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Improvement of Widening Joint Design and Construction Practices for Flexible Pavements

Florida DOT Project #BDX93

FINAL REPORT

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EXECUTIVE SUMMARY

Few guidelines exist statewide, or even nationwide, for assisting designers in selecting appropriate roadway widening techniques. Current Florida Department of Transportation (FDOT) specifications provide a basic framework for widening hot-mix asphalt (HMA) pavements. However, the existing guidance does not address alternative construction techniques and treatments used in current practice for constructing more durable longitudinal joints.

This report identifies factors impacting the performance of flexible road widening with a focus on the longitudinal joint between existing pavements and new widening sections. A review of available literature related to lane widening of HMA roadway pavements was conducted, and an eight-page questionnaire was developed and distributed to State highway agencies (SHAs), research centers, and industry to determine the state-of-the-practice regarding the design and construction of longitudinal joints in widened roadway sections.

The following is a summary of recommendations for longitudinal joint design and construction from practices identified in literature and responses to the questionnaire:

Planning and Design

1. Match widened design sections to existing pavement sections. This will typically provide good functional results if drainage is provided for, and if the existing section is structurally adequate.
2. Perform thorough site investigations. Pavements often differ from design, and undocumented widenings may have been performed by maintenance in the past. Compare plans with core samples and ground penetrating radar (GPR) surveys. Deflection testing and a field survey to identify distress types, severities, and locations are strongly recommended. Widening a weak pavement may be false economy.
3. Consider using less permeable surface mixes by using the smallest nominal maximum aggregate size (NMAS) mix that is appropriate, using a finer gradation, and lower design air void level for additional binder. Use lift thicknesses that are a minimum of four times the NMAS of coarse gradation mixes and three times the NMAS for fine gradation mixes.
4. Pay for tack coat as a separate bid item to facilitate having a sufficient amount of material applied.
5. Use concrete base in sections where widening is less than 4 feet wide.
6. Consider full depth reclamation and overlay for widening severely deteriorated pavements. This practice is popular in Texas. Texas reclaims, widens, and cement stabilizes the existing pavement material and uses it as a strong subbase followed by a flexible base with a two-course surface treatment or hot-mix asphalt depending on the traffic needs.

Joint Type and Location

1. Avoid placing the joint in a wheel path. Consider shifting widening to one side of the roadway to prevent this condition.
2. Mill or cut back existing pavement a sufficient distance to reach more stable and workable face to compact material against. This will also allow more space for suitable

compaction equipment. Milling equipment may produce more even cut lines and cleaner joint faces than grader blades.

3. Stagger widening joints into the existing pavement to avoid constructing a weak vertical plane into the pavement cross-section. Offset vertical joints at least 6 inches apart between successive layers.
4. Consider using notched or wedge joints. These joints are more effective at preventing reflective cracking, differential settlement, and have shown better performance than traditional butt joints. Wedge joints require slightly higher operator proficiency to construct. All have been successfully used on recent widening projects in Wyoming.
5. Overlay the existing pavement and widened section to bridge and improve the performance of the widening joint.

Placing Hot-Mix Asphalt

1. A joint matcher provides the best means of placing material at the correct depth to match cold joints. This is most optimal when paving the surface lift.
2. Material from the second pass should overlap joints that have been milled or cut back by approximately 0.5 inch. Notched wedge joints should have 0.5 to 1.5 inches of material overlap. Avoid luting or raking the overlapped material.
3. Remove excess overlapped material with a flat-end shovel. Do not broadcast material across the mat.
4. Paver auger gates and tunnels should be extended to within 12 to 18 inches of the end gate to ensure material is not being pushed and segregated. The vibrator screed should be turned on all the time.

Joint Compaction

1. Build up hot-side of the joint so that the surface is approximately 0.1-inch higher after rolling. This ensures the joint was not starved of material or bridging of the roller occurred.
2. Compact the confined edge of a joint with the first pass of a vibratory roller drum on the hot mat, but stay back from the joint 6 to 8 inches on the first pass. Overlap onto the cold mat 4 to 6 inches on the second pass.
3. Use a rubber tire roller when intermediate rolling to knead loose material into the joint. Straddle the joint with the back outside tire, and align the front outside tire just inside the edge of the joint.

Joint Treatments

1. Hot-applied rubberized asphalt joint adhesives are the best material for improving joint performance; however, they are costly.
2. Double tack joint faces when using an asphalt emulsion.
3. At minimum, tack the vertical face of the joint with the same material being used to tack the mat.
4. Apply a surface sealer product or overband joints with densities less than 92% of TMD with a PG binder to increase longevity of joint.
5. Infrared joint heating has proven to increase compaction at the joint by 1 to 2% in Tennessee, Canada, and New England. This treatment is most beneficial in cold weather paving.

6. Keep longitudinal cracks that appear at the joint sealed.

Quality Control

1. Ensure satisfactory materials are used. Monitor and control subgrade moisture and density.
2. Conduct a pre-paving meeting to discuss methods to be employed during construction for ensuring proper construction of the longitudinal joint. Discuss the joint type to be used and role each paving crew member has in achieving good joint density.
3. Determine optimum rolling pattern for density at the joint, and construct a test strip.
4. Monitor density in the field with a nuclear density gauge correlated to cores. Recommend placing the gauge parallel to the joint and offsetting the gauge 2 inches from the joint to ensure the gauge is seated. Take an average of 2 or 4 one-minute readings. Rotate the gauge 180-degrees between each reading.

In addition to this technical report (product of Tasks 1 and 2), the contract for Project # BDX 93 called for the development of a guide document (Task 3) for the design and construction of the longitudinal joint in lane widening projects. Additionally, an implementation plan was prepared that can be used to put the new technology into practice. These documents are attached to this report as special appendices, such that they can be separated as stand-alone documents.

INTRODUCTION

Purpose and Scope

The purpose of most lane widening projects is to enhance mobility, improve traffic flow and increase safety. Additional highway lanes, safety improvements, and traffic feature additions, such as turn lanes, are often required to increase traffic volume or address unforeseen conditions not accounted for in the original design. A successful road widening project is a function of many of the key factors and considerations listed below:

- Longitudinal Construction Joints
- Performance of Joint Between Existing Pavement and Widening Lane
- Stabilization of Subgrade and Pavement Layers
- Pavement Edge-drains and Subsurface Drainage
- Pavement Edge Drop-Offs
- Geosynthetic Reinforcement
- Construction Techniques and Equipment
- Embankment Widening

The weakest link will define the lifetime of the structure. If just one consideration is neglected, significant failures may occur. Normally defects are not generally apparent immediately after construction; however, the effectiveness of the widening usually becomes clear after a period of time. Design and construction guidelines are needed to help designers decide when project restrictions require deviation from “best practices”.

Few guidelines exist statewide, or even nationwide, for assisting designers in selecting appropriate widening techniques. Current Florida Department of Transportation (FDOT) specifications provide a basic framework for widening hot-mix asphalt (HMA) pavements. However, the existing guidance does not address alternative construction techniques and treatments used in current practice for constructing more durable longitudinal joints in widened roadway sections.

The purpose of this report is to identify factors impacting the performance of flexible road widening with a focus on longitudinal joints between the existing pavement and the new lane widening pavement. This report contains a review of available literature related to lane widening of HMA roadway pavements. Documents reviewed are referenced within the report, and the review is organized by the bulleted factors and considerations shown above.

LITERATURE REVIEW

Flexible Pavement Longitudinal Construction Joints

FDOT (2008)[11]

Guidance provided in the 2008 FDOT Flexible Pavement Design Manual lacks details and descriptions of what engineers must explicitly specify and put into design drawings for road widening. The guidance requires longitudinal joints to be offset 6 to 12 inches and located away from wheel paths. Hot-mix asphalt structural layers are to be brought up to the top of the existing asphalt layers. Then an overlay can be constructed full width over the existing roadway and the widening to minimize the possibility of a longitudinal crack at this joint. In some cases, a leveling course can be placed on the existing roadway prior to the base widening being constructed; though, it may be desirable to place the leveling over both the main roadway and the widening area to remove construction variances.

Zinke et al. (2008) [29]

Connecticut has observed longitudinal cracks opening in flexible pavements that are constructed with traditional butt joints. Zink et al. conducted a study comparing the densities of traditional HMA butt joints and alternative notched wedge joints, shown in Figure 1, constructed over 10 resurfacing projects in Connecticut between 2006 and 2007. Nine of the 10 projects were constructed with butt joints. One project utilized the notched wedge joint exclusively, and two of the projects included both the notched wedge joint and butt joint.

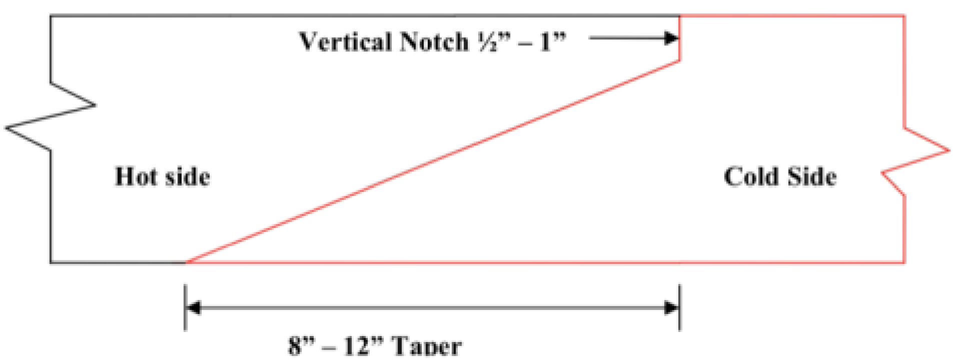

Figure 1. Alternative notched wedge joint.

Traditional butt joints were constructed by aligning the edge of the second paver pass with the edge of the first paver pass and maintaining an overlap of 1.0 to 1.5 inches of hot material from the second pass to ensure an adequate amount of material for compaction. Notched wedge joints were formed by using a paver wing attachment for extruding the edge shape (Figure 2) and a vibrating plate compactor attached to the paver to compact the wedge (Figure 3).

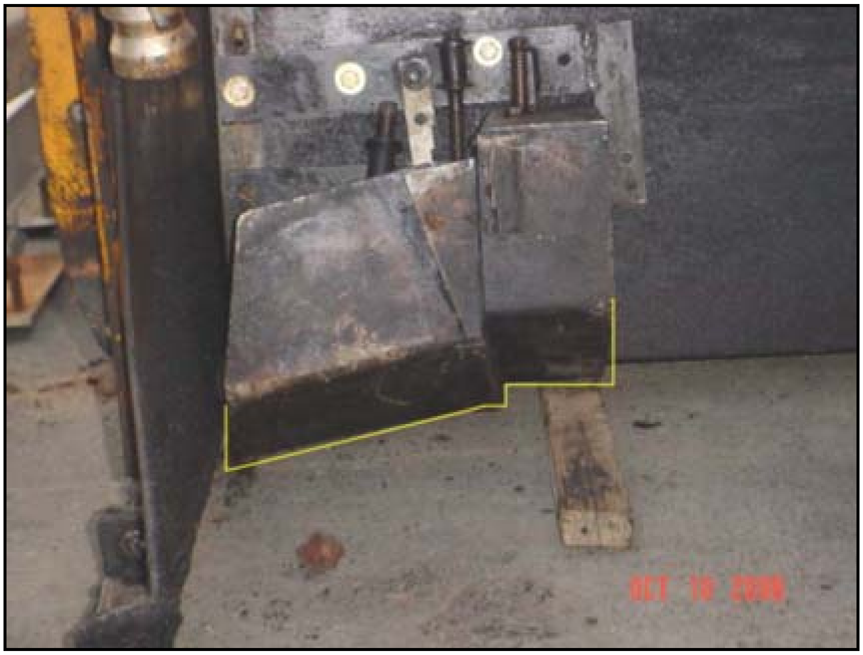

Figure 2. Notched wedge forming device.

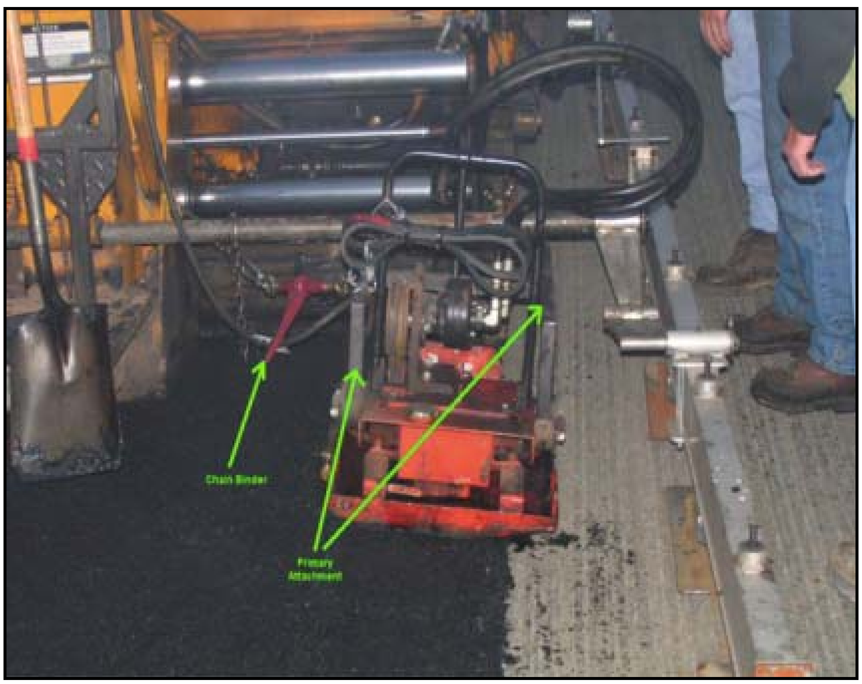

Figure 3. Wedge compaction device.

Six-inch cores were taken on the joints and at 6 and 12 inches on either side of the joints at random locations at each site. A total of 155 cores were taken. Density averages calculated at the following locations for each joint type:

- Location A: One-foot from the cold side of the joint
- Location B: Six-inches from the cold side of the joint

- Location C: Centered over the joint
- Location D: Six-inches from the hot side of the joint
- Location E: One-foot form the hot side of the joint

Results are provided in Table 1.

Table 1. Comparison of butt and wedge joint densities.

Butt Joint Measurement Location	A	B	C	D	E
Sample Size	38	29	26	39	39
Average Density	89.9	87.4	85.6	90.4	91.2
Notched Wedge Joint Measurement Location	A	B	C	D	E
Sample Size	15	14	11	15	14
Average Density	90.3	89.0	88.8	89.2	90.0

The notched wedge joint provided a higher overall density directly over the joint. Material on the hot side of the joint was denser with both construction methods as expected. The notched wedge joints provided more uniform densities over the inspected areas than the butt joints did. This was particularly evident in the location 6-inches on the cold side as well as directly on the joint location itself.

The authors reported the use of the notched wedge joint did not impede the paving process during the three investigated pilot projects and assumed crews will also become more familiar and efficient with this process as they gain experience with it.

Buncher and Rosenberger (2012)[3]

Hot-mix asphalt longitudinal joint failures are the result of low density, permeability, segregation, and lack of adhesion at joint interfaces. A 2009 Federal Highway Administration (FHWA) survey of their divisional offices found that approximately half of their engineers are unhappy with their state's longitudinal joint performance. There is a wide variation regarding how states address longitudinal joints in their specifications. Two-thirds of states have specifications for longitudinal joint construction. Half of those are prescriptive specifications and the other half are performance specifications requiring longitudinal joint densities ranging from 88 to 92 percent of theoretical maximum density. Buncher and Rosenberger developed a series of best practices for specifying and constructing HMA longitudinal joints based on the following:

- Analysis of an FHWA survey to their state Division Offices on specifications, methods, and performance of longitudinal joints
- Review of existing literature and research
- Identification of areas where there is consensus and areas where there is not
- Interviews with acknowledged paving experts and contractors
- Visits to states that have implemented a longitudinal joint specification

A summary of the longitudinal joint best practices recommendations for design, paving, joint treatments, compaction, testing, and specifications reported are provided below.

Design

- Stagger longitudinal joints horizontally between layers by at least 6-inches. This practice does not apply when placing HMA over jointed portland cement concrete (PCC).
- Do not place longitudinal joints in wheel paths.
- Have well-defined specifications for the placement and quality assurance testing of longitudinal joints
- Use lift thicknesses that are a minimum of four times the nominal maximum aggregate size (NMAS) of coarse gradation mixes and three times the NMAS for fine gradation mixes.
- Consider using less permeable surface mixes by using the smallest NMAS mix that is appropriate, using a finer gradation, and lower design air void level for additional binder.
- Pay for tack as a separate bid item to facilitate having a sufficient amount of material applied.
- Applying surface sealer products at widths of 1 to 2 feet, or "overbanding" with a PG binder at a width of approximately 4 inches will increase the longevity of joints not meeting a minimum density requirement.

Paving

- Control mix segregation.
- Maintain constant paver speed.
- Place straight pilot lanes.
- Use a paver joint matcher mounted a few feet in front of the auger, most optimal when paving surface lift.
- Auger gates and tunnels should be extended to within 12 to 18 inches of the end gate to ensure material is not being pushed and segregated.
- Firmly seat end gate on existing pavement surface.
- Vibrator screed should be turned on all the time.
- Use a 1-inch joint overlap when closing butt or notched wedge joints. Use 0.5-inch overlap if joint is milled or cut back.
- Remove excess overlapped material with a flat-end shovel, and avoid luting or raking overlapped material.
- Do not broadcast excess material across the mat.
- Build up hot-side of the joint so that the surface is approximately 0.1-inch higher after rolling.

Joint Treatments

- Infrared joint heaters can improve joint density by 1 to 2%. These are most beneficial in cold weather paving.
- Hot-applied rubberized asphalt sealant joint adhesives, though costly, are the best material for improved joint performance.
- Double tack joint faces when using an emulsion.
- PG binders provide greater residual binder.

- At minimum, tack the vertical face of the joint with the same material being used to tack the mat.

Compaction

- Use a vibratory roller drum extended approximately 6-inches over the unconfined edge of the mat on the first pass.
- Compact the confined edge of a joint with the first pass of a vibratory roller drum on the hot mat, but staying back from the joint 6 to 8 inches on the first pass. Overlap onto the cold mat 4- to 6-inches on the second pass.
- Use rubber tire roller when intermediate rolling to knead loose material into the joint. Straddle the joint with the back outside tire and align the front outside tire just inside the edge of the joint.
- Do not operate rubber tire rollers near the unsupported mat edge due to excessive lateral movement.

Testing and Specifications

- Contractor's quality control program should include:
  - Constructing a longitudinal joint as part of the test strip.
  - Determining an optimum rolling pattern for compaction at the joint.
  - Monitoring joint compaction with a density gauge offset 2-inches from the visible joint. Two or four 1-minute readings should be averaged at each location, with the gauge being rotated 180-degrees between readings. The gauge should be calibrated to mat cores.
- The following pay scale for longitudinal joint density is recommended:
  - ≥ 90% of TMD: earns 100% pay.
  - ≥ 92% of TMD: earns maximum bonus.
  - Between 92% and 90% TMD: pro-rated bonus.
  - < 90% of TMD: reduced pavement, and require the joint be sealed by either overbanding (with a PG binder) or a surface seal product.
- Overband or use a surface sealer on joint densities less than 92% TMD.

Kandhal and Mallick (1997) [21]

Thirty pilot HMA test sections were constructed between 1992 and 1995 on roadways in Michigan, Wisconsin, Colorado, and Pennsylvania to evaluate the performance of twelve longitudinal joint construction techniques. Test sections were evaluated after one to four years of being in service. The joint construction techniques evaluated are provided in Table 2.

Table 2. Longitudinal joint techniques evaluated.

	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 visual inspection of the joints was performed on the Colorado project after 2 years in service, on the Michigan project after 3 years in service, on the Wisconsin project after 4 years in service, and on the Pennsylvania project after 1 year in service.

Rolling the joint from the hot side gave the best performance followed by rolling from the hot side 6-inches away from the joint. The 0.5-inch (12.5-mm) notch with 12:1 taper, also known as the Michigan joint, had the best potential of obtaining a satisfactory joint. The notch was described as being essential to joint performance. The edge restraining device and cutting wheel were both effective at producing a satisfactory joint; however, these techniques are subject to operator skill. The authors recommend always overlapping the cold joint with 1 to 1.5 inches of material on the second pass and rolling the joint with a vibratory roller as soon as possible to obtain the highest possible density. Highway agencies are recommended to specify joint density to be not less than two percent of density specified in the lanes away from the joint.

Scherocman (2004)[27]

Scherocman identified causes of poor flexible pavement joints and provided general guidelines for construction of durable longitudinal joints between traffic lanes and between the mainline pavement and the adjacent roadway shoulder. He suggests that care must be taken to accomplish the following four primary tasks:

1. Compaction of the unsupported edges of the first lane paved (cold side)

HMA densification is typically more difficult to obtain on the cold side of a joint compared to the hot side (second lane paved) of the same joint due to difficulties compacting the unsupported edge of the first lane placed. Adequate compaction of the unsupported edge of the first lane of pavement placed is one of the keys to the construction of a durable longitudinal joint. In most cases, the slope of the outside edge of the mix should be controlled by an edger plate or the end of the paver screed. Scherocman recommends placing the mat with a 60 degree edge taper.

A pneumatic tire roller should not be used within 6 inches of the unsupported edge of the lane to prevent pushing the mix sideways due to the high pressure rubber tires. Scherocman suggests using a steel wheel roller in lieu of a pneumatic tire roller to compact HMA at the joint on the first lane for this reason.

If the edge of the drum of the steel wheel roller is positioned inside the unsupported edge of the pavement lane, the mix has a tendency to widen out, and a crack will typically form at the edge of the drum shown in Figure 4.

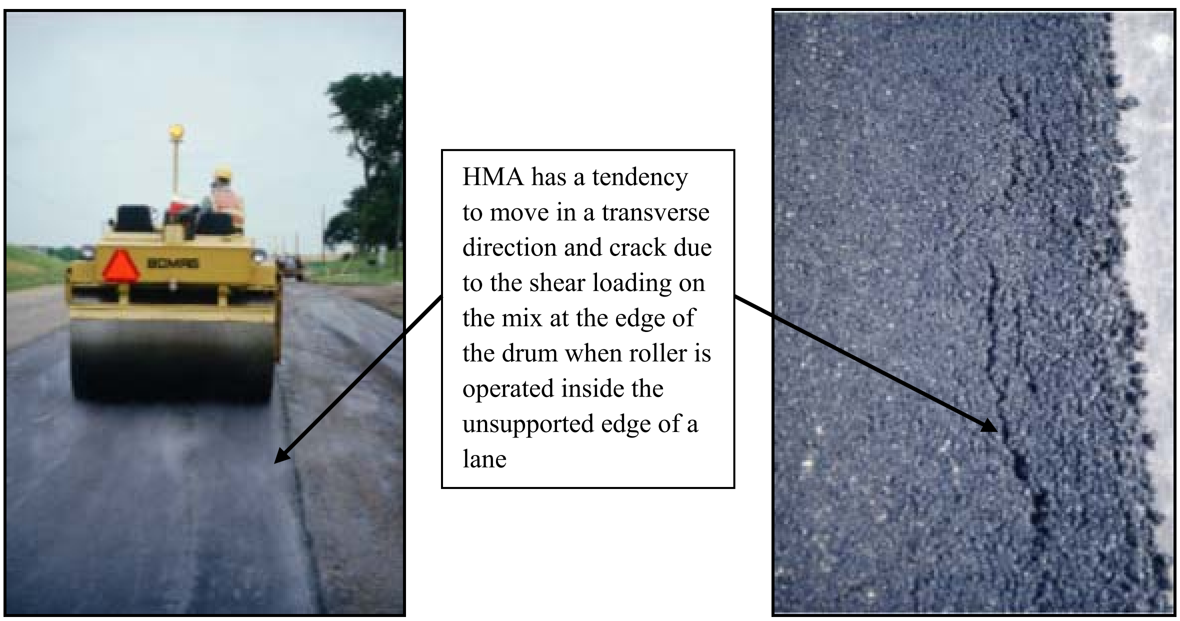

Figure 4. Operating roller drum edge inside the edge of unsupported pavement lane.

Placing the edge of the steel drum directly over the unsupported edge will usually prevent the crack from forming at the edge of the roller drum; however, the mix at the unsupported edge of the drum will still move transversely under the force of the roller. This transverse movement of the mix will hinder densification of the mix at the unsupported edge.

According to Scherocman, the proper location for edge of the steel drum should be extended over the edge of the lane by approximately 6 inches, as shown in Figure 5, to mitigate both transverse movement of the mix and cracking.

Figure 5. Roller drum extended over unsupported edge of pilot lane.

2. Overlap of mix from the hot side of the joint over top of the cold side

The amount of overlap of mix from the hot side onto cold side is critical for two reasons:

- Excess mix placed over the edge of the cold side will have to be removed by raking the joint, or it will be crushed during compaction.
- A depression will occur on the hot side of the longitudinal joint if insufficient mix is placed over the edge of the cold side.

Scherocman recommends the proper amount of overlap should be 1 to 1.5 inches when placing an adjoining lane to a sloped lane formed by the edger plate of a paver screed. When placing a lane along the vertical face of a lane that has been milled, he recommends 0.4 to 0.6 inches of mix overlap.

Figure 6 illustrates both cases of excessive and proper overlap of mix from the hot side over the top of the cold side of the joint.

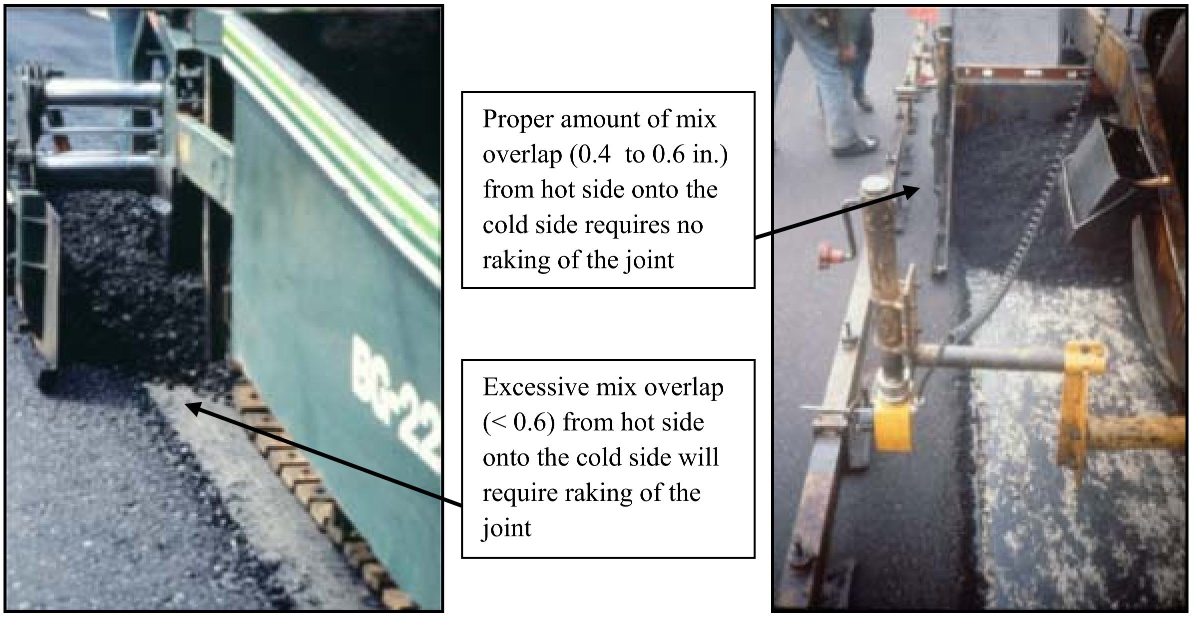

Figure 6. Mix overlap when placing second lane.

3. Raking of mix off the cold side of the joint

Raveling of the longitudinal joint is most often caused by excessive raking of the joint where mix needed at the joint is moved into the interior of the hot side of the joint. This problem usually occurs on the hot side of the longitudinal joint and can be prevented by placing the proper amount of mix overlapping the joint. No raking of the mix at the longitudinal joint is necessary if the proper amount of mix is placed. Improper raking of the longitudinal joint is shown in Figure 7.

Figure 7. Improper raking of the longitudinal joint.

4. Compaction of the joint between the two lanes

Scherocman reported that the practice of compacting longitudinal joints by rolling the joint from the cold side is inefficient for several reasons:

- Majority of the weight of the compaction equipment is on the previously compacted mix.
- The temperature of the newly placed HMA decreases as the roller is focused over the cold mix, reducing the opportunity to obtain the desired level of density in the new mix.
- The amount of compactive effort that can be applied to the mix at the joint is significantly reduced as a vibratory roller cannot be operated in vibratory mode on the cold side of the longitudinal joint.
- Only a minimum amount of the roller weight will be in contact with the mix at the joint if there is a different cross slope between the two lanes, such as when the joint is located at the crown of a roadway.

Compacting the longitudinal joint from the hot side of the joint, by either placing the drum of a steel wheel roller 10 in. over the top of the joint or the outside tire of a pneumatic tire roller directly at the joint is optimal. Figure 8 shows a steel wheel roller compacting longitudinal joints from both the hot side and cold side of the joint.

Figure 8. Techniques for compacting HMA longitudinal joints.

NAPA (2002)[19]

The National Asphalt Pavement Association (NAPA) reported on a National Center for Asphalt Technology (NCAT) study conducted in the early 1990s, where various joint techniques were studied, and cores were taken on both sides of the joint to determine where failures were occurring. The study found that an area of low density and high air voids, as annotated as C in

Figure 9, is created on the unconfined edge of the first lane placed. The area is located 6 to 8 inches from the center of the joint. This area of poor compaction allows water to enter, and freezing may break out the asphalt and lead to premature failure.

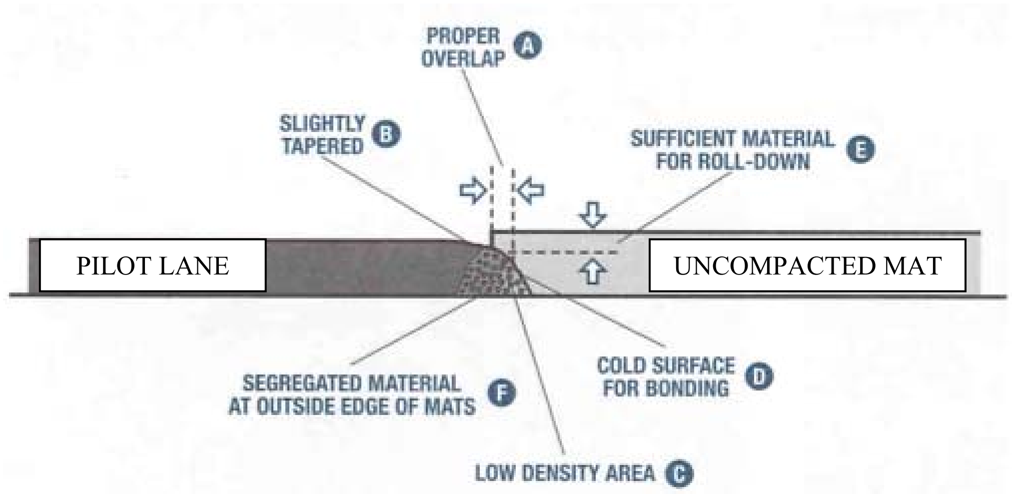

Figure 9. Low density area of longitudinal joint.

NAPA reported that several states have had good success with a tapered joint (similar to that reported by Zinke et al. 2008) to remedy the low density area. The tapered joint is shown in Figure 10.

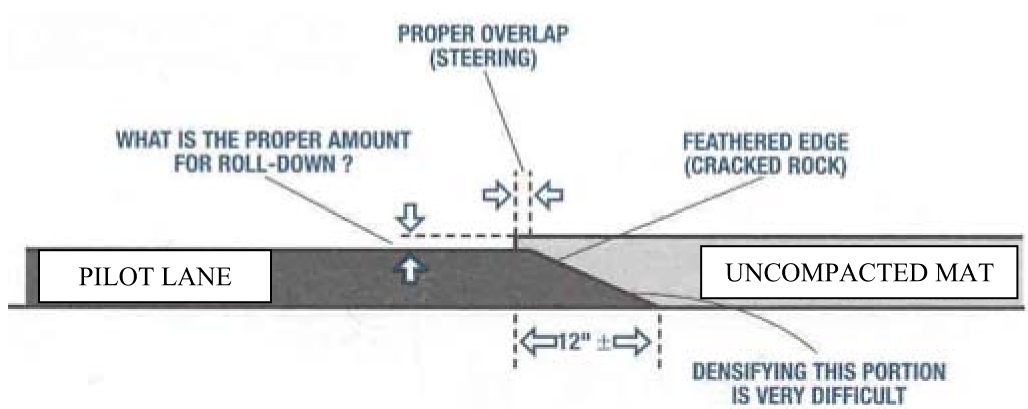

Figure 10. Tapered flexible joint.

Despite its success, NAPA discussed several concerns with the tapered joint technique:

- Densification of the tapered portion of the mat is difficult on the first pass
- Steering the paver is difficult with no definite edge to follow
- Maintaining overlap is difficult with this technique
- Aggregate particles may crack during compaction on the feathered edge areas
- The volume of material required for roll down changes along the taper

- It is inherently difficult to place material with tapers and ultimately compact a horizontal surface

Offei et al. (2013)[9]

The Wyoming Department of Transportation (WYDOT) conducted a comprehensive study of joint performance associated with lane widening; the research was conducted by the University of Wyoming and was a Federal Highway Administration (FHWA) sponsored project. The research looked at several methods for constructing the joint between the existing and new asphalt surface sections, including vertical, tapered, and stepped joints when widening an existing asphalt roadway.

Figure 11 shows the concept of the vertical joint where the cut begins from the top HMA layer and goes to bottom of the base layer. For this joint type, a tapered crushed base (CB) layer is constructed under 2 in. of hot plant mix (HPM) with hot plant mix leveling (HPML) course to match existing plant mix pavement (PMP) prior to a full width HPM overlay.

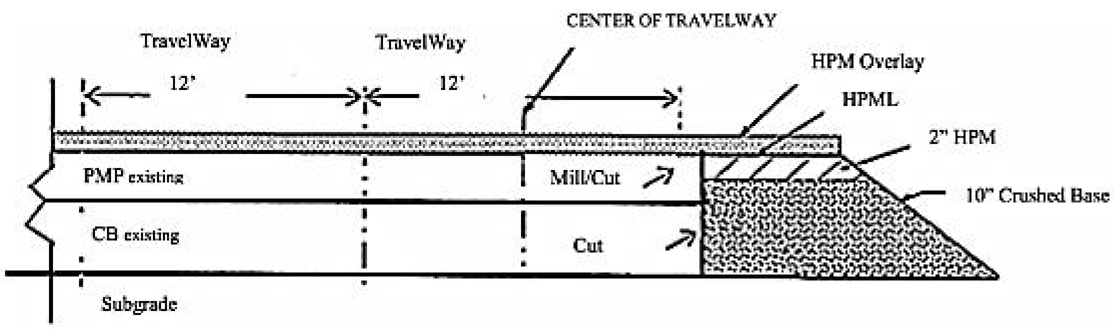

Figure 11. Vertical joint type.

Figure 12 illustrates the tapered joint type where part of the pavement is milled or cut vertically and then the remaining pavement of the asphalt and base materials are cut in a semi-vertical line that is greater than the angle of repose of the base material and greater than the existing surface taper.

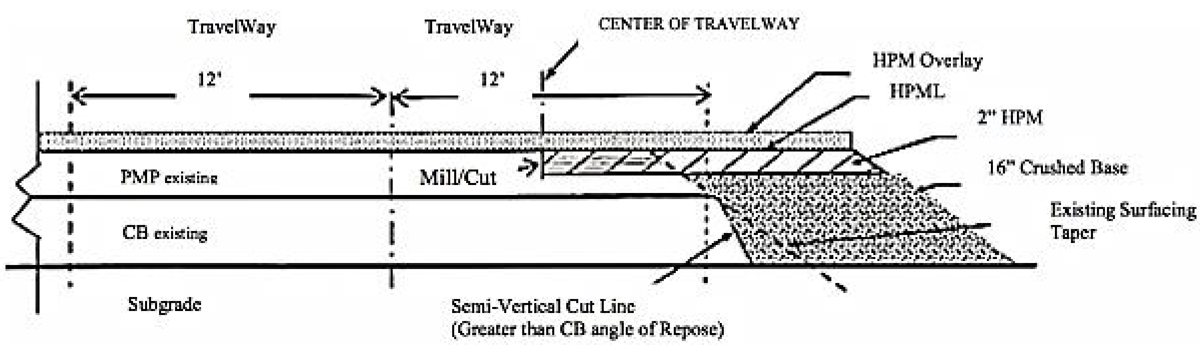

Figure 12. Tapered joint type.

A stepped or notched joint, where the existing HMA layer is vertically cut for its full depth and the base material is also vertically cut full depth is illustrated in Figure 13. Here the vertical cuts of the HMA and base layers are offset by 1 foot. The stepped joint concept is usually used for existing pavement sections that have cement treated bases (CTB) but is also used for non-treated, crushed bases as well.

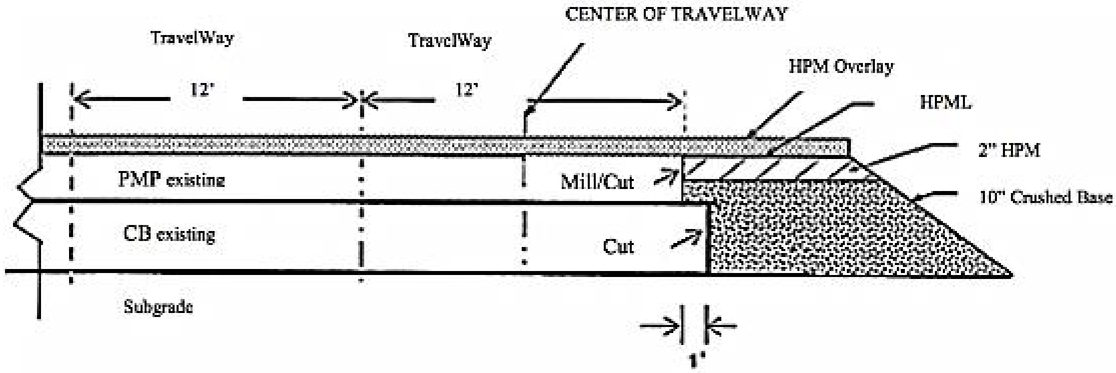

Figure 13. Stepped or notched joint type.

WYDOT currently uses all three methods of joint widening construction. The purpose of the research was to evaluate road widening projects to determine if there is a preferred joint construction method. Both the stepped and tapered joints offer cost savings as more of the existing pavement material is retained when compared to the vertical cut. A fourth method used for shoulder widening is to lay the asphalt directly over the existing base course taper.

Thirty projects were selected for evaluation of joint performance. Construction for most of the projects started in early 2012 and was completed in late 2012. All the newly constructed projects are on state highways. The research consisted of cracks and distress observations, field tests using falling weight deflectometer and dynamic cone penetrometer. The typical crack observed is shown in Figure 14.


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Figure 14. Typical longitudinal crack observed.

As part of the project, other state DOTs were contacted, and survey results were obtained from Colorado, Idaho, Montana, North Dakota, South Dakota, Nebraska, and Utah. The survey contained ten questions on type(s) of pavement joint construction technique(s) utilized by their agencies. Table 3 presents the preferences of the responding states for using the joint types shown in **Error! Reference source not found.**.

