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TECHNIQUES FOR ASPHALT
PAVEMENTS**

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LONGITUDINAL JOINT CONSTRUCTION TECHNIQUES FOR ASPHALT PAVEMENTS

Prithvi S. Kandhal and Rajib B. Mallick¹

ABSTRACT

Thirty hot mix asphalt (HMA) test sections were constructed in Michigan (1992), Wisconsin (1992), Colorado (1994), and Pennsylvania (1995) to evaluate the effectiveness of twelve different longitudinal joint construction techniques. The performance of these test sections was evaluated in 1996 after one to four years in service.

The joints with high densities generally show better performance than those with relatively low densities. The Michigan joint technique (12.5 mm vertical offset and 12:1 taper) appears to have the best potential of obtaining a satisfactory longitudinal joint. The cutting wheel and the edge restraining device techniques have good potential but are too much operator dependent to obtain consistent results. Among the three different joint rolling techniques used in all four projects, rolling the joint from hot side generally gave the best performance followed by rolling from hot side 152 mm away from the joint. Paver manufacturers should consider modifying the paver design to obtain a Michigan type, high density unconfined wedge in the lane paved first. Highway agencies should specify minimum compaction levels to be achieved at the longitudinal joint.

Key Words: longitudinal joint, construction, HMA, hot mix asphalt, asphalt concrete.

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LONGITUDINAL JOINT CONSTRUCTION TECHNIQUES FOR ASPHALT PAVEMENTS

BACKGROUND

Cracking and raveling are the two main distress conditions which are commonly encountered at the longitudinal joints of multilane hot mix asphalt (HMA) pavements. These distresses are caused by relatively low density and surface irregularity at the joints. A density gradient also exists across a typical longitudinal joint. Such a density gradient is caused by the low density at the unconfined edge when the first lane (hereinafter called the cold lane) is paved, and a relatively high density at the confined edge, when the adjacent lane (hereinafter called the hot lane) is paved. Usually the density at a longitudinal joint is about one to two percent less than the density in the lanes away from the joint (1, 2, 3). However, it is not uncommon to encounter joint densities which are significantly lower than usual. Hence, there is a need to identify suitable joint construction techniques which will result in more uniform density across a longitudinal joint and, therefore, minimize or eliminate cracking and raveling problems at the joint.

OBJECTIVE

The objective of this study is to evaluate different longitudinal joint construction techniques used in HMA paving projects in four different states in the U.S.

SCOPE

This study involves the evaluation of different longitudinal joint construction techniques used on four projects since 1992: (a) seven techniques on I-69 in Michigan (1992), (b) eight

techniques on State Route 190 in Wisconsin (1992), (c) seven techniques on I-25 in Colorado (1994), and (d) eight techniques on State Route 441 (1995) in Pennsylvania.

TEST PLAN

The construction techniques used in this study are shown in Table 1. HMA in the adjacent (hot) lane of all projects except Wisconsin was placed such that the end gate of the paver extended over the top of the first (cold) lane by about 25-38 mm (1-1½ inch). The height of the uncompacted mix in the hot lane was about 1¼ times the compacted lift thickness to ensure a requisite amount of HMA for compaction. Raking was done with a view to provide extra material to be compacted by the roller in the hot lane near the joint in order to achieve high density. On the Wisconsin project the HMA mix in the hot lane was placed flush (with no overlap) against the unconfined edge of the cold lane. The placing technique required very close attention of the paver operator which was not always possible. If the hot lane is placed only three mm (C inch) away from the edge of the cold lane due to oversight, a built-in crack results.

The overlapped HMA was not luted (raked) back on the Colorado project. Although vibratory compaction is preferable, especially when rolling a longitudinal joint from the hot side, only static compaction was used on Michigan and Wisconsin projects.

The various techniques of longitudinal joint construction and/or rolling given in Table 1 are discussed briefly in the following sections.

Rolling From Hot Side

Compaction at the joint was done from the hot side of the lane being constructed wherein

Table 1. Longitudinal Joint Construction Techniques

	Construction/Rolling Technique	Project			
		MI	WI	CO	PA
1.	Rolling from hot side	X	X	X ^a	X
2.	Rolling from cold side	X	X	X ^a	X
3.	Rolling from hot side 152 mm (6 inch) away from joint	X	X	X ^a	X
4.	(12:1) Tapered joint with 12.5 mm offset without tack coat	X	X ^b		
5.	(12:1) Tapered joint with 12.5 mm offset with tack coat	X	X ^b		
6.	Edge restraining device		X		X
7.	Cutting wheel with tack coat	X	X	X ^a	X
8.	Cutting wheel without tack coat			X ^a	
9.	Joint maker	X	X		X
10	Tapered (3:1) joint with vertical 25 mm offset			X	
.					
11	Rubberized asphalt tack coat			X	X
.					
12	NJ Wedge (3:1) and infrared heating				X
.					

