these sections 12 to 15 years after placement.



Longitudinal Joint Seal 12 Yrs Later



Longitudinal Joint Seal 12 Yrs Later



Longitudinal Joint Seal 15 Yrs Later