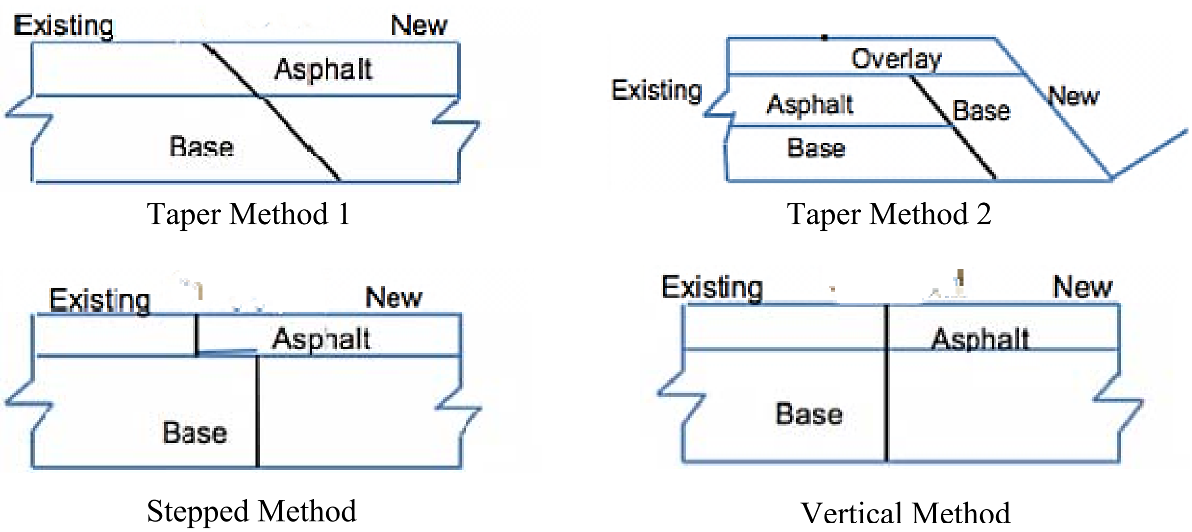

Figure 15. Joint types.

Table 3. Joint types preferred by indicated state DOTs.

Joint Type	CDOT	IDOT	MDOT	NDDOT	SDDOT	NEDOT
Tapered Method 1	X					
Tapered Method 2			X			
Stepped Method	X	X				
Vertical Method	X			X	X	X

Montana State Department of Transportation (MDOT) uses “Tapered Method 2” but with a widening overlay placed flush with the existing pavement surface and another overlay over the entire finished pavement surface. The reason for this variation is that shoulders are designed with 20-year pavement life based on the Equivalent Single Axle Loads (ESALs) within the travel lane. Nebraska State Department of Roads (NEDOR) uses a variation of the “Vertical Method”, but widening is carried out using recycling of the mainline (either partial or full depth), and thereafter the entire pavement is covered with overlay.

Tapered Method 1 and Tapered Method 2 are variations of the tapered widening joint (as shown in Figure 12). Tapered Method 1 has the base and asphalt of the widened section laid flush with the corresponding base and asphalt of the existing section. In the Tapered Method 2, widening base material is laid flush with the asphalt of the existing section and both sections covered with an overlay.

Distress for vertical widening joints was observed to be greater than those for tapered widening joints. Results show consistently more longitudinal cracks on vertical joint widening projects compared to tapered joint widening projects for each level of cracking severity.

Most of the deterioration occurred in the travel lane. Analysis of joints located in the travel lane (wheel paths) indicated significant differences between joints in and away from the wheel path. It was determined that joints located in the wheel path have more cracks along the joint lines compared to joints located away from the wheel paths.

Conclusions from the project indicate the tapered joint technique gives relatively better pavement strength compared to the vertical joint type. The vertical joint was determined to have an 18 percent increase in cost compared to the tapered joint due to retaining material in the taper area and the eliminating bituminous pavement cutting of the vertical joint.

Estakhri et al. (2001)[12]

Joint density tests were made on the longitudinal construction joint of several Texas highway pavements. The research indicated low density at the edge of the first paved lane. An example of this is shown in Figure 16, which is the mean density profile on Loop 323 in Tyler, Texas.

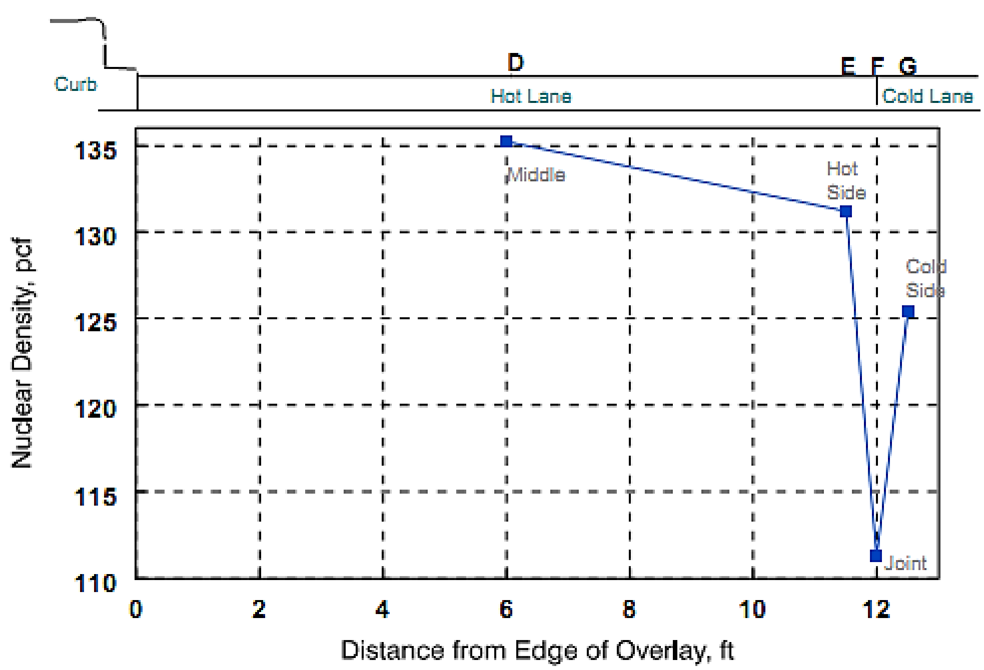

Figure 16. Mean density profile for Loop 323 in Tyler, Texas.

Keefe, T. J. (2014)[16]

Deterioration of the construction joint between existing roadway and widened sections has historically been an issue for pavement engineers and highway agencies and continues to be problematic for FDOT. As an example, this joint performance issue is occurring on a 3.7-mile segment of SR 400 (I-4) in Volusia County, FL where the original four-lane roadway was widened to six lanes in 2008. A typical section detail of the widening is shown in Figure 17. The existing roadway was widened fourteen feet to accommodate a new traffic lane and an additional two feet of inside paved shoulder. This modification shifted striping of the travel lanes so that the longitudinal widening constructing joint is situated beneath the right wheel path area of the middle lanes. A longitudinal crack from this underlying juncture propagated to the surface of the roadway in three to four years after construction concluded. This crack will likely worsen over time with continued traffic loading and moisture infiltration.

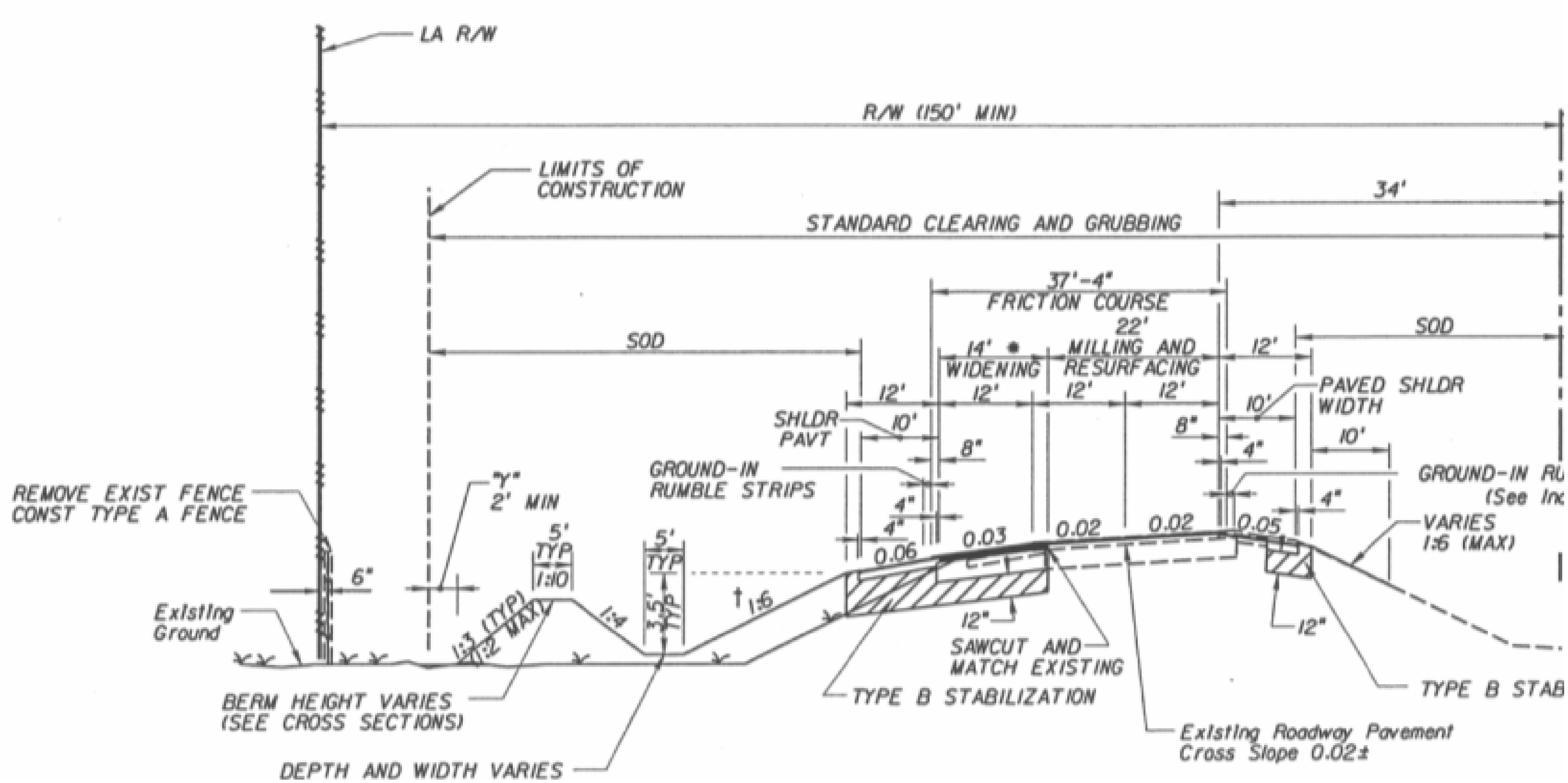

Figure 17. SR 400 typical widening section Volusia County, FL.

Keefe, T. J. (2012)[22]

A segment of SR 400 (I-4) in Seminole County, FL was widened from four lanes to six lanes in 1998. The new lane widening included a transition from inside the median area to outside the median area as shown in Figure 18.

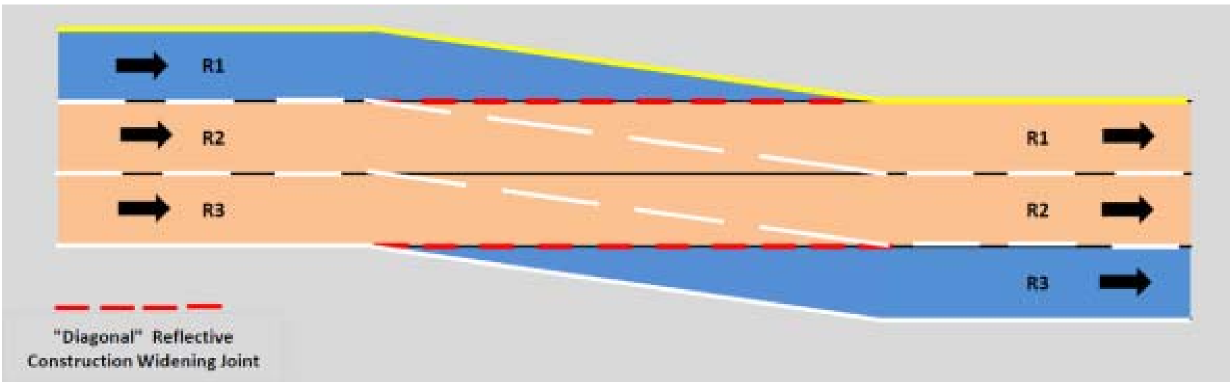

Figure 18. Seminole County SR 400 widening transitions.

A severe reflective joint crack was observed across the full diagonal width of the travel lanes in a 2012 survey, shown in Figure 19.

Figure 19. Diagonal reflective cracking in transition area of SR 400 widening.

FDOT *Pavement Survey and Evaluation Report: State Road 400 (I-4)* recommends the following rehabilitation technique for the inside/outside lane transition to minimize the reoccurrence of the reflective joint crack (Keefe, 2008)[17]:

1. Increased milling depth from 3.25 inches to 4.75 inches in the inside and outside lanes.
2. After milling, seal the remaining diagonal construction joint (crack) with a hot bituminous joint sealant.
3. Place a 1.5 inch structural asphalt lift in milled area.

4. Place a pavement reinforcement product (Tensar GlassGrid TF®) as an interlayer between structural asphalt lifts to strengthen pavement to bridge over the diagonal construction widening joint.

The Florida design team elected to perform a trench repair over the joint, similar to what has been done on the Florida Turnpike in the past, in lieu of using pavement reinforcement products. This project is currently under construction with anticipated completion in April 2015.

Stabilization of Subgrade and Pavement Layers

Little (1995)[23]

Three mix design methods for selecting optimum lime content for pavement subgrade and base stabilization are given in Little's *Handbook for Stabilization of Pavement Subgrades and Base Courses with Lime*. The methods discussed are the Thompson Procedure, Eades and Grim, and the Texas Procedure:

1. Thompson Procedure

   Conditions for the Thompson Procedure vary on the objectives of the stabilization and desired field service conditions. Minimum unconfined compressive strength requirements are specified in Table 4.

Table 4. Thompson Procedure minimum strength requirements for lime stabilization.

Layer Type	No Freeze-Thaw Activity (lb/in^2) (ASTM D-5102)	Freeze-Thaw Activity (lb/in^2) (ASTM D-5102)
Base	150	200
Subbase	100	150

   Thompson's mix design procedure is presented in Figure 20.

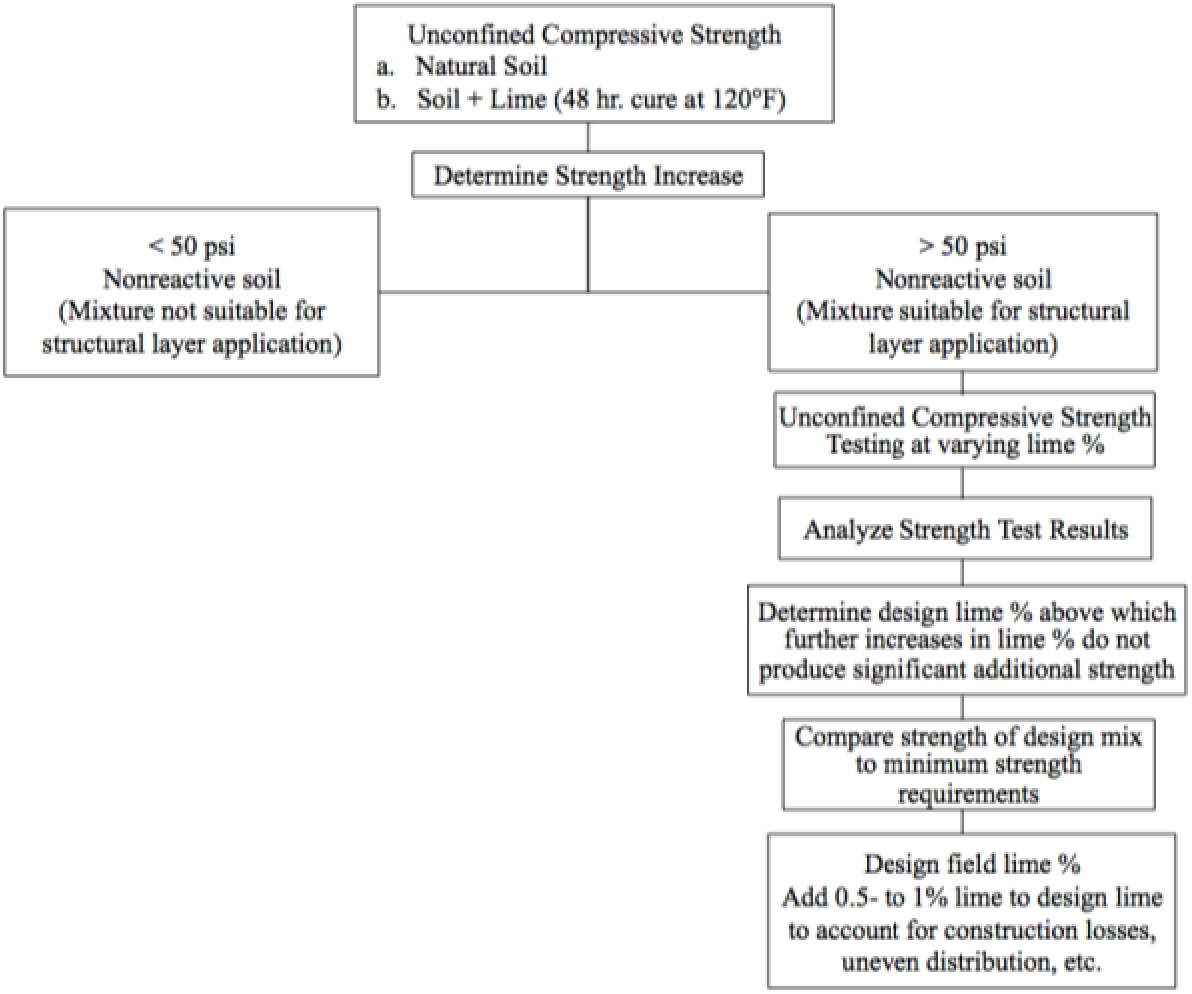

Figure 20. Mix design flow chart for Thompson Procedure.

2. Eades and Grim Procedure

   The Eades and Grim Procedure determines the least amount of lime required to produce a pH of 12.4 in a soil-lime mixture. This process is defined in ASTM D 6276 and is based on the idea that the addition of sufficient lime will satisfy the cation exchange capacity and all initial short term reactions, as well as provide a high enough pH to sustain the strength-producing lime-soil pozzolanic reactions.

3. Texas Procedure

   The Texas Procedure for determining optimum lime content for stabilization uses a chart based on plasticity index, percent soil binder, and pH to choose target lime content. Unconfined compressive strengths of 150 pounds per square inch (psi) for a stabilized base and 50 psi for a stabilized subgrade are recommended. The Texas Method is provided in *Tex-121-E*.

Hilbrich (2007)[15]

A 2007 multi-district survey within the Texas Department of Transportation (TxDOT) on pavement widening techniques found full depth recycling was the first alternative among many TxDOT districts for widening pavements in poor condition.

From gathered responses, Hilbrich made the following recommendations for full depth recycling projects:

- Limit the existing HMA surface being reworked into the existing base to less than 50 percent
- Cores should be taken from the existing pavement or ground penetrating radar (GPR) survey performed because existing material thicknesses can vary
- A complete laboratory investigation is highly recommended to develop the pavement design

Figure 21 shows a typical section for widening flexible pavements in poor condition using full depth recycling. Table 5 includes the recommended design criteria for TxDOT full depth recycling. Texas Triaxial Class 1 base is required to meet compressive strengths of 45 psi and 175 psi at confining pressures of 0 psi and 15 psi respectively. This specification is based on shear strength parameters of cohesion between 5 psi and 10 psi and a friction angle of 50°. Class L and M bases are required to meet a minimum 7-day unconfined compressive strength of 300 psi and 175 psi, respectively.

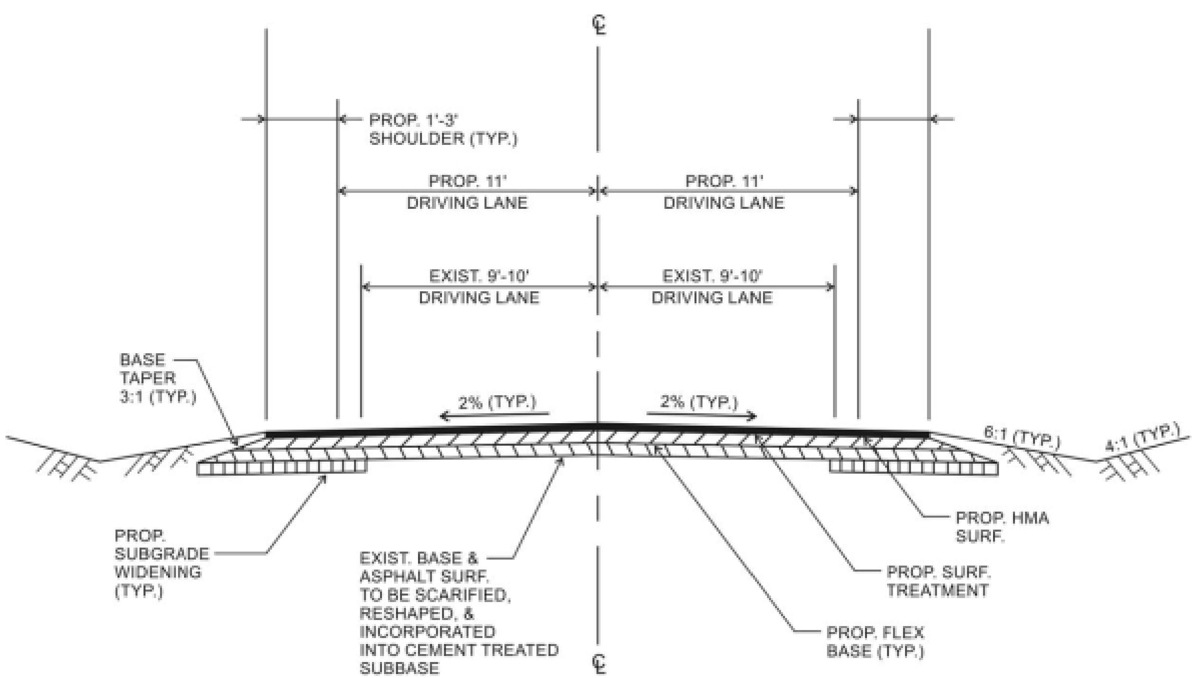

Figure 21. Widening flexible pavements in poor condition using full depth recycling.

Table 5. Recommended design criteria for TxDOT full depth recycling.

DISTRICT OBJECTIVE	BASE THICKENING	UPGRADE BASE TO CLASS 1	CREATE A SUPER FLEXIBLE BASE	CREATE A STABILIZED BASE (CLASS L)	CREATE A STABLIIZED BASE (CLASS M)
USED WHEN	• Existing base is uniform • No widespread structural damage • Existing subgrade is good (<15ksi) • Low traffic	• Low - moderate traffic • Good subgrade • Moisture not of a concern	• High Volume Roadways • Moisture a concern • Reasonable subgrade > 10ksi • Early opening to traffic	• Bridging over poor subgrade • Strengthening required • Low quality variable base/stripped HMA • Higher Rainfall • Early opening to traffic	• Bridging over poor subgrade • Strengthening required • Low quality variable base • Higher rainfall • Early opening to traffic
SELECTION OF STABILIZER[1]	No stabilizer added to the existing material (This is a base thickening project, where new untreated granular material is placed on top of existing)	*Full Texas Triaxial Test method 117-E 10 day capillary rise, then* • 45 psi at 0 psi confining • 175 psi at 15 psi confining (add low levels of stabilizer)	*Full Texas Triaxial Test Method 117-E* • 60 psi at 0 psi confining • 225 psi at 15 psi confining • <0.5% gain in moisture over molding moisture after 10 days capillary	*Texas Method 121-E 7 day moist cure, then* • Unconfined strength > 300 psi • 100% retained unconfined strength after 10 days capillary rise (To reduce time consider 85% retained strength after 4 hour submersion)	*Test Method 121-E 7 day moist cure, then* For Cement • Unconfined strength > 175 psi • 100% retained unconfined strength after 10 days capillary rise For lime or fly ash • 100 psi after capillary rise (To reduce time, consider 85% retrained strength after 4 hour submersion)
FPS 19 MODULI[2]	70 ksi	100 ksi	125 ksi	200 ksi	150 ksi
COMMENTS	• New base should be of higher or equal quality than existing, and • Blending of existing and new base strongly recommended to avoid trapping moisture in upper layer			• Avoid cutting into high PI subgrade if existing structure is thin, and add new base before milling where needed • To avoid longitudinal cracking, consider grids and flex base overlay where the PI subgrade soils > 35 • Max RAP 50% • If lab strength >350 psi, then consider precracking • Max cement 4%	• Avoid cutting into high PI subgrade if existing structure is thin, and add new base before milling where needed • To avoid longitudinal cracking, consider grids and flex base overlay where the PI subgrade soils > 35 • Max RAP 50% • Blend of stabilizers often useful

1. Obtain samples of the existing materials by field auger. If the flexible material is susceptible to breakdown in the lab, then use only the ½ inch fraction in laboratory test program. This is in attempt to partially account for aggregate breakdown during the recycling process
2. TxDOT Flexible Pavement Design System (FPS) 19 design moduli for each base class

Pavement Edge-drains and Subsurface Drainage

NCHRP (2002)[20]
A 2002 National Cooperative Highway Research Program (NCHRP) Research Results Digest article presented findings of NCHRP Project 1-34, *Performance of Subsurface Pavement Drainage*, which sought to evaluate the following three objectives:

1. The overall effect of sub-surface drainage of surface infiltration water on the performance of AC and PCC pavements.
2. The specific effectiveness of permeable base and associated edge-drains, as well as traditional dense-graded bases with and without edge-drains.
3. The specific effectiveness of retrofitted surface drainage on existing pavements.

NCHRP Project 1-34 included extensive field performance assessments of flexible pavement sections in 23 U.S. states and Canada. Data were also gathered for more than 300 flexible and rigid pavements from FHWA Rigid Pavement Performance Rehabilitation (RPPR) and Long-Term Pavement Performance (LTPP) databases. The performance of drained and non-drained sections at each project site was compared, and data were analyzed with mechanistic-empirical models for flexible pavement fatigue cracking and rutting. Most flexible pavements in the study carried fewer than 5 million ESALs, with a maximum of 10 million.

The overall findings of this study indicated that subsurface drainage features that are properly designed and constructed may decrease the occurrence of rutting and fatigue cracking in flexible pavements. A life-cycle cost analysis conducted for flexible pavements showed the following results:

- Conventional non-drained AC over unbound dense aggregate base course is the least cost-effective design considered due to fatigue cracking.
- The placement of an edge-drain on this pavement reduced the fatigue cracking and made the design more cost-effective.
- The incorporation of a permeable layer beneath the dense asphalt-bound layer was even more cost-effective.
- Daylighted permeable aggregate base resulted in the most cost-effective design of all, assuming similar performance and reduced cost.

Conversely, clogged edge-drain outlets were found to have a detrimental effect on the performance of flexible pavement sections containing a permeable base. The inability to drain a permeable layer leads to increased fatigue cracking and rutting.

The authors recommend the use of thicker layers of asphalt-bound aggregates and full-width paving to prevent moisture from infiltrating into lane and shoulder cracks. The use of non-stripping aggregates was also found to be important, as was the placement of a granular layer at the bottom of the dense AC layer to avoid a bathtub effect. The performance of a drained pavement was found to largely be a function of the quality of design, construction, and maintenance.

Baumgardner (2002)[2]

Baumgardner identified maintenance as being most critical to the continued success of any longitudinal edge-drain. Plugged drainage may be worse than no drainage system because the pavement system becomes permanently saturated. The cost to state highway agencies in terms of poor pavement performance may be significant for those who do not properly inspect and maintain edge-drains. Baumgardner suggested drains be inspected at least once a year with video equipment, ditches be kept clean of debris, vegetation be removed from around outlet pipes twice a year, and all ditches be mowed and kept clean of debris.

Baumgardner also recommended painting arrows on the shoulders (Figure 22) to aid locating drain outlets that may be overgrown with vegetation and the use of larger headwalls for outlet pipes (Figure 23).

Figure 22. Painted arrow reference marker.

Figure 23. Large headwall for outlet pipe.

Advantages of larger headwalls for outlet pipes include:

- Easier for maintenance personnel to locate
- Vegetation is located farther away from the outlet pipe
- Erosion potential is reduced
- Potential for cutting or crushing the outlet pipe is reduced

Deschamps, et al. (1999)[8]

Deschamps, et al. noted that consideration must be given to the relative permeability of the original embankment soil and the soil used to widen the embankment for two reasons:

1. If the new fill soil has greater permeability than the existing embankment soil, water can infiltrate surficial soils and become perched on existing fill soils, leading to softening and reduction in shear strength.
2. If the new fill soil has less permeability than the existing embankment soil, groundwater flowing laterally may become trapped inside the embankment. This scenario could lead

to a reduction in stability due to a reduction in shear resistance and an increase in seepage stresses.

Deschamps recommends an approach for edge drainage shown in Figure 24 to be considered in lieu of detailed analyses when the existing and new embankment soils are of similar classification (Liquid Limit ± 5, Plasticity Index ± 5) and lateral groundwater flow through the embankment is expected to be minor:

1. Construct benches with adequate grade to induce lateral flow of any infiltration that encounters a less permeable interface, and thereby, minimize perched water at the interface between materials.
2. Install a perforated drain along the vertical cut of the first bench located outside the pavement edge. The drain should be covered with an appropriate filter fabric that is compatible with the embankment soil type, and be outfitted with protected outlets at appropriate intervals along the length of the embankment.

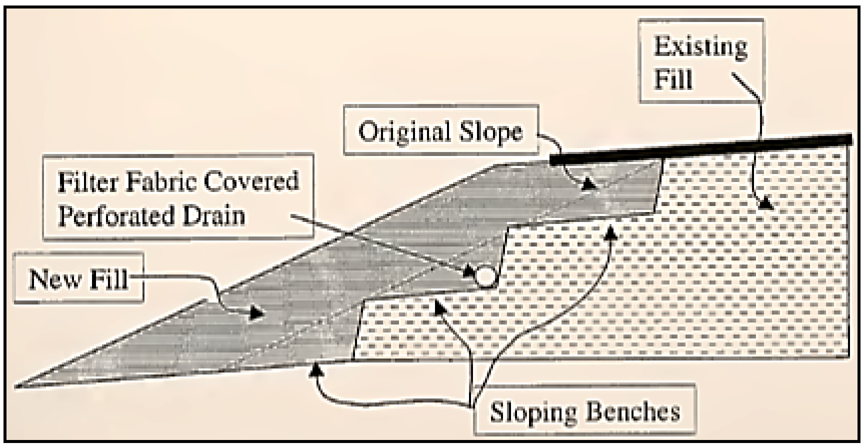

Figure 24. Recommended drain placement along vertical cut outside of pavement edge.

Pavement-Edge Drop-Offs

Graham, J.L., et al. (2011)[14]

Graham, et al. reported that pavement-edge drop-off hazards are often found on two-lane rural highways with adjacent unpaved shoulders and two-lane highways with narrow paved shoulder with widths of one to four feet. The edge drop-offs form along the edge of highways between periods of maintenance, where maintenance crews do not keep material against the pavement edge.

If a vehicle encounters a pavement-edge drop-off and leaves the traveled way, resistance from the road edge on the vehicle's tires may cause the driver to overcorrect his steering angle when re-entering the roadway, resulting in a loss of vehicle control. The authors report that edge drop-off heights can vary from less than one inch to six inches or more, and maintenance standards usually require maintenance when the drop-off exceeds 1.5 to 2.0 inches.

The safety edge is a treatment that slopes the pavement edge at an angle of 30 degrees to reduce the resistance of the tire remounting the roadway. Figure 25 illustrates a detail of the safety edge.

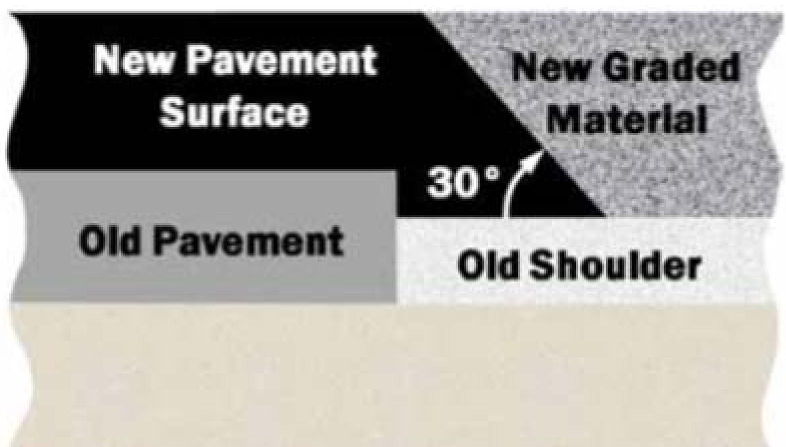

Figure 25. Safety edge.

The effectiveness of the safety edge treatment with respect to reducing crashes and fatalities was investigated in this study. The evaulation included an empirical Bayes (EB) analysis for determinng a crash reduction factor for the treatment and a benefit-cost analysis. The safety edge treatment was implemented at 261 sites in Georgia, 148 sites in Indiana, and 6 sites in New York for this study. Analysis was focused on three types of roadway segments:

1. Rural multilane roadways with paved shoulders with widths of 4 ft or less
2. Rural two-lane roadways with paved shoulders with widths of 4 ft or less
3. Rural two-lane roadways with no paved shoulders

The benefit-cost ratio for the edge treatment was determined according to Equation 1. The service life of the safety edge treatment was assumed to be seven years.

$$B/C = \frac{(N_{FI} C E_{SE} C_{FI} + N_{PDO} E_{SE} C_{PDO})(P/A, i\%, n)}{CC_{SE}} \qquad \text{Eq. (1)}$$

Where:

B/C = benefit-cost ratio
N_{FI} = number of fatal and injury crashes per mile per year before application of the safety edge treatment
N_{PDO} = number of pavement-edge drop-off (PDO) crashes per mile per year before application of the safety edge treatment
E_{SE} = effectiveness (percent reduction in crashes) for application of the safety edge treatment
C_{FI} = cost savings per crash for fatal and injury crashes reduced
C_{PDO} = cost savings per crash for PDO crashes reduced
(P/A, *i*, n) = uniform series present worth factor
i = minimum attractive rate of return (discount rate), expressed as a proportion (i.e., *i* = 0.04, for a discount rate of 4 percent)
n = service life of safety edge treatment (years)
CC_{SE} = cost for application of the safety edge treatment (dollars per mile)

Results indicated that the minimum benefit-cost ratios (Figure 26) are at least four times the maximum benefit-cost ratios (Figure 27). The safety edge treatment is likely to be a good safety investment in most situations, especially for roadways with higher traffic volumes where higher crash frequencies are expected.

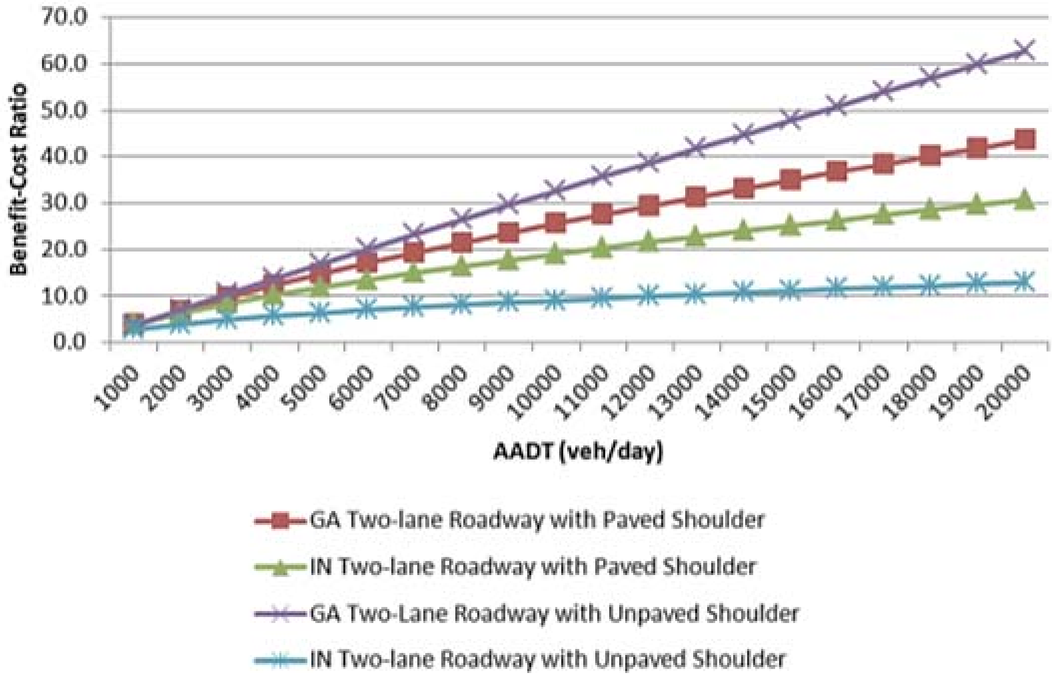

Figure 26. Minimum benefit-cost ratios for the safety edge treatment as a function of AADT.

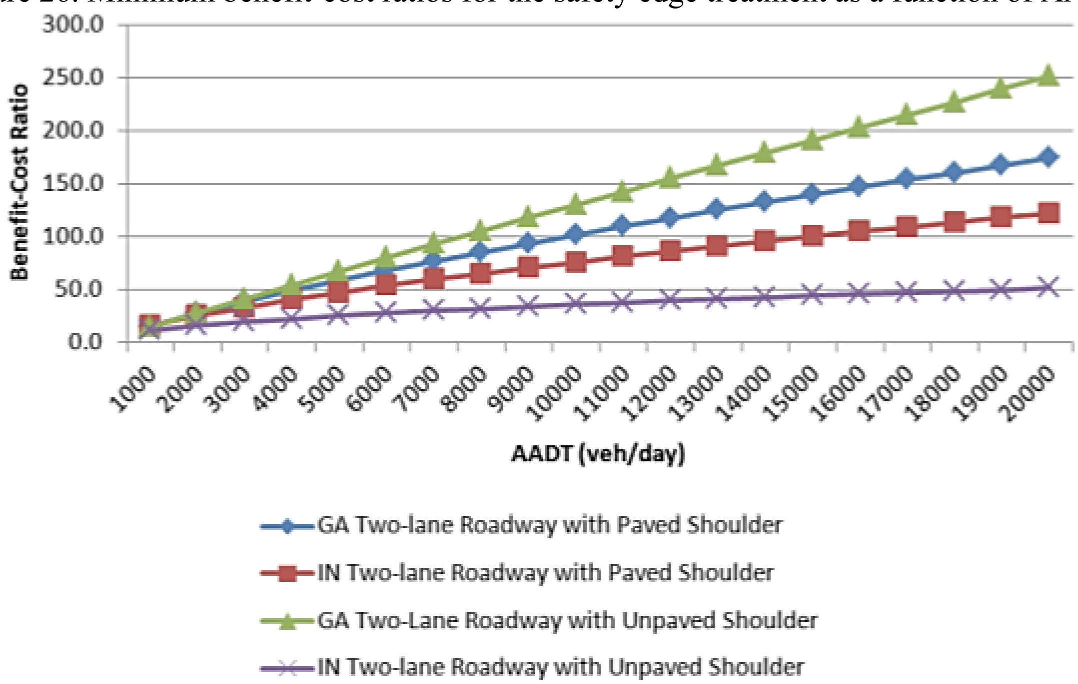

Figure 27. Maximum benefit-cost ratios for the safety edge treatment as a function of AADT.

The EB evaluation for the safety edge treatment with three years of crash data found that 56 of 81 sites showed a positive safety effect for the safety edge treatment; however, only 11 of the comparisons were statistically significant. The safety edge treatment was found to be most effective on rural two-lane highways, reducing total crashes 5.7 percent. The authors suggest that although the positive effectiveness of the treatment on crash reduction is small, the economic analysis supports that it is highly cost-effective.

Lawson and Hossain (2004)[18]

Lawson and Hossain reported best practices for pavement edge maintenance to safely provide a means for vehicles to reenter the roadway without over-steering. They reported that a simple and cost-effective approach to dealing with pavement-edge drop-offs during construction is to install a 45-degree asphalt fillet along the edge of the pavement to tie in the existing shoulder into the resurfaced roadway. A hot or cold asphalt mix is recommended when the wedge height is 6 inches or less. A granular base is recommended when the wedge hight is greater than 6 in. Additional traffic control recommendations for dealing with pavement-edge drop-offs in construction zones is provided in Table 6.