^a Unconfined edge had a 3:1 taper

^b Tapered (12:1) joint did not have any vertical offset

a major portion of the roller wheel remained on the hot side with about 152 mm (6 inch) overlap on the cold lane (Figure 1A).

Rolling From Cold Side

Rolling was done in the static mode with a major portion of the roller wheel on the cold side with about 152 mm (6 inch) of the roller wheel on the hot side of the joint. This technique is believed to produce a “pinching” effect on the joint (Figure 1B). However, timing in this type of rolling is critical. When the roller is operated on the cold side, the hot side undergoes cooling which can make it difficult to achieve the desired compaction level.

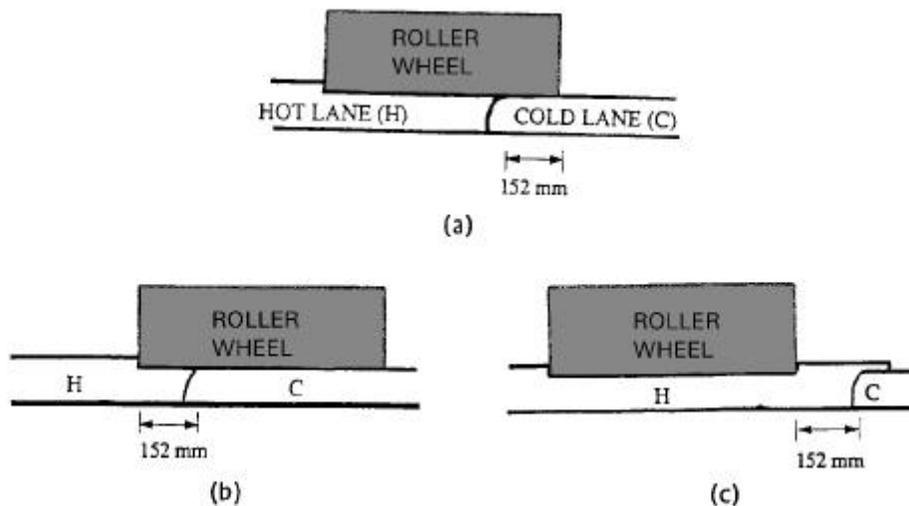


Figure 1. (a) Rolling from hot side, (b) Rolling from cold side, and (c) Rolling from hot side 152 mm away from joint.

Rolling From Hot Side 152 mm (6 inch) Away From Joint

Compaction in this method was started with the edge of the roller about 152 mm (6 inch) from the joint on the hot side (Figure 1C). The lateral pushing of the material toward the joint during the first pass of the roller is believed to produce a high density at the joint. This method is particularly recommended by some asphalt paving technologists for tender mix or thick lifts, which have the potential for the mix to be pushed towards the joint.

Tapered (12:1) Joint with 12.5 mm Offset Without Tack Coat

In this so-called Michigan wedge joint technique, the joint between the adjacent lanes is constructed as two overlapping wedges. The wedge joint is formed by tapering the edge of the lane paved first. The taper is then overlapped when the subsequent adjacent lane is placed. A taper of 1:12 (vertical/horizontal) was used. A schematic of the joint is shown in Figure 2a. The taper

was formed by attaching a steel plate to the paver screed. After the initial lane was placed, and tapered to the required slope, the lane was compacted with the roller not extending more than 51 mm (2 inch) beyond the top of the unconfined edge (4). The tapered, unconfined face of the wedge was compacted with a small roller attached to the paver. The tapered face was not tack coated in this section. The adjacent lane was placed on the next day.

Tapered Joint (12:1) with 12.5 mm Offset with Tack Coat

This technique was similar to the above technique except that a tack coat was applied on the unconfined, tapered face of the cold lane before the overlapping wedge was placed and compacted. The tack coat is generally applied to prevent the ingress of water and to obtain good adhesion between the lanes.

Edge Restraining Device

The restrained edge compaction technique utilizes an edge-compacting device which provides restraint at the edge of the first lane constructed. The restraining device consists of a hydraulically powered wheel which rolls alongside the compactors drum simultaneously pinching the unconfined edge of the first lane towards the drum providing lateral resistance (5). This technique is believed to increase the density of the unconfined edge. The adjacent lane is then abutted against the initial lane edge. Compaction was performed by rolling from the hot side. A schematic of the edge restraining device is shown in Figure 2B.