Table 6. Traffic control needs in construction zones for edge drop-off conditions.

Edge Drop Height (in.)	LATERAL POSITION OF EDGE DROP					
	In Wheel Track	*In Lane*	*On Lane Line*	*At Edge of Pavement*	*At Edge of Shoulder*	*Outside of Shoulder up to 30 ft.*
1 to 1-1/4	Uneven Pavement Sign	Uneven Pavement Sign	Uneven Pavement Sign	Low Shoulder Signs	Do Nothing	Do Nothing
1-3/8 to 2	Disallowed	Disallowed	Channelizing Devices with Steady-Burn Lights	Channelizing Devices with Steady-Burn Lights	Channelizing Devices with Steady-Burn Lights	Do Nothing
2-1/8 to 5-7/8	Disallowed	Disallowed	Channelizing Devices with Steady-Burn Lights	Channelizing Devices with Steady-Burn Lights	Channelizing Devices with Steady-Burn Lights	Channelizing Devices
5 or more	Disallowed	Disallowed	Disallowed	Positive Barrier	Positive Barrier	Channelizing Devices with Steady-Burn Lights

Geosynthetic Reinforcement

Darling (1999)[7]

In a 1998 study, 7.68 miles of flexible roadway on U.S. 190 in Hammond, Lousiana were milled, treated with a geosynthetic reinforcing mesh, overlaid with HMA, and monitored for a period of five years. This study included the addition of inside and outside ten-foot wide lanes at two intersections. The typical cross-sections for lane additions is shown in Figure 28.

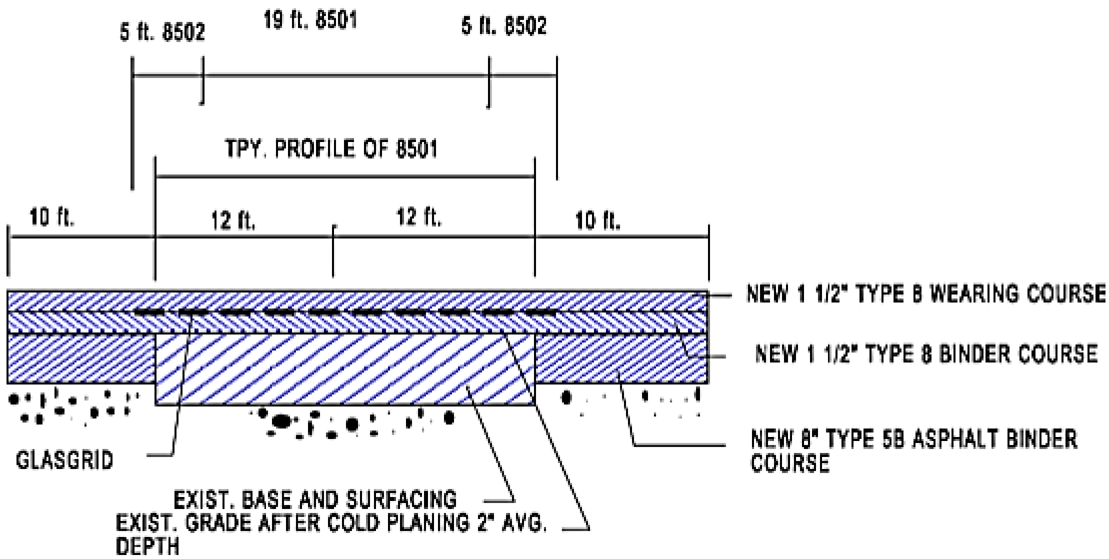

Figure 28. Typical roadway widening profile at intersections.

The site pictured in Figure 29 exhibited extensive block cracking prior to rehabilitation. The crack pattern consisted of four longitudinal cracks in each lane with frequent intersecting transverse cracks dividing the pavement into blocks varying from 1foot by 1 foot to 10 feet by 10 feet. Darling reported 48 percent of block cracks were of low-severity: *hair line cracks with no spalling or faulting.* He reported 50 percent of block cracks were medium-severity: *cracks with low severity spalling; faulting less than ¼ inch; crack width 1/8 inch or less*. Only 2 percent of block cracks were reported as high-severity: *cracks with moderate or high severity spalling; faulting ¼ inch or more; crack width greater than 1/8 inch.*

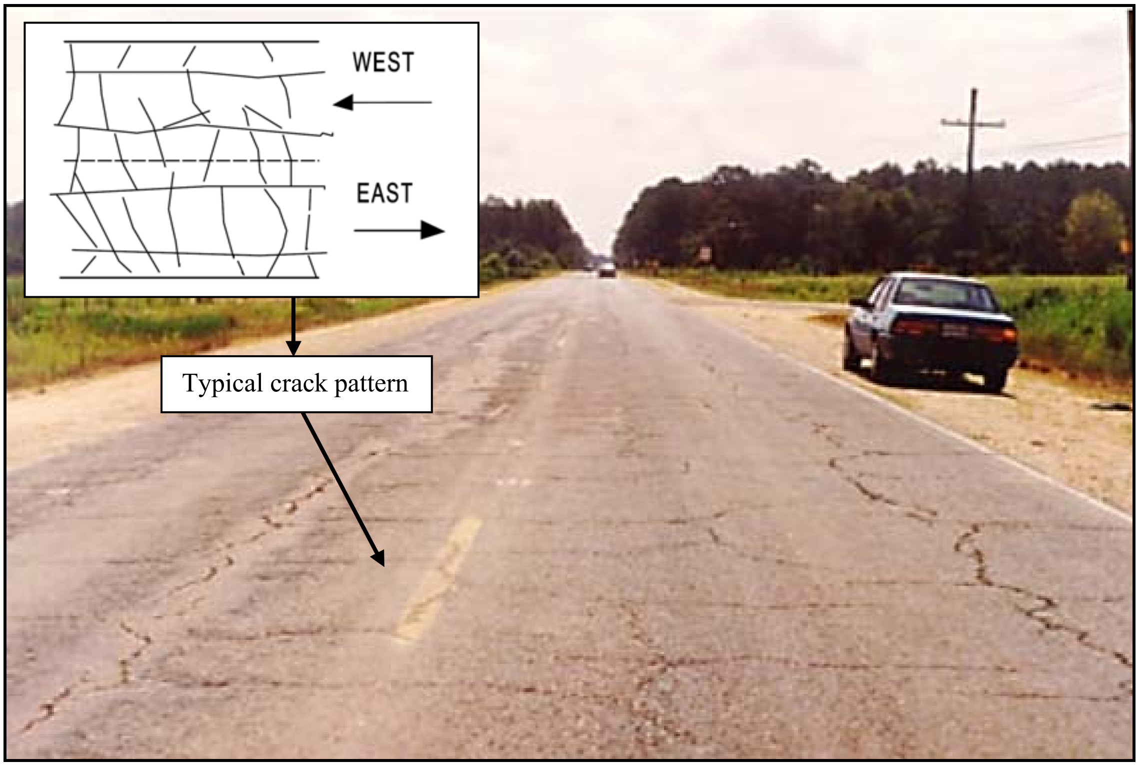

Figure 29. Block cracking present prior to rehabilitation and widening.

GlasGrid7 8501® was placed over the full width of the roadway to reduce the overlay thickness requirement as well as reduce thermal and stress related cracks from reflecting through the surface of the new asphalt overlay. GlasGrid7 8502®, a heavier mesh designed to retard cold construction joints from reflecting to the surface, was placed between the binder course and wearing course of the widened sections. Mechanical properties of the GlasGrid7® products used are provided in Table 7.

Table 7. Mechanical properties of geosynthetic reinforcement.

	GlasGrid7® Product	
	8501	8502
Tensile Strength across Width (kN/m)	100	200
Tensile Strength across Length (kN/m)	100	100
Modulus of Elasticity (MPa)	69,000	69,000

The rehabilitation procedure consisted of:

1. Milling 2 in. to 4 in. of existing layer of aspahlt
2. Filling the most severe transverse and some longitudinal cracks by:
    a. Cutting 1 in. to 3 in. wide by 2 in. deep segments
    b. Cleaning the cut with high pressure compressed air (160-180 psi)
    c. Applying emulsified tack SS1H @ 60EC to routed cracks and allowing to cool
    d. Filling routed cracks with HMA binder course

e. Compacting HMA with vibratory steel-wheel roller
3. Place 1.5 inch binder course

The geosythenthic fabric was placed by a tractor at a rate exceeding the speed of paving with no time delays. A fish-scale adhesion pull-up test measured 16 to 24 lbs resistance between grid and binder, which allowed for slow moving traffic over the reinforcement with no observed adverse effects.

A small area of damage to the fabric was observed during paving due to truckers locking their brakes and then being moved forward by the paver. The project engineer modified the roll-to-roll overlap placement on the fourth day of paving to maintain 2 in. to 6 in. roll-to-roll overlaps in an orientation away from wheel paths in an effort to prevent HMA trucks from disturbing longitudinal laps. HMA compaction was measured at 92 to 94 percent theoretical maximum density (TMD).

The site was monitored periodically to evaluate the performance of the reinforced mesh treatment. Figure 30 charts the observed percentage reflection of lane widening joints by length for both reinforced and control pavement sections over the five years after treatment.

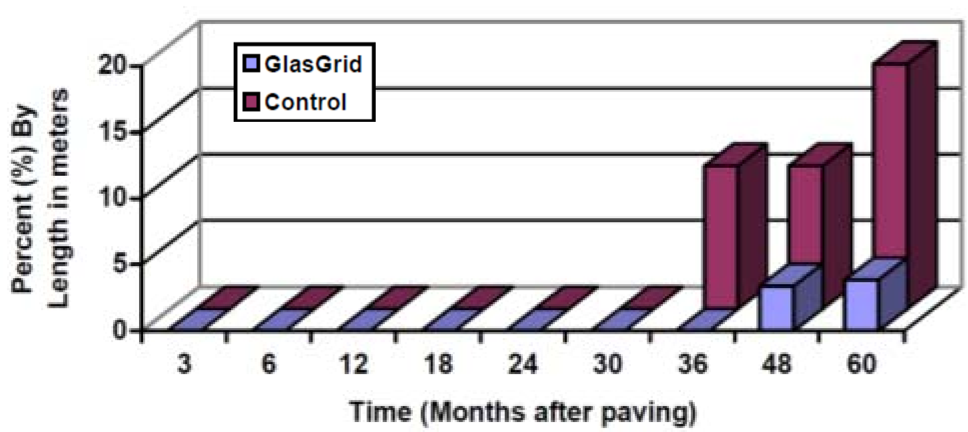

Figure 30. Percent reflection of lane widening joints by length.

Lane widening joint cracking became visible during the 36-month inspection on the control section. This cracking became visible on the reinforced section during the 48-month inspection, where 3.4 percent of the treated joints were reflecting, and 10.8 percent of the untreated controlled joints were reflecting.

At the five year inspection, the untreated lane widening joints showed an increase in reflection to 18.53 percent, almost double the length of cracking that was seen during the four-year inspection. Lane widening joint reflection increased to 3.8 percent at the five-year inspection over the reinforced sections. Cracks in both sections were low severity during the five year inspection. Overall, control sections exhibited about eleven times more cracking than sections treated with geosynthetic reinforcement, supporting that reinforced pavement outperformed the non-reinforcement pavement in terms of retarding cracks and joint reflection.

Buttlar et al. (2000)[3]

A 2000 Illinois DOT (IDOT) study examined performance of fifty-two projects across Illinois, comparing reflective cracking over widened pavement sections treated with a nonwoven polypropylene paving fabric. The fabric was placed either in strips longitudinally over lane-widening joints or over the entire paved area. The base for asphalt overlays at each site was originally constructed of rigid pavements.

Comparisons of measured reflected cracking in treated and control sections showed that the geosynthetic treatments retarded longitudinal reflective cracks from developing but did not significantly retard transverse reflective cracking. Buttlar estimated reinforcement to the widened joint areas increased the rehabilitation life span by 3.6 years, while treatments over the entire pavement increased rehabilitation life span by 1.1 years. Reduction to life-cycle cost was found to be statistically insignificant and was estimated to be a 6.2%. Buttlar concluded that serviceability was generally improved with treatment over rigid bases; however, crack reflection was not retarded relative to untreated areas.

Chowdhury, et al. (2009)[6]

Chowdhury, et al. summarized findings regarding the use of geosynthetic treatments to mitigate reflective cracking in HMA overlays in Washoe County, Nevada. Findings are presented in Table 8.

Table 8. Summary of Nevada experience with reflective cracking mitigation techniques.

Treatment	Description	Performance
NF-1.5	No Fabric + 1.5" HMA Overlay	Retarded reflective cracking for 1 to 3 years after construction.
NF-2.0	No Fabric + 2.0" HMA Overlay	Retarded reflective cracking for 1 to 3 years after construction.
NF-2.5	No Fabric + 2.5" HMA Overlay	Retarded reflective cracking for 1 to 5 years after construction.
F-2.0	Non-woven Geotextile Fabric + 2.0" HMA Overlay	Retarded reflective cracking for 1 to 5 years after construction.
F.2.0s	Non-woven Geotextile Fabric + 2.0" HMA Overlay + slurry seal some years prior treatment application	Retarded reflective cracking for 3 to 5 years after construction with some sections showing reflective cracking within the first year after construction.
P-2.0	Petromat + 2.0" HMA overlay	Retarded reflective cracking for 1 to 5 years after construction. Most of the sections exhibited reflective cracking, either fatigue or longitudinal, and transverse cracking at the end of the 5-year analysis period.
P-2.0s	Petromat + 2.0" HMA overlay + slurry seal some years prior treatment application	Retarded reflective cracking for 1 to 5 years after construction on half of the sections and for at least 5 years on the remaining half of the sections. The sections did not develop fatigue cracking during the 5-years analysis period.

Construction Techniques and Equipment

Lawson (2004)[18]

A common response to a 2004 Texas Department of Transportation (TxDOT) multi-district road-widening survey was that obtaining required density is difficult when constructing narrow pavement additions. This difficulty is often due to insufficient weight of narrow compaction equipment to compact typical lift thicknesses. Maintenance supervisors and pavement contractors reported to Lawson that this can be overcome by decreasing lift thicknesses to four inches. Narrow rollers that Lawson identified as being readily available in Texas for road-widening projects are presented in Figure 31 through Figure 35.

Operating Weight (lb):	5,975
Centrifugal Force (lb):	6,070
Working Width (in):	47
Engine:	Deutz® D2011 L02 I
Rated Power (hp):	31
Speed (mph):	0-6.2

Figure 31. Dynapac® CC122

Operating Weight (lb):	9,680
Centrifugal Force (lb):	15,000
Working Width (in):	50
Engine:	Cat® 3054C Diesel
Rated Power (hp):	83
Speed (mph):	0-5.5

Figure 32. Caterpillar® CP-323C.

Operating Weight (lb):	8,598
Centrifugal Force (lb):	19,109
Working Width (in):	47
Engine:	Duetz® D 2011 L3i
Rated Power (hp):	45
Speed (mph):	0-5.6

Figure 33. Bomag® BW 124 PDH.

Operating Weight (lb):	10,700
Centrifugal Force (lb):	18,120
Working Width (in):	54
Engine:	Deutz® Type F3L 912
Rated Power (hp):	62
Speed (mph):	0-5.6

Figure 34. Hamm® Model 2220 D.

Operating Weight (lb):	11,250
Centrifugal Force (lb):	18,120
Working Width (in):	54
Engine:	Deutz® Type F3L 912
Rated Power (hp):	62
Speed (mph):	0-6.5

Figure 35. Hamm® Model 2222 DS.

Florida Turnpike Enterprises (2014)[13]

Two-feet wide trenching and an HMA overlay were specified to repair a longitudinal asphalt crack in a recent FDOT project to improve Florida Turnpike Mainline (SR 91) from Glades Road to south of the Atlantic Avenue interchange in Palm Beach County. Figure 36 illustrates the trench joint repair detail.

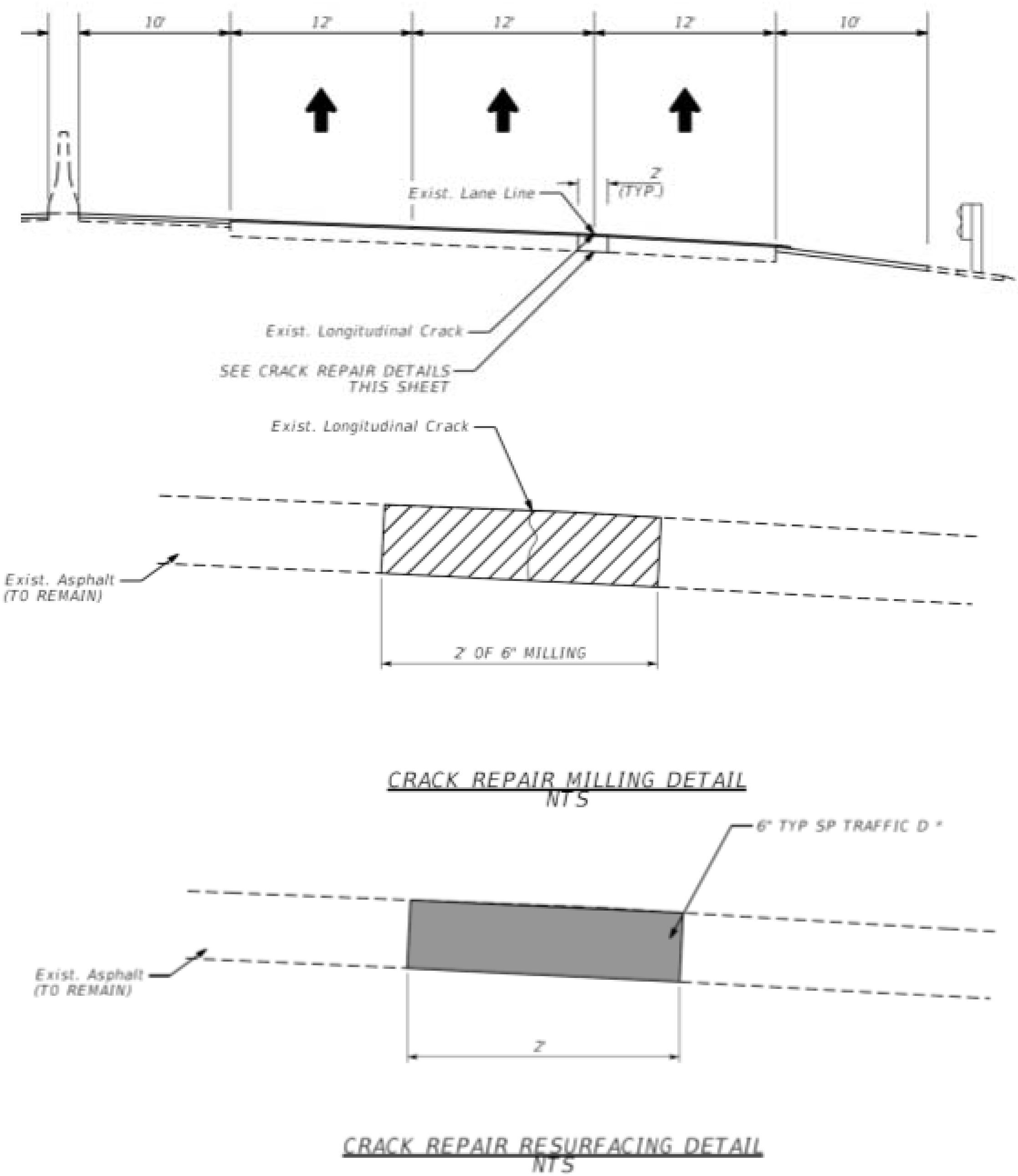

Figure 36. Trench joint repair detail.

It was determined the trench design width was too narrow for the contractor's equipment to achieve density. The contractor agreed to increase the trench width from 24 inches to 26 inches at no additional cost to achieve proper compaction with available equipment.

Figure 37. Milling and overlay of longitudinal crack.

The authors recommend increasing trench design widths to a minimum 26 inches to avoid future issues. Florida Turnpike Enterprises (FTE) suggests that placing multiple lifts with smaller equipment was viable; however, the operation may take longer with significant impact to motorists.

Al-Jaf, et al. (2004)[1]

The Namibian Road Authority in Southern Africa claims success with a non-traditional method for widening flexible pavements to remediate deteriorated flexible pavement edges in remote and austere locations. A coarse-graded emulsion based slurry seal has been used as a low-cost alternative to conventional methods for widening roadways exhibiting edge breaks and pavement-edge drop-offs. This technique was sought as treatment to reduce the cost of transporting large quantities of scarce aggregate to austere sites, decrease the length of construction periods, and reduce maintenance costs.

Al-Jaf, et al. reported that pronounced flexible pavement edge breaks contributed to many single-vehicle accidents caused by loss of control and overtaking maneuvers when vehicles traveled off and back onto the roadway. The accident rate observed between 1996 to 2000 was 56 percent higher than the generally accepted rate of 0.99 accidents per million vehicle kilometers on a 109-mile (mi) section of the Namibian Trunk Route 1 roadway between Rehoboth and Mariental. Accident data observed over the five-year period is shown in

Table 9.

Table 9. Trunk Route 1 accident statistics prior to treatment.

Category	Average per Annum	% of Total
Damage only	41	32.2
Slight injuries	12	18.4
Serious Injuries	7	10.9
Fatal	6	8.5
Total	66	100.0

The coarse graded slurry was mixed in a continuous-mix truck and conveyed to a drag box for placing in a single pass. Slurry was placed in an average lift thickness of 1.4-inches and rolled with a pneumatic tired roller three hours after placement prior to opening to traffic.

The placement technique is shown in Figure 38; Figure 39 shows the finished edge widening on Route 1.

Figure 38. Coarse-graded slurry placement.

Figure 39. Finished edge widening overview.

The slurry is a continuous graded aggregate with larger stones to withstand heavy traffic loadings. A blend of 13.2 mm and 9.5 mm single sized stone aggregate and minus 6.7 mm crusher dust was specified. Aggregate grading used in the slurry is provided in Table 3.

Table 10. Aggregate grading.

Sieve Size (mm)	Cumulative % Passing by Mass
13.2	96 – 100
9.5	70 – 80
6.7	40 - 60
4.75	35 - 50
2.36	20 - 40
1.18	10 -15
0.600	5 - 15
0.300	3 - 11
0.150	1 - 8
0.075	0 - 5

According to the authors, this method is only appropriate for roads where suitable shoulder material is present. The most likely failure mode for slurry widening would be rutting.

Cross Slopes

FDOT (2014)[25]

The 2014 FDOT design criteria for resurfacing, restoration, and rehabilitation (RRR) of streets and highways in the *FDOT Plans Preparation Manual: Volume 1* specifies existing pavement and shoulder cross slopes shall be reviewed for compliance and be field verified by one of the following:

1. Full Digital Terrain Model for the roadway width – evaluate cross slope on tangent sections at 100-foot intervals.
2. Vehicle Mounted Scanner – prior to design, using the results of the scan, determine roadway limits where cross slope is potentially out of tolerance and request Digital Terain Model of the roadway width for these limits. Evaluate cross slope on tangent sections at 100-foot intervals.

Criteria for roadway and freeway cross slopes are provided in Table 11; standard freeway cross-slopes are illustrated in Figure 40.

Table 11. Allowable roadway cross slopes.

Facility or Feature	Standard	Allowable Range
Two-Lane Roads	0.02	0.015 - 0.030
Multilane Roads	0.02	0.015 - 0.040
Shoulders	0.06	Adjacent Lane Cross Slope - 0.080
Parking Lanes	0.05	0.015 - 0.050

Figure 40. Standard FDOT freeway cross slopes.

An allowable range of 0.015 to 0.025 is acceptable for the 0.02 freeway cross slopes shown in Figure 40, and a range of 0.025 to 0.035 is specified as acceptable for the 0.03 freeway cross slopes.

On resurfacing, restoration, and rehabilitation (RRR) projects where existing ditches can be modified for storm water management purposes, the use of steeper than standard sideslopes and additional depth may be cost-effective; however, values selected shall generally be the flattest that are practical. Guidelines are provided for both front slopes and back slopes.

<u>Guidelines for Front Slopes:</u>

- 1:6 is desirable
- 1:4 may be constructed within the clear zone
- 1:3 may be constructed outside the clear zone
- Existing front slopes 1:3 or flatter may remain within the clear zone. Shielding may be required
- Steeper than 1:3 shall be shielded as per *Design Standards, Index 400, General Notes*
- Consideration should be given to flattening slopes of 1:3 or steeper at locations where run-off-the-road type crashes are likely to occur (e.g., on the outsides of horizontal curves)
- The proposed construction should not result in slopes steeper than the existing slopes in violation of previously specified values

<u>Guidelines for Back Slopes:</u>

- 1:4 is desirable
- 1:4 may be constructed in the clear zone
- 1:2 may be constructed outside the clear zone without shielding
- Existing back slopes 1:2 and flatter may remain
- Existing back slopes steeper than 1:3 within the clear zone may require shielding

Soil slopes and foundations over soft soils may be reinforced by geosynthetic products approved in *FDOT Design Standards Index 501*. Design procedures are provided in Section 31.4.3 of the *FDOT Plans Preparation Manual, Volume I.*

Embankment Widening

Deschamps, et al. (1999)[8]

In the 1990s, several failures occurred in Indiana highway embankments that were widened and steepened. Deschamps surveyed state and federal transportation agencies to gather both technical problems for design engineers and practical implementation problems during construction of steepening sideslopes of existing embankments (Table 12).

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Table 12. Embankment widening technical problems.

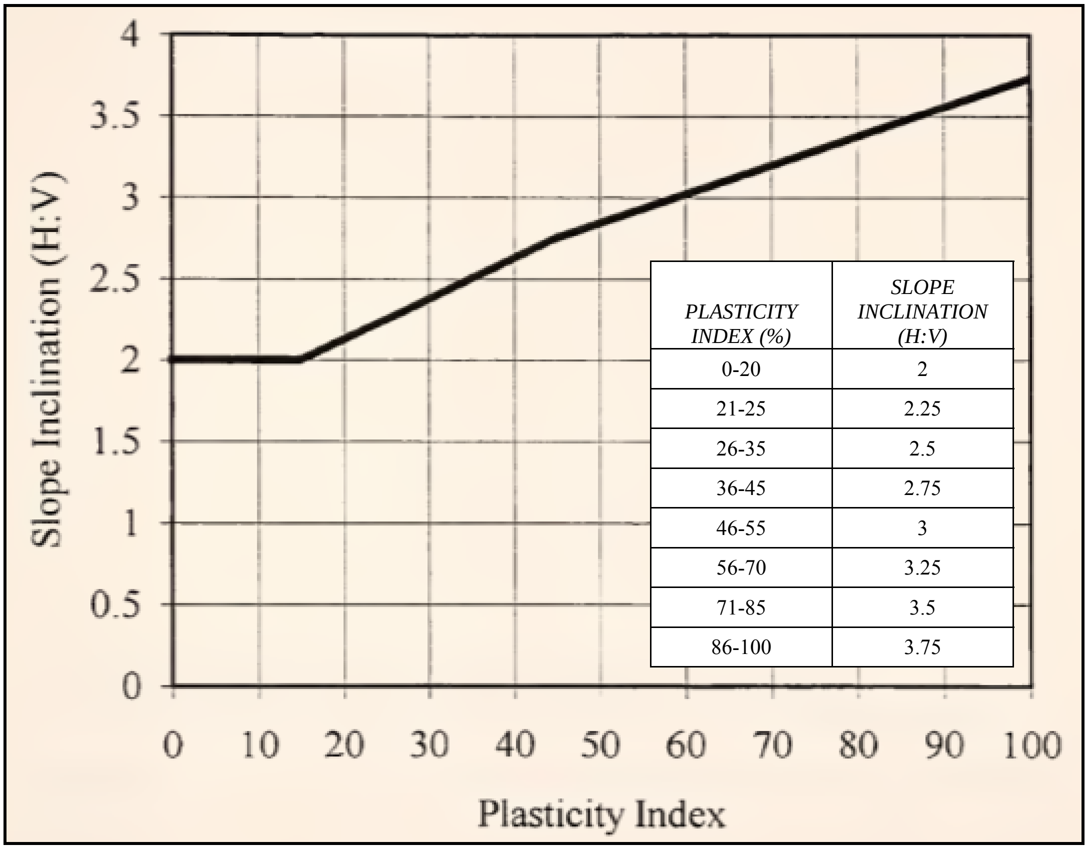
Design Engineers	Construction Personnel
• Steepening sideslopes reduces the margin of safety with respect to slope stability of an embankment • Designer must consider both stability of embankment and stability of the wedge fill placed to widen embankment • Preferential failure planes can develop at interface between original embankment and fill placed to steepen slope • Traditional stability analyses may not be capable of evaluating stability of wedge fill placed on a sideslope	• The work area available at the toe and crest of the highway may be limited by site constraints • Placing additional earthfill on an existing embankment can be complicated by slope • Traditional equipment may not be suitable for fill placement and compaction • Plans and specifications may not sufficiently convey the design engineer's intentions

Deschamps conducted an investigation of five Indiana DOT (INDOT) projects where widening and steepening of existing embankments was performed. Three of the five projects were considered failures, and two of the projects were considered successful and exhibited no distress. Deschamps reported that a number of factors influenced the ultimate stability of the failed embankment slopes with failure to comply with INDOT specifications being the overarching problem. Deschamps made the following recommendations for future embankment widening projects:

1. Remove existing vegetation and organic top soil to obtain an adequate construction joint between old and new fill and to eliminate the potential for weak seams to develop because of decomposition.

2. Construct benches in existing slopes to provide a good construction joint between old and new fill and to provide a horizontal surface upon which adequate compaction of the lifts can be achieved. A 10 foot bench should be proved on all slopes steeper than 4V:1H.

3. Embankments built with higher plasticity soils should be constructed at flatter slopes to provide adequate margins of safety. Recommended slope inclinations for given plasticity indices are provided in Figure 41.



PLASTICITY INDEX (%)	*SLOPE INCLINATION (H:V)*
0-20	2
21-25	2.25
26-35	2.5
36-45	2.75
46-55	3
56-70	3.25
71-85	3.5
86-100	3.75

Figure 41. Recommended slope inclination as a function of plasticity.

4. Compact fills to a minimum dry density equal to or greater than 95 percent of the maximum dry density achieved in the standard Proctor tests with the water content of the fill being -2 percent to +1 percent of the optimum moisture obtained in the Proctor test.

5. When the width of the embankment widening is less than the width of conventional compaction equipment, it may be necessary to compact lifts wide enough to accommodate the equipment.

6. Consideration needs to be given to the permeability of the existing embankment material and the material to be used in the widening. If the permeability of the new material is greater than the existing, then water can infiltrate, which could lead to a reduction in shear strength of the material. Also, if the permeability is less than that of the existing material, then water may become trapped within the embankment.

QUESTIONNAIRE RESPONSES

This section summarizes 20 responses provided by highway agencies, research centers, and industry that participated in a flexible lane widening survey conducted in October 2014. The survey was designed to assess national perspective on current longitudinal joint construction practices, specifications, and joint performance. Complete responses are provided in Appendix A.

All but one agency rated its overall experience with flexible pavement lane widening, particularly the performance of the juncture between new and existing pavement, as fair or good. No group reported a poor experience. New Jersey reported an overall excellent experience with joint performance. Results are provided in Table 13.

Table 13. Overall agency experience with lane widening.

Agency	Excellent	Good	Fair	Poor
Alabama DOT		●		
Arkansas DOT			●	
Colorado DOT		●		
Kentucky DOT		●		
Maryland DOT		●		
Mississippi DOT		●		
Montana DOT		●		
New Jersey DOT	●			
New Jersey Turnpike Authority		●		
New York DOT			●	
North Carolina DOT			●	
Tennessee DOT		●		
Texas DOT Austin District		●		
Texas DOT San Antonio District		●		
Texas DOT Maintenance Division		●		
Virginia DOT		●		
Federal Highway Administration	----	----	----	----
National Center for Asphalt Technology			●	
University of Texas CTR			●	
Lane Construction Corporation			●	

Selection of widening projects on flexible pavement

Traffic level and safety were cited as the most common factors reported influencing decisions to widen a lane. Results are provided in Table 14.

Table 14. Overall agency experience with lane widening.

Agency	Traffic Level	Safety	Access
Alabama DOT	●	●	
Arkansas DOT	●	●	
Colorado DOT	●	●	●
Kentucky DOT	●	●	●
Maryland DOT	●	●	●
Mississippi DOT	●	●	●
Montana DOT	●	●	
New Jersey DOT	●	●	●
New Jersey Turnpike Authority	●	●	●
New York DOT	●	●	
North Carolina DOT	●	●	●
Tennessee DOT	●	●	●
Texas DOT Austin District	●	●	●
Texas DOT San Antonio District	●	●	
Texas DOT Maintenance Division	●	●	
Virginia DOT	●	●	
Federal Highway Administration	●	●	
National Center for Asphalt Technology	●	●	
University of Texas CTR	●	●	●
Lane Construction Corporation			

General experience with lane widening projects

Colorado, Mississippi, Tennessee reported no history of major problems with widened section joint performance outside of normal long-term issues with longitudinal joint performance of surface mixtures on all projects. The most common distresses observed by the remainder of agencies at the joint between existing lanes and new widened lanes are longitudinal cracking, reflective cracking, and differential settlement between sections. Table 15 presents the most common issues mentioned.

Table 15. Problems reported at widening joint.

Problem at Widening Joint	Number of Agencies
Longitudinal crack formation	8
Reflective Cracking	7
Differential settlement	7
Poor compaction	3
Trapped moisture	3
Raveling at joint	2

A general consensus on many aspects of best practices to mitigate longitudinal joint problems was found between agencies. Practices reported that have been successful to overcome early joint deterioration with widening projects are summarized in the following sections.

Widening structure should match existing cross section

Most agencies recommended matching widened cross sections to existing cross section and addressing internal drainage if the existing section is structurally adequate. Texas noted close inspection of the existing pavement prior to designing the widening section is critical. In some cases, an existing pavement will have already been widened in the past, but this is not necessarily evident from looking at the surface condition. Widening might have been performed by maintenance crews and be undocumented. Ignoring this condition may lead to variability in lateral stiffness of the pavement structure and joint lines shifted into wheel paths. However, only five agencies routinely use a falling weight deflectometer (FWD) to verify structural adequacy of candidate widening sections. Texas and Maryland have had success using both ground penetrating radar (GPR) and pavement core samples to identify layers in existing pavements. From the contractor perspective, Lane Construction Corporation reported that states are often minimizing pre-construction surveys to verify existing conditions, and pavements often vary from design. These incidences can lead to the contractor performing the work at existing contract unit prices even though most all occurrences are significant changes in scope and materially different than the original design.

Texas has used full depth HMA for the full width of the widening to limit consolidation in the new section. In some cases, this either caused drainage problems where the widened HMA section would dam up water, or the section would act monolithically and exhibit poor load transfer, as the widened HMA section was much stiffer than the existing pavement section. Texas also reported that some contractors prefer to use asphalt stabilized base for the widened section because it is faster to place and provides a riding surface at the end of the day without need for applying any further surfacing. Placing an asphalt stabilized base adjacent to a pavement constructed with un-stabilized granular base can easily lead to trapped moisture at the joint interface and rutting or transfer cracking once wheel loads are applied at the joint. In these cases, Texas will place a 4-inch layer of crushed granular base in the widening trench, and asphalt stabilized base is then placed over the granular base to eliminate the trapped moisture problem.

New York has a mature system with many pavements that are thick from several cycles of overlays and well drained in most cases. They report matching new sections to existing sections generally gives good functional results.

Do not place joint in a wheel path
There was a strong consensus between all groups to avoid placing joints in wheel paths, citing this practice always leads to a higher rate of joint deterioration. Two agencies reported this condition is exacerbated on routes where the joint is placed under heavy traffic and heavy repetitive wheel loads. If possible, the joint line should be shifted further into the existing pavement to reduce or eliminate this condition. Sometimes this will mean placing the joint in the center of a lane. New York occasionally places all of the widening on one side of a highway to avoid having a widening joint in a wheel path. Leaving the joint in the wheel path to maximize use of the existing roadway pavement is false economy.

One additional requirement the New Jersey Transit Authority (NJTA) has with regard to the planned location of longitudinal joints in the surface course is that they be offset 1-foot from the proposed location of traffic stripes. This is to allow for future crack sealing of longitudinal joints without compromising traffic stripes.

Stagger joints between pavement layers
Twelve of thirteen agencies practice staggering joints between pavement layers. There was some variation in approaches used to tie into existing sections; however, most groups reported offsetting joints 6-inches between successive layers. A minimum offset of 6-inches is defined as a best practice by NCAT and FHWA. Montana and Kentucky use a longitudinal edge key to notch into the existing section, such as detailed in Figure 42. Montana reported a lower occurrence of joint reflection and differential settlement at the joint when placing a gravel base in 8-inch lifts, notching into the existing road section, and placing at least one lift of new asphalt pavement beyond the widened section onto the existing surface to bridge the joint.

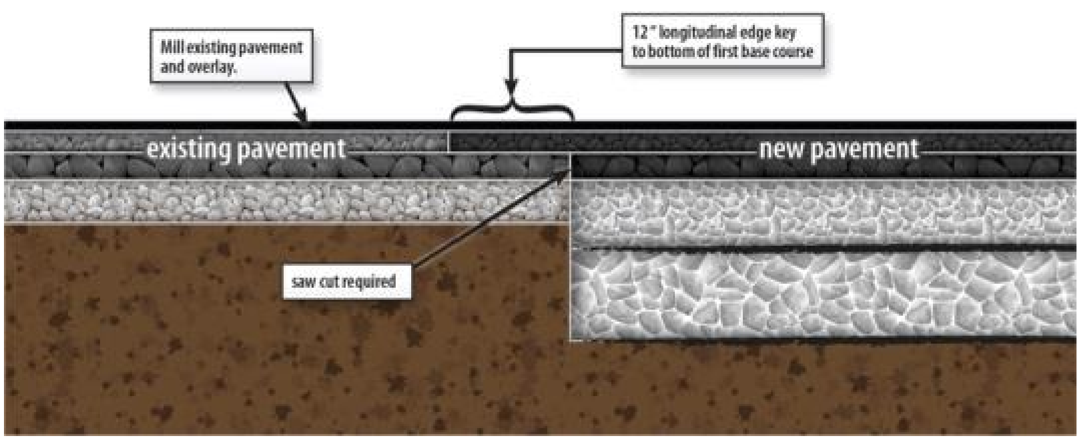


Figure 42. Notched edge cross section (courtesy of Kentucky DOT).

North Carolina has lessened problems with reflective cracking by milling pavement adjacent to a widened section to a depth of 1.5-inches, then surfacing both the widening and existing pavement. Lane Construction Corporation typically tries to implement an offset joint detail on their design-build contracts and prefers to use a 1-foot offset into the top lift of adjacent flexible pavement section. They reported that some districts in Florida are including offset joints in widened section designs and hope to see this practice being used uniformly across all Florida districts.

Position joint a sufficient distance into existing pavement

The location of the joint between an existing and new pavement structure may vary due to condition of edge of the pavement. Kentucky, Montana, Virginia, and Lane Construction Corporation prefer to place widening joints 12-inches inside the existing pavement. Colorado tries to place the joint within 2-feet of the lane line.

Texas commonly places the joint within 4 ft of the edge on narrow widening and 12 to 14 ft from the edge on extra lanes to avoid wheel paths. Texas noted difficulties when saw cutting at the extreme edge of the pavement to maximize use of the existing pavement structure. This practice can lead to joint failures when new base is compacted against the older, deteriorated and nonuniform materials that are likely found at the edge of the roadway. The existing pavement edge typically has the worst quality material and is composed of maintenance repairs, base material that is deteriorated or has vegetation growing through the pavement within about 6-inches of the edge. Placing the joint farther into a more stable and workable face will also allow more space to fit compaction equipment (Figure 43).

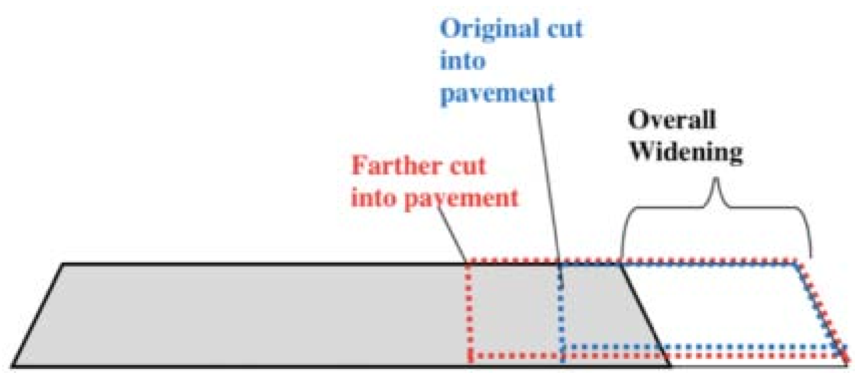


Figure 43. Position joint farther into existing pavement for an interface with more sound material and space for compaction [5].

Bridge longitudinal widening joint with an overlay

Placing an overlay over the entire roadway in conjunction with joint staggering is a best practice recommended by FHWA and NCAT to help mitigate stacking of underlying joints. Six agencies reported placing HMA across the entire width of travel lanes to avoid a longitudinal widening joint on the surface of the pavement.

University of Texas reported that narrow widening projects are often funded using Safety Bond or Highway Safety Improvement Program funds which do not allow for structural strengthening of the pavement during a widening project. These funds (CAT 3) are to provide for widening of the pavement for safety purposes at the maximum benefit versus cost. This precludes use of a structural asphalt layer and typically involves placement of a surface treatment. On projects funded with CAT 1 funds, again these projects are often lower volume routes that might carry heavy trucks, but placing a structural ACP layer across the entire pavement surface would in most cases be considered cost prohibitive.

Treatments typically used for widened-section longitudinal joint performance

Only 4 of the 20 agencies reported the use of joint adhesives, though it was strongly recommended in current literature. Applying a tack coat to the open face of joints was the most frequently reported treatment. Treatments reported are provided in Table 16.

Table 16. Treatments used to improve joint performance

Treatment	Number of Agencies
Tack coat joint face	7
Joint adhesive/sealer	4
Grid reinforcement	1
Full depth HMA in widened section	1

Geotextile fabric reinforcement has been used in Texas, Mississippi, research projects in Arkansas, and on concrete joint repairs before asphalt overlays in Kentucky. Texas has had success embedding Glassgrid 2-ft on either side of a HMA joint as an effective, however costly practice. Geotextile reinforcements are also often used in Texas when rehabilitating pavement over expansive soils to resist tensile stresses associated with soil movement. New York has had issues with fabrics not being strong enough to resist forces involved at widening joints in its pavements. New Jersey is currently proposing the use of special mixtures, such as Matrix Asphalt over Binder Rich Intermediate Course to inhibit reflective cracking in composite pavement widening projects. No special treatments are typically used in New Jersey for widening flexible pavement structures.

Keep joint sealed

Four agencies reported performance benefits of monitoring and sealing joints as needed in widening sections. Colorado routinely uses a crack sealant to fill longitudinal cracks that appear on widened pavement sections during its normal maintenance routine.

Provide neat vertical faces

Neat vertical faces free of dirt and debris will provide a surface for uniform tack coat adhesion and the best condition for achieving proper compaction along joints. Agencies reported both the use of milling machines and saws to create vertical cuts.

Texas favors using a milling machine to provide vertical face to compact newly placed base material against. Uneven cut lines and joint faces have been experienced on projects that use a grader blade to widen the pavement and poor compaction has been identified in these “sluffed” areas. In a few cases on rough Farm to Market roads, Texas has used a paver to place a thin hot mix layer to level up rough edges.

Widening design

Engineers within areas, regions, or districts usually perform widened pavement section designs internally. Five states reported that a pavement design group generates designs for widening sections. Three states reported occasional use of consultants. Just over half of agencies reported using some form of the AASHTO Design Guide for the design of widened pavement sections. Matching the existing pavement is typically the key driver for design. Eight of the agencies have a minimum requirement to match widened pavement sections to existing pavement sections. Methods used to generate widened section pavement designs are presented in Table 17. Sample flexible pavement widening cross sections routinely used in New Jersey, Maryland and Texas are provided in Appendix B.

Table 17. Design methods used for widened pavement sections.

Agency	AASHTO Design Guide	MEPDG	Other Internal Design Procedure	Design Details
Alabama DOT			●	Typically match existing roadway layers.
Arkansas DOT	●			Arkansas uses AASHTO Design Guide but in process of moving to MEPDG; running both designs now, but uses AASHTO Design Guide for final decision.
Colorado DOT		●		Prior to July 1, 2014, Colorado used the AASHTO Design Guide.

Table 17. Design methods used for widened pavement sections.

Agency	AASHTO Design Guide	MEPDG	Other Internal Design Procedure	Design Details
Kentucky DOT			●	Kentucky uses the KY ME Design Method which includes KY soaked CBR and KY ESALs to evaluate with internal M-E design curves; will migrate to new curves based MEPDG Analysis and Calibration/Verification in near future.
Maryland DOT			●	Maryland's internal design procedure uses AASHTO 1993, MEPDG and RSL, since individually all have their limitations.
Mississippi DOT	●			----
Montana DOT	●			Montana uses AASHTO Design guide for surface design, but that does not address subgrade issue. Though it is not a requirement, Montana typically matches the surfacing.
New Jersey DOT	●			----
New York DOT			●	New York has a series of design charts based loosely on the 1986 AASHTO design method, heavily modified to reflect New York experience and performance.
North Carolina DOT	●			----

Table 17. Design methods used for widened pavement sections.

Agency	AASHTO Design Guide	MEPDG	Other Internal Design Procedure	Design Details
Tennessee DOT	●			Tennessee uses AASHTO Design Guide '93.
Texas DOT Austin District			●	Texas uses FPS21, state specific software.
Texas DOT San Antonio District			●	Texas uses FPS21, state specific software.
Texas DOT Maintenance Division				Texas uses FPS21, state specific software.
Virginia DOT	●			----

The most common field tests performed to gather data for generating a design are FWD, cores, soil borings, and GPR. Eleven agencies regularly conduct a structural evaluation for lane widening projects. The number of agencies using each data collection method is presented in Table 18.

Table 18. Most common data collected in routine structural evaluations

Test	Number of Agencies
Falling Weight Deflectometer	5
Pavement Cores	3
Soil borings	3
Ground Penetrating Radar	2
Visual Survey	2
Dynamic Cone Penetrometer	1

Six agencies reported having the following design guidance on lane widening and design of the longitudinal joint:

- Arkansas In curb and gutter sections where the widening is 4-feet or less, concrete base is used in the widening instead of aggregate or asphalt, then overlaid with a 2- to 4-inch lift of asphalt surface course. Arkansas also shifts the alignment and does all of the widening on one side of the roadway if the width of the widening is small.

- Maryland — Widened sections should be at least as thick as the existing pavement. Concrete base is used in widened sections where the lane width is less than 4-feet wide. Applying tack coat to the face of vertical saw cuts is required.
- Montana — Subgrade material and gravel base is to be placed in 8-inch lifts and notched into the existing road section. In addition, if the native material is inadequate, the widened embankment may be constructed of higher quality material. At least one lift of new asphalt pavement extends beyond the widened section onto the existing surface to bridge over the joint.
- Virginia — Pavement design for an asphalt widening meets or exceeds the depths and types of layers in the existing pavement. Subsurface drainage of the existing and proposed pavement is to be addressed in the pavement design. The adjacent travel lane is milled to a minimum depth of 1.5 inches and replaced with an asphalt surface course to match the existing pavement.
- New Jersey — HMA surface courses are constructed for the full width of travel lanes.
- Texas — Narrow widening projects often include a general note indicating that the joint line is 'saw cut'. However, in practice, based on interviews, this can mean use of a milling machine, use of a motor grader with a coulter blade (an agricultural implement) or a grader with a widening attachment. Other general notes relate to requirements limiting widening to 1 mile or less based on a demonstration by the contractor that the amount of widening trench opened can be filled and compacted to provide a widening surface within the same business day. Some plan sets also include a detail drawing of the widening joint; however, this varies.

Quality Control Testing

No special quality control procedures outside of standard construction specifications for widening sections were reported for lane widening projects. Agencies reported practicing the standard state inspection quality control procedures for constructing subgrade, base, and structural asphalt materials; ensuring quality materials are placed at correct elevations, adequate density is achieved, drainage layers are aligned, and layer thicknesses are correct. Efforts are made to ensure subgrade resilient moduli of the widened section are similar to the existing section. One agency regularly conducts proof rolling inspection of subgrade to identify and correct soft spots on widening projects. NCAT recommends monitoring material segregation, which may be an issue in widened sections. New Jersey is in the process of developing a specification with required quality control testing for all longitudinal cold joints.

Subgrade and Base Stabilization

Seven of 20 agencies reported having no routine method for subgrade and base stabilization. The limited area of many widening projects creates difficulties bringing in equipment to apply and stabilize mixes. Chemical stabilization is commonly reserved for projects in Arkansas and Kentucky where the widened section exceeds the width of a single lane. Kentucky normally places one foot of aggregate and fabric or geogrid base reinforcement for single lane additions and uses cement or lime stabilization for interstate widening projects. The use of lime stabilization, cement stabilization, and geosynthetics were most commonly reported. The number of agencies reporting routine use of each method is presented in Table 18.

Table 19. Most common data collected in routine structural evaluations.

Method	Number of Agencies
No standard practice	7
Geosynthetics	3
Lime stabilization	3
Cement stabilization	3
Full depth reclamation	2
Do not use stabilization	2
Subsurface grout injection	1

Secondary consolidation of widened sections on rural roadways has led Texas to rehabilitate many roadways where the original pavement may be denser than a constructed widening. Texas reclaims, widens, and cement stabilizes the existing pavement material and uses it as a strong subbase followed by a flexible base with a two-course surface treatment or hot-mix asphalt depending on the traffic needs. This practice is often used on projects where each side of the roadway is widened by 2 to 8 feet. Using this method, the joints are eliminated at the pavement edge, the contractor can use full-size construction equipment to construct the project which allows better compaction operations.

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APPENDIX A. QUESTIONNAIRE RESPONSES

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A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.1. Who is responsible for designing the widening the of pavement sections?

Agency	*Answer*	*Comments*
Alabama DOT	The local Region or Division office.	----
Arkansas DOT	Roadway Design Division	----
Colorado DOT	The regional designers or the consultants that we hire.	----
Kentucky DOT	Pavement design section or project designer.	Pavement design section or project designer depending on ADT and length of project.
Maryland DOT	The Pavement & Geotechnical Division, Pavement Design Section.	----
Mississippi DOT	District Materials Engineer	Designs are developed with input from District Construction personnel and project office personnel.
Montana DOT	In-house designers and engineering consultants	The Montana Department of Transportation performs in-house design and also utilizes engineering consultants.
New Jersey DOT	Pavement Designers of NJDOT Pavement, Drainage, Management, Technology.	----
New Jersey Turnpike Authority	Consultants	The New Jersey Turnpike Authority (NJTA) employs professional engineering services from outside consultants for pavement widening type projects.
New York DOT	Highway design project team.	Pavement widenings are designed on a case-by-case basis by the highway design project team. Some general guidance is given in our Highway Design Manual and our Comprehensive Pavement Design Manual, but no specific sections are required.

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.1. Who is responsible for designing the widening the of pavement sections?

Agency	*Answer*	*Comments*
North Carolina DOT	Typically Division Design Engineer	For projects whose main function is lane widening, the work is typically done by the Division Design Engineer. Where the lane widening is done as part of some other goal, for example bridge replacement, it may be done by design engineers in the Roadway Design Unit.
Tennessee DOT	In-house by TDOT staff	TDOT procures widening projects to grading and paving contractors through the traditional low bid system. Project design is typically performed in-house by TDOT staff.
Texas DOT Austin District	The district pavement engineer.	----
Texas DOT San Antonio District	A collaboration of plan designers, area engineers, maintenance supervisors, and materials/pavement engineer.	----
Texas DOT Maintenance Division	Engineers within districts.	----
Virginia DOT	District Pavement Design Engineers or District Materials Engineer	----
Federal Highway Administration	----	----
National Center for Asphalt Technology	DOT personnel or consultant to DOT	----
University of Texas CTR	District Pavement Engineers or District Pavement Preservation Engineers.	Area Office Engineers or staff may develop widening designs and plans in many cases. Maintenance Sections also perform narrow widening projects using in-house maintenance funds or through Routine Maintenance Contracts.

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.1. Who is responsible for designing the widening the of pavement sections?

Agency	*Answer*	*Comments*
Lane Construction Corporation	Owner provided Design Engineer.	----

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.2. What is the overall experience of your state with lane widening, particularly performance of the juncture between new and existing pavement?

Agency	*Excellent*	*Good*	*Fair*	*Poor*
Alabama DOT		•		
Arkansas DOT			•	
Colorado DOT		•		
Kentucky DOT		•		
Maryland DOT		•		
Mississippi DOT		•		
Montana DOT		•		
New Jersey DOT	•			
New Jersey Turnpike Authority		•		
New York DOT			•	
North Carolina DOT			•	
Tennessee DOT		•		
Texas DOT Austin District		•		
Texas DOT San Antonio District		•		

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.2. What is the overall experience of your state with lane widening, particularly performance of the juncture between new and existing pavement?

Agency	*Excellent*	*Good*	*Fair*	*Poor*
Texas DOT Maintenance Division		•		
Virginia DOT		•		
Federal Highway Administration	----	----	----	----
National Center for Asphalt Technology			•	
University of Texas CTR			•	
Lane Construction Corporation			•	

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.3. What factors influence decisions to widen a lane?

Agency	*Traffic Level*	*Safety*	*Access*
Alabama DOT	•	•	
Arkansas DOT	•	•	
Colorado DOT	•	•	•
Kentucky DOT	•	•	•
Maryland DOT	•	•	•
Mississippi DOT	•	•	•
Montana DOT	•	•	
New Jersey DOT	•	•	•
New Jersey Turnpike Authority	•	•	•
New York DOT	•	•	
North Carolina DOT	•	•	
Tennessee DOT	•	•	•
Texas DOT Austin District	•	•	•
Texas DOT San Antonio District	•	•	•
Texas DOT Maintenance Division	•	•	
Virginia DOT	•	•	
Federal Highway Administration	•	•	
National Center for Asphalt Technology		•	
University of Texas CTR	•	•	•

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.3. What factors influence decisions to widen a lane?

Agency	*Traffic Level*	*Safety*	*Access*
Lane Construction Corporation	•	•	•

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.4. What problems, if any, has your agency had with the joint between the existing and new widened lane? How have you resolved these problems?

Agency	*Answer*
Alabama DOT	Reflection of joint up through overlying layers. Occasional settlement of widened area.
Arkansas DOT	Sometimes the joint will reflect through the asphalt pavement layers. Issue has not been resolved.
Colorado DOT	No major problems. After a period of time, we will see a longitudinal crack appear. This crack is usually at a minor severity level and we will use a crack sealant to fill it during our normal maintenance period.
Kentucky DOT	Problems Raveling and occasionally settlement. Solutions Raveling – mill 12” width of surface or surface and one base course, like an edge key, in order to have new surface (and the upper base course if possible) overlap the joint so there is not a vertical joint between the existing and new pavement. Settlement – Pavement overlap (as mentioned above). Better preparation of the subgrade – perhaps excavate 1 foot and place 1 foot of rock (#2, #3, or #23) and fabric for construction platform.
Maryland DOT	Only problems are for roads originally built with concrete several decades ago, then overlaid with asphalt, then widened without any engineering with too-thin flexible pavement. The longitudinal joint eventually reflects through, but it’s a minor problem compared to transverse joint reflective cracking in the composite pavement and alligator cracking in the widening.
Mississippi DOT	No major problems.

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.4. What problems, if any, has your agency had with the joint between the existing and new widened lane? How have you resolved these problems?

Agency	*Answer*
Montana DOT	A longitudinal crack can develop at times. There may also be some differential settlement between the old section and the new widening. However, it doesn't occur that frequently. We place the subgrade material and gravel base in 8-inch lifts and notch it into the existing road section. In addition, if the native material is questionable, we may construct the widened embankment of higher quality material (A-1-a). At least one lift of new asphalt pavement extends beyond the widened section onto the existing surface. This helps bridge over the joint.
New Jersey DOT	We notice high severity fatigue cracking in the wheel path within widened flexible pavement along composite pavement. We also observe longitudinal reflection cracking within the wheel path when widened pavement is flexible along composite pavement. For high severity fatigue cracking, we are reconstructing full depth flexible pavement within the wheel path. For reflection cracking, we are proposing special mixes: e.g. Stone Matrix Asphalt over Binder Rich Intermediate Course to inhibit reflection cracking. The selection of mix is traffic dependent. For widening with flexible pavement along flexible pavement, we do not see any additional distress because we are resurfacing entire width of travel lane by milling and paving with surface course. Therefore, we do not create any additional longitudinal cold joint on the surface between existing and widening lanes.

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.4. What problems, if any, has your agency had with the joint between the existing and new widened lane? How have you resolved these problems?

Agency	*Answer*
New Jersey Turnpike Authority	Unless a contractor employs best construction practices regarding construction and compaction of longitudinal pavement joints there is a tendency for them to prematurely fail. During pavement construction the NJTA requires the following steps be taken to ensure construction of the best performing longitudinal pavement joints 1. Prior to the start of paving operations in the field NJTA convenes a Pre-Paving Meeting to discuss methods to be employed during construction to ensure proper construction of pavement joints. 2. Contractor required at start of paving operations to construct a test strip for each course of pavement to be constructed to determine project density and rolling pattern requirements. Density is determined in the field by use of a nuclear density gauge, as well as core samples to correlate nuclear gauge results. Core results shall yield bulk and maximum specific gravities of the asphalt course and air void content. Nuclear density gauge results shall yield bulk specific gravity, maximum density based on the maximum specific gravity results obtained from core samples and air void content. The referenced tests are performed at various locations throughout the pavement course being constructed including along the longitudinal joint. 3. During construction ensure contractor employs proper rolling techniques to minimize lateral creep and maximize density along the unsupported joint. 4. During construction of adjacent lanes ensure contractor bumps material along the joint to ensure maximum compaction. 5. When constructing multiple pavement courses (base, intermediate and surface course) ensure adequate stepping of longitudinal joints to prevent the creation of a “weak zone” at the joint.
New York DOT	All pavement joints can be a problem, depending on age, quality of construction, and location. Whenever possible, we try to keep the widening joint out of the wheelpath. Sometimes, that means placing all of the widening on one side of a highway. In any event, good construction practices, particularly with the joint, are essential. Matching the new section to the existing is a good practice, and internal drainage should be properly addressed.
North Carolina DOT	We have had problems with reflective cracking. The adjacent pavement is often milled to a depth of 1.5: and a surface layer is placed over both the widening and the adjacent existing pavement.

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.4. What problems, if any, has your agency had with the joint between the existing and new widened lane? How have you resolved these problems?

Agency	*Answer*
Tennessee DOT	We are not aware of any mass issues with this. We occasionally experience long-term issues with longitudinal joint performance of surface mixtures on all projects, including resurfacing projects, but I am not aware of any consistent issues on widening projects.
Texas DOT Austin District	In many cases, the existing lanes have been consolidated over many years, and are relatively denser than the constructed widening. This leads to secondary consolidation of the newly constructed widening lane. In other cases, a roadway will be widened with little to no rehabilitation of the existing lanes; this is typically the case for a safety project in which the scope is limited. In this case, the existing lanes deteriorate at a higher rate than the newer constructed widened sections. In general, we have found it is more effective (performance and cost) to rehabilitate the full width, especially rural 2 lane roadways. We reclaim, widen, and cement stabilize the existing pavement material and use it as a strong subbase. We will place a flexible base with a surface (2 course surface treatment or hot-mix asphalt depending on the traffic needs). We will also utilize geosynthetic reinforcement when rehabilitating pavement over expansive soils to resist tensile stresses associated with soil movement.

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.4. What problems, if any, has your agency had with the joint between the existing and new widened lane? How have you resolved these problems?

Agency	*Answer*
Texas DOT San Antonio District	<u>Problems</u> 1) Different pavement structures between existing pavement and widened pavement (this practice stems from saw cutting existing pavement edge at various locations and adding on widened section). Led to consolidation differences in different structures, which led to cracking at the joint, which led to water infiltration, which led to failures at the joint. 2) Widening with little to no right of way, which can be difficult to accommodate if funds are limited. Left with a small area to widen, and if it's less than 6' cannot get adequate compaction as most rollers are not smaller than 6' in width. 3) To speed up construction, have utilized full depth HMA for widened section that is significantly deeper than the existing pavement. As a result water has been trapped in the existing lanes leading to more rapid deterioration in those lanes. <u>Resolutions</u> 1) If existing pavement is in structurally good condition, the widened pavement cross section will match the existing in order to limit differential settlement. 2) Modified saw cut location to provide at least 6' wide area for compaction. 3) Use of a crack relief asphalt binder spanning the joint and overlay. 4) Use of glassgrid spanning 2' on either side of the joint, but must use a hot applied AC for this application (expensive, but effective). 5) After widening place overlay/surface treatment across all lanes. 6) subgrade widen, spread existing material and stabilize, add new flex base and place new surface material across all lanes (~20% more expensive than just saw cut and widen with all virgin material).

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.4. What problems, if any, has your agency had with the joint between the existing and new widened lane? How have you resolved these problems?

Agency	*Answer*
Texas DOT Maintenance Division	Cracking reflected in the surface of asphalt or seal coat and in seal coat surface only surfaces, there is consolidation along the joint.
Virginia DOT	Problems 1) Non-continuous structure under widened lane leading to "break-over" when traffic begins to travel over widened portion. 2) Longitudinal joint deteriorates quickly if not sufficiently compacted. Resolutions 1) Make sure design of new widened portion is sufficient for loading and joint between old and new underlying structure are not under heavy traffic. 2) Keep joint sealed, and ensure adequate density at construction.
Federal Highway Administration	----
National Center for Asphalt Technology	Joints often open with time. Joint is sealed as needed. This opening of a joint can be minimized if we ensure the use of proper materials and obtain good compaction. Also, helpful if joints in layers can be staggered. Not always possible.
University of Texas CTR	On narrow widening projects, TxDOT has experienced problems in some districts with reflective cracking, rutting in the existing (original lane), rutting in the newly widened section, and settlement of the widened section. Certain Districts have determined that scarifying and re-compacting the entire, existing pavement structure to provide a subbase, overlaid with a new base layer and surface treatment or thin overlay (still only widening each side by 2' - 8' - so narrow widening) - provides a better performing pavement. Using this method, the joints are eliminated at the pavement edge, the contractor can use full-size construction equipment to construct the project which allows better compaction operations and other benefits described below. The contractor can also maintain better quality control of the materials and construction process which results in a more uniform pavement structure across the entire width and along the project limits. When pavements are

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.4. What problems, if any, has your agency had with the joint between the existing and new widened lane? How have you resolved these problems?

Agency	*Answer*
University of Texas CTR	widened on either side by from 2' to 8' (termed narrow widening in Texas), the contractor is often not able to use full size construction equipment to compact the subgrade, base and surface layers. In addition, practices vary from district to district regarding how the widened section joint line and trench are opened during the initial construction phases. These practices vary even between Area Offices in the same District, but this can be due to changes in terrain conditions (hilly or flat), type of materials being excavated (rock, soil etc.) and other factors. TxDOT requires the contractor to have the widened section filled with base, compacted and primed by close of business each day so that traffic can operate on the narrow widening section. This typically limits widening project daily production rates to 1 mile or less per day. The trench section may be cut with a grader blade, grader blade with widening attachment, a milling machine or other types of equipment. Based on field visits to projects under construction, a milling machine gives the best vertical face cut and provides a good surface to compact the newly placed base against. Projects that use a grader blade to widen the pavement typically leave an uneven, cut line and joint face with base material which sluffs off into the trench. Though base is placed in the widened trench and compacted, poor compaction typically occurs at these sluffed areas - which later allow for moisture penetration, and deformation under heavy wheel loads. In a few cases, on rough Farm to Market roads, a contractor has first used a paver to place a thin hot mix layer using the plan quantity for level up material. This provides a much smoother surface for guiding the milling machine and is a good practice. However, problems can occur if the milling machine operator tries to maximize the amount of existing pavement that is left in place and runs the milling machine almost directly on the edge of the existing pavement. The existing pavement edge typically has the worst quality material and is composed of maintenance repairs, base material that is deteriorated or has vegetation growing through the pavement within about 6" of the edge in many cases. Thus, it is a much better practice to mill more of the existing pavement to ensure that the joint line is in good material. Cutting the trench line either with a grader blade or a milling machine at the extreme edge of the pavement to maximize use of the existing pavement structure is false economy and leads to joint failures (new base compacted in the widening trench is placed against older, deteriorated materials that are not uniform). Another problem with joint construction involves close control by the contractor of watering practices to keep down dust. There have been cases in which watering during hot summer conditions has resulted in overwatering of the new base material in the trench which is then surfaced. This later can lead to lower than anticipated base moduli due to wet base material, which cannot support heavy

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.4. What problems, if any, has your agency had with the joint between the existing and new widened lane? How have you resolved these problems?

Agency	*Answer*
University of Texas CTR	truck wheel loads. In other cases, the moisture within the widened base section can be drawn into the existing (very dry) pavement causing weakening of the existing pavement and rutting. Additional challenges occur when the pavement that is being widened is constructed on an embankment section. If the widened section does not have sufficient lateral support and/or the side slope is too steep, this can lead to settlement problems. The Austin District has addressed these type of issues using fabrics / geo-textiles to provide additional support in widening sections along embankment areas. Another problem which is common with all types of widening projects, not just narrow widening --- is to ensure that the widening joint line is not within the wheel path. Many narrow widening projects in Texas are constructed to provide additional width along routes carrying large numbers of heavy trucks - heavy wheel loads from repetitive loads can result in deterioration of the joint - again, it is better to move the joint line further into the existing pavement to reduce or eliminate this condition. Another challenge that can occur with the joint area is mis-match of the existing pavement materials with the materials used for the widening. Often contractors prefer to use asphalt stabilized base for the widened section since it is faster to place and provides a riding surface at the end of the day with need for applying any further surfacing. However, placing an asphalt stabilized base adjacent to a pavement constructed with un-stabilized granular base can easily lead to trapped moisture at the joint interface and rutting / transfer cracking once wheel loads are applied at the joint. Another type of joint failure can occur due to widening with ASB followed by extreme low winter temperatures and freezing precipitation. I have viewed projects which have been widened using ASB and had to be repaired with a new widening section and new surface within 2 to 3 years because the winter following completion of the project involve very low temperatures (well below freezing) and moisture. Again, trapped moisture against the ASB face and freezing temperatures resulted in the joint expanding and reflecting to the surface. TxDOTs practice, when stabilized base is used in the widening trench is to place a 4" layer of crushed granular base first to act as a drainage layer. The ASB is then placed over the granular base which eliminates the trapped moisture problem. Another issue involves close inspection of the existing pavement prior to designing the widening section. In some cases, an existing pavement has already been widened in the past, but this is not necessarily evident from looking at the surface condition. The widening might have been performed by maintenance crews or under a regular construction project perhaps 8 or 10 years ago and all of the employees familiar with the old project have retired. Thus the new widening project is built which might result in many different types of undesirable, non-uniform lateral pavement layer thicknesses and

A.1 SELECTION OF WIDENING PROJECTS ON FLEXIBLE PAVEMENT

A.1.4. What problems, if any, has your agency had with the joint between the existing and new widened lane? How have you resolved these problems?

Agency	*Answer*
University of Texas CTR	designs which provide inadequate drainage or improper support. Examples are: 1) Old 18' wide flexible base pavement widened 15 years ago to 22' using asphalt stabilized base. The current designer does not perform adequate project plan review or field testing to identify that the pavement has already been widened before and designs a new widening sections with granular base and surface treatment. This results in two joint lines and an intermediate section of ASB which results in variability in the lateral stiffness of the pavement structure. Since the new widened section will result in a wider lane and possibly a paved shoulder, the wheel paths can be shifted which now places heavy wheel loads on the old or new joint causing rapid deterioration. 2) Field testing using a Falling Weight Deflectometer is strongly recommended to ensure the existing pavement is a candidate for narrow widening. If the existing pavement is too weak, widening the pavement with a stronger section is false economy. 3) It is very important for the designer to research previous plans to learn the types of construction that has been performed, including previous widening projects. Drought conditions can also cause problems if trees or vegetation exist along a widened section. The root system will draw moisture from under the pavement resulting in dessication of the subgrade and base layers which can create reflective cracking at the joint as well as longitudinal cracking beginning at the pavement edge and radiating inward toward the center of the pavement with each dry season. There are many other problems that can occur at the joint line of a widened section due to inadequate compaction from inability to compact the joint material properly - narrow compaction equipment can help. However, I have personally seen contractors running a full size roller placed half-way on the existing pavement and half-way on the widened section trying to get compaction. However, any elevation differences between the surfaces can result in uneven compactive effort across the entire roller width and poor compaction at the joint. Please review Project 0-6748 for further information.
Lane Construction Corporation	Florida DOT has just started in some Districts to install offset joints when tying in new flexible pavements to existing. This reduces/prevents vertical shear conditions. Unfortunately, this best management practice is not being utilized uniformly across all Florida DOT Districts.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.1. Is a structural evaluation routinely conducted for lane widening projects? If so, please describe the evaluation procedure, data collected, and how collected data is used to generate a design.

Agency	*Answer*	*Comments*
Alabama DOT	No	----
Arkansas DOT	Yes	Soil borings and traffic data are collected. From this data, the R-value converted to a soil resilient modulus and the ESALS are used to determine the required structural number from Darwin 3.01. Using this structural number, two to three alternatives are developed. The alternatives are discussed amongst Roadway Design Division and the District overseeing construction of the project. Roadway Design Division and the District both recommend which alternate they think is best for that project, and the pavement design is sent to the Assistant Chief Engineer of Design for final alternate selection and approval. For pavement design purposes, the widening section is done like it is a full depth new section of pavement. This process will soon be updated to use PavementME instead of Darwin for the new MEPDG process.
Colorado DOT	Yes	We use a 20-year design life for the anticipated traffic, and we will get a soil profile of the existing material.
Kentucky DOT	Yes	Treat widening as a new pavement design – need CBR and ESALs to design pavement under current KY Pavement Design Procedures. Evaluate existing structure to see if overlay of existing pavement is required.
Maryland DOT	Yes	GPR, FWD and coring may be done, and a visual survey is performed. A structural evaluation similar to any other roadway would be done for the widening only, since 99 times out of 100 that will control the design.
Mississippi DOT	Yes	We use FWD, Traffic counts, AASHTO design for some of our widening projects.
Montana DOT	No	----
New Jersey DOT	Yes	We design the widening portion for the expected future traffic and existing site condition and then look at the overall performance of pavement from drainage point of view. We match with the existing lane as a minimum requirement for the widening.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.1. Is a structural evaluation routinely conducted for lane widening projects? If so, please describe the evaluation procedure, data collected, and how collected data is used to generate a design.

Agency	*Answer*	*Comments*
New Jersey Transit Authority	No	The NJTA has in place standard pavement sections for each of its two (2) roadways (Garden State Parkway (GSP) and New Jersey Turnpike (TPK) that have proven to be very successful in withstanding the wheel loading for the type and volumes of traffic travelling each roadway (GSP has a high volume of passenger vehicles while the TPK has a high volume of heavy truck traffic).
New York DOT	No	We have very few structural issues with our pavements. On a mature system in a wet-freeze environment, all of the structural problems have been exposed and resolved long ago. After several cycles of overlays, our pavements are thick and in most cases well-drained. Matching the new to the old will generally give good functional results.
North Carolina DOT	No	----
Tennessee DOT	Yes	Core samples are collected to determine existing pavement section. Old plans of original and resurfacing projects are checked for drainage layers in order to match the existing drainage layer with new drainage layer.
Texas DOT Austin District	Yes	We use GPR and FWD.
Texas DOT San Antonio District	Yes	FWD to evaluate existing roadway condition and obtain stiffness of subgrade. Collect bores to identify if existing material is stabilized or re-usable. Backcalculate moduli values and run remaining life analysis on existing roadway to identify it's suitability for existing traffic levels.
Texas DOT Maintenance Division	No	Generally matching existing pavement structure.
Virginia DOT	Yes	Well, maybe. It depends on the conditions of the project. Mainly, designers attempt to mirror the existing mainline pavement structure as long as that appears to be adequate.
Federal Highway Administration	Yes	Usually an agency will conduct some coring of the paved shoulders to determine the structure.
National Center for Asphalt Technology	No	Evaluation would be best but can’t always be done.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.1. Is a structural evaluation routinely conducted for lane widening projects? If so, please describe the evaluation procedure, data collected, and how collected data is used to generate a design.

Agency	*Answer*	*Comments*
University of Texas CTR	No	Some districts do perform FWD testing of the existing pavement to ensure it is a good candidate for narrow widening. In some cases, it is found that the existing pavement is not a candidate for narrow widening, but for full depth reclamation. Deflection testing, a field survey to examine distress types, severity and location are all extremely important to ensuring a project is a candidate for narrow widening and to help in designing the widening section.
Lane Construction Corporation	No	Lane Construction is a general contractor, and the owner typically handles this process. On design build projects when we have input into pavement selection/design, we do look at this detail.

A.2. WIDENING DESGIN REQUIREMENTS

A.2.2. Does your agency have a requirement to match widened pavement sections to existing pavement sections?

Agency	*Yes*	*No*
Alabama DOT	•	
Arkansas DOT		•
Colorado DOT		•
Kentucky DOT		•
Maryland DOT		•
Mississippi DOT		•
Montana DOT		•
New Jersey DOT	•	
New Jersey Transit Authority	•	
New York DOT	•	
North Carolina DOT		•
Tennessee DOT	•	
Texas DOT Austin District	•	
Texas DOT San Antonio District	•	
Texas DOT Maintenance Division		•
Virginia DOT	•	
Federal Highway Administration	•	
National Center for Asphalt Technology		•
University of Texas CTR		•
Lane Construction Corporation		•

A.2 WIDENING DESIGN REQUIREMENTS

A.2.3 What design method is used?

Agency	*AASHTO Design Guide*	*MEDPG*	*Other Internal Design Procedure*	*Comments*
Alabama DOT			•	Widening is typically designed with the same buildup as existing roadway.
Arkansas DOT	•			Currently, AHTD still uses the AASHTO Design Guide, but we are in the process of moving to MEPDG. We are running both designs parallel right now, but using the AASHTO Design Guide for the final decision.
Colorado DOT		•		Prior to July 1, 2014, CDOT used the AASHTO Design Guide.
Kentucky DOT			•	We use the KY ME Design Method: uses KY soaked CBR and KY ESALs to evaluate with our M-E design curves. We plan to migrate to new curves based on our results of MEPDG Analysis and Calibration/Verification in the near future.
Maryland DOT			•	Our internal design procedure makes use of AASHTO 1993, MEPDG and RSL, since individually all have their limitations.
Mississippi DOT	•			----
Montana DOT	•			We use the ASHTO Design guide for surfacing design but that doesn't address subgrade issue. Though it's not a requirement, we typically match the surfacing.
New Jersey DOT	•			----
New Jersey Transit Authority			•	The NJTA has its own Design Manual consultants must follow during the design process. For items not adequately covered in the Manual the consultant is referred to AASHTO A Policy on Geometric Design of Highways and Streets and AASHTO Roadside Design Guide.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.3 What design method is used?

Agency	*AASHTO Design Guide*	*MEDPG*	*Other Internal Design Procedure*	*Comments*
New York DOT			•	We have a series of design charts based very loosely on the 1986 AASHTO design method, heavily modified to reflect New York experience and performance.
North Carolina DOT	•			----
Tennessee DOT	•			AASHTO Design Guide '93.
Texas DOT Austin District			•	TxDOT FPS21.
Texas DOT San Antonio District			•	FPS21, DarWIN (for concrete).
Texas DOT Maintenance Division			•	For other widening that is substantial, meaning a full lane, etc, a design evaluation will be performed with state specific design software (FPS21).
Virginia DOT	•			----
Federal Highway Administration	•			Currently the MEPDG is only used for the pavement design of new or total reconstruction of pavements. Other factors such as matching the existing pavement are usually the key drivers for design of widening projects. Most times a pavement design will be required and conducted (typically using AASHTO 93 or other state approved procedure), but it is not the primary driver for the structural makeup of the widening. Usually matching existing pavement and grade considerations (curb and gutter) drive the pavement design.
National Center for Asphalt Technology	•			Typically use standard design procedure, which may vary from state to state. At this point most still use AASHTO or some form of AASHTO.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.3 What design method is used?

Agency	*AASHTO Design Guide*	*MEDPG*	*Other Internal Design Procedure*	*Comments*
University of Texas CTR			•	FPS 19 is a TxDOT flexible pavement design program used for designing full width pavements. This program can be used to help design a widening section, but the program does not incorporate a specific module for this purpose. Many designs are based on district experience, previous performance history and the specific conditions of the project. The TxDOT Pavement Design Guide does indicate that drainage conditions should be considered when designing a widening section - however, as previously discussed actual practice can vary from district to district.
Lane Construction Corporation	----	----	----	Done by others.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.4. Where is the joint between existing and new structure located?

Agency	*Answer*
Alabama DOT	The joint is at the edge of existing pavement.
Arkansas DOT	The location varies based on the existing lane widths, the existing number of lanes, the new lane widths, and the new number of lanes.
Colorado DOT	We try and get the sawcut at the lane line or within 2 feet of the lane line. We try to enforce them to stay away from any wheel path.
Kentucky DOT	Usually 12 inches inside limits of existing pavement.
Maryland DOT	----
Mississippi DOT	----
Montana DOT	We typically cut the pavement 1 foot from the edge of pavement. It may vary depending on the condition of the paved shoulder
New Jersey DOT	Having the longitudinal joint on the surface within the wheel path is not desirable, and we do not allow it. As mentioned above, we resurface the entire width of travel lane to avoid having the joint in a wheel path.
New Jersey Transit Authority	For the construction of multiple course pavements the NJTA has established longitudinal pavement stepping requirements. One additional requirement the NJTA has with regard to the planned location of longitudinal joints in the surface course is that they be offset 1'-0" from the proposed location of traffic stripes. This is to allow for future crack sealing of longitudinal joints without compromising traffic stripes.
New York DOT	Whenever possible, it is located outside of the wheelpath. If that cannot be accommodated, then a different solution, such as reconstruction, is often considered. Widening joints directly in the wheelpath underperform compared to the rest of the pavement.
North Carolina DOT	Typically where the existing pavement ends.
Tennessee DOT	It depends on the cross section of the old and new pavement. In some situations, it exists at the middle of the lane not on the wheel path.
Texas DOT Austin District	When widening to existing structures, we stagger joints. Sometimes this means milling into the adjacent existing section. We also use a seal coat over the final structure, full width to seal off all construction joints prior to the final surface course.
Texas DOT San Antonio District	Preferred to be at the edge of a lane, but if not possible limit to center of the lane.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.4. Where is the joint between existing and new structure located?

Agency	*Answer*
Texas DOT Maintenance Division	Generally within 4 feet of the edge on narrow widenings and 12-14 feet from the edge on extra lanes. Avoid wheel paths.
Virginia DOT	At least 12" into existing pavement.
Federal Highway Administration	A best practice is usually to offset joints 6 inches between successive lifts. This is difficult to do in a widening project. Most often a final lift is placed on the whole roadway, which can span the widening and help mitigate the stacking of the underlying joint. Often a crack will develop at the widening joint.
National Center for Asphalt Technology	The joint is located at the edge of existing pavement. It is good if this can be done in conjunction with an overlay so that the overlay can be placed over existing pavement and widening section. This will help to improve the performance over the joint where widening begins.
University of Texas CTR	The location of the joint line can vary as previously discussed. Some designers try to maximize use of the existing pavement width and place the joint line within 6" of the pavement edge. This is a bit tricky since the "existing pavement edge' on an FM road can be variable due to repairs or deterioration. Some plans specify that the joint is placed 1' inside the lane - other projects place the joint line further into the lane to ensure that the widened section is constructed adjacent to good quality material.
Lane Construction Corporation	Preferred placement is 1.0' offset into the top lift of adjacent flexible pavement section.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.5. What special treatments are used to ensure the longitudinal joint (between new pavement and existing pavement) gives good performance?