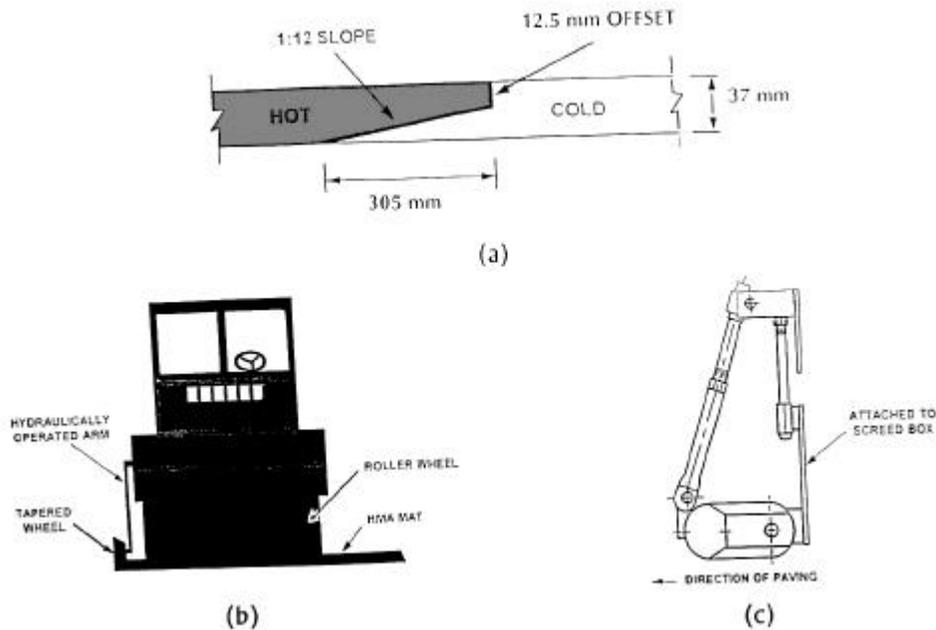


Figure 2. (a) Schematic of Michigan joint (12.5 mm offset and 12:1 taper), (b) Schematic of edge restraining device, and (c) Schematic of joint maker.

Cutting Wheel with Tack Coat

The cutting wheel technique involves cutting 38-51 mm (1½-2 inches) of the unconfined, low density edge of the initial lane after compaction, while the mix is still plastic. A 254 mm (10 inch) diameter cutting wheel mounted on an intermediate roller is generally used for the purpose (5). The cutting wheel can also be mounted on a motor grader which was the case in Michigan and Colorado.

A reasonably vertical face at the edge is obtained by this process which is then tack coated before the placement of the abutting HMA. Compaction was performed by rolling from the hot side. This method generally results in an increase in density at the joint (1, 5).

Cutting Wheel without Tack Coat

This type of joint was constructed in the same way as the above joint except that no tack coat was applied to the vertical face before placement of the adjacent hot lane.

Joint Maker

This was an automated joint construction technique, and a recent innovation in joint making technology. It consisted of a device (Figure 2C) which is attached to the side of the screed at the corner during construction. The device forces extra material at the joint through an extrusion process prior to the screed. A kicker plate is also furnished which is attached to the side of the paver to lute back the overlapped HMA mix without the help of a lute man. It is claimed that proper use of the joint maker ensures high density and better interlocking of aggregates at the joint. Rolling of the joint was done from the hot side.

Tapered (3:1) Joint with Vertical 25 mm Offset

In this method used in Colorado, the unconfined edge of the 50 mm thick cold lane was constructed with a 25 mm (1 inch) vertical step (offset) at the top of the joint. The remainder of the joint was constructed with a 3:1 taper. The vertical face was not tacked, but the taper surface was tacked, before placement of adjacent hot material. The vertical step (offset) was formed by placing a 610 mm (2 feet) long piece of 51 mm x 51 mm (2 in. x 2 in.) angle iron under the drag device used to form the 3:1 taper. There was some pulling of the larger particles of aggregate, but the overall vertical step face was satisfactory. Rolling of the joint was done from the hot side.

Rubberized Asphalt Tack Coat

The unconfined edge of the first paved lane adjacent to the joint was not provided with any taper in this experimental section. On the following day, a rubberized asphalt tack coat (Crafco pavement joint adhesive Part Number 34524) was applied on the face of the unconfined edge before placing the adjacent lane. The thickness of the tack coat was about 3 mm (1/8 in.). Rolling of the joint was done from the hot side.

New Jersey Wedge (3:1)

In this technique used on Pennsylvania project, a wedge joint consisting of a 3:1 taper was formed during the construction of the cold side by using a sloping steel plate attached to the inside corner of the paver screed extension. During the second pass of the paver an infrared heater was used to heat the edge of the previously placed layer to a surface temperature of about 93°C (200°F). During placement of the hot side material, the cold side was overlapped by 50 to 75 mm (2 to 3 inches). The overlapped material was luted (raked) back 75 to 100 mm (3 to 4 inch) from the edge of the cold mat. Rolling of the joint was done from the hot side.

In the Michigan project, the ambient temperature was 8-14°C (46-58°F), and the temperature of the mix behind the paver was between 143 to 147°C (290 to 297°F). During construction in the Wisconsin project, the temperature of the mix behind the paver was noted to be between 135 and 149°C (275 and 300°F). Both Michigan and Wisconsin projects involved a dense graded HMA wearing course 38 mm (1.5 inch) in thickness. In the Colorado project, the temperature of the mix before breakdown rolling was approximately 143°C (290°F). The work consisted of removing 102 mm (4 inch) of HMA of the existing pavement and replacing it with an

HMA overlay 102 mm (4 inch) thick. The different joint construction techniques were used in construction of the wearing course. In the case of Pennsylvania project, the ambient air temperature during paving ranged from 9°C to 22°C (48°F to 72°F). In this project, the joints were constructed in a wearing course, 38 mm (1.5 inch) thick, placed on a binder course 51 mm (2 inch) thick.

In all the 30 experimental test sections, pavement cores were obtained right on the joint and 300 mm away from the joint, immediately after construction. The bulk specific gravity of the cores was then determined according to ASTM D2726. A minimum of six sets of cores (each set consisting of one at the joint and one away from the joint) were obtained from each of the test sections. Each test section was 152 m (500 feet) long. The density data was then analyzed statistically to differentiate and group the joints according to their density. The joint construction techniques were then ranked according to the density of the joints. These joints have also been evaluated by a team of engineers at least once a year since construction. The density and the performance data were evaluated and the joint construction technique(s) which resulted in good joints have been identified in subsequent sections.

Density of cores taken from cold mat, and rankings of techniques based on the joint density as a percentage of the cold mat density are not presented here due to restriction of space but are described in detail in References 6 and 7.

TEST RESULTS AND VISUAL EVALUATIONS

Test results and visual evaluations of joints in different projects are described in the following sections.

Test Results and Analysis, Michigan Project

The joint density values obtained in different sections (constructed with different longitudinal techniques) were analyzed statistically and the techniques were ranked on the basis of density values at the joints (6). Fisher's Protected Least Significant Difference (LSD) Procedure was utilized to group the different techniques such as Groups A, B, and C. Figure 3 shows the average joint densities and the ranking of the different techniques. Based on the groupings, the Michigan joint consisting of 12:1 tapered joint with 12.5 mm offset (with and without tack coat) and the cutting wheel (with tack coat) gave the highest densities at the joint. It should be noted that the density obtained right at the joint of the 12:1 tapered joint is contributed mostly by the tapered edge of the cold lane. Among the three rolling techniques, rolling from hot side gave the highest density at the joint followed by rolling from hot side 152 mm (6 inches) away from the joint.

Visual Evaluation of Michigan Project

The last visual inspection was made on September 21, 1995, about three years after construction. The observations are given in Table 2. All test sections except the Michigan joint with 12:1 taper and 12.5 mm offset, with and without tack coat, have developed a significant amount of cracking at the joint. However, the width of crack and the extent of raveling on cold side varies. The techniques were ranked as follows from best to worst:

- Tapered (12:1) joint with 12.5 mm offset without tack coat
- Tapered (12:1) joint with 12.5 mm offset with tack coat

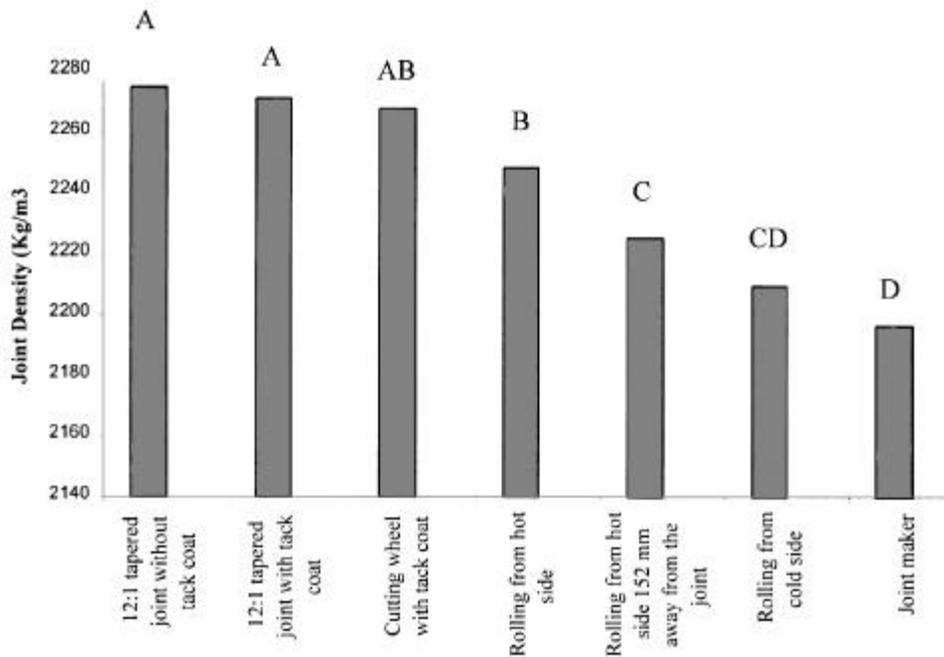


Figure 3. Joint density in Michigan project (letters indicate ranking of construction technique; means within the same ranking group do not differ at significance level (α) of 0.05).