Agency	*Answer*
Alabama DOT	Edge of existing pavement must be neatly cut with motor grader wheel or saw and covered with asphalt tack or joint sealant prior to placement of new asphalt mix for widening.
Arkansas DOT	None.
Colorado DOT	Usually we will put a 2-inch HMA overlay across the entire width.
Kentucky DOT	Mill 12 inches into existing pavement; either surface depth or perhaps half depth if possible.
Maryland DOT	No special treatments; just follow specifications.
Mississippi DOT	We use a sealer.
Montana DOT	We place the subgrade material and gravel base in 8-inch lifts and notch it into the existing road section. In addition, if the native material is questionable, we may construct the widened embankment of higher quality material (A-1-a). At least one lift of new asphalt pavement extends beyond the widened section onto the existing surface. This helps bridge over the joint.
New Jersey DOT	Paving entire width of travel lane or avoiding joint on the surface within the wheel path.
New Jersey Transit Authority	Unless a contractor is paving in echelon the NJTA requires all cold longitudinal joints to receive a coating of polymerized joint adhesive.
New York DOT	We match the existing section as closely as possible, and we cut back the existing pavement layers so that new layers can be “stepped” onto the existing section.
North Carolina DOT	None—pavement is often milled to a depth of 1.5-inces, and a surface layer is placed over both the widening and the adjacent existing pavement.
Tennessee DOT	Not aware of any special treatment techniques being used. We do specify that on all HMA construction projects and application of bituminous material (tack coat) is required to be placed on the face of all joints prior to paving.
Texas DOT Austin District	See answer to question 2.4. We also require milling equipment to construct vertical cuts.
Texas DOT San Antonio District	Rubberized asphalt, grid reinforcement and hot applied tack coat, staggered mill/overlays.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.5. What special treatments are used to ensure the longitudinal joint (between new pavement and existing pavement) gives good performance?

Agency	*Answer*
Texas DOT Maintenance Division	None--although materials selection can come into play. Some areas (districts) will use full depth HMAC to avoid consolidation issues.
Virginia DOT	Tack construction joint, and extend into existing pavement structure.
Federal Highway Administration	Proper tacking of the joint, use of Crafco joint adhesive, staggering joints, fogging of the joint after construction.
National Center for Asphalt Technology	Compaction is key. May want to overbuild slightly immediately adjacent to joint so that good compaction can be obtained. We are now doing this on airfields where asphalt is placed next to concrete and it seems to perform much better because of the increased density.
University of Texas CTR	Some projects incorporate fabrics or geotextiles to help stabilize the widening section. In some cases, the contractor will spray the joint face with water to help 'bond' the widening material to the existing material, though the effectiveness of this practice is not proven. I have seen references from other states or countries that show the contractor spraying the joint with an asphalt tack coat, though I have not seen this practice in Texas.
Lane Construction Corporation	Bind top lift(s) of structural asphalt with 1.0' minimum overlap joint.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.6. Do you have design guidance on lane widening and design of the longitudinal joint? If so, please provide what design guidance is used.

Agency	*Yes*	*No*	*Comments*
Alabama DOT		•	----
Arkansas DOT	•		We have guidance on minimum widths for constructability purposes. If there widening width is small, we shift the alignment to one side and do all of the widening to one side if possible. Also, in curb and gutter sections where the widening is 4’ or less, we provide quantities of Portland Cement Concrete Base to use in the widening instead of aggregate or asphalt. We then overlay the PCCB with 2”-4” of ACHM Surface Course.
Colorado DOT		•	----
Kentucky DOT		•	Mill 12 inches wide in order to overlap the joint with new pavement. Try to prevent a completely “cut through” vertical joint.
Maryland DOT	•		For the lane widening, must be at least 4’ wide to be constructed with asphalt. Narrower must have a concrete base. Total pavement box should be at least as thick as the adjacent pavement.
Mississippi DOT		•	We haven’t done a lot of widening projects since I started doing them on a regular basis, but I just work with input from District Construction and project officer personnel when I do them.
Montana DOT		•	We have guidance on what issues must be addressed when a project involves widening. However, this guidance does not apply to surfacing structure or widening techniques.
New Jersey DOT		•	We do not have any written guideline. We evaluate each project based on the design procedure discussed above.
New Jersey Transit Authority		•	Beyond the responses provided above the NJTA does not provide specific design guidance on the construction of longitudinal pavement joints.
New York DOT		•	We have very general guidance only. In our Highway Design Manual: https://www.dot.ny.gov/divisions/engineering/design/dqab/hdm/chapter-3 In our Comprehensive Design Manual: https://www.dot.ny.gov/divisions/engineering/design/dqab/cpdm

A.2 WIDENING DESIGN REQUIREMENTS

A.2.6. Do you have design guidance on lane widening and design of the longitudinal joint? If so, please provide what design guidance is used.

Agency	*Yes*	*No*	*Comments*
North Carolina DOT		•	----
Tennessee DOT		•	----
Texas DOT Austin District		•	----
Texas DOT San Antonio District		•	----
Texas DOT Maintenance Division		•	----
Virginia DOT	•		----
Federal Highway Administration	----	----	----
National Center for Asphalt Technology		•	Stagger joints if possible. Consider overbuilding slightly to improve compaction.
University of Texas CTR		•	Project 0-6748 has provided a compendium of best practices and lessons learned. However, it is uncertain if this information is being considered for development of design standards, recommendations or other guidance.
Lane Construction Corporation		•	----

A.2 WIDENING DESIGN REQUIREMENTS

A.2.7. Do you have special provisions on your construction specifications? If so, please describe what special provisions are typically included.

Agency	*Yes*	*No*	*Comments*
Alabama DOT		•	----
Arkansas DOT		•	No special provisions for longitudinal joint construction.
Colorado DOT		•	
Kentucky DOT		•	----
Maryland DOT		•	----
Mississippi DOT	----	----	----
Montana DOT		•	Requirements provided earlier are part of our standard specifications.
New Jersey DOT	•		Standard Specifications require HMA surface course to be constructed for the full width of the travel lane.
New Jersey Transit Authority	•		----
New York DOT		•	----
North Carolina DOT		•	----
Tennessee DOT		•	----
Texas DOT Austin District		•	----
Texas DOT San Antonio District		•	----
Texas DOT Maintenance Division		•	----
Virginia DOT	•		For trench widening, add notes to special provisions. Otherwise, use standard drawing.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.7. Do you have special provisions on your construction specifications? If so, please describe what special provisions are typically included.

Agency	*Yes*	*No*	*Comments*
Federal Highway Administration	----	----	----
National Center for Asphalt Technology		•	----
University of Texas CTR	•		Narrow widening projects often include a general note indicating that the joint line is 'saw cut'. However, in practice, based on interviews, this can mean use of a milling machine, use of a motor grader with a coulter blade (an agricultural implement) or a grader with a widening attachment. Other general notes relate to requirements limiting widening to 1 mile or less based on a demonstration by the contractor that the amount of widening trench opened can be filled and compacted to provide a widening surface within the same business day. Some plan sets also include a detail drawing of the widening joint; however, this varies.
Lane Construction Corporation		•	----

A.2 WIDENING DESIGN REQUIREMENTS

A.2.8. Are any special materials such as geotextiles, stabilizing agents, or special mixes used, particularly along the longitudinal joint? If so, please describe what special materials are typically used.

Agency	*Yes*	*No*	*Comments*
Alabama DOT		•	----
Arkansas DOT		•	Geotextile fabrics have been used in research projects.
Colorado DOT		•	
Kentucky DOT		•	Might try a geogrid "glass grid" over the joint. We have used this method on JPC joint repairs before AC overlays.
Maryland DOT		•	----
Mississippi DOT	•		We have used a geotextile fabric, and/or geogrid on some projects.
Montana DOT	----	----	We may use a higher quality fill material for the construction of the subgrade. Geotextiles may be used in very limited situations.
New Jersey DOT		•	We do not have any special mixes for the joint. Per our Standard Specification, we apply a uniform coating of polymerized joint adhesive to the existing/old vertical surface before paving. This coating is required on all cold joints.
New Jersey Transit Authority	•		While the NJTA will specify the use of all of the above the only material specifically used at longitudinal joints is Polymerized Joint Adhesive.
New York DOT		•	Normal materials are used, and stepped if possible. Fabrics of any kind are not strong enough to resist the forces involved at a widening joint.
North Carolina DOT		•	----
Tennessee DOT		•	----
Texas DOT Austin District	•		We use geogrid reinforcement to minimize reflective cracking associated with movement at the edge of pavement.
Texas DOT San Antonio District	•		Rubberized asphalt, grid reinforcement and hot applied tack coat, staggered mill/overlays.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.8. Are any special materials such as geotextiles, stabilizing agents, or special mixes used, particularly along the longitudinal joint? If so, please describe what special materials are typically used.

Agency	*Yes*	*No*	*Comments*
Texas DOT Maintenance Division	•		Sometimes cement treated where cement, concrete, or asphalt is there originally. Geogrid is used on occasion.
Virginia DOT		•	----
Federal Highway Administration	•		Crafco joint adhesive.
National Center for Asphalt Technology		•	----
University of Texas CTR	•		Geotextiles are sometimes used as previously discussed.
Lane Construction Corporation		•	Not necessary.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.9. What quality control testing and inspection is conducted to ensure lane widening and joint construction meets requirements at the *subgrade level*?

Agency	*Answer*
Alabama DOT	Compaction of subgrade is required to the satisfaction of the Engineer.
Arkansas DOT	In-place densities must be 95% of maximum laboratory density; 1 test per 12,000/sy.
Colorado DOT	We require moisture/density control on the subgrade material. If required, we will specify a minimum R-Value for the subgrade material.
Kentucky DOT	Must meet our standard specifications like any other project.
Maryland DOT	Refer to the specifications. Nothing extraordinary.
Mississippi DOT	Densities on underlying material, regular QC testing on materials used.
Montana DOT	Standard inspection procedures are used to ensure that the subgrade is constructed according to specifications (8" lifts, notching into existing embankment, compaction tests).
New Jersey DOT	We do not have any additional QC testing.
New Jersey Transit Authority	Prior to the start of paving operations in the field NJTA convenes a Pre-Paving Meeting to discuss methods to be employed during construction to ensure proper construction of pavement joints. Contractor required at start of paving operations to construct a test strip for each course of pavement to be constructed to determine project density and rolling pattern requirements. Density is determined in the field by use of a nuclear density gauge.
New York DOT	Proper compaction and drainage installation.
North Carolina DOT	As specified in standard specifications.
Tennessee DOT	Efforts are made to make sure subgrade resilient moduli are similar (existing to widening).
Texas DOT Austin District	Visual inspection by TxDOT inspection. Density controlled.
Texas DOT San Antonio District	Typically a proof roll and correcting soft spots.
Texas DOT Maintenance Division	Depending on the width of the widening, this could be density control or "ordinary" compaction.
Virginia DOT	Standard soils QA testing: soil moisture and compaction.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.9. What quality control testing and inspection is conducted to ensure lane widening and joint construction meets requirements at the *subgrade level*?

Agency	*Answer*
Federal Highway Administration	----
National Center for Asphalt Technology	Ensure good density adjacent to joint and elsewhere. Use nuclear gage. Ensure satisfactory materials used. Ensure surface of subgrade at proper elevation.
University of Texas CTR	Based on field visits to on-going narrow widening construction projects, compaction of the subgrade might or might not be performed. The majority of districts do not stabilize the subgrade due to delays in construction and opening to traffic by close of business. Some contractors use narrow pneumatic tired or steel wheel rollers to compact the subgrade. I have not personally seen any type of testing performed to ensure that uniform compaction was achieved.
Lane Construction Corporation	None.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.10 What quality control testing and inspection is conducted to ensure lane widening and joint construction meets requirements at the base level?

Agency	Answer
Alabama DOT	Compaction of any base material is required to the satisfaction of the Engineer.
Arkansas DOT	In-place densities.
Colorado DOT	Typically, CDOT will use at least 6 inches of an Aggregate Base Course material. We will monitor the moisture/density and gradation of this material.
Kentucky DOT	Must meet our standard specifications like any other project.
Maryland DOT	Refer to the specifications. Nothing extraordinary.
Mississippi DOT	Densities on underlying material, regular QC testing on materials used.
Montana DOT	Standard inspection procedures are used to ensure that the subgrade is constructed according to specifications (8” lifts, notching into existing embankment, compaction tests).
New Jersey DOT	We do not have any additional QC testing.
New Jersey Transit Authority	The NJTA has stringent requirements for the types of materials used, as well as how they are to be placed, graded and tested to ensure construction of long-lasting roadway pavement.
New York DOT	Proper compaction and joint construction, including tack coats. “Base” is our bottom layer of hot mix asphalt. The granular subbase beneath is simply properly compacted.
North Carolina DOT	As specified in standard specifications.
Tennessee DOT	Aggregate bases are compacted to required density adjacent to existing and are the same thickness bituminous bases (drainage layers) are aligned to insure that subsurface water can be removed effectively. If the old pavement has a drainage layer, one is provided for the new also.
Texas DOT Austin District	Visual inspection by TxDOT inspection. Density controlled.
Texas DOT San Antonio District	Potential use of geogrid, density control/thickness control.
Texas DOT Maintenance Division	Depending on the width, there might be density control or "ordinary" compaction.
Virginia DOT	Standard asphalt concrete QA testing: thickness, density.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.10 What quality control testing and inspection is conducted to ensure lane widening and joint construction meets requirements at the base level?

Agency	Answer
Federal Highway Administration	----
National Center for Asphalt Technology	Ensure good materials are used and adequate density obtained. Ensure surface of base at proper elevation. Watch out for segregation, which may be a big problem in these areas.
University of Texas CTR	Base material is typically placed using a belly dump and then worked back and forth with a grader. This material is then bladed into place and compacted. I have not seen any specific type of testing performed to ensure adequate compaction or consistent compaction along the joint; though I have only visited perhaps 8 or 10 projects. Practices might vary from district to district.
Lane Construction Corporation	None.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.11 What quality control testing and inspection is conducted to ensure lane widening and joint construction meets requirements at the structural asphalt level?

Agency	Answer
Alabama DOT	Compaction is required to the satisfaction of the Engineer. The asphalt mixture must also meet various test at the point of production, i.e., asphalt content, air voids, VMA, etc.
Arkansas DOT	Field or laboratory densities; 1 per sublot, or 750 tons.
Colorado DOT	CDOT follows all our typical HMA requirements.
Kentucky DOT	Must meet our standard specifications like any other project.
Maryland DOT	Refer to the specifications. Nothing extraordinary.
Mississippi DOT	Densities on underlying material, regular QC testing on materials used.
Montana DOT	We have standard testing procedures for all asphalt paving. These are included in Section 401 of our standard specifications. They can be found on the MDT website at the following location: http://www.mdt.mt.gov/business/contracting/standard_specs.shtml
New Jersey DOT	We do not have any additional QC testing for longitudinal joints, but we are in process of developing a specification with required QC testing for all longitudinal cold joints.
New Jersey Transit Authority	Prior to the start of paving operations in the field NJTA convenes a Pre-Paving Meeting to discuss methods to be employed during construction to ensure proper construction of pavement joints. Contractor required at start of paving operations to construct a test strip for each course of pavement to be constructed to determine project density and rolling pattern requirements. Density is determined in the field by use of a nuclear density gauge, as well as core samples to correlate nuclear gauge results. Core results shall yield bulk and maximum specific gravities of the asphalt course and air void content. Nuclear density gauge results shall yield bulk specific gravity, maximum density based on the maximum specific gravity results obtained from core samples and air void content. The referenced tests are performed at various locations throughout the pavement course being constructed including along the longitudinal joint.
New York DOT	Proper compaction and joint construction, including tack coats.
North Carolina DOT	As specified in standard specifications.
Tennessee DOT	New pavement thickness is equivalent to existing and compacted as required.
Texas DOT Austin District	Visual inspection by TxDOT inspection. Longitudinal joint density and in-place air voids.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.11 What quality control testing and inspection is conducted to ensure lane widening and joint construction meets requirements at the structural asphalt level?

Agency	Answer
Texas DOT San Antonio District	Longitudinal joint density profiles, thermal profiles, visual inspection.
Texas DOT Maintenance Division	If asphalt is placed, the normal placement specifications are used. Generally, narrow widths with primarily granular base are with covered with a chip seal.
Virginia DOT	Standard asphalt: thickness, density, straightedge (maybe).
Federal Highway Administration	----
National Center for Asphalt Technology	Ensure mix is satisfactory. Watch out for segregation. Apply tack between existing pavement and widening material. Ensure good compaction. May want to overbuild slightly on top layer so that adequate density can be obtained. If possible stagger joint. For example if widening is done in conjunction with overlay, the joint can be staggered in the upper joint(s).
University of Texas CTR	Narrow widening projects are quite often funded using Safety Bond money or Highway Safety Improvement Program funds which do not allow for structural strengthening of the pavement during a widening project. The idea of these funds (CAT 3) are to provide for widening of the pavement for safety purposes at the maximum Benefit / Cost ratio. This precludes use of a structural ACP layer and typically involves placement of a surface treatment. On projects funded with CAT 1 funds, again these projects are often lower volume routes that might carry heavy trucks, but placing a structural ACP layer across the entire pavement surface would in most cases be considered cost prohibitive.
Lane Construction Corporation	None.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.12 What is your agency's practice, as related to lane widening projects, concerning use of subgrade and base stabilization?

Agency	Answer
Alabama DOT	Typically not required.
Arkansas DOT	It is not used much, mainly due to limited area of most notch and widen jobs. Most jobs are not widened enough to allow machinery to apply and mix stabilization.
Colorado DOT	No standard practice.
Kentucky DOT	Generally we use the these forms of stabilization: 1. 1 foot rock and fabric 2. 3 inches extra DGA and geogrid 3. Chemical stabilization (lime or cement) For a small lane addition project such as widening for a left turn lane, chemical stabilization is not typically worth the effort and we would normally use: 1 foot of rock and fabric or geogrid. For the interstate widening projects, we have been using cement or lime stabilization most often.
Maryland DOT	Refer to the specifications. Nothing extraordinary.
Mississippi DOT	Chemical treatment of materials by either lime or concrete stabilization, depending on the plasticity index and/or volume change of material in-place. Also removing any high volume change material and backfilling with borrow excavation.
Montana DOT	We haven't used chemical stabilization, but we are researching various methods.
New Jersey DOT	If necessary, we do consider subgrade stabilization. We are also considering using Cold-in-place (with foam or emulsion) and Full Depth Reclamation with cement (one project already completed successfully) for reconstructing thin shoulder.
New Jersey Transit Authority	The level of subgrade and base stabilization on NJTA projects is dependent upon underlying soil conditions. On recent GSP Bridge replacement and widening contracts in areas with soil conditions known to be poor geotextiles were utilized to provide rigidity to fill material placed within the roadway to prevent future roadway settlement. The NJTA is just now experimenting with subsurface grout injection below sections of roadway constructed in known marshy areas and experiencing considerable settlement.
New York DOT	We do not use subgrade or subbase stabilization.
North Carolina DOT	Subgrade and base stabilization are typically not used.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.12 What is your agency's practice, as related to lane widening projects, concerning use of subgrade and base stabilization?

Agency	Answer
Tennessee DOT	We do not generally use geosynthetics or grids for stabilization. If the existing subgrade was stabilized, we would require similar stabilization on the proposed or undercut the existing to provide a thickness (equivalent) aggregate layer.
Texas DOT Austin District	Typically reclaim and cement stabilize existing materials.
Texas DOT San Antonio District	Lime stabilization of subgrade, geogrid on top of subgrade, cement stabilization of base, geogrid on top of stabilized base.
Texas DOT Maintenance Division	Narrow width pavements do not have stabilized subgrade and might use cement treated base. Larger widths might have lime treated subgrade, cement treated subgrade, and/or lime or cement treated base.
Virginia DOT	Depends on the soils.
Federal Highway Administration	----
National Center for Asphalt Technology	Stabilization may be helpful. Depending on size of widening project may want to consider flowable fill.
University of Texas CTR	Unless the narrow widening is being performed through full depth reclamation, it is very unlikely that subgrade or base chemical stabilizers would be used due to construction delays and the need to open the entire lane including the widening section back to traffic. As previously mentioned, ASB might be used on some projects and is likely the most common stabilized material used for base layers.
Lane Construction Corporation	----

A.2 WIDENING DESIGN REQUIREMENTS

A.2.13 What is your agency's practice, as related to lane widening projects, concerning selection of base and surface course materials?

Agency	*Answer*
Alabama DOT	When required, local material sources used for borrow or aggregate material.
Arkansas DOT	Typically asphalt is used, but if the Contractor requests to use Portland cement concrete base on curb and gutter projects at no additional cost to the Department, it is usually granted.
Colorado DOT	No standard practice.
Kentucky DOT	Must meet current Superpave requirements.
Maryland DOT	See previous.
Mississippi DOT	Base materials (borrow excavation) depends on the availability of materials in the area. HMA depends on the ADT and % truck traffic as to which type to be used.
Montana DOT	They must meet our standard specifications.
New Jersey DOT	We do not have separate criteria for selection of material for the widening section. We select surface course for the project depending upon the traffic loading, type of pavement (flexible or composite) etc.
New Jersey Transit Authority	Standard NJTA pavement practices dictate the use of polymer modified surface and intermediate course pavements such as HMA 12.5M76 Surface Course and HMA 19M76 Intermediate Course. The use of polymer modified binder is to provide better temperature stability and higher rut resistance. HMA mixes with an "M" compaction level are used for improved crack resistance (higher AC content). OGFC and AR-OGFC surface course mixes are specified on GSP projects in areas with residential neighborhoods located immediately adjacent the NJTA right-of-way.
New York DOT	Ordinary materials are used, similar to the rest of the project.
North Carolina DOT	Asphalt base and surface are typically used. Mix type is selected based on traffic level.
Tennessee DOT	Aggregate base is usually limestone or river gravel (depending on available materials) and similar in thickness to the original. Surface course materials are similar as we can make them and drainage courses are aligned, when present.
Texas DOT Austin District	No different than ordinary pavement design and construction.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.13 What is your agency's practice, as related to lane widening projects, concerning selection of base and surface course materials?

Agency	*Answer*
Texas DOT San Antonio District	Base: depending on confining pressure from roadway width (i.e. shoulders > 3') will require a more cohesive material that meets triaxial test requirements. Surface course: nothing that is not considered for typical roadway repair.
Texas DOT Maintenance Division	This is district (regional) dependent. Lower volume roadways will have a fine, dense grade aggregate base or HMAC. HMAC depends on how difficult roadway is to build under traffic and how narrow a placement. Lower volume roadways will most likely be two chip seals and larger might have 2-6" of HMAC. Most of the HMAC is dense grade and increasing use of Superpave HMAC.
Virginia DOT	Match existing until surface. Then attempt to apply new surface across all lanes.
Federal Highway Administration	----
National Center for Asphalt Technology	Use existing specs for base and surface course materials.
University of Texas CTR	Texas is a very large state with large variations in rainfall east to west, freezing temperatures north to south and local material types. Traffic conditions also vary extensively due to energy sector development (oil, gas, wind energy), agriculture, dairy farming, quarry operations, industry, port and freight activity etc. Thus, design practices and methods vary across the state though practices are standardized in relation to the geometric design factors considering the functional classification of the route. The geometric design factors and the pavement design need to be considered together since certain criteria such as heavy truck off-tracking, the design vehicle used for the project, side slope rates, and other factors also affect pavement performance.
Lane Construction Corporation	----

A.2 WIDENING DESIGN REQUIREMENTS

A.2.14 What is your agency's practice as related to lane widening projects, concerning design of narrow trench repairs for deteriorated longitudinal joints?

Agency	*Answer*
Alabama DOT	No standard practice. If cracked, we typically mill it off to surface treatment and repave.
Arkansas DOT	Does not occur; narrow trenches and repair of longitudinal joints only are uncommon.
Colorado DOT	No standard practice. We have filled large (greater than 1 inch) cracks with 1/2 inch nominal aggregate size HMA. Sometimes, we will use a pothole material to fill the large cracks.
Kentucky DOT	• Level and wedge as necessary rather than trench the joint. • Possibly use a geogrid glass-grid if available funding. • Milling and inlaying is also considered.
Maryland DOT	If deeper than one lift, must be at least 4' wide to ensure adequate compaction.
Mississippi DOT	Remove and replace failing materials and backfill with HMA. Most of our recent repairs have been on preventative maintenance projects.
Montana DOT	We have not used this treatment.
New Jersey DOT	We have provision for HMA repair prior to milling and paving. We include item and quantity for the project, if necessary.

A.2 WIDENING DESIGN REQUIREMENTS

A.2.14 What is your agency's practice as related to lane widening projects, concerning design of narrow trench repairs for deteriorated longitudinal joints?

Agency	*Answer*
New Jersey Transit Authority	The NJTA has in place an annual pavement-resurfacing program on both the GSP and TPK roadways. Areas of deteriorated pavement are milled to a consistent depth and resurfaced. Typically, one lane is milled and resurfaced before the adjacent lane is started. In this manner the construction of the new pavement surface course is never unsupported and so long as the new pavement is "bumped" at the longitudinal joint good compaction is typically achieved. When resurfacing the adjacent lane the milling operation is required to extend approximately 2" into the new lane pavement further minimizing any areas of lower compaction. In addition, the use of Polymerized Joint Adhesive improves the bond between lanes contributing to a better performing longitudinal joint. As a result, we are seeing a reduction in moderate to severe joint failures. At areas where longitudinal joint failure is experienced and the quantity of repair considerable the NJTA has performed narrow "trench type" joint repairs by using a small milling machine. In areas of localized joint failure saw-cutting and jackhammering is used. The keys to a good joint repair are neat vertical edges, clean repair area, sufficient tack coat placement to all existing surfaces and sufficient material placed to ensure good densification.
New York DOT	We do not do trench repairs. They create two longitudinal joints where previously there was only one. It doubles your troubles.
North Carolina DOT	Can be milled and replaced with asphalt.
Tennessee DOT	I do not know of any project with this treatment.
Texas DOT Austin District	If the circumstance permits, we would use full depth hot-mix asphalt.
Texas DOT San Antonio District	Not used.
Texas DOT Maintenance Division	Generally does not occur. Cold mix patching material is probably used most frequently to level up depressions and smooth joints.
Virginia DOT	No standard practice.
Federal Highway Administration	----

A.2 WIDENING DESIGN REQUIREMENTS

A.2.14 What is your agency's practice as related to lane widening projects, concerning design of narrow trench repairs for deteriorated longitudinal joints?

Agency	*Answer*
National Center for Asphalt Technology	Flowable fill might be good here. Difficult to place material in trenches and obtain good compaction.
University of Texas CTR	Localized maintenance repairs will vary significantly from district to district. Edge repairs are often performed using a grader with a widening blade attachment, a dump truck(s) with cross conveyer - the edge repair typically uses RAP and is not a structural widening, it is to provide edge repairs and at times additional width for striping.
Lane Construction Corporation	----

A.3 GENERAL EXPERIENCE WITH LANE WIDENING PROJECTS

A.3.1. Has your agency encountered problems with placing a widening joint in the wheel path? Please briefly describe difficulties and resolutions.

Agency	*Yes*	*No*	*Comments*
Alabama DOT	•		Occasional reflective cracking of joint up through overlying layers.
Arkansas DOT		•	Joints in the wheel path are avoided.
Colorado DOT		•	----
Kentucky DOT	•		Joints in the wheel path can ravel worse. We strive to keep joints out of the wheel path.
Maryland DOT		•	----
Mississippi DOT	----	----	----
Montana DOT	•		Sometimes. We try to avoid placing the joint in the wheel path. It can create a longitudinal joint. We typically seal the crack and may do rut filling if needed.
New Jersey DOT		•	Depending upon needs for the project, a joint between existing and widening section may exist within the wheel path. However, our specification requires paving entire width of travel lane to avoid any longitudinal cold joint on the surface. We have not noticed any problem due to joint below surface course. Also, all widening needs to be completed prior to the main line treatment.
New Jersey Transit Authority	•		The placement of longitudinal joints within the wheel path is not desirable and should be avoided to the fullest extent possible. Even a well-constructed joint placed in a wheel path has a tendency to fail in time.
New York DOT	•		Joints in the wheelpath collect water, deteriorate faster, and ravel out. Durability of the surface courses is a major problem. Keep widening joints out of the wheelpath.
North Carolina DOT	•		Pavement deterioration occurs in this case. The most common resolution is repeated repair.
Tennessee DOT	•		For that reason we do everything possible to keep a construction joint from occurring in the wheel path.
Texas DOT Austin District	•		The joint ravels or ruts. We purposely design the joint to be placed between the wheel paths.
Texas DOT San Antonio District	•		This is always a problem and will always lead to a maintenance issue. Modify joint to middle of the lane, or place grid/crack relief layer at the joint and overlay.

A.3 GENERAL EXPERIENCE WITH LANE WIDENING PROJECTS

A.3.1. Has your agency encountered problems with placing a widening joint in the wheel path? Please briefly describe difficulties and resolutions.

Agency	*Yes*	*No*	*Comments*
Texas DOT Maintenance Division	•		Cracking at the joint and consolidation at the joint. Moving joint out of wheelpath is best resolution. Structural section and attention to consolidation of materials has helped.
Virginia DOT	•		Particularly when significant materials change (not recommended), as in when full-depth asphalt lanes are added to rigid existing, we've experienced a "break-over".
Federal Highway Administration	----	----	----
National Center for Asphalt Technology	•		Very difficult to obtain good performance when joint is in wheel path. Good materials and compaction must be obtained. Also, may want to stagger joint for each layer being constructed.
University of Texas CTR	•		As previously discussed
Lane Construction Corporation	•		Some limited Florida DOT projects have placed by design a longitudinal joint in the wheel path. Apparent design flaw appears to be the result of inexperienced designers or the desire to save a buck by minimizing new pavement section area.

A.3 GENERAL EXPERIENCE WITH LANE WIDENING PROJECTS

A.3.2. How does your agency resolve problems with vertical construction faces at the widening joint? Please briefly describe difficulties and resolutions.

Agency	*Answer*
Alabama DOT	There is no policy for widening. Specifications for new construction require staggering longitudinal joints six inches apart between layers.
Arkansas DOT	Vertical faces are inspected to insure they are formed properly and free of dirt and debris. There is also a requirement to apply tack coat onto adjoining vertical faces.
Colorado DOT	Usually, CDOT will place a good tack coat along the vertical face and overlay the entire roadway with at least two inches of HMA.
Kentucky DOT	We saw cut a neat vertical face, then use the aforementioned longitudinal edge key to offset a new joint between the new and existing.
Maryland DOT	No longer an issue. Refer to the specifications section 504.03.07 http://www.marylandroads.com/ohd/part3.pdf
Mississippi DOT	----
Montana DOT	We only have a vertical construction face for the asphalt pavement. All base course and subgrade faces are notched, typically on a 3H:1V slope although this may vary considerably.
New Jersey DOT	We have not observed any such problem.
New Jersey Transit Authority	The Authority requires the joint between existing and new construction to either be sawcut vertical or milled vertical prior to placement of new lane pavement to promote the best possible condition for achieving proper compaction along the joint.
New Jersey Transit Authority	The Authority requires the joint between existing and new construction to either be sawcut vertical or milled vertical prior to placement of new lane pavement to promote the best possible condition for achieving proper compaction along the joint.
New York DOT	We tack coat the asphalt layers to improve joining with the new asphalt.
North Carolina DOT	----
Tennessee DOT	If the face is not stable it may be skimmed or sawed back to form a workable face.
Texas DOT Austin District	Use miller to construct the vertical face.
Texas DOT San Antonio District	Temporary shoring if more than 3'.

A.3 GENERAL EXPERIENCE WITH LANE WIDENING PROJECTS

A.3.2. How does your agency resolve problems with vertical construction faces at the widening joint? Please briefly describe difficulties and resolutions.

Agency	*Answer*
Texas DOT Maintenance Division	Attempt to stagger joints vertically when practical.
Virginia DOT	Heavy tack.
Federal Highway Administration	----
National Center for Asphalt Technology	Compaction is difficult. Flowable fill may work good if not too much material required. Stagger joints if possible. Overbuild top layer slightly so that good compaction can be obtained. Good if the top layer can be placed all the way across existing pavement and widening.
University of Texas CTR	As previously discussed.
Lane Construction Corporation	I am Contractor. This is usually handled by the Florida DOT. In design build projects we typically try to implement an offset joint detail. On existing projects, if we bring up the issue on existing projects we are usually met with skepticism with the first thought being that we are only looking for a Change Order instead of looking at Best Management Practices.

A.3 GENERAL EXPERIENCE WITH LANE WIDENING PROJECTS

A.3.3. Has your agency encountered any problems with design cross-sections that do not match existing section? Please briefly describe difficulties and resolutions.

Agency	*Yes*	*No*	*Comments*
Alabama DOT		•	----
Arkansas DOT	•		Yes, some existing cross sections do not match what the construction plans show as existing. When fewer asphalt layers exist, where there should be more, the material is removed and replaced with the design layers of material. There has also been cases of more aggregate base course than expected. In that instance, the complete removal of the shoulder was not deleted, and the pavement was built up from sound existing material.
Colorado DOT		•	----
Kentucky DOT	•		We use level and wedging (or milling) to correct. We also have had issues where the widening occurs on the high side of a super. The Superpave mixes are so porous compared to the old "I" mixes that it creates some significant water issues.
Maryland DOT	•		Just about every pavement section on the network does not quite match the design. Cores and GPR provide the answer.
Mississippi DOT	----	----	----
Montana DOT		•	We generally conduct field surveys for widening projects, so the designed cross sections are developed using the field measurements.
New Jersey DOT		•	----
New Jersey Transit Authority		•	The Authority has a standard pavement section that has proven to perform well for the traffic conditions on each of the Authority's two roadways (Garden State Parkway and New Jersey turnpike). As such, the Authority does not perform a pavement design for each new construction contract.
New York DOT	•		Different sections behave differently. Frost will lift them differently; their support of traffic is different. A crack will always form between them, allowing water in to deteriorate the materials in the section. Do not do this.
North Carolina DOT		•	----

A.3 GENERAL EXPERIENCE WITH LANE WIDENING PROJECTS

A.3.3. Has your agency encountered any problems with design cross-sections that do not match existing section? Please briefly describe difficulties and resolutions.

Agency	*Yes*	*No*	*Comments*
Tennessee DOT	•		We do everything possible to avoid this occurrence.
Texas DOT Austin District	•		In this case, we will schedule a level-up course or profile mill to re-establish the cross slope.
Texas DOT San Antonio District	•		CRCP in existing vs. flexible at the widened section. Resulted in major failures at the joint.
Texas DOT Maintenance Division	•		Flex sections adjacent to cement stabilized sections tend to consolidate. Level-up has been primary means of reestablishing cross-slope. HMAC next to a flexible section has created some rutting issues next to the HMAC.
Virginia DOT	•		See comment above regarding flexible lane additions to composite lanes.
Federal Highway Administration	----	----	----
National Center for Asphalt Technology	•		Must keep stiffness of existing pavement and widened area about the same otherwise there will be differential settlement/compaction.
University of Texas CTR	•		□□□□□□□□□□□□□□□□□□□□□□□□
Lane Construction Corporation	•		All the time. Florida DOT and many other state agencies have minimized the pre-construction survey to verify existing conditions. This causes a lot of issues. The usual DOT position is that the Contractor "figure it out" and perform their work at existing contract unit prices even though most all occurrences are actually true significant changes in work scope and materially different than original bid docs.

A.3 GENERAL EXPERIENCE WITH LANE WIDENING PROJECTS

A.3.4. If your agency has encountered any additional construction problems, please list/describe the problem and how it was resolved.

Agency	*Answer*
Alabama DOT	----
Arkansas DOT	We encountered dirt in joints between driving lanes and shoulder in a section scheduled to be widened on an interstate. The “dirty” material was cut back further into the driving lane.
Colorado DOT	----
Kentucky DOT	We have had issues with subsurface drainage in super elevated sections. We try to grade the subgrade to the outside to prevent subsurface water from ponding against the old pavement. Also, if only widening for a 2-foot shoulder, it will fall apart if it is a “thin” design. Cars will wander onto that 2-foot shoulder if you build it. We also have had issues where the widening occurs on the high side of a super. The Superpave mixes are so porous compared to the old “I” mixes that it creates some significant water issues.
Maryland DOT	----
Mississippi DOT	----
Montana DOT	----

A.3 GENERAL EXPERIENCE WITH LANE WIDENING PROJECTS

A.3.4. If your agency has encountered any additional construction problems, please list/describe the problem and how it was resolved.

Agency	*Answer*
New Jersey DOT	The existing travel lanes are widened depending upon the need of the project. If a full depth shoulder exists along a travel lane, we use the existing shoulder as a travel lane by restriping. If a full depth shoulder is not available, we reconstruct full depth pavement. All reconstruction needs to be completed prior to the treatment on the existing lane. Our specification requires constructing a surface course for the full width travel lane. Therefore, we do not see any longitudinal cold joint on the surface between the existing and widening lane. We have not noticed any problem caused by the joint below surface course. We have observed structural distress in the flexible pavement of the widened lane when the widening section is along the composite pavement and widened section is located within the wheel path. To resolve this problem, we are reconstructing flexible pavement within the wheel path along the existing composite pavement. We also observe longitudinal reflection cracking along the longitudinal joint between existing composite pavement and widened flexible pavement. In order to inhibit this cracking, we are using special mix: e.g. Stone Matrix Asphalt over Binder Rich Intermediate Course for the entire width of travel lane. As discussed above, we do not see any additional surface distress when the flexible widened pavement is along the existing flexible pavement.
New Jersey Transit Authority	----
New York DOT	----
North Carolina DOT	----
Tennessee DOT	I'm not sure whether we've encountered such problem.
Texas DOT Austin District	----
Texas DOT San Antonio District	----
Texas DOT Maintenance Division	Width of widened section can be a problem when equipment is unable to compact material. No solution except make it wider or use of bituminous mixes.
Virginia DOT	----
Federal Highway Administration	----

A.3 GENERAL EXPERIENCE WITH LANE WIDENING PROJECTS

A.3.4. If your agency has encountered any additional construction problems, please list/describe the problem and how it was resolved.

Agency	*Answer*
National Center for Asphalt Technology	Differential settlement or openings of the longitudinal joint are biggest problems. Key to good performance is good compaction in all layers.
University of Texas CTR	----
Lane Construction Corporation	----

A.4 WIDENING FLEXIBLE PAVEMENT SECTIONS IN GOOD CONDITION

Candidate pavement section is in good condition and exhibits no structural distress:

Flexible pavement section in good condition.

A.4.1. Does your agency have typical pavement section(s) that would be used for this case?

Agency	*Yes*	*No*
Alabama DOT		•
Arkansas DOT		•
Colorado DOT		•
Kentucky DOT	•	
Maryland DOT		•

A.4 WIDENING FLEXIBLE PAVEMENT SECTIONS IN GOOD CONDITION

A.4.1. Does your agency have typical pavement section(s) that would be used for this case?

Agency	*Yes*	*No*
Mississippi DOT	----	----
Montana DOT	----	----
New Jersey DOT		•
New Jersey Transit Authority		•
New York DOT		•
North Carolina DOT		•
Tennessee DOT		•
Texas DOT Austin District		•
Texas DOT San Antonio District		•
Texas DOT Maintenance Division	•	
Virginia DOT	•	
Federal Highway Administration	----	----
National Center for Asphalt Technology		•
University of Texas CTR	•	
Lane Construction Corporation	•	

A.4 WIDENING FLEXIBLE PAVEMENT SECTIONS IN GOOD CONDITION

A.4.2. What construction techniques and specifications would your agency recommend for this case?