- Cutting wheel
- Joint maker
- Rolling from hot side
- Rolling from hot side 152 mm (6 inch) away from joint
- Rolling from cold side

The tapered (12:1) joint with 12.5 mm offset has given the best performance on this project. There is no significant difference between the performance of this joint type with and without tack coat. The joint without tack coat had slightly higher average density at the joint compared to the joint with tack coat and, therefore, may have performed slightly better. However, a tack coat is desirable to obtain good bond at the joint. The performance or ranking of all joints

Table 2. Visual Evaluation of Michigan Project (September 1995)

Technique Used	Cracking at Joint		Raveling of Mat Adjacent to Joint (Cold Side)	Comments
	Width, mm	% Length		
Rolling from hot side	6-12	100	Slight	
Rolling from cold side	12	100	Slight	Crack wider than the previous and the next section
Rolling from hot side 152 mm (6 inch) away from joint	6-12	100	Slight	
Tapered (12:1) joint with 12.5 offset without tack coat	-	0	None to slight	Two 3-mm wide cracks 2-3 m long
Tapered (12:1) joint with 12.5 mm offset with tack coat	-	3	Slight	
Cutting wheel with tack coat	3-6	80	Slight	
Joint maker	3-6	90	Slight	

appears to have been influenced generally by the overall density at the joint when constructed. Of the three rolling techniques tried, rolling from hot side and rolling from hot side 152 mm (6 inch) away from the joint have given better performance than rolling from cold side. It is no longer possible to continue the comparative visual evaluation of this project because all cracks were routed and sealed with a rubberized asphalt crack sealer in 1995.

Test Results and Analysis, Wisconsin Project

The different techniques were grouped by the Fisher's Protected Least Significant Difference Procedure (6) according to the joint density values. Figure 4 shows the average joint

densities and the ranking of the different techniques. Based on the groupings, the edge restraining device and the cutting wheel produced the highest densities, followed by the Michigan joint (12:1 taper without 12.5 mm offset) and the joint maker. Of the three rolling techniques, rolling from hot side gave the highest density at the joint followed by rolling from hot side 152 mm (6 inch) away from the joint.

Visual Evaluation of Wisconsin Project

The last visual inspection was made on May 30, 1996, about 4 years after construction. The observations are given in Table 3. Cracking at the joint has occurred in all eight sections. However, the width and condition of crack, and the extent of raveling on the cold side vary. The

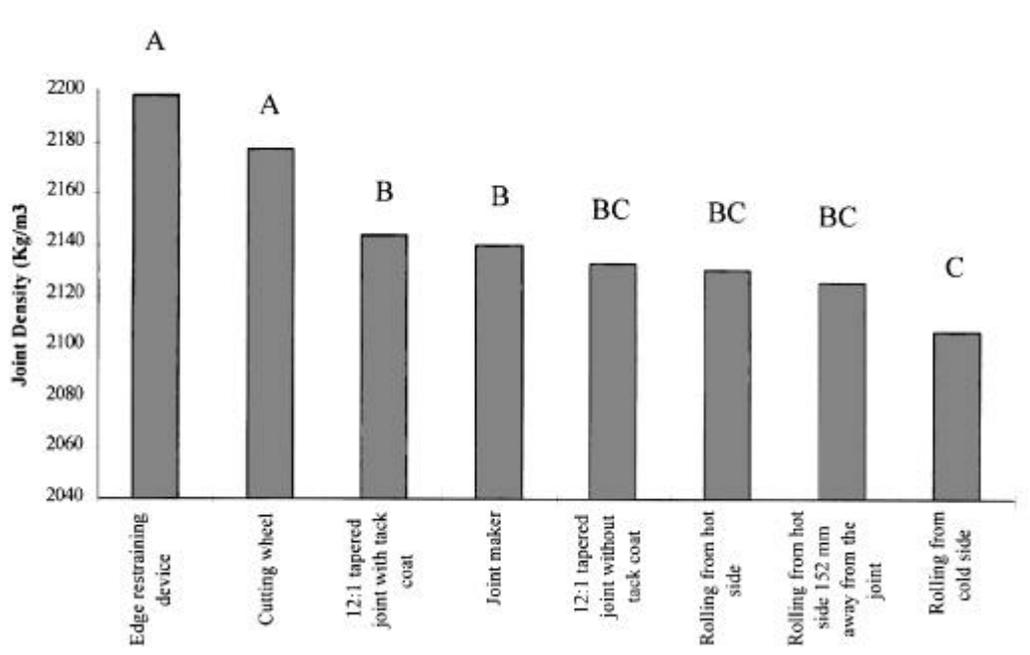


Figure 4. Joint density in Wisconsin project (letters indicate ranking of construction technique; means within the same ranking group do not differ at significance level (α) of 0.05).

Table 3. Visual Evaluation of Wisconsin Project (May 1996)

Technique Used	Cracking at Joint		Raveling of Mat (cold side): Severity and % length	Comments
	Width, mm	% Length		
Rolling from hot side	3-6	100	Slight (100)	Crack has spalled at some places
Rolling from cold side	6	100	Slight to moderate (100)	Crack has spalled at some places
Rolling from hot side 152 mm (6 inch) away from joint	6	100	Slight (100)	Crack has spalled at some places
Tapered (12:1) joint without tack coat	3-6	95	Slight (100)	Crack has spalled at some places
Tapered (12:1) joint with tack coat	3-6	100	Slight (80)	Crack has spalled at some places
Edge restraining device	3	90	Slight (80)	Crack has spalled at some places
Cutting wheel with tack coat	6	100	Slight (80)	Crack has spalled at some places
Joint maker	3-6	100	Slight (80)	Crack is braided at some places

techniques were ranked as follows from best to worst.

- Edge restraining device
- Tapered (12:1) joint with tack coat
- Tapered (12:1) joint without tack coat
- Joint maker
- Cutting wheel with tack coat
- Rolling from hot side
- Rolling from hot side 152 mm away

- Rolling of cold side

There are only subtle differences in the performance of all test sections. This may have happened because all joints were made as butt joints (without any overlap) and the average density at the joint in all test sections was relatively lower than normally expected. Tapered joint may have performed better if a vertical offset was provided like in the Michigan project. The tacked tapered joint performed slightly better than the untacked tapered joint. The performance or ranking of the joints appears to have been influenced generally by the overall density at the joint. Of the three rolling techniques tried, rolling from hot side gave the best joint after 4 years followed by rolling from hot side 152 mm (6 inch) away from the joint.

Test Results And Analysis, Colorado Project

The joint construction techniques were ranked statistically according to the joint density values. Duncan's Multiple Range Test was used to group the different techniques (7). The average joint densities and groupings are shown in Figure 5. The technique with 3:1 taper and 25 mm offset produced the highest density, followed by cutting wheel with tack coat. Surprisingly, the technique of rolling from hot side produced the lowest density when the unconfined edge of the cold mat had a 3:1 taper in this project. No density measurements were made in the test section where rubberized asphalt tack coat was used.

Visual Evaluation of Colorado Project

The last visual inspection was made on May 21, 1996 about 2 years after construction. The observations are given in Table 4. The seven different types of longitudinal joint construction

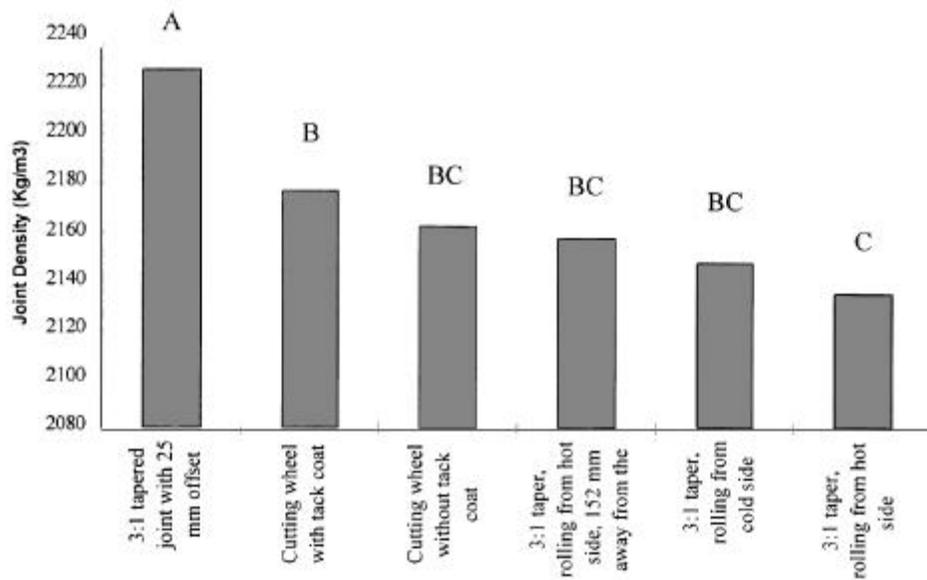


Figure 5. Joint density in Colorado project (letters indicate ranking of construction technique; means within the same ranking group do not differ at significance level (α) of 0.05).

techniques evaluated on this project were ranked as follows from best to worst.