Agency	*Answer*
Alabama DOT	Excavate shoulder to depth and width required keeping a neat vertical edge on existing pavement edge, compaction of subgrade to satisfaction of Engineer, place asphalt tack or joint sealant on face of existing pavement, placement and compaction of required asphalt widening layers to satisfaction of Engineer.
Arkansas DOT	Standard notch and widening specifications.
Colorado DOT	Saw cut at the white line. Place the required thickness of base course material. Place the required thickness of HMA, and chip seal the entire surface.
Kentucky DOT	Preferably to widen to one side. Saw cut a vertical face and use a 12-inch longitudinal edge key as mentioned previously.
Maryland DOT	See earlier discussion.
Mississippi DOT	----
Montana DOT	If we were to widen this section, we would use our standard design and construction techniques, which have been described previously.
New Jersey DOT	----
New Jersey Transit Authority	1. Sawcut and/or mill existing edge of pavement to produce vertical joint. 2. Construct apply polymerized joint adhesive to all cold joints. 3. Construct new base course pavement. 4. If pavement section requires an intermediate course lift offset joint from the base course lift. 5. Finally, offset surface course joint from intermed. Course joint. Surface course joint is recommended to be offset from the location of lane striping to allow future joint sealing without obscuring the striping.
New York DOT	----
North Carolina DOT	Typically we would excavate the area of widening, place 4- to 5.5-inches of B25.0B, and overlay existing and widening with 1.5 inches of SF9.5A.
Tennessee DOT	Match existing pavement section. Increase aggregate base depth, if necessary, to insure layers are aligned.
Texas DOT Austin District	It appears the existing pavement is in good condition. We would add a minimum of 4 foot shoulder, but as wide as we can afford. If the existing section is structurally adequate for future 20 year ESALs, the widened section would match the adjacent section. If not, we would either rehabilitates the pavement full width and utilize full depth reclamation OR match the existing section, but perform a structural overlay for full width.

A.4 WIDENING FLEXIBLE PAVEMENT SECTIONS IN GOOD CONDITION

A.4.2. What construction techniques and specifications would your agency recommend for this case?

Agency	*Answer*
Texas DOT San Antonio District	Saw cut at edge line, match existing pavement, overlay/surface treatment across all lanes.
Texas DOT Maintenance Division	Same construction specifications. Mostly in typical section of what is built.
Virginia DOT	----
Federal Highway Administration	----
National Center for Asphalt Technology	Use conventional specifications, and pay close attention to compaction. Watch out for segregation.
University of Texas CTR	In some cases the joint line is moved further into the pavement lane so that the wheel path is not on a joint and so that the joint line face is cut in 'good' existing pavement material.
Lane Construction Corporation	Usually add 4' or 5' paved shoulders. Enhance safety if vehicles veer from an existing travel lane or provide buffer for bike/pedestrian traffic.

A.4 WIDENING FLEXIBLE PAVEMENT SECTIONS IN GOOD CONDITION

A.4.3. Has your agency encountered any problems with widening sections that were originally in good condition? Please briefly describe difficulties and resolutions.

Agency	*Yes*	*No*	*Comments*
Alabama DOT		•	Excavate shoulder to depth and width required keeping a neat vertical edge on existing pavement edge, compaction of subgrade to satisfaction of Engineer, place asphalt tack or joint sealant on face of existing pavement, placement and compaction of required asphalt widening layers to satisfaction of Engineer.
Arkansas DOT		•	----
Colorado DOT		•	----
Kentucky DOT	•		For 2 foot widening, ensure full depth pavement and a full depth dga wedge, otherwise vehicles will tear it up.
Maryland DOT		•	----
Mississippi DOT	----	----	----
Montana DOT		•	----
New Jersey DOT		•	----
New Jersey Transit Authority	•		----
New York DOT	•		Eventually, all pavement sections deteriorate. Widenings deteriorate at a different rate than the rest of the pavement, which was placed at a different time. Better or worse, the entire pavement rehabilitation schedule will be driven by the performance of the worst part.
North Carolina DOT		•	----
Tennessee DOT		•	----
Texas DOT Austin District	•		Years ago, our district had the habit of performing all widening with full depth HMA. In some cases, this either cause drainage issue as the HMA section would dam up water draining transversely OR it would act monolithically and exhibit poor load transfer as the HMA section was much stiffer than the existing pavement section.

A.4 WIDENING FLEXIBLE PAVEMENT SECTIONS IN GOOD CONDITION

A.4.3. Has your agency encountered any problems with widening sections that were originally in good condition? Please briefly describe difficulties and resolutions.

Agency	*Yes*	*No*	*Comments*
Texas DOT San Antonio District		•	----
Texas DOT Maintenance Division	•		Same problems as above. Mostly when section is not rehabilitated when widening occurs, the section not touched tends to fail more rapidly (miss-evaluate the condition of the existing section).
Virginia DOT		•	----
Federal Highway Administration	----	----	----
National Center for Asphalt Technology		•	----
University of Texas CTR	•		As previously discussed, freezing precipitation, drought, increased heavy truck operations due to energy sector traffic all can result in rapid deterioration of a widened pavement that was previously performing satisfactorily.
Lane Construction Corporation	•		Usually on when tying into existing side streets and driveways. Cross slope issues. Especially in super elevated sections.

A.5 WIDENING FLEXIBLE PAVEMENT SECTIONS IN POOR CONDITION

Candidate pavement section is in poor condition and exhibits rutting and/or longitudinal cracking.

Flexible pavement section in poor condition.

A.5.1. Does your agency have typical pavement section(s) that would be used for this case?

Agency	*Yes*	*No*
Alabama DOT		•
Arkansas DOT		•
Colorado DOT		•
Kentucky DOT		•
Maryland DOT		•

A.5 WIDENING FLEXIBLE PAVEMENT SECTIONS IN POOR CONDITION

A.5.1. Does your agency have typical pavement section(s) that would be used for this case?

Agency	*Yes*	*No*
Mississippi DOT	----	----
Montana DOT		•
New Jersey DOT		•
New Jersey Transit Authority	•	
New York DOT		•
North Carolina DOT		•
Tennessee DOT		•
Texas DOT Austin District		•
Texas DOT San Antonio District		•
Texas DOT Maintenance Division	•	
Virginia DOT	•	
Federal Highway Administration	----	----
National Center for Asphalt Technology		•
University of Texas CTR	•	
Lane Construction Corporation		•

A.5 WIDENING FLEXIBLE PAVEMENT SECTIONS IN POOR CONDITION

A.5.2. What construction techniques and specifications would your agency recommend for this case?

Agency	*Answer*
Alabama DOT	Excavate shoulder to depth and width required keeping a neat vertical edge on existing pavement edge, compaction of subgrade to satisfaction of Engineer, place asphalt tack or joint sealant on face of existing pavement, placement and compaction of required asphalt widening layers to satisfaction of Engineer. Mill existing wearing layer to remove cracking and rutting, possible placement leveling and surface treatment layer followed by new wearing layer.
Arkansas DOT	Pavement and subgrade cores would be gathered at locations of the cracking and the rutting and at locations where the pavement appears to be good. These cores would be analyzed by the Materials Division to determine the cause of the failures. Then, based on the data, Materials Division would make recommendation on how best to correct the problem when the widening project is constructed. Specific techniques and specifications would vary greatly in different projects.
Colorado DOT	Saw cut the joint as close as possible to the outer edge. Place base material. Mill 2 inches off the full-width. Place HMA in widened section, and overlay the entire surface with at least 2 inches of HMA.
Kentucky DOT	We would probably saw cut the vertical face just inside the crack, especially if the “original” old pavement went to this point, but was slowly widened over the years. Resurface the entire pavement and ensure there is no surface joint over the new joint. Trenching may also be performed in the area where the widening is to take place. Specific depths and material thicknesses would be determined by funding.
Maryland DOT	This really isn’t that bad. It could probably be taken care of with a simple overlay.
Mississippi DOT	----
Montana DOT	We don’t have a “typical” treatment. They are determined on a case-by-case basis. The basis for the pavement deterioration would be determined (age, subgrade failure, surfacing failure, etc.). If the plant mix surface is distorted with substantial cracking (alligator cracking- worst case), we may elect to pulverize the existing asphalt, in addition to the widening. If the severe deterioration is localized we may elect to dig out and replace portions of the road surface.
New Jersey DOT	----

A.5 WIDENING FLEXIBLE PAVEMENT SECTIONS IN POOR CONDITION

A.5.2. What construction techniques and specifications would your agency recommend for this case?

Agency	*Answer*
New Jersey Transit Authority	It appears this roadway was widened at some time subsequent to its original construction, hence the longitudinal edge crack present in the photograph, and the widened section may not have been sufficient to handle vehicle loading it is being subject to. As such, any future widening of this roadway should extend back into the existing roadway to capture portion of roadway that may not have been constructed to sufficient cross section. 1. Sawcut and/or mill existing edge of pavement to produce vertical joint. 2. Construct apply polymerized joint adhesive to all cold joints. 3. Construct new base course pavement. 4. If pavement section requires an intermediate course lift offset joint from the base course lift. 5. Finally, offset surface course joint from intermed. Course joint. Surface course joint is recommended to be offset from the location of lane striping to allow future joint sealing without obscuring the striping.
New York DOT	I would try to widen all to one side, to get the widening crack and the existing cracks out of the wheel paths. Drainage should be added, as that pavement section has very poor drainage, which is probably why it is cracking. Mill the surface to get a good layer for the final overlay to bond with.
North Carolina DOT	Widening would be handled similar to a road in good condition; however, treatment of existing pavement would be on a case-by-case basis and may include patching or mill and replace with asphalt.
Tennessee DOT	A new surface is usually provided (over old and new section) to prevent this. Crack sealing may be accomplished before the final surface is installed.
Texas DOT Austin District	If this is a drought induced longitudinal crack, we perform dynamic cone penetration (DCP) transversely to determine the depth of the shear failure, especially with steep front slopes. We would use geogrid reinforcement in the final section and most likely, we would rehabilitate full width.
Texas DOT San Antonio District	Redesign pavement cross section that would be used for entire roadway. Collect existing materials, run multiple lab tests to identify existing materials reclamation capability, reconstruct entire roadway.
Texas DOT Maintenance Division	Same specifications--in typical sections and plans used. This would occur more frequently in HMAC overlays or widening rather than chip seals over granular base.
Virginia DOT	----

A.5 WIDENING FLEXIBLE PAVEMENT SECTIONS IN POOR CONDITION

A.5.2. What construction techniques and specifications would your agency recommend for this case?

Agency	*Answer*
Federal Highway Administration	----
National Center for Asphalt Technology	Must first investigate cause of problem and address cause. If an overlay will correct then suggest that widening be done and entire area overlayed.
University of Texas CTR	No standard typicals are available, but typical sections have been developed that would address Full depth reclamation, or other repair options.
Lane Construction Corporation	Remove all existing asphalt, and re-work aggregate base course. Add paved shoulder. Repave roadway and shoulders top lift of structural asphalt in one pass.

A.5 WIDENING FLEXIBLE PAVEMENT SECTIONS IN POOR CONDITION

A.5.3. What inspections are performed, and what quality control testing is performed for this case?

Agency	*Answer*
Alabama DOT	Customary inspections for good paving practices, smoothness, density (if required). Testing at plant would be customary also, i.e., asphalt content, air voids, VMA, etc.
Arkansas DOT	Cores would be gathered at locations of the cracking and the rutting and at locations where the pavement appears to be good.
Colorado DOT	All typical CDOT requirements for subgrade, base course and HMA.
Kentucky DOT	Cores or cut a trench to see what is occurring through the structure.
Maryland DOT	The same as for any project.
Mississippi DOT	----
Montana DOT	Visual, soils surveys, and geotechnical analysis of borings.
New Jersey DOT	----
New Jersey Transit Authority	Visual inspection and core sampling of the pavement section to the left of the longitudinal crack. If determined section is consistent across entire roadway, check condition of subsurface soils to determine if high moisture is present below roadway.
New York DOT	During design, a pavement evaluation is performed to determine the best treatment. During construction, inspectors are on hand to ensure proper construction practices are followed.
North Carolina DOT	As given in standard specifications.
Tennessee DOT	Regular density testing and QC are performed on all paving and resurfacing.
Texas DOT Austin District	Visual inspection by TxDOT inspection. Density controlled.
Texas DOT San Antonio District	Density control, approved material sources, material durability testing.
Texas DOT Maintenance Division	If equipment could be fit into the widened section for good compaction, there might be density control as opposed to "ordinary" compaction or compaction by judgment.
Virginia DOT	Doesn't look that bad. Would core to see if lower layers are in good shape and to determine the original full-depth section.

A.5 WIDENING FLEXIBLE PAVEMENT SECTIONS IN POOR CONDITION

A.5.3. What inspections are performed, and what quality control testing is performed for this case?

Agency	*Answer*
Federal Highway Administration	----
National Center for Asphalt Technology	Must control quality of mix and compaction.
University of Texas CTR	As previously discussed.
Lane Construction Corporation	Florida DOT uses QC 2000.

A.5 WIDENING FLEXIBLE PAVEMENT SECTIONS IN POOR CONDITION

A.5.4. Has your agency encountered any problems following construction of widening sections where the original pavement was in poor condition? Please briefly describe difficulties and resolutions.

Agency	*Yes*	*No*	*Comments*
Alabama DOT		•	----
Arkansas DOT	•		Reflective cracking.
Colorado DOT		•	----
Kentucky DOT		•	No known situations.
Maryland DOT		•	----
Mississippi DOT	----	----	----
Montana DOT	----	----	I'm sure we have blown our assessment of pavement condition in certain cases. The difficulties include increased maintenance costs and additional expense in design and paving projects. We would follow the treatments described above.
New Jersey DOT		•	If existing pavement is structurally in poor condition, we consider structural improvement of the existing pavement. If existing pavement is in poor condition other than structurally, we select appropriate treatment for the improvement of existing pavement and the same treatment is applied on the widening area to achieve equal performance life.
New Jersey Transit Authority		•	----
New York DOT	•		These are always a problem. The better answer for these pavements is complete reconstruction. Widening a bad pavement is always a bad idea.
North Carolina DOT	•		----
Tennessee DOT		•	----
Texas DOT Austin District	•		----

A.5 WIDENING FLEXIBLE PAVEMENT SECTIONS IN POOR CONDITION

A.5.4. Has your agency encountered any problems following construction of widening sections where the original pavement was in poor condition? Please briefly describe difficulties and resolutions.

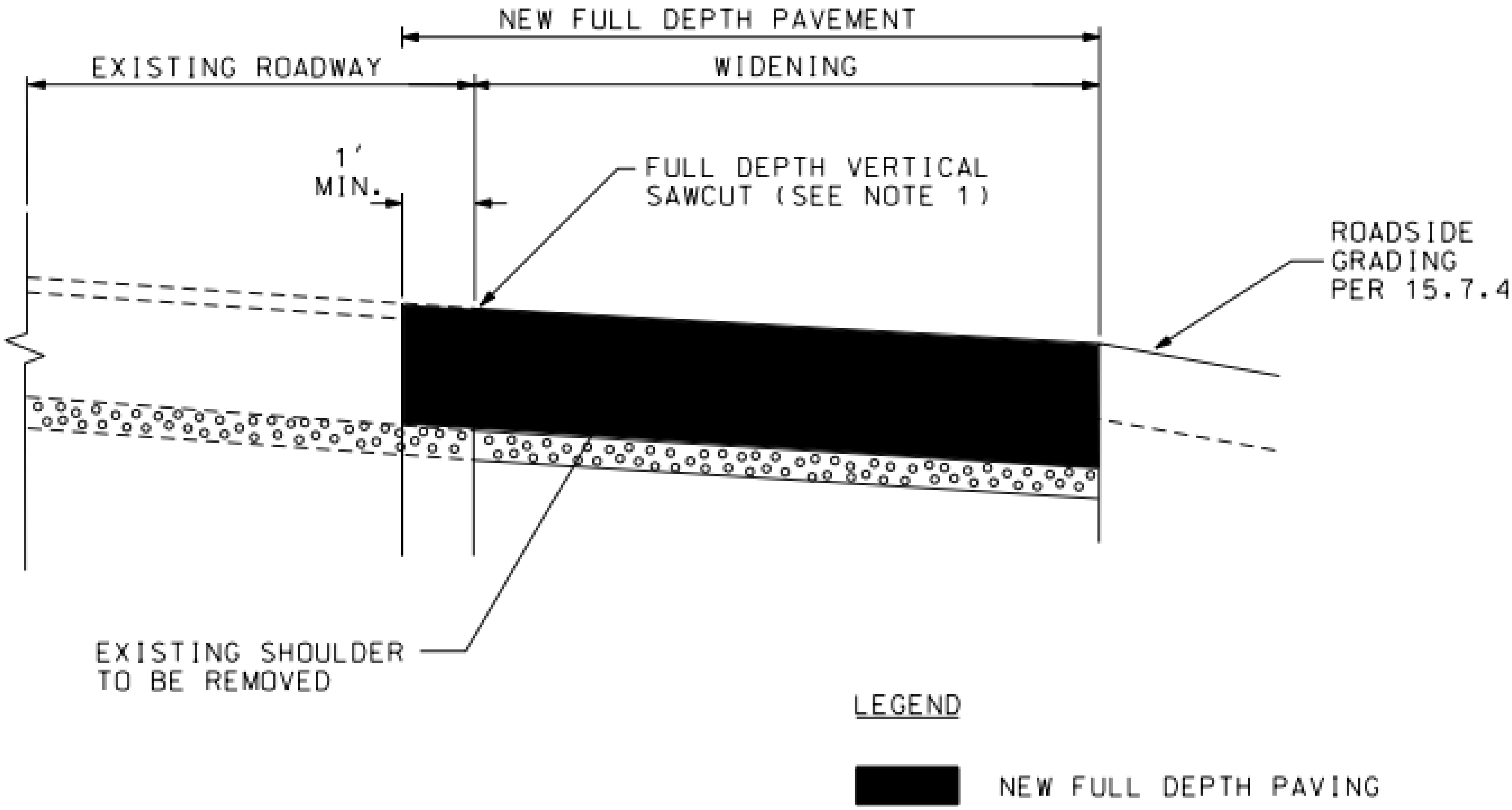
Agency	*Yes*	*No*	*Comments*
Texas DOT San Antonio District		•	----
Texas DOT Maintenance Division	•		Usually lower volume. Flexible base next to existing is most typical.
Virginia DOT	•		Yes, original pavement was in poor condition; design fix was either revisited or remained inadequate.
Federal Highway Administration	----	----	----
National Center for Asphalt Technology		•	----
University of Texas CTR	•		Deformation of the existing pavement adjacent to the joint line and other performance problems.
Lane Construction Corporation	•		Common practice in Florida is not to remove all structural asphalt from existing travel lanes. On roads in good condition this ok. On roads in poor condition this is not. To ensure the new widening and existing roadway perform within the same expected life cycle, the structural asphalt of both pavement sections should be similar in age and design.

APPENDIX B. SAMPLE FLEXIBLE PAVEMENT WIDENING DESIGN CROSS SECTIONS

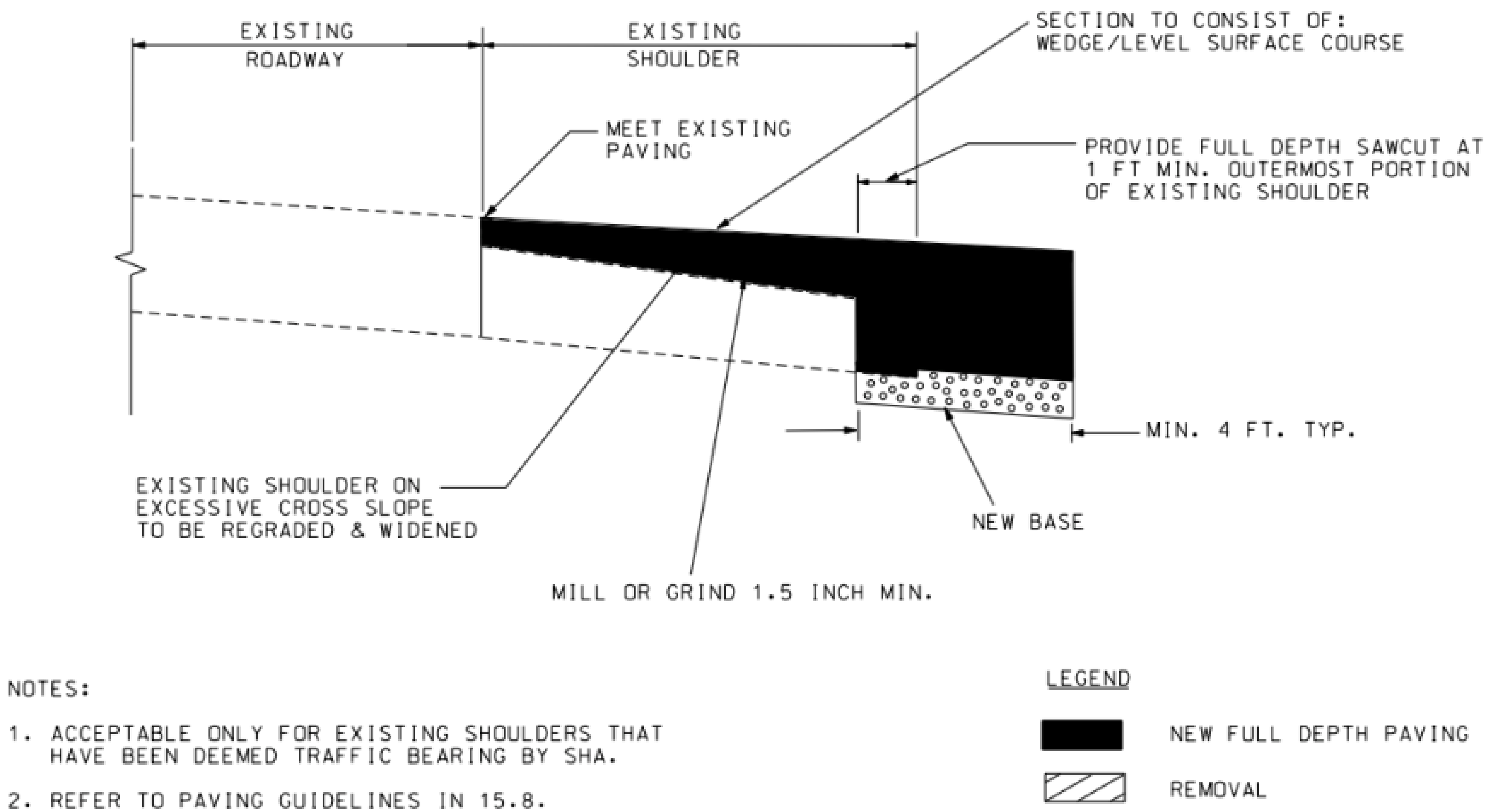
B.1. Sample Flexible Pavement Widening Design Cross Sections

Flexible pavement widening cross sections routinely used in Maryland, Texas, and New Jersey are provided in Figure B-1 through Figure B-12.

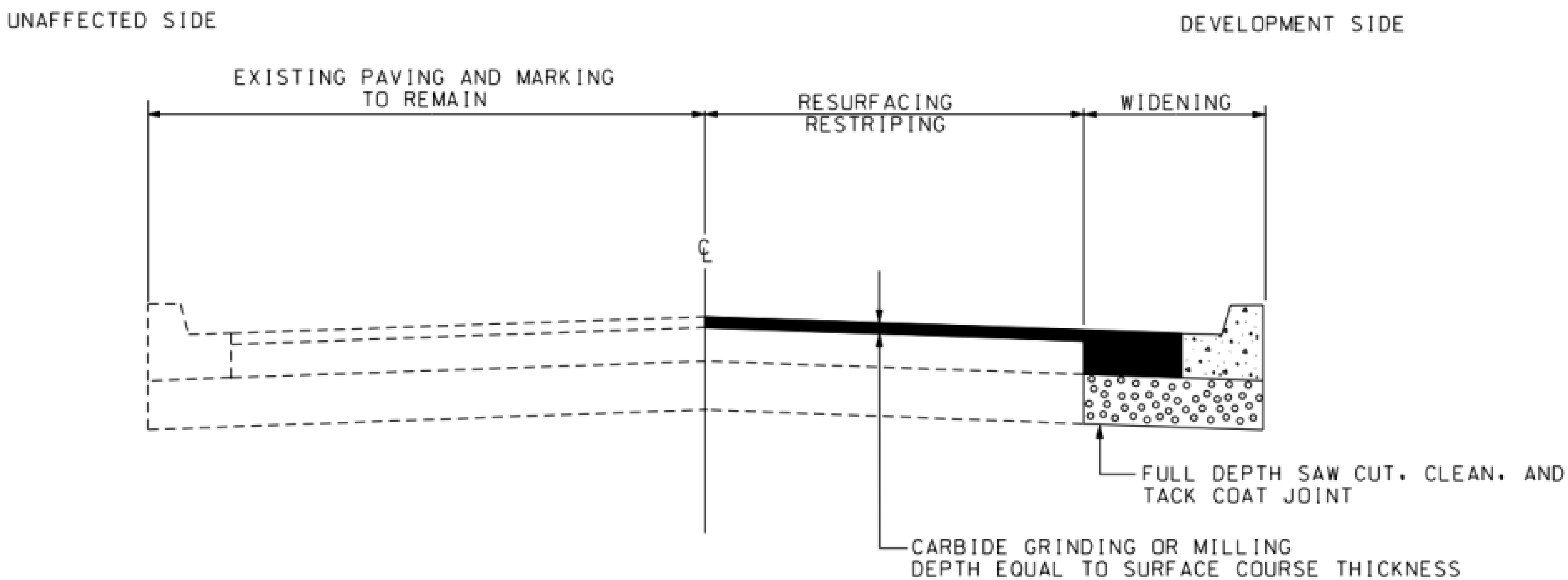
B.1.1. Maryland Flexible Pavement Widening Cross Sections



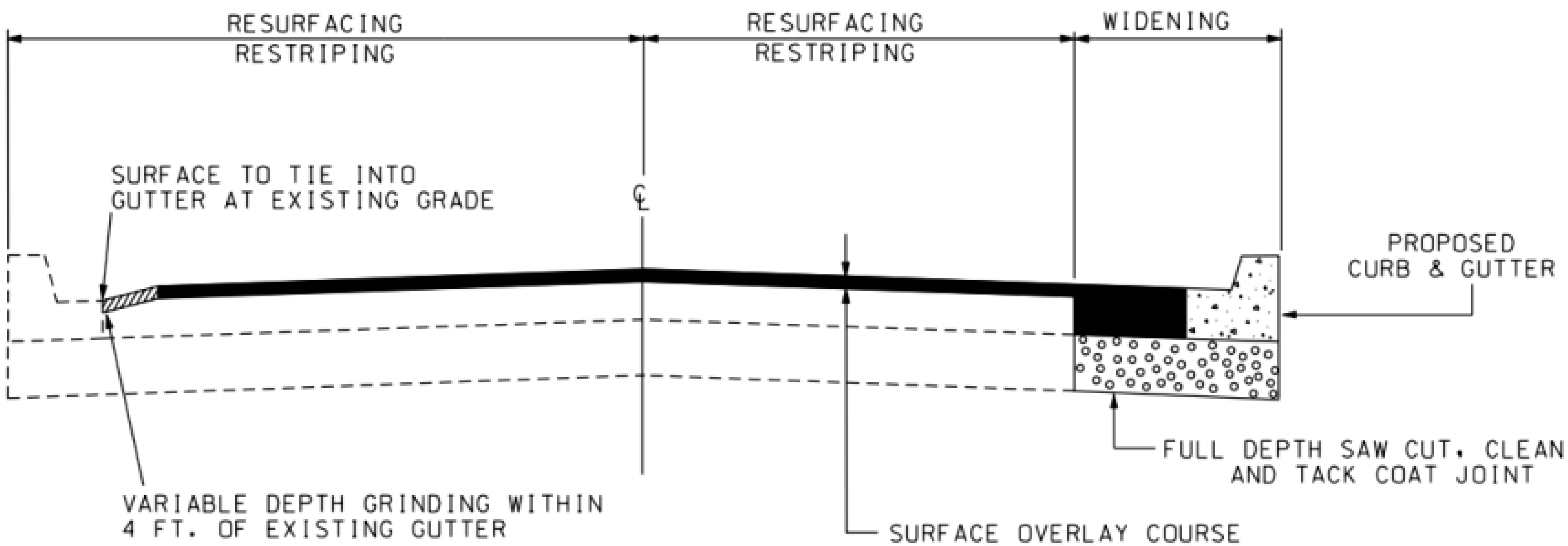
B-1. Typical Shoulder Removal and Full Depth Widening [28]



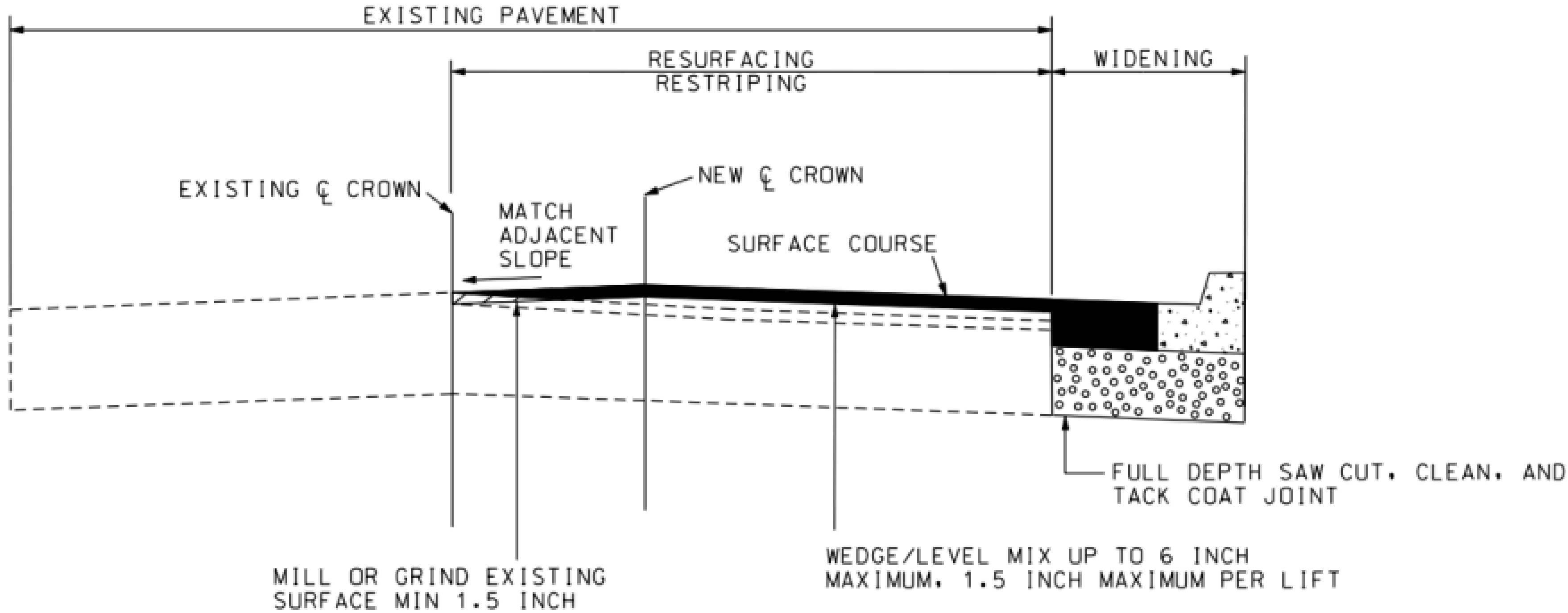
B-2. Typical Shoulder Build-up Section [28]



B-3. Typical Half Section Resurfacing (Mill & Overlay) [28]

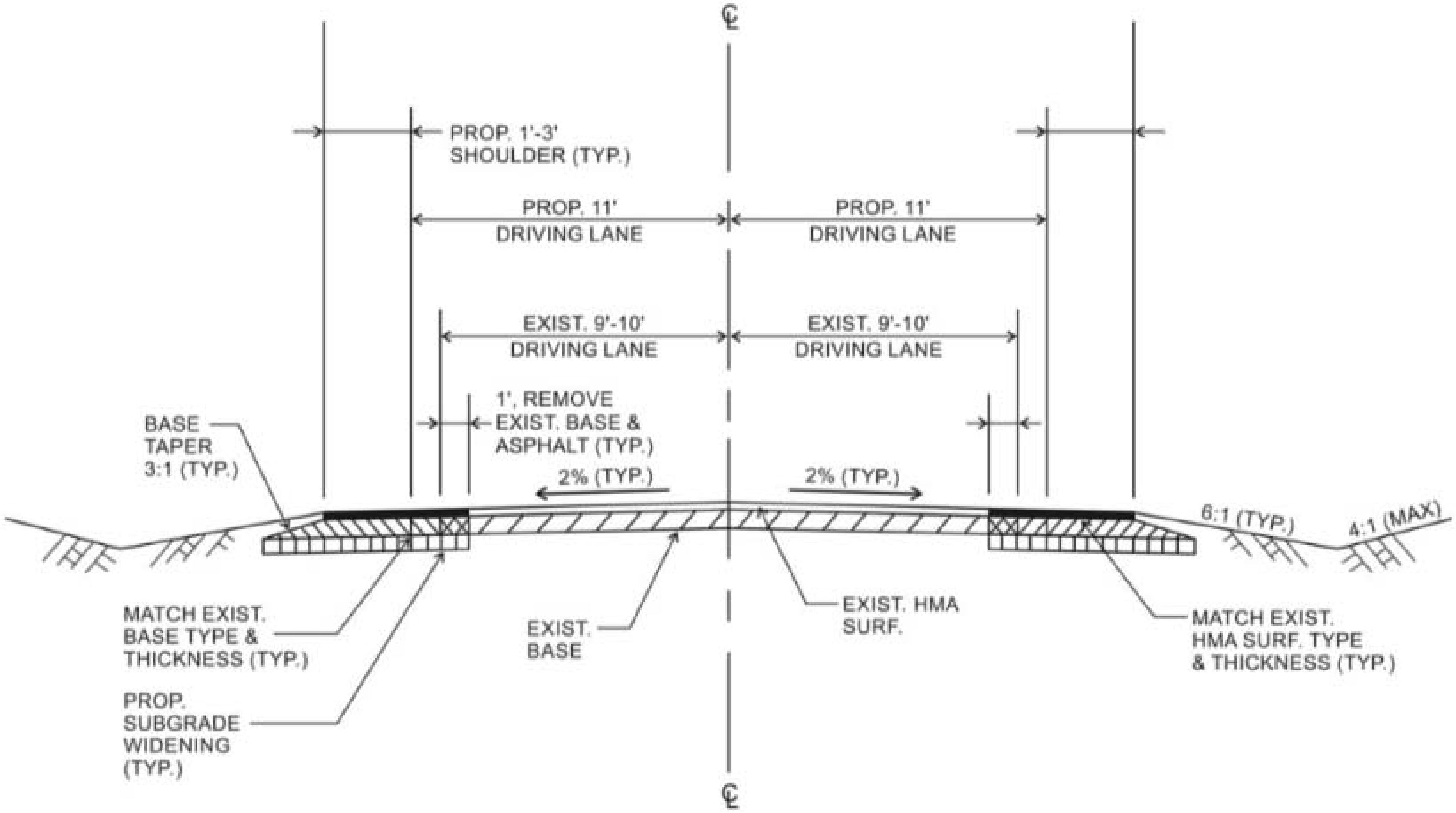


B-4. Typical Full Section Overlay [28]

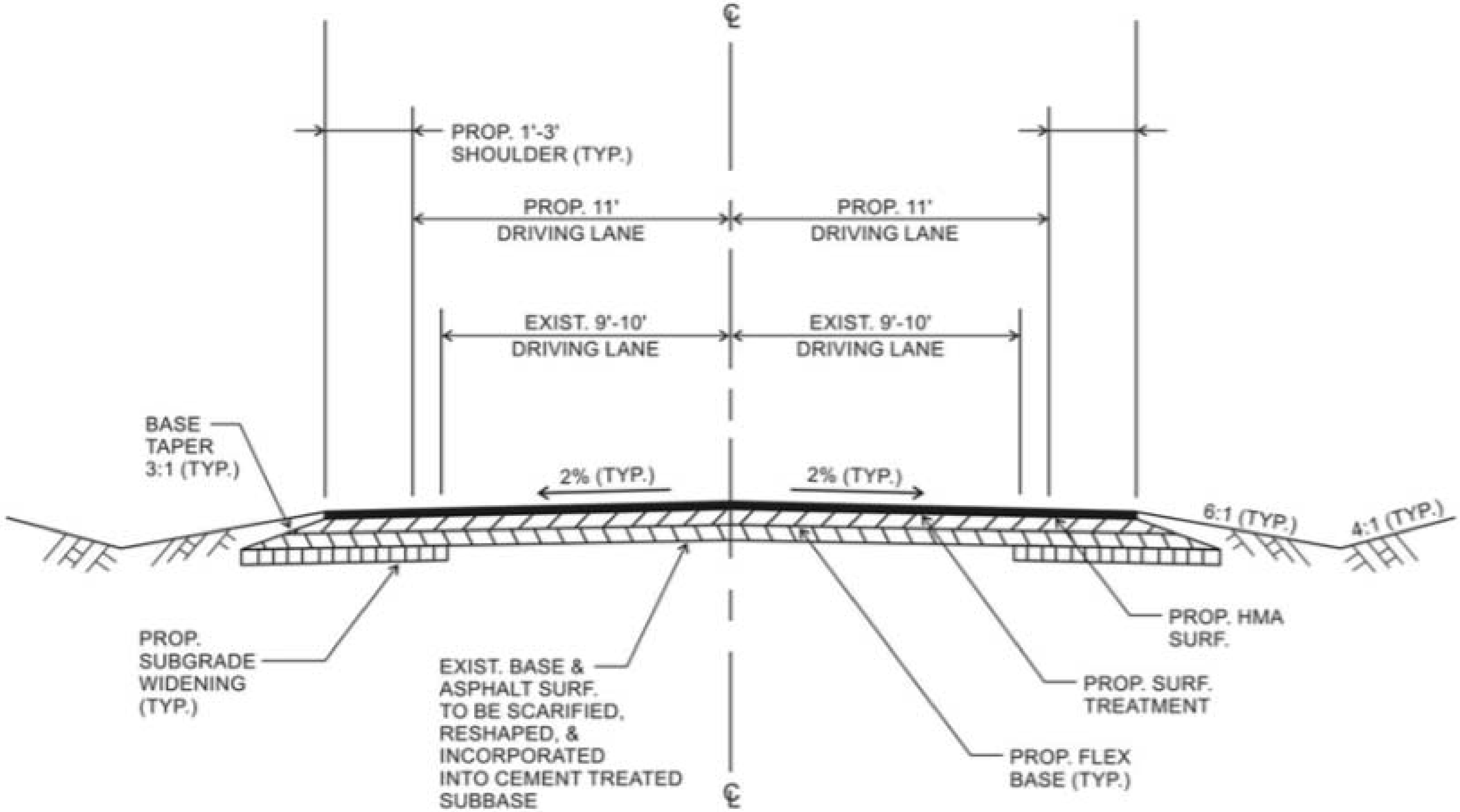


B-5. Typical Wedge/Level and Overlay for Crown Shift [28]