- Tapered (3:1) joint with 25 mm vertical offset
- Cutting wheel with tack coat
- Rubberized asphalt tack coat
- Cutting wheel without tack coat
- 3:1 taper, rolling from hot side 152 mm (6 inch) away from joint
- 3:1 taper, rolling from hot side
- 3:1 taper, rolling from cold side

The performance or ranking of the joints seems to have been influenced generally by the overall density at the joint. These rankings are likely to change in the future based on the long-

Table 4. 1996 Visual Evaluation of Colorado Project (May 1996)

Technique Used	Cracking at the Joint		Raveling of Mat on Cold Side: Severity and % Length	Average Rating*	Comments
	% Length	Av. Width (mm)			
Rolling from hot side (3:1 taper)	65	3-6	Slight to moderate - 100%	4.4	Cold Side has longitudinal crack 152 mm (6 in.) away from the joint; snow plow damage on the hot side.
Rolling from cold side (3:1 taper)	80	6	Slight to moderate - 100%	2.4	Worse than section rolled from hot side.
Rolling from hot side 152 mm (6 in.) away from joint (3:1 taper)	10	3	None to slight - 20%	8.0	Better than section rolled from hot side.
Cutting wheel with tack coat	3	3	None	8.7	Good joint.
Cutting wheel without tack coat	5	3	None to slight	8.1	Good joint.
Tapered (3:1) joint with 25 mm vertical offset	10	3	None	8.8	Good Joint. Joint is mostly invisible. Cracks on each end of the test section.
Rubberized asphalt tack coat	4	3	None to slight	8.4	Good joint.

*Average of 5 evaluators on a scale of 1 to 10 (1 = poor, 10 = good)

term performance (in terms of cracking and raveling). Of the three rolling techniques tried, rolling from the hot side 152 mm (6 inch) away from joint seems to be the best at this time followed by rolling from the hot side. The rubberized asphalt tack coat technique has given very satisfactory

results during two years in service. However, the advantages, if any, of applying heavy tack coat on the unconfined edge of the first lane will most likely be evident after a few years in service.

Test Results and Analysis, Pennsylvania Project

The joint density values were used to group the different joint construction techniques. The rankings were done by Duncan's Multiple Range Test. Figure 6 shows the results. The edge restraining device produced the highest density followed by cutting wheel with tack coat, joint maker, and rolling from cold side techniques, all of which produced similar densities. Rolling from hot side 152 mm (6 inch) away from joint and rolling from hot side produced the next lower densities, followed by the rubberized asphalt tack coat and NJ wedge (3:1) techniques.

Visual Evaluation of Pennsylvania Project

The last visual inspection was made on July 18, 1996 about one year after construction. The observations are given in Table 5. No test section has developed any cracking at the joint after the first severe winter. However, some test sections have developed some raveling right at the joint in variable widths ranging from 0 to 75 mm (0 to 3 inch). The eight techniques were ranked and grouped as follows from best to worst.

- Cutting Wheel
- Rubberized asphalt tack coat
- Rolling from hot side
- Joint maker
- Rolling from hot side 152 mm (6 inch) away from joint

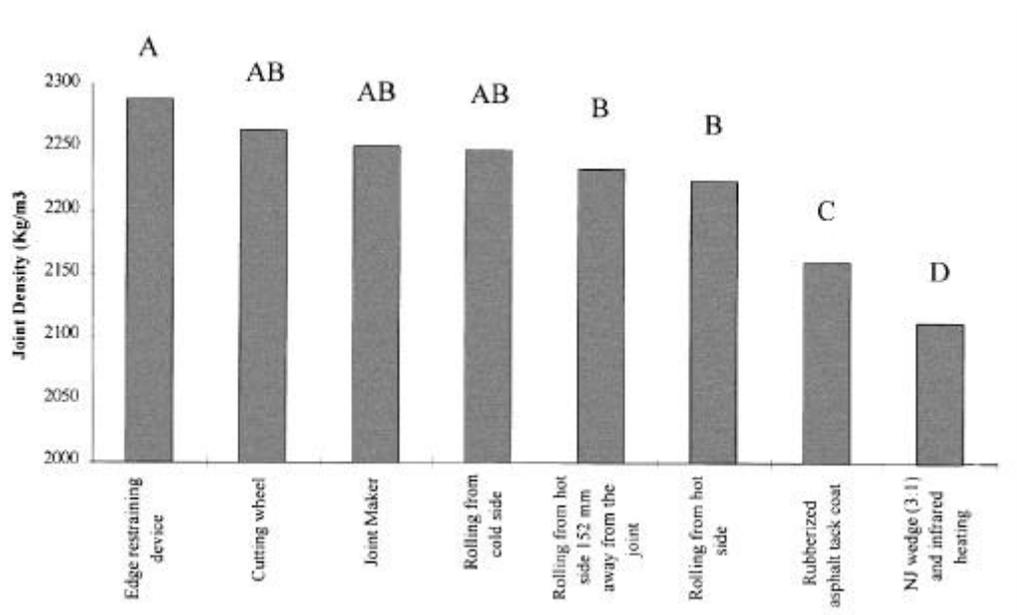


Figure 6. Joint density in Pennsylvania project (letters indicate ranking of construction technique; means within the same ranking group do not differ at significance level (α) of 0.05).