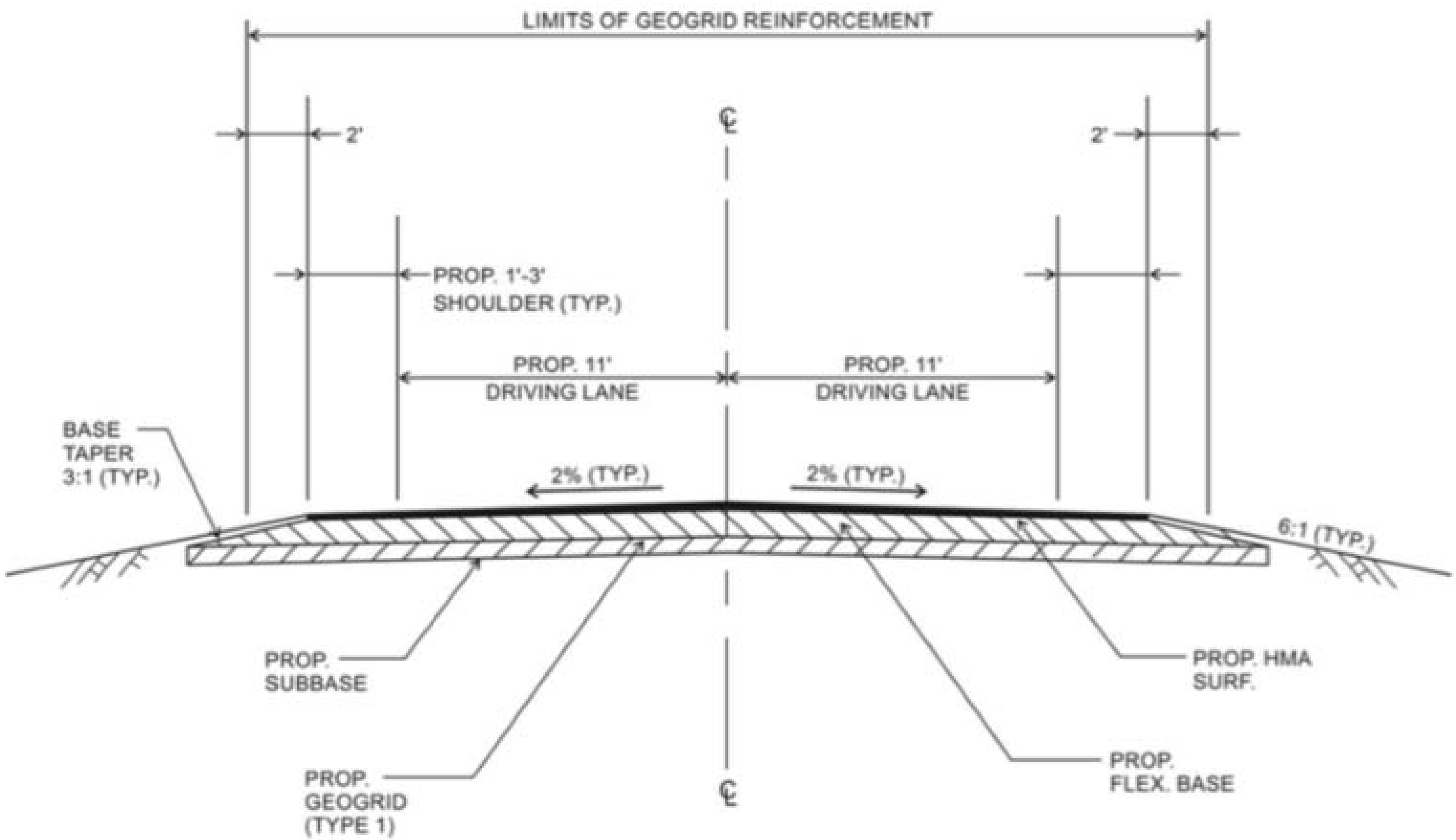
B.1.2. Texas Flexible Pavement Widening Cross Sections



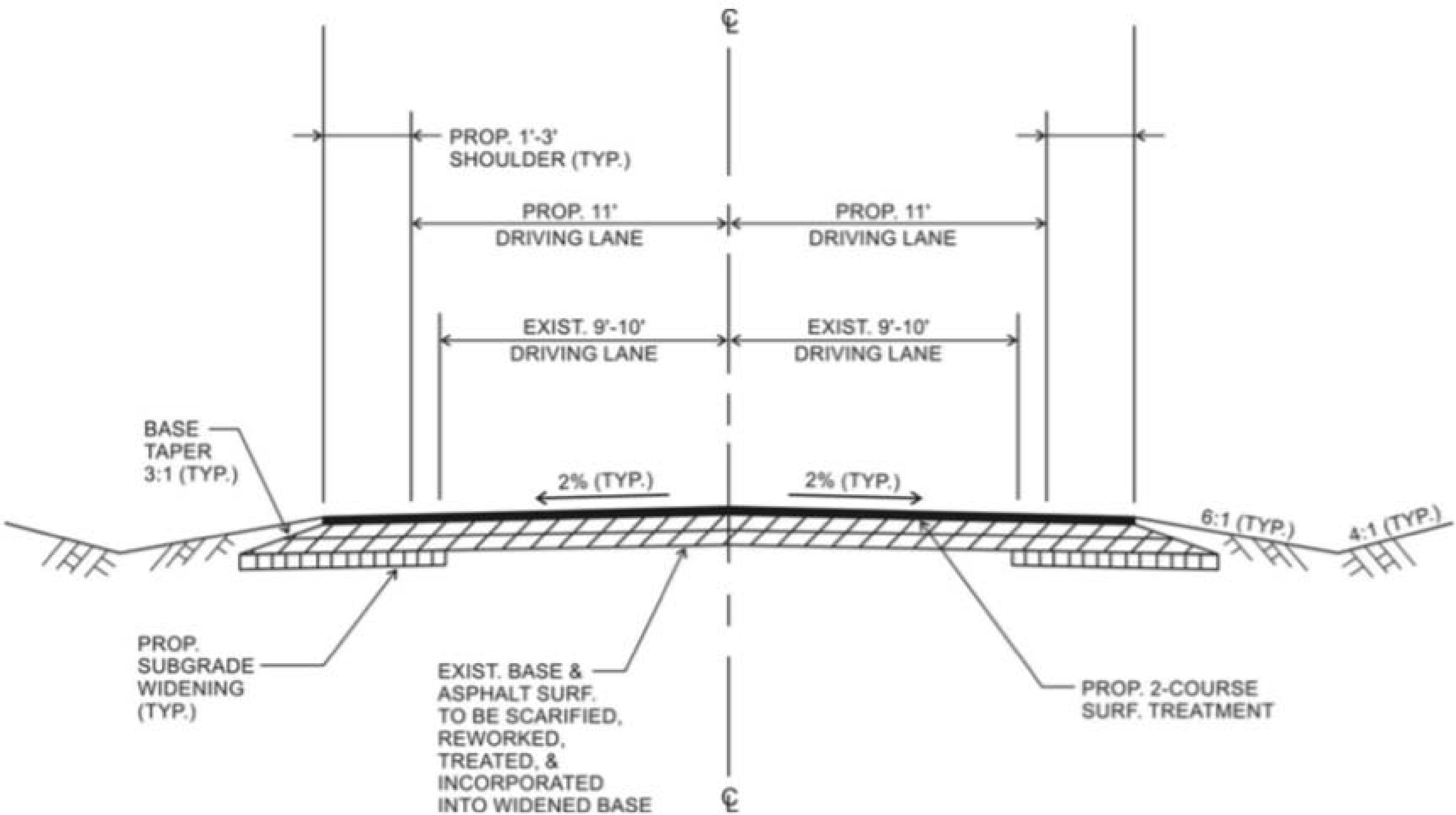
B-6.Typical Section for Widening Flexible Pavements in Good Condition [15]



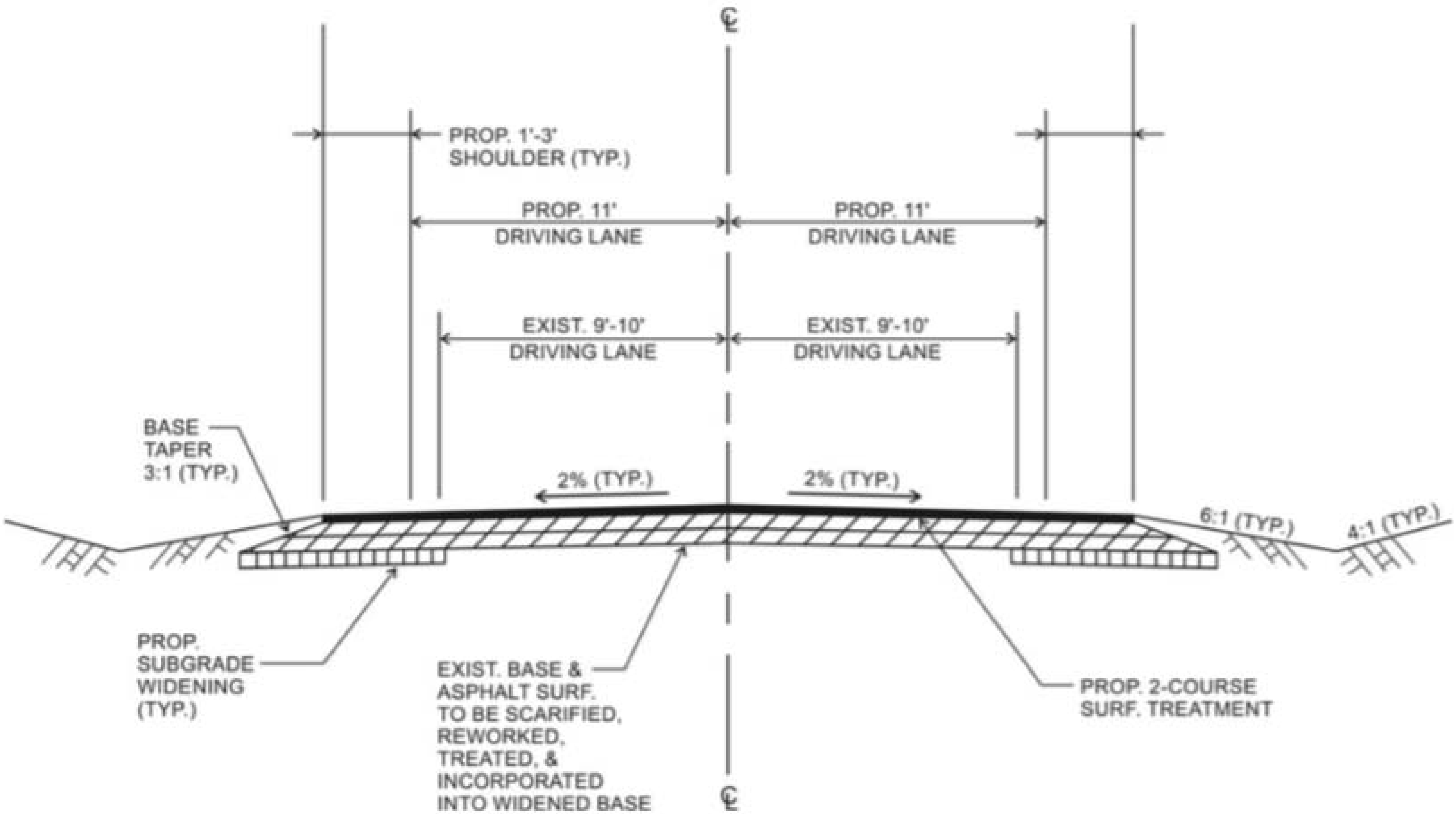
B-7.Typical Section for Widening Flexible Pavements in Poor Condition Using Full Depth Recycling [15]



B-8.Typical Section for Widening Flexible Pavements in Poor Condition on Highly Plastic Subgrade [15]

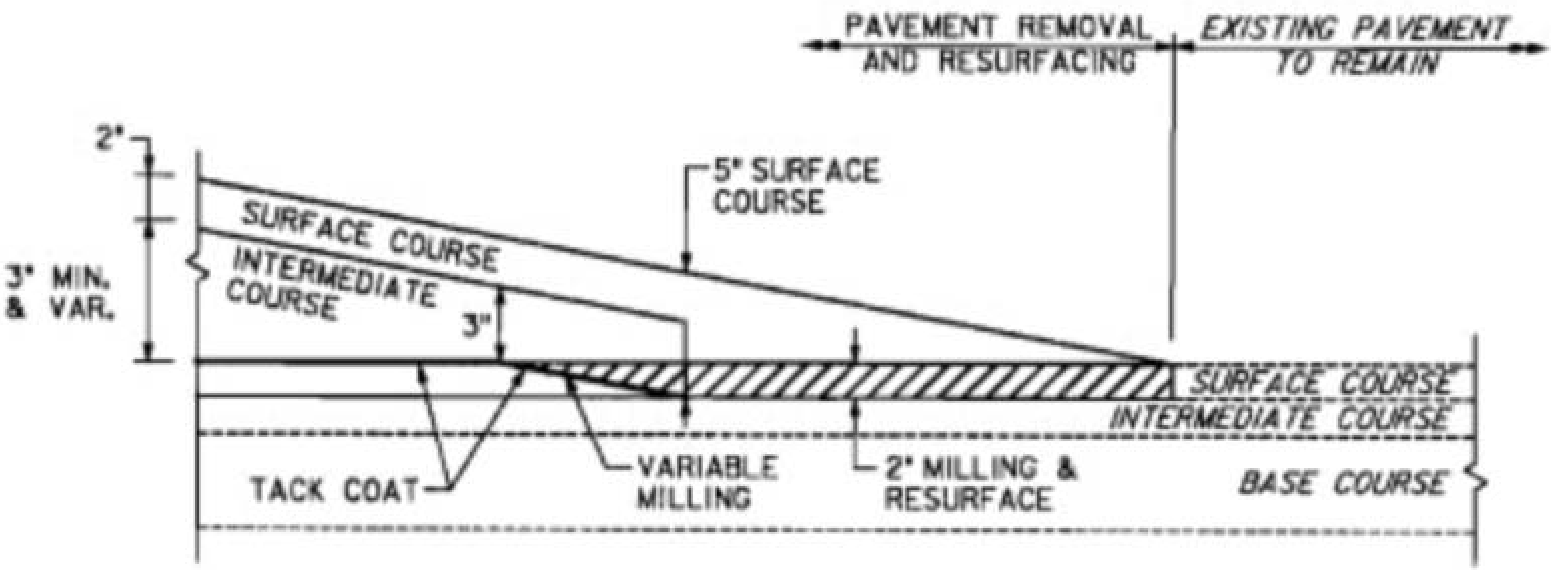


B-9.Typical Section for Widening Flexible Pavements in Poor Condition by Reworking the Existing Base [15]

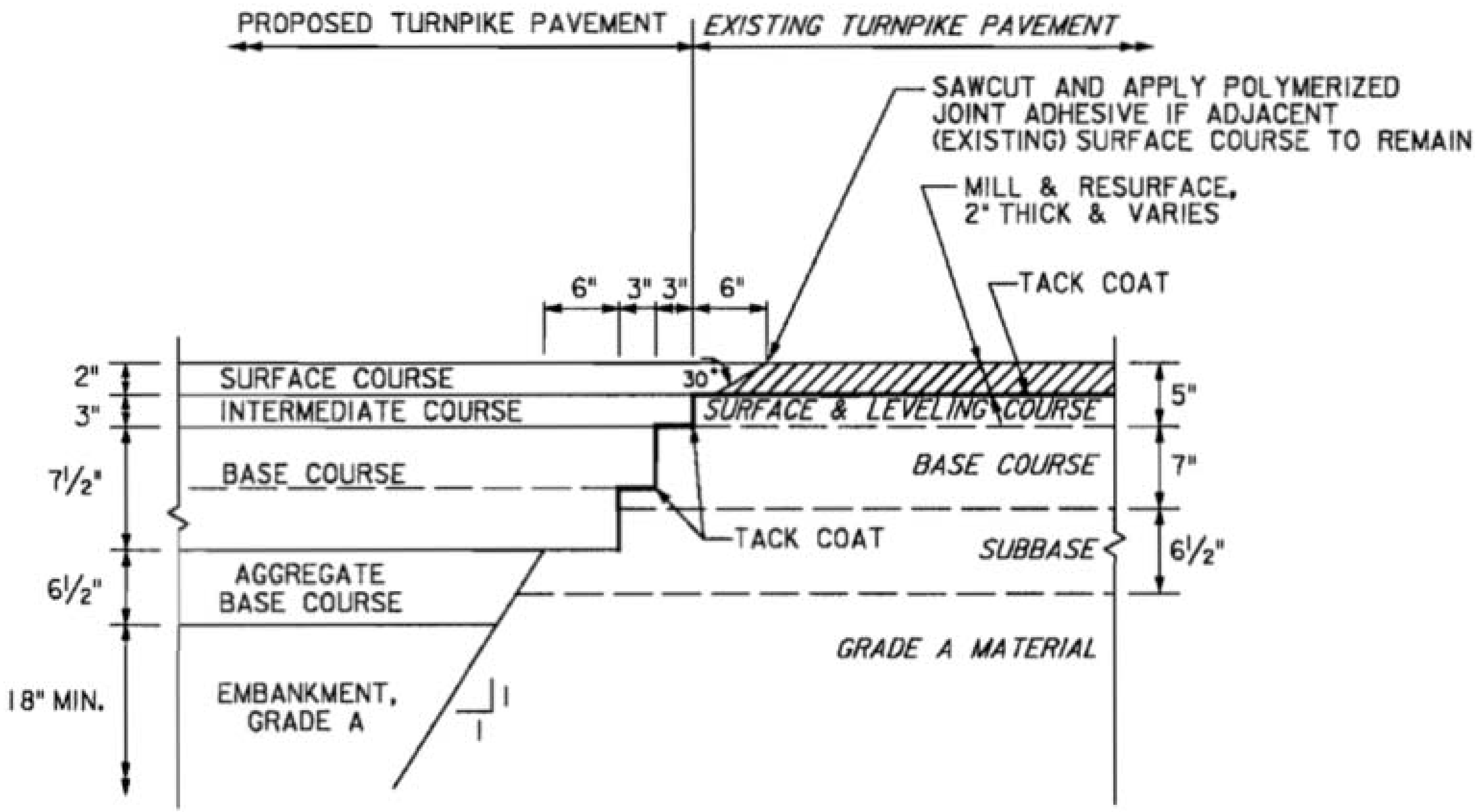


B-10.Typical Section for Widening Jointed Concrete Pavements [15]

B.1.3. New Jersey Turnpike Authority Pavement Widening Cross Sections



B-11.Pavment Removal and Reconstruction Detail [24]



B-12.New Pavement Interface with Existing Pavement Section [24]

GUIDEBOOK FOR LANE WIDENING PROJECTS ON FLEXIBLE PAVEMENT ROADWAYS IN FLORIDA

September 2015

Florida Department of Transportation

Preface

About This Guidebook

This guide provides the latest knowledge, techniques, and technologies for widening or addition of lanes on asphalt-surfaced highways in Florida. The guidance on lane widening and longitudinal joint construction is aimed at engineer personnel responsible for planning, designing, and constructing widened flexible pavement roadway sections. Factors impacting the performance of flexible road widening with a focus on the longitudinal joint between existing pavements and new widening sections are identified.

This guidebook was prepared by Applied Research Associates, Inc. (ARA) with funding from the Florida Department of Transportation (FDOT).

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Acknowledgements

The FDOT Research Panel that oversaw this project was instrumental in identifying key issues and concerns related to lane widening of asphalt pavements.

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Objective

The purpose of most lane widening projects is to enhance mobility, improve traffic flow, and increase safety. Additional highway lanes, safety improvements, and traffic feature additions, such as turn lanes, are often required to increase traffic volume or address unforeseen conditions not accounted for in the original design.

Few guidelines exist statewide, or even nationwide, for assisting designers in selecting appropriate roadway widening techniques. Current Florida Department of Transportation (FDOT) specifications provide a basic framework for widening hot-mix asphalt (HMA) pavements. However, the existing guidance does not address alternative construction techniques and treatments used in current practice for constructing more durable longitudinal joints.

This guide provides best-practice strategies to improve the widening joint (between new and existing asphalt pavements) design and joint construction quality in Florida. This guide is intended as a reference text for engineering personnel responsible for planning, designing, and constructing widened flexible pavement roadway sections. The material in this manual supplements the FDOT *Flexible Pavement Design Manual*.

Note that the guidance is only for asphalt roadways and that the term HMA is used generically in this document and may be a substitute for other asphalt pavement types such as warm mix asphalt (WA), stone matrix asphalt (SMA), etc.

Scope

This guide does not offer prescriptive step-by-step specifications for designing and constructing widened flexible pavement roadway sections; however, it provides guidance that can supplement practitioners' own professional experience and judgment.

Issues with Lane Widening

The joint is the weakest area of the pavement.

The deterioration of the joint (juncture) that has historically developed with lane widening projects has plagued pavement engineers and highway administrators for many years. Even when dedicated attention has been given to the design and construction effort, many of these longitudinal joints show some level of deterioration. Current FDOT specifications require longitudinal joints be offset 6 to 12 inches and located away from the wheel path, but this has not resolved the problem. Performance life of construction joints required to widen the roadway or add

features may be decreased due to issues associated with their location and construction quality.

Typical pavement related issues experienced with widening

1. Formation of a crack at the longitudinal joint of widened sections, which reflects to the surface.
2. Difficulties achieving density on narrower widening sections with normal compaction equipment.
3. Selection of proper quality control procedures to ensure quality materials are placed at correct elevations, adequate density is achieved, drainage layers are aligned, and layer thicknesses are correct.
4. Accelerated deterioration of joints placed in traffic wheel paths.
5. Designing widened sections for pavements in poor condition.
6. Failures due to vertical shear conditions created by butt joint construction between layers.
7. Poor drainage and structural failures due to incompatible base materials in the widened section or when the widening cross-section does not match the existing roadway cross-section.
8. When to use subgrade stabilizers.

Longitudinal joint reflective cracking

Compacting narrow widening sections

Widening roadways in poor condition

Inspecting quality of widened sections

Lane Widening Categories

Lane widening projects are selected for a number of reasons, including improved safety, increased capacity, and enhanced traffic operations. Each lane widening project has unique requirements and challenges. The typical categories for lane widening are:

1. Addition of lane to right side of existing roadway
2. Addition of lane to left side of existing roadway
3. Widening existing lane without shoulder
4. Widening of existing lane with addition of shoulder
5. Widening that includes embankment construction
6. Removal of existing shoulder and addition of new lane
7. Addition of exit ramp
8. Widening existing exit ramp

There are unique challenges for each of the lane widening categories. From a design point of view, the location of the longitudinal joint between new and existing pavement, and the design cross-section of that joint, are the most critical factors. The construction challenges are achieving uniformity of materials placed near the joint and adequate density in all component layers, particularly at this longitudinal joint.

This guide provides some generic cross-sections for lane widening projects, but the drawings must be customized for each particular project.

Planning for Lane Widening Projects

Planning for a lane widening project begins with the objective in mind and identification of unique conditions and requirements. The following table lists the typical steps in the planning and preparation.

Steps for lane widening project planning.

Step 1	Define scope of project in terms of extent of lane widening and project objectives
Step 2	Site evaluation including subsurface evaluation (quality assessments of surface and base layers, subgrade sampling and characterizations) and profiles and grade of existing roadway
Step 3	Determine design traffic – traffic assessment and load spectra for thickness design calculations
Step 4	Selection of materials and mixes for new construction – concern for subsurface drainage
Step 5	Select concept for lane widening in terms of subsurface drainage, requirements for use of stabilized materials, and details for the longitudinal joint between existing pavement and new pavement
Step 6	Determine design concept for longitudinal joint between existing pavement and new construction
Step 7	Develop design sections and layer requirements
Step 8	Develop plans and construction specifications

Lane widening projects are not that much different from most reconstruction projects as far as data gathering, assessment of site conditions, and traffic control during construction.

Some key factors to consider when planning road widening projects:

- Excavation and removal of existing materials to minimize disturbance to pavement layers and subgrade
- Design and construction of longitudinal joint between existing pavement and widening lane
- Stabilization of subgrade and pavement layers
- Pavement edge drains and subsurface drainage
- Pavement edge drop-offs
- Geosynthetic reinforcement
- Construction techniques and equipment
- Embankment widening
- Quality control plan

Design and Typical Plan Sections

The following design inputs and alternatives for overcoming early longitudinal joint deterioration are discussed in this section:

1. Widened structure cross-section
2. Subsurface drainage provisions
3. Joint type selection
4. Joint location
5. Selection of joint treatments
6. Typical cross-sections

Widening Structure Cross-Section

If the existing pavement is structurally adequate with adequate drainage, designing the widened pavement cross-section to match the existing roadway is generally optimal. It is important to match the stiffness and load bearing capacity of the existing pavement and the widened section; otherwise, there may be differential settlement. The best results are achieved when an HMA overlay can be placed over existing pavement and widening section as the final surface and paved in one pas of the paver. The final surface 9either FC-5 or FC-9.5/12.5) can be paved much similar to preceding structural layers with typical stagger/overlap of paving joints.. This will bridge the joint and help to improve the performance over the joint where widening begins.

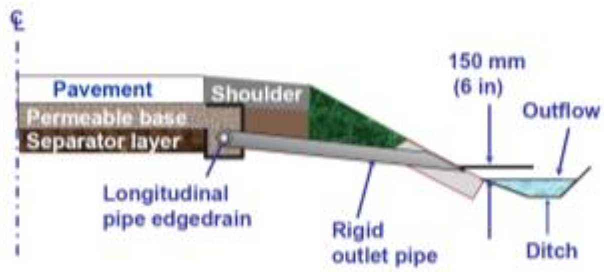
Pavement sections often do not match design cross-sections due to construction variability and undocumented maintenance.

Extract pavement cores and perform ground penetrating radar (GPR) surveys, as necessary, to validate as-built designs and identify anomalies.

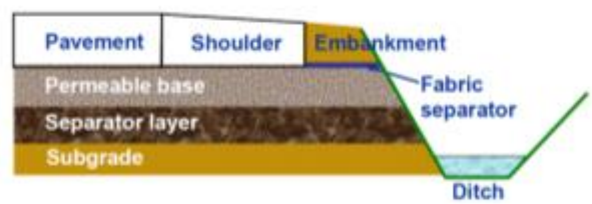
Subsurface Drainage

Proper drainage of the pavement structure is imperative in the design and construction of widened sections. Placing an impervious (stabilized) base adjacent to a pavement constructed with unstabilized granular base can lead to trapped moisture at the joint interface, causing rutting and/or cracking under traffic loads. These areas may also consolidate under load. In these cases, consider placing a 4-inch layer of fairly open-graded crushed granular base in the widening trench, then place stabilized base over the granular base to eliminate the trapped moisture problem. Super elevations or cross-section slopes should be addressed during design to account for surface drainage during construction.

Subsurface drainage systems that are properly designed and constructed have been shown to decrease the occurrence of rutting and fatigue cracking in flexible pavements. Poor drainage can result in decreased bearing capacity, edge deformation, and ponding water. Subsurface drainage can be accomplished with an open-graded drainage layer with edge drains and outlet pipes or day-lighted permeable bases with water flow through the edge of the embankment. The permeable base layer (typically 4 inches thick) needs a suitable separator layer beneath it to prevent subgrade fines from migrating up into and clogging the base. This may be an appropriately graded untreated aggregate subbase, a geotextile fabric, or a layer of subgrade soil treated with sufficient lime or cement to achieve good long-term stability and resist erosion.



The incorporation of a permeable edge drained base beneath the pavement can reduce or eliminate the risk of damage to the pavement as a result of water infiltration into the pavement system.



Day-lighted permeable aggregate base performs as well as edge drained permeable base when properly designed, constructed, and maintained, and it may be more cost-effective.

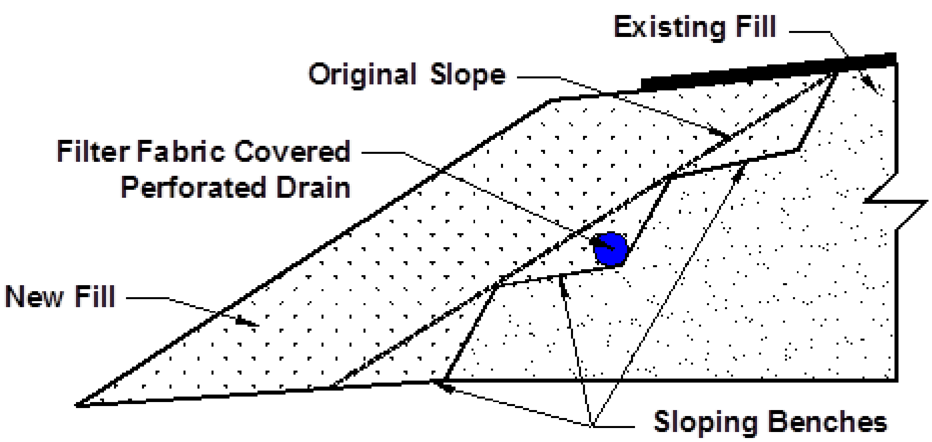
Where site conditions are suitable, day-lighting versus longitudinal edge drains and outlets may be more cost-effective.

Day-lighted permeable bases offer potential savings in materials, equipment, and time as compared to installation of edge drains, outlets, and headwalls.

Day-lighted permeable bases are well suited for roadways with flat grades (1 percent or less) and shallow ditches where it is difficult to outlet drainage pipes at an adequate height above the ditch. A day-lighted permeable base is simpler to construct than a permeable base with edge drains and outlets. The day-lighted base/subbase interface should have a cross slope of 3 percent to remove water effectively from the pavement structure. The bottom exposed edge of the day-lighted base should be at least 6 inches above the 10-year-storm flow line of the ditch to prevent water from backing up into

on existing fill soils, leading to softening and reduction in shear strength.

Consideration must be given to the relative permeability of the original embankment soil and the soil used to widen the embankment. In this case, consider constructing benches with adequate grade to induce lateral flow of any infiltration that encounters a less permeable interface, thereby minimizing perched water at the interface between materials.



Install a perforated drain along the vertical cut of the first bench located outside the pavement edge. The drain should be covered with an appropriate filter fabric that is compatible with the embankment soil type, and it should be outfitted with protected outlets at appropriate intervals along the length of the embankment.

the day-lighted base during or after a heavy rainfall.

The use of asphalt stabilized base for the widened section can be expedient since it is faster to place and provides a temporary riding surface at the end of the construction day with no need for applying any further surfacing.

If new fill soil has greater permeability than the existing embankment soil, water can perch

Drains should be inspected at least once a year with video equipment, vegetation removed from around outlet pipes twice a year, and all ditches mowed and kept clean of debris. Neglected and deteriorating drainage systems can accelerate pavement deterioration, resulting in decreased bearing capacity along the thinner edges of the roadway, edge deformation, rutting, and ponding of water. Occasional grading of the exposed edge of the day-lighted bases may be necessary to remove soil, vegetation, and debris. Material may be flushed out from the edge of the base with a water hose, but high-pressure water should not be used, as this can damage the base and undermine the subbase.

Painting arrows on the shoulders to aid locating drain outlets that may be overgrown with vegetation and the use of larger headwalls for outlet pipes are good practices.

Painted arrow reference marker to aid locating drain outlets.

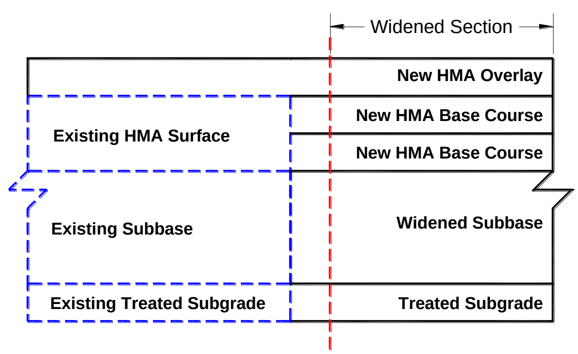
Advantages of larger headwalls for outlet pipes include the fact they are easier for maintenance personnel to locate, vegetation is located farther way from the outlet pipe, erosion potential is reduced, and the potential for cutting or crushing the outlet pipe is reduced.

During construction, measures should be taken to prevent water from entering the roadway and weakening the pavement structure. Steps that can be taken to prevent ingress of moisture include:

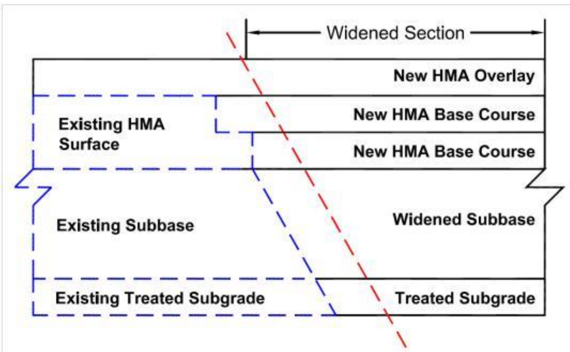
- Avoid formation of a sump or water-trapping barrier against new construction
- Pump out any water from the widening excavation
- Correct any defects in the drainage system
- Use a geosynthetic separator to prevent clay migration from a soft subgrade
- Apply adequate tack coat to existing HMA
- Match the surface course of the widening to the existing surface

Joint Types

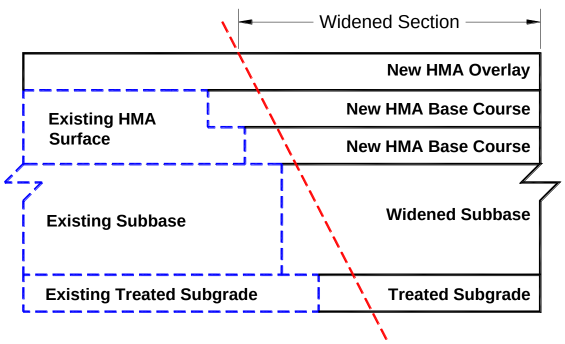
Several longitudinal joint types are available for constructing the joint between an existing roadway and new widening section, including: vertical, tapered, and stepped joints.



<u>Vertical Joint</u>: the existing roadway is sawcut from the top HMA layer to the bottom of the base layer. This is not the recommended method since it is difficult to prevent undermining of granular layers, and it puts the entire longitudinal joint in one vertical plane.



Tapered Joint: ***the existing HMA is milled or sawcut vertically, then the remaining pavement layers (base and subbase) are cut at an angle that is greater than the angle of repose of the base/subbase (generally about 45 degrees).***



Stepped Joint: ***pavement layers are cut in a stair-step pattern, which approach avoids constructing a weak vertical plane into the pavement cross-section.***

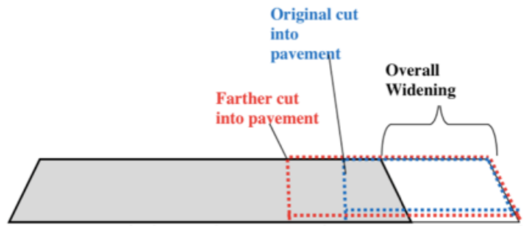
The stepped joint type has been widely used by highway agencies to mitigate longitudinal joint deterioration with widening projects. Not all states were contacted but the stepped joint is used in Alabama, Kentucky, Maryland, Montana, Texas and is recommended by the National Center for Asphalt Technology. When stair-stepping joints, offset each successive layer a minimum of 6 inches; 1-foot spacing has been successfully used on widening projects in Florida. Use additional steps for thick layers of a given material; each step should not exceed 6.0 to 8.0 inches vertically.

Having at least one lift of new HMA extend beyond the widened section onto the existing surface to bridge over the joint is a best practice.

Stair-stepping of consecutive pavement layers as the pavement structure is constructed is a best widening practice for reducing the occurrence of reflective cracking and minimizing differential settlement along the joint.

Joint Location

The location of the joint between the existing and new pavement structures may vary due to the condition of the pavement edge. Placing the joint at the extreme edge of the existing pavement to maximize use of the existing pavement structure can lead to joint failures when new pavement layers are compacted against older, deteriorated, and non-uniform materials that are often found at the edge of the roadway. The existing pavement edge typically has the worst quality material and is composed of maintenance repairs and base material that is deteriorated, and there may be vegetation growing through the pavement within about 6 inches of the edge. The existing pavement should be removed (cut back) at least 12 inches to sound material. Placing the joint into a more stable and workable face will allow more space to fit compaction equipment. The widening joint should be either in the center/midpoint of expected designated traffic lane width or at edge of designated travel lane. It should never be allowed anywhere close to wheel path of the designated lane.



Position the joint farther into the existing pavement for an interface with more sound material and space for compaction.

Placing the joint in wheel paths is poor practice that always leads to a higher rate of joint deterioration, especially on routes where the joint is placed under heavy traffic and heavy wheel loads.

Therefore, the joint line should be shifted as necessary into the existing pavement to eliminate the joint from being near the wheel path (including outside of traffic wander width). This may require removal of additional existing pavement structure.

One option is to place all of the widening on one side of a roadway to avoid having a widening joint in a wheel path. Leaving the joint in the wheel path to maximize use of the existing roadway pavement is false economy.

Consider offsetting longitudinal joints in the HMA surface course by 1 foot from the proposed location of traffic stripes. This will allow for future crack sealing of longitudinal joints without compromising traffic stripes.

Overlay the existing pavement and widened section to bridge and improve the performance of the widening joint.

Eliminate Shoulder Joint

When widening includes the paving of adjacent shoulders, the layer thickness of the upper pavement layer and shoulder should be the same and paved in a single pass. Therefore, the same mix type would be used on the shoulder as used in the widened lane. Eliminating the joint will result in a more consistent and longer lasting pavement.

Selection of Joint Treatments

Joint treatments are effective for increasing joint adhesion where the hot and cold sides of the joint fail to adequately bond to one another. The following techniques can be utilized to strengthen the joint:

1. Hot-applied rubberized asphalt joint adhesives are the best material for improving joint performance; however, they are proprietary and costly.
2. Double tack joint faces when using an asphalt emulsion.
3. Apply a surface sealer product or overband joints with a PG binder when densities are less than 92 percent of theoretical maximum density. Pay for tack as a separate bid item to ensure tack is applied at the appropriate rate.
4. Infrared joint heating has proven to increase compaction at the joint by 1 to 2 percent. This treatment is most beneficial in cold weather paving.

The vertical face of widening joints should, at a minimum, be tacked with the same material being used to tack the mat. The tack should extend past the full paving width. It is critical that the vertical face of the widening joint is clean and tack is adequately cured. Debris left on the vertical face from sawing or milling will affect the adhesion of the emulsion or sealant.

Rubberized joint adhesives improve performance.

Use a rubberized joint adhesive material to obtain the most consistent high-quality joint.

Surface seal joints with poor density.

Extend tack beyond edge of mat.

Infrared joint heaters improve joint density.

Cross Slopes

On resurfacing, restoration, and rehabilitation projects where existing ditches can be modified for storm water management purposes, the use of steeper than standard side slopes and additional depth may be cost-effective; however, values selected shall generally be the flattest that are practical.

Guidelines for Front Slopes:

- 1:6 is desirable
- 1:4 may be constructed within the clear zone
- 1:3 may be constructed outside the clear zone
- Consideration should be given to flattening slopes of 1:3 or steeper at locations where run-off-the-road type crashes are likely to occur (e.g., on the outsides of horizontal curves)
- Existing front slopes 1:3 or flatter may remain within the clear zone; shielding may be required
- 1:4 is desirable
- Steeper than 1:3 shall be shielded as per *Design Standards, Index 400, General Notes*

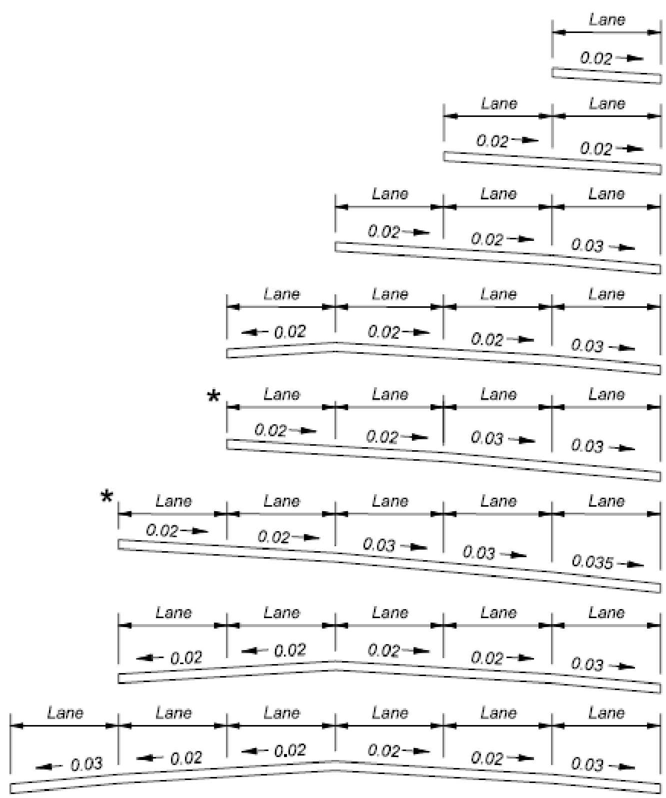
A cost-effective design preference for widening roadway sections is to slope all lanes in the same direction to minimize drainage infrastructure. Eight standard pavement cross slopes are FDOT approved. If the widening design results in a differing pavement cross slope section, then a Design Variation is required, and a hydroplaning analysis should be performed.