- Rolling from cold side
- Edge restraining device
- New Jersey wedge 3:1 with infrared heater

Although the edge restraining device section has high average density at the joint, its performance appears to be dependent upon the experience of the roller operator who has to keep the device properly aligned and pressed against the unconfined edge. The middle portion of this section is very good.

These one-year rankings are likely to change in the future based on the long-term performance (in terms of cracking and raveling).

Table 5. Visual Evaluation of Pennsylvania Project (July 1996)

Technique Used	Cracking at Joint	Raveling at Joint	Raveling of Adjacent Cold Mat	Average Rating*	Comments
Joint maker	None	Slight, 0-20 mm wide, 10%	None	8	Joint is visible
Rolling from hot side	None	None to slight, 0-20 mm wide, 1%	None	10	Joint is not visible at most places
Rolling from cold side	None	Slight to moderate, 25-50 mm wide, 60%	None	5	Joint is partially visible
Rolling from hot side 152 mm (6 inch) away from joint	None	Slight, 0-25 mm wide, 30%	None	6	Joint is partially visible
Cutting wheel with tack coat	None	None to slight, 1%	None	10	Joint is partially visible
Edge restraining device	None	Moderate, 25-75 mm wide, 70%	None	4	Middle portion looks very good
Rubberized asphalt tack coat	None	None to slight, 1%	None	10	Joint is not visible at most places
NJ Wedge (3:1) and infrared heating	None	Moderate, 25-75 mm wide, 80-90%	None	3	Joint is mostly visible

*Average of 5 evaluators on a scale of 1 to 10 (1 = poor, 10 = good)

CONCLUSIONS AND RECOMMENDATIONS

Thirty test sections were constructed in Michigan, Wisconsin, Colorado, and Pennsylvania to evaluate the effectiveness of 12 different longitudinal joint construction techniques. These test sections were evaluated in 1996 after one to four years in service. The following conclusions can be drawn at the present time from this research project.

1. The performance ranking of the different joint construction techniques appears to have been influenced by the overall density at the joint obtained by the technique. The joints with high densities generally show better performance than those with relatively low densities.
2. On Michigan project, the Michigan joint (12.5 mm vertical offset and 12:1 taper) has given the best performance after three years in service.
3. On Wisconsin project, the edge restraining device and the Michigan joint have given better performing joints after four years in service.
4. On Colorado project, the tapered joint (25 mm vertical offset and 3:1 taper), the cutting wheel, and the rubberized tack coat (joint adhesive) have given better performing joints after two years in service.
5. On Pennsylvania project, the cutting wheel, the rubberized tack coat (joint adhesive), and rolling from hot side have given the best performance after only one year in service.
6. Among the three different joint rolling techniques used in all four projects, rolling the joint from hot side generally gave the best performance followed by rolling from hot side 152 mm (6 inches) away from the joint.

These projects will be visually evaluated for at least five years after construction. The

performance rankings reported in this paper are likely to change in the future based on the long-term performance (in terms of cracking and raveling). However, at this time the following general recommendations are made:

1. The Michigan joint (12.5 mm vertical offset and 12:1 taper) has the best potential of obtaining a satisfactory longitudinal joint. The vertical offset is considered very essential to its performance.
2. Both cutting wheel and the edge restraining device have a good potential of obtaining a satisfactory joint. However, these techniques are operator dependent and, therefore, may not give consistent performance results.
3. The hot side should always overlap the cold side by 25-38 mm (1-1½ inch) at the joint. A butt joint is not desirable.
4. Rolling of the longitudinal joint should be done from the hot side with a vibratory roller as soon as possible. The objective should be to obtain the highest possible density at the joint to ensure best performance.
5. Paver manufacturers should consider attaching a steel plate to the paver screed to obtain a Michigan type wedge or taper joint, and installing some additional tamping or vibrating mechanism near the edge of the paver screed to obtain a relatively high density in the unconfined wedge or taper. The preceding modifications to the paver will make the longitudinal joint construction less dependent upon the paver and roller operators.
6. Highway agencies should specify minimum compaction levels to be achieved at the longitudinal joint. This will further ensure best possible performance of the longitudinal joint. It is recommended that the density at the joint be not more than two percent lower

than the density specified in the lanes away from the joint.

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