*For design speeds ≤ 65mph. Section acceptable for hydroplaning up to a 5% longitudinal slope.

Guidelines for Back Slopes:

- 1:4 may be constructed in the clear zone
- 1:2 may be constructed outside the clear zone without shielding
- Existing back slopes 1:2 and flatter may remain
- Existing back slopes steeper than 1:3 within the clear zone may require shielding.

A cost-effective design preference for widening roadway sections is to slope all lanes in the same direction to minimize drainage infrastructure.



Standard FDOT pavement cross slopes

Typical Cross-Sections

Design alternatives for candidate widening projects where the existing pavement is in both good and poor condition are illustrated in this section. The cross-sections provided serve as a reference to show successful practice on road widening projects. Consult the district or state roadway design engineer for final design of pavement widening sections.

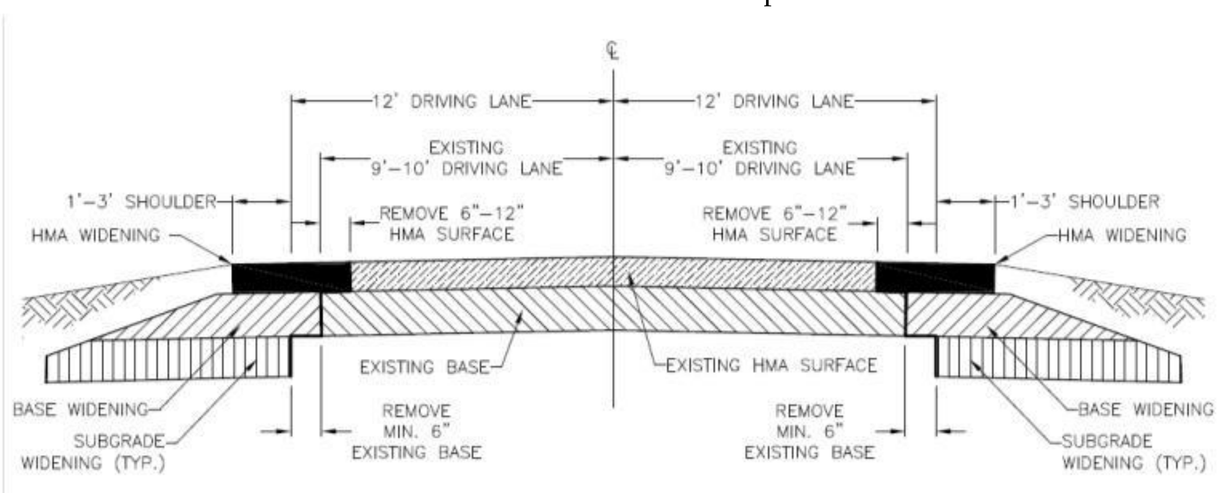
With any recycling technique, it is highly recommended that a GPR survey be conducted and/or pavement cores taken to verify existing material and layer thicknesses. These test results will confirm if the roadway has sufficient existing base for the widening method selected.

Removal of the existing shoulder should cut back into the existing pavement structure far enough to remove any unsuitable material at edge of the existing pavement structure. Then the existing pavement layers should be removed in a stair-step manner with a minimum 6-inch step at each layer interface.

<u>Existing Pavement in Good Condition:</u>

Recommended procedures for widening pavements in good condition, with no structural failures, include:

1. Avoid placing the joint in a wheel path.
2. Notch down using a stair-step approach when removing existing pavement.
3. Widen subgrade using ordinary compaction and density control; replace any unsuitable soil with approved material.
4. Proof roll subgrade to ensure uniform pavement support.
5. Place base materials to match existing material. (If full-depth HMA is to be used, place drainage layer between the HMA and subgrade and day light drainage layer.)
6. Place new HMA surface on the widened section with similar mix characteristics as the existing pavement.



Typical section for widening flexible pavements in good condition

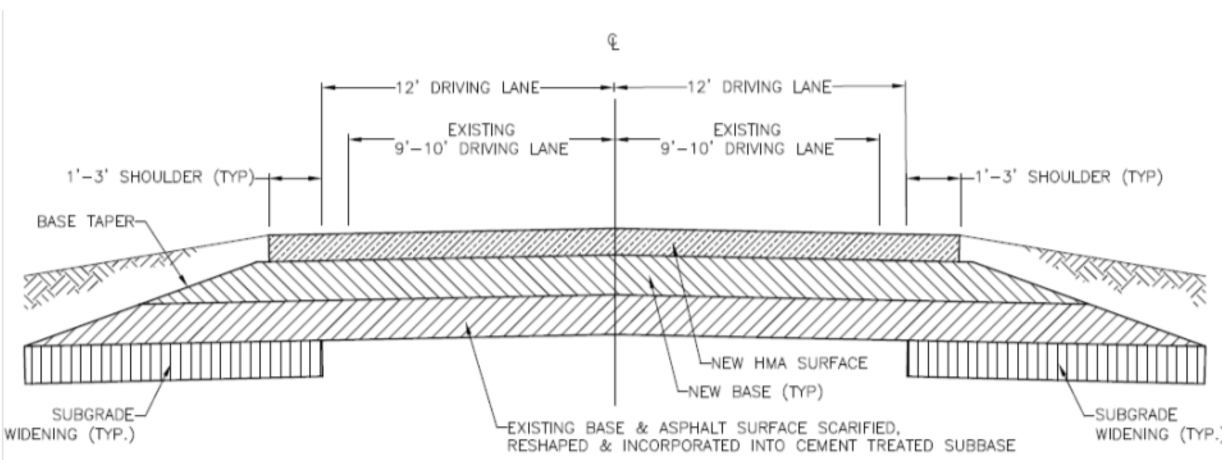
Existing Pavement in Poor Condition:

If the existing roadway exhibits substantial distress, a site investigation should be performed at cracking and rutting locations to determine the cause of the failures. Improvements should be made as necessary to correct deficiencies prior to widening. Some possible repair options are:

- Mill existing wearing layer (to remove cracking and rutting)
- Place HMA leveling course
- Patch localized areas of severe deterioration
- Add subsurface drainage
- Improve base course as necessary
- Add new HMA surface

Recycling the existing roadway into the widening can be cost-effective when the existing pavement is in poor condition, exhibiting considerable rutting and/or longitudinal cracking. Full-depth recycling has become a feasible alternative when the existing pavement is in poor condition. Full-depth recycling construction includes:

1. Avoid placing the joint in a wheel path.
2. Prepare subgrade for widening section using ordinary compaction and density control; replace any unsuitable soil with approved material.
3. Remove existing HMA and use as reclaimed asphalt pavement (RAP) in new HMA production (optional).
4. Rework existing base and subbase and stabilize, if needed. Avoid contaminating reworked subbase with subgrade soil.
5. Place any new base material in maximum 6-inch compacted lifts.
6. Add new HMA surface (using RAP removed from existing surface).

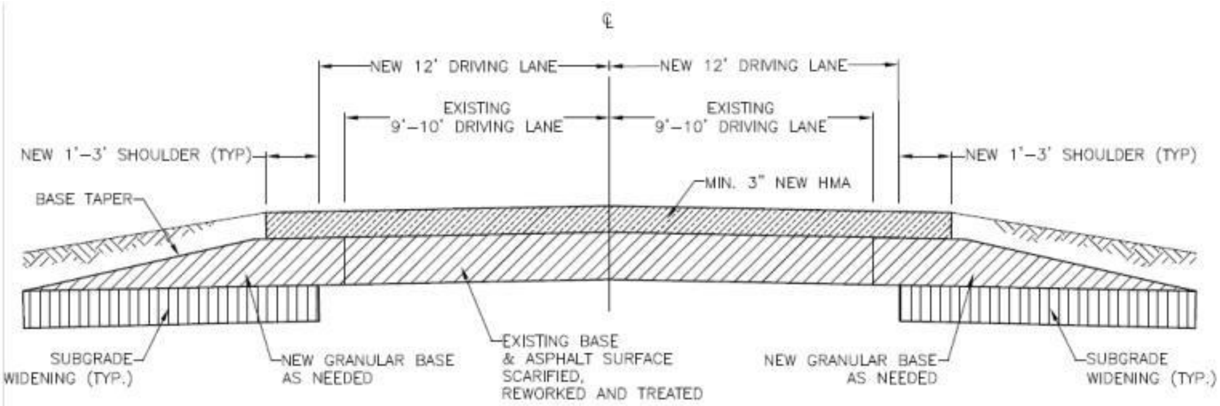


Typical section for widening flexible pavements in poor condition using full depth recycling

Low Volume Roads:

On lower volume roadways (less than 1,000 vehicles per day) in poor condition, a common practice is to process the existing HMA surface and granular base using full-depth reclamation and then resurface with new HMA. Steps in the process are:

1. Widen subgrade using standard compaction and density control; replace any unsuitable subgrade with approved material.
2. Rework existing HMA surface and base into a stabilized base using full-depth reclamation.
3. Add new widening portion using properly designed pavement cross-section.
4. Apply new HMA surface with minimum 3-inch thickness over entire roadway.



Typical Section for Widening Flexible Pavements in Poor Condition by Reworking the Existing Base

Construction Issues

Construct pavement layers as indicated in the section "Design and Typical Plan Sections." The stair-step method is normally the preferred method. The plans should call for offsets in the longitudinal joint that produce a stair-step configuration for all layers starting at the subgrade to the top of the new HMA. The steps should be horizontally offset a minimum of 6 inches. The longitudinal joint at the surface should be either in the center/midpoint of expected designated traffic lane width or at edge of designated travel lane. It should never be close to wheel path of the designated lane. Extreme care should be used to ensure that the existing materials are not disturbed and that new materials are adequately compacted against the existing materials. The construction of this joint is the key to successful performance of the widened lane. Undermining of granular layers can result in low-density materials and possible voids at the new joint.

Removal of Existing Materials

The existing HMA should be cut by sawing or milling along the line that will be the longitudinal joint at the surface.

Additional cuts should be made at appropriate offsets as indicated on plan drawings to produce the stair-step configuration. Extreme care must be exercised to prevent disturbance of the underlying pavement layers. Motor graders should not be used to make the cut adjacent to the existing pavement; the grader blade will leave an uneven cut line, and the joint face with base material will slough off into the trench. Although base is placed in the widened trench and compacted, poor compaction typically occurs at these sloughed areas, which later allow for moisture penetration and deformation under heavy wheel loads. Density measurements should be made at points 6, 12, and 18 inches from the cut line in all new materials.

The full cut should be at least 12 inches inside the edge of the existing pavement structure. As described herein, a stair-step cut is recommended which pushes the cut at the surface to be even further inside of the existing pavement edge.

The cut area must then be protected from damage by weather or construction activities as the new widened pavement section is constructed. Any soft, yielding subgrade should be removed and replaced with suitable soil.

Joint Construction

The edge (vertical face) of the existing HMA surface pavement layer along the longitudinal joint should be tack coated or treated with a joint adhesive prior to placement of new HMA along the joint. If asphalt emulsion is used for tack coat, then the joint face should be double tack coated. The use of a PG binder for tack coating will provide a greater residual binder. The preferred method is to use a joint adhesive; several commercial products are available. Joint adhesives are hot-applied rubberized asphalt sealant applied to the vertical face of the existing HMA and any new paving lane joints.

New paving lane joints should be cut vertically with a cutting wheel, or the tapered joint should be used.

HMA Compaction

HMA lift thicknesses should be a minimum of four times the nominal maximum aggregate size (NMAS) for coarse graded materials to facilitate compaction and three times the NMAS for fine graded mixes.

Most contractors have developed roller patterns that work well for compacting HMA. When they begin a new job, the pattern may have to be modified slightly since the best method of rolling HMA will change from one mix to another. Some mixtures are more tender and some are stiffer, resulting in a need for modification of the rolling technique. The longitudinal joint is almost always rolled first, and then the roller moves to the far side of the paving lane and works back toward the longitudinal joint with each succeeding pass.

There are a number of ways to roll the joint, but the most important thing is, when finished, the joint should meet density, smoothness, and mixture quality requirements. The use of a rubber tire roller to help compact the joint is desirable since the kneading action of this roller will help to ensure better compaction of the mixture in and adjacent to the joint. As always, when using the rubber tire roller, be sure that excessive pick up of the mixture on the rubber tires does not occur.

Initial compaction of the longitudinal joint should be performed before rolling the mat. There are three ways that are generally used to compact the joint: vibratory roller on cold mat overlapping 6 inches on hot mat (run in static mode), vibratory roller on hot mat overlapping 6 inches on cold mat (run in vibratory mode), or keep vibratory roller on hot mat and 6 inches away from joint (run in vibratory mode) then roll this 6 inches of remaining material on the next pass. All three of these methods have been used successfully. The way contractors roll the joint is not overly important, but it is important that they meet density and smoothness requirements when finished and there is no segregation in or adjacent to the joint.

Current FDOT lift thicknesses for HMA should be strictly enforced. The 334 Specifications for Type SP structural courses have maximum thickness allowed for Type SP-9.5 up to 1.5 inches; for Type SP-12.5 up to 2.5 inches; and for Type SP-19.0 up to 4.0 inches.

One problem that often occurs with rollers is a tendency to operate the rollers too fast.

Generally, a rubber-tire roller can be operated at a faster rate of speed than a steel-wheel roller, but a general rule of thumb for all rollers is that they should operate at about walking speed. If the mix is rolled too fast, it will provide less compaction per pass and will tend to push and shove the mix, especially when stopping and starting. It is easier to achieve compaction when rolling at a slow rate of speed, and it is easier to produce a smooth surface. Generally, a satisfactory roller sequence is initial rolling with a vibratory compactor, intermediate rolling with a rubber-tired roller, and finish rolling with a steel-wheel roller in static mode.

Another common problem when rolling is the development of roller marks, especially when turning, stopping, etc. These roller marks are difficult to roll out with the finish roller, and sometimes they contribute to cracking at the location of the roller mark.

It is easier and quicker to construct a good joint than a bad one.

Compacting Materials in Narrow Lanes

A common problem when constructing narrow lanes is obtaining required density in each of the component layers of the construction. This difficulty is often due to insufficient weight of compaction equipment to compact typical (6-inch) lift thicknesses. One way to overcome this difficulty is by decreasing lift thicknesses to a maximum of 4.0 inches in all unbound materials (base and subbase). Narrow rollers are readily available from various equipment manufacturers for road-widening projects including compaction in narrow lanes and trenches. Some agencies use full-depth HMA for construction of narrow lanes where compaction is difficult, which is acceptable, but it requires proper attention to subsurface drainage.

Embankment Widening

Some issues as related to the design and construction of embankment slopes are noted in the following table.

Embankment widening technical issues.

Design	Construction
• Steepening side-slopes reduces the margin of safety with respect to slope stability of an embankment	• The work area available at the toe and crest of the highway may be limited by site constraints
• Designer must consider both stability of embankment and stability of the wedge fill placed to widen embankment	• Placing additional earth fill on an existing embankment can be complicated by steeper slopes
• Preferential failure planes can develop at interface between original embankment and fill placed to steepen slope	• Traditional equipment may not be suitable for fill placement and compaction
• Traditional stability analyses may not be capable of evaluating stability of wedge fill placed on a side-slope	• Plans and specifications may not sufficiently convey the design engineer's intentions

The following recommendations may be useful for embankment widening projects:

1. Remove existing vegetation and organic top soil to obtain an adequate construction joint between old and new fill and to eliminate the potential for weak seams to develop because of decomposition.

2. Construct benches in existing slopes to provide a good construction joint between the old and new fill and to provide a horizontal surface upon which adequate compaction of the lifts can be achieved. A 10-foot bench should be proved on all slopes steeper than 4V:1H.

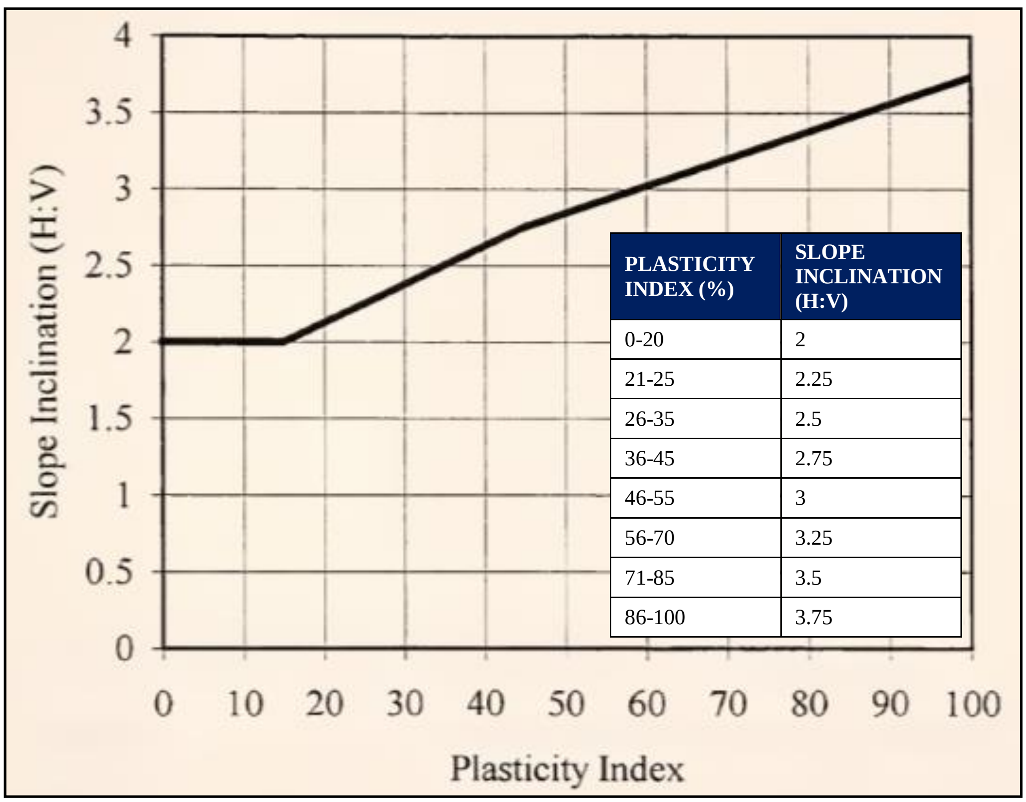
3. Compact fills to a minimum dry density equal to or greater than 95 percent of the maximum dry density achieved in the standard Proctor tests with the water content of the fill being -2 percent to +1 percent of the optimum moisture obtained in the Proctor test.

It may be necessary to extend the width to accommodate the equipment or obtain compactors that match the embankment.

4. When the width of the embankment widening is less than the width of conventional compaction equipment, it may be necessary to extend the width to accommodate the equipment or obtain compactors that match the embankment.

5. Consideration should be given to the permeability of the existing embankment material and the material to be used in the widening. If the permeability of the new material is less than the existing, then water may become trapped in the existing subgrade and lead to a reduction in shear strength.

Embankments built with higher plasticity soils should be constructed at flatter slopes to provide adequate margins of safety. Recommended slope inclinations for given plasticity indices are provided in the chart below.



PLASTICITY INDEX (%)	SLOPE INCLINATION (H:V)
0-20	2
21-25	2.25
26-35	2.5
36-45	2.75
46-55	3
56-70	3.25
71-85	3.5
86-100	3.75

Recommended slope inclination as a function of plasticity

Quality Control

The first step toward achieving satisfactory quality in the lane widening construction is the contractor quality control (CQC) plan. The FDOT Materials Manual requires producers and contractors to have an accepted QC plan and may also require an accreditation or certification to ensure compliance with industry standards.

The primary purpose of the CQC plan is to measure those quality characteristics and to inspect those activities that impact the production at a time when corrective action can be taken to prevent appreciable nonconforming material from being incorporated into the project. The contractor's CQC team should be able to quickly identify any nonconforming material that is being produced. It is recommended that FDOT specify all the requirements and material properties that must be tested and require these be included in the CQC plan.

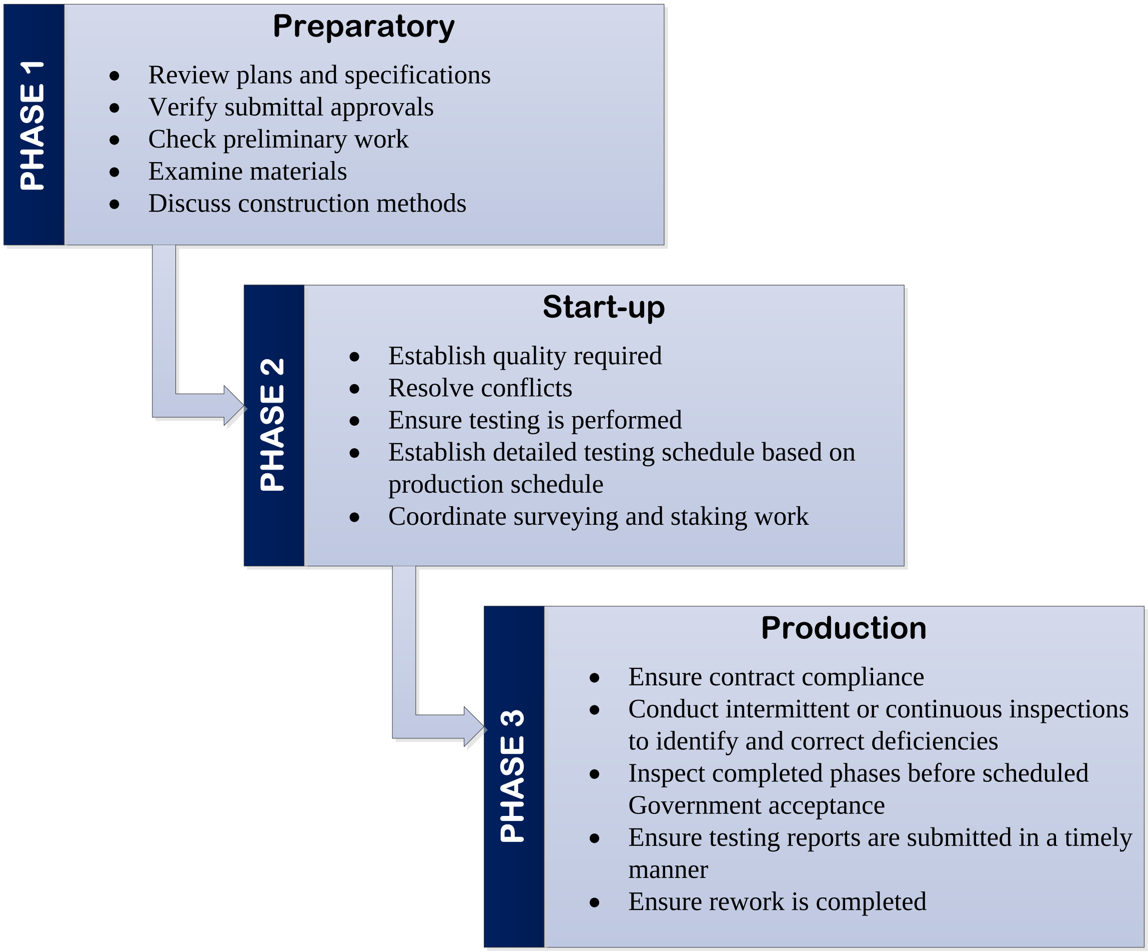
The CQC plan should cover all project construction, not just the HMA pavement. Subcontractors need to be included in this plan, which typically means identifying a responsible party and obtaining a quality control procedure from the subcontractor.

As with all FDOT construction projects, all materials, mixes, and processes used in lane widening projects must comply with applicable FDOT specifications and conform to project plans. The FDOT Materials Manual establishes quality control and process control standards for production and construction operations. FDOT design and construction engineers must assure that well-defined specifications have been provided for the placement and CQC testing is conducted on all materials along the longitudinal joint between the existing pavement and the new widening pavement; this is critical for all pavement layers and particularly so for the new HMA joint.

Full time inspection is critical to ensuring acceptable quality in lane widening projects. The FDOT quality assurance (QA) team should have established guidelines for:

- Review and acceptance of submittals
- Responses to requests for information from the contracor or suppliers
- Inspection of all stages of construction
- Sampling and testing
- Acceptance and rejection of completed work

QA generally includes three phases, covering the following:



FDOT's *Construction Project Administration Manual* describes roles of QA and CQC with regard to the duties and responsibilities of construction inspectors that monitor a contractor's construction operations in the field. In addition, it delineates the QA/CQC procedures that construction inspectors must use in order to satisfactorily perform their duties as the FDOT's first line QA/CQC representatives in the field. These procedures cover inspector training, preparation, and performance.

The FDOT *Standard Specifications for Road and Bridge Construction* provide the detail specifications for all roadway construction.

Submitttals of Materials and Mixes

The project specifications and contract documents should address the submittal process for all aspects of the work to include receiving, handling, reviewing, and approving submittals from the contractor. The CQC plan should describe the proposed method of making submittals. Submittals not providing complete information, not in proper format, or not meeting other contract specification requirements should be rejected. Some important subbmittal key items are:

- Units of weights and measures used on all submittals are to be the same as those used in the contract drawings.

- Each submittal is to be complete and in sufficient detail to allow ready determination of compliance with contract requirements.
- The CQC manager should check and approve all items prior to submittal and stamp, sign, and date indicating action taken.
- Proposed deviations from the contract requirements are to be clearly identified.
- Submittals requiring Government approval are to be scheduled and made prior to the acquisition of the material or equipment covered in the submittal.

Field Inspection

The following sub-sections are intended to provide supplementary information specifically for lane-widening projects.

Site Preparation. The field inspector's responsibilities start with the contractor's traffic control plan and initial site set-up. Safety is always a paramount issue.

Removal of Existing Material. The equipment and procedure for cutting and removal of existing pavement structure (along the lognitudal joint) must produce straight lines and clean vertical faces. Loosening and undermining of the existing material that is to reamain is not acceptable. Generally, using a milling machine is acceptable. If other methods are to be used, such as a motor grader, then a vertical sawcut should be made through all HMA material and any bound (stabilized) layers prior to removal. Any damaged material, including subgrade, must be removed and replaced with approved material.

Subgrade Preparation. Subgrade or base material that is not adequately compacted may settle over time, which in turn causes the overlying pavement to settle and crack. This can lead to roughness and early pavement failure.

HMA Joint Construction. Aggregate segregation, which is "the non-uniform distribution of coarse and fine aggregate components within the asphalt mixture," can result in reduced fatigue life, rutting, raveling, and moisture damage. Inadequate compaction results in a pavement with decreased stiffness, reduced fatigue life, accelerated aging/decreased durability, rutting, raveling, and moisture damage. These effects can cause a severe reduction in pavement life.

Discussion of the HMA joint construction was provided in the previous chapter.

Sampling and Testing. Sampling and testing methods and frequencies should be determined based on the current FDOT *Standard Specifications for Road and Bridge Construction*. The important issues as related to lane-widening projects are:

- Monitor cross slope measurments during milling operations every 250 feet (Section 327-3).
- Check asphalt temperature in the first five trucks, then every fifth load thereafter (Section 330-6.3).
- Verify tack coat spread rate as necessary to meet specifications (Section 300-8.4).
- Calculate the asphalt spread rate at the beginning of each day and continue checking the spread rate a minimum of once every 200 tons of material is placed to ensure the spread rate is within 5 percent of the target spread rate (Section 330-2.2).
- Check pavement cross slope once every 100 feet, ensuring slopes are ±0.2 percent and ±0.5 percent of plan tolerance on the mainline and shoulder, respectively (Section 330-12.5).
-

- Inspect/conduct density checks on new materials at 6, 12, and 18 inches from the joint to ensure adequate compactive effort in this area of the widening.
- Take density core samples in the HMA and at the longitudnal joint for density assessment (Sections 330-2.2 and 334-4.3.2).
- Take three non-density cores per day at random locations (Section 330-2.2)
- Check that smoothness meets the ±0.5-inch requirement for intermediate layers and ±3/16-inch requirement for the surface layer (Section 330-12).

Compliance with Drawings and Details. FDOT provides opportunities for the district construction offices to become involved in the design process. By taking advantage of this opportunity, the construction offices can make positive comments that will:

- Improve the design of the lane-widening project
- Improve the construction process and minimize the duration of construction activities
- Prevent problems during the actual construction of the project
- Ensure that the proper specifications have been used
- Ensure there is no conflict between or among contract documents

QA inspectors have the responsibility to ensure that all construction is in compliance with construction drawings and details.

Compacting Materials in Narrow Lanes. The most difficult area in which to achieve required density is along the edge next to the existing pavement section. Density tests with nuclear gages may not be able to measure density along this area, and other suitable methods may be required.

Embankment Widening. The design criteria for resurfacing, restoration, and rehabilitation of streets and highways in the *FDOT Plans Preparation Manual: Volume 1* specify that existing pavement and shoulder cross slopes shall be inspected for compliance and field verified by one of the following:

1. Full Digital Terrain Model for the roadway width – evaluate cross slope on tangent sections at 100-foot intervals.
2. Vehicle Mounted Scanner – prior to design, using the results of the scan, determine roadway limits where cross slope is potentially out of tolerance and request Digital Terrain Model of the roadway width for these limits. Evaluate cross slope on tangent sections at 100-foot intervals.

Criteria for roadway and freeway cross slopes are provided below.

Allowable roadway cross slopes

Facility or Feature	Standard	Allowable Range
Two-Lane Roads	0.02	0.015 - 0.030
Multilane Roads	0.02	0.015 - 0.040
Shoulders	0.06	Adjacent Lane Cross Slope - 0.080
Parking Lanes	0.05	0.015 - 0.050

An allowable range of 0.015 to 0.025 is acceptable for the 0.02 freeway cross slopes, and a range of 0.025 to 0.035 is acceptable for the 0.03 freeway cross slopes.

Maintenance and Performance of Longitudinal Joints on Lane Widening Projects

To increase the longevity of the longitudinal joint after it has been constructed, sealers can be applied along the joint in widths of 1 to 2 feet. Sealers include diluted emulsions and rejuvenators, both of which should be applied no more than 2 feet wide over the joint before the application of permanent pavement markings. Traditionally, agencies have been wary of applying fog seals over mainline pavements due to friction concerns; however, these concerns can be mitigated if only a small, lightly traveled area is properly treated. In addition, if the emulsion is diluted slow setting type, and if the application rate is carefully monitored, most of the treatment can be expected to be absorbed into the pavement.

All pavements deteriorate over time and with use; proper maintenance can extend pavment life and maintain desired levels of service.

Recommendations for both design and construction of lane-widening projects, as described herein, should be reviewed and the guidance taken into consideration in the maintenance program.

Any cracks that develop in the widened area, particularly along the longitudinal joint between the original pavement and the widened section, should be routed and sealed immediately.

Crack sealing quality issues are usually associated with poor workmanship. Commonly addressed quality issues are provided in the following table.

It is recommended that FDOT track performance of longitudinal cracks in lane widening projects by close monitoring with Florida's transportation asset management system pavement surface condition database. That information can be used to measure the benefit in terms of reduced deterioration of the recommendations made herein for design and construction of the longitudinal joint of the widened lane.

Common crack sealing quality issues

	PROBLEM						
	ALL SEALS				EMULSION SEALS ONLY		
CAUSE	Tacky / Picks up	Re-Cracks Quickly	Bumpy Surface	Separation from Crack Sides	Emulsion Sealer not Breaking	Emulsion Sealer Breaks too Fast	Emulsion Sealer Washes Off
Crack wet					●		●
Sealant not cured	●			●		●	
Crack dirty	●	●		●		●	
Insufficient sanding	●			●		●	
Poor finish, wrong tools	●	●	●	●		●	
Sealant too cold		●	●				
Sealant too hot	●			●			
Application too high	●		●	●			
Application too low		●	●				
Sealant degraded due to Overheating	●	●	●	●	●	●	●
Rain during application					●		●
Cold weather		●			●		
Hot weather	●		●	●		●	

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- Burton, M. et al, *Flexible Pavement Narrow Widening Best Practices and Lessons Learned*, FHWA/TX-14/0-6748-2, University of Texas Center for Transportation Research, Austin, TX, September 2014.
- Caltrans Maintenance Technical Advisory Guide, pp. 3-1 to 3-26, California Department of Transportation, Sacramento, CA, October 2003.
- Deschamps, R., C. Hynes, and P. Bourdeau. Embankment Widening Design Guidelines and Construction Procedures, FHWA/IN/JTRP-99/4, Joint Transportation Research Program, West Lafayette, IN, 1999.
- FDOT Manual of Uniform Minimum Standards for Design, Construction and Maintenance for Streets and Highways (2013 Florida Greenbook), Florida Department of Transportation, Tallahassee FL, Revised September 3, 2015.
- FDOT Materials Manual, Florida Department of Transportation, Tallahassee FL, Revised October 16, 2014.
- Flexible Pavement Design Manual, Florida Department of Transportation, Tallahassee, FL, 2008.
- FDOT Standard Specifications for Road and Bridge Construction 2016, Florida Department of Transportation, Tallahassee FL, 2016.
- Hilbrich, S. and T. Scullion. Guidelines for Design of Flexible Pavement Widening, 0-5429-P2, Texas Transportation Institute, College Station, TX, 2007.
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IMPLEMENTATION PLAN

Florida DOT Project # BDX93

Improvement of Widening Joint Design and Construction Practices for Flexible Pavements

September 2015

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BACKGROUND

The purpose of this implementation plan is to demonstrate the results of the FDOT research study to improve performance of the longitudinal joint adjacent to widened lanes. FDOT Project 002224, "Improvement of Widening Joint Design and Construction Practices for Flexible Pavements," resulted in two products: (1) a technical report with recommendations based on a literature review and survey of selected state DOTs and (2) a guide document highlighting improvements to the design and construction of the longitudinal widening joint.

The implementation plan recommends:

- Updating current FDOT manuals, specifications, and standards to address best practices in the lane widening design and construction.
- Distributing the "Guidebook for Lane Widening Projects on Flexible Pavement Roadways in Florida" to all design and construction offices within the FDOT. The guidebook can also serve as a best practices manual.
- Using PowerPoint presentations and webinar sessions to transfer the technology to the FDOT design and construction personnel. These training materials can also be used to educate contractor personnel about proper construction methods.
- Conducting demonstration/pilot projects that will put the new technology into practice.
- Monitoring performance to ensure new guidelines are validated and satisfactory.

UPDATE SPECIFICATIONS AND STANDARDS

The following summarizes best practices recommendations for design and construction of lane widening of flexible paved roadways and longitudinal joint between existing pavement and the widened pavement. The research team recommends updating current FDOT specifications and standards to incorporate these best practices.

Planning and Design

- Match existing sections. Matching widened design sections to existing pavement sections will typically provide good functional results if there is adequate drainage (i.e., positive drainage of the pavement surface and of subsurface pavement and base layers) and the existing section is structurally adequate.
- Perform thorough site investigations. Pavements often differ from what is shown on design and construction records, and undocumented widening may have been performed in the past. Compare plans with core samples and ground penetrating radar (GPR) surveys. Deflection testing and a field survey to identify distress types, severities, and locations are strongly recommended. Widening a weak pavement may be false economy.
- Consider using less permeable surface mixes. Performance is generally enhanced by using the smallest nominal maximum aggregate size (NMAS) mix that is appropriate, using a finer gradation, and using a lower design air void level to allow for additional

binder. Use lift thicknesses that are a minimum of four times the NMAS of coarse gradation mixes and three times the NMAS for fine gradation mixes.

- Pay for tack coat as a separate bid item. Use of a separate line item for task coat generally makes it easier for contactors to use a sufficient amount of material. Alternatively, develop a test and/or inspection method to ensure a sufficient amount of material is being applied.
- Use concrete base in sections where widening is less than 4 feet wide.
- Consider full-depth reclamation of existing pavement materials (hot mix asphalt [HMA], base, subbase) with an HMA overlay for widening severely deteriorated pavements. Cement stabilization of the existing pavement materials as part of the reclamation is common practice; the amount of cement needs to be based on laboratory tests and analysis.

Joint Type and Location

- Avoid placing the joint in a future wheel path. Consider shifting widening to one side of the roadway to prevent this condition.
- Mill or cut back existing pavement a sufficient distance to reach a more stable and workable face to compact material against. This approach will also allow more space for suitable compaction equipment. Note that milling equipment will generally produce more even cut lines and cleaner joint faces than grader blades.
- Stagger widening joints. Stair-stepping into the existing pavement avoids constructing a weak, full-depth vertical plane into the pavement cross-section. Offset vertical joints at least 6 inches between successive layers.
- Consider using notched or wedge joints. These joints are more effective at preventing reflective cracking and differential settlement, and they have shown better performance than traditional butt joints. Wedge joints require slightly higher operator proficiency to construct.
- Overlay the existing pavement and widened section as well as shoulder to eliminate a longitudinal joint in the surface.
- Select the proper type of longitudinal construction joint. Because of the need to open the highway to traffic during construction, two major types of longitudinal construction joints should be included in the demonstration projects:
    - Butt joints are more common to HMA overlays with lift thicknesses of 2 inches or less. HMA lifts with thickness greater than 2 inches are usually tapered because of safety issues in opening the roadway to traffic prior to placing the lift in the adjacent lane. Two types of butt joints have been used to evaluate the performance on longitudinal construction joints: a standard butt joint created by the paver's end plate and a sawed (or cut) butt joint. The sawed butt joints increase construction costs because of the added equipment and time that is needed for sawing along the HMA mat's edge to remove the edge material. Sawed butt joints are more commonly used for new highway construction, where the pavement is not immediately reopened to traffic and heavy loads. Sawed

longitudinal construction joints are typically not used on roadway widening and/or rehabilitation projects because of the need to open up the roadway to traffic prior to placing the adjacent mat. For this reason, it is recommended that only butt joints created by the paver be included in the demonstration project.

- Tapered longitudinal construction joints are needed for safety purposes when the HMA lift thickness exceeds two inches and the contractor is required to open the lane to traffic prior to placing the adjacent lane. Two types of tapered joints are recommended for use in the sampling matrix or factorial: a standard taper and a notched edge or wedge joint. The notched wedge joint has a flatter taper (1:12 slope) than the standard tapered joint.

Placing Hot-Mix Asphalt

- A joint matcher provides the best means of placing material at the correct depth to match adjacent cold joints. This is most beneficial when paving the surface lift.
- Material from the second pass should overlap joints that have been milled or cut back by approximately 0.5 inch. Notched wedge joints should have 0.5 to 1.5 inches of material overlap. Avoid luting or raking the overlapped material.
- Remove excess overlapped material with a flat-end shovel. Do not broadcast material across the mat.
- Paver auger gates and tunnels should be extended to within 12 to 18 inches of the end gate to ensure material is not being pushed and segregated. The vibrator screed should be turned on all the time.

Joint Compaction

- Build up the hot side of the joint so that the surface is approximately 0.1 inch higher after rolling. This procedure ensures the joint was not starved of material, the new material is adequately compacted, and there was no bridging of the roller on the existing adjacent pavement.
- Compact the confined edge of a joint with the first pass of a vibratory roller drum on the hot mat, but stay back from the joint 6 to 8 inches on the first pass so as to “push” the hot material into the joint. Overlap onto the cold mat 4 to 6 inches on the second pass.
- Use a rubber tire roller for intermediate rolling to knead loose material into the joint. Straddle the joint with the back outside tire, and align the front outside tire just inside the edge of the joint.

Joint Treatments

- Hot-applied rubberized asphalt joint adhesives can improve joint performance.
- Double tack joint faces when using an asphalt emulsion.
- At minimum, tack the vertical face of the joint with the same material being used to tack the mat.

- Consider a surface sealer or overband of joints with densities less than 92 percent of theoretical maximum density (TMD) with a performance-graded (PG) binder to increase longevity of joint.
- Infrared joint heating can increase compaction at the joint by 1 to 2 percent, particularly when paving in cooler weather.
- Seal longitudinal cracks that appear at the joint.

Quality Control

- Ensure that durable materials meeting specifications are used and placed properly.
- Monitor and control subgrade moisture and density.
- Conduct a pre-paving meeting to discuss methods to be employed during construction to ensure proper construction of the longitudinal joint and minimize rework. Discuss the joint type to be used and the role of each paving crew member in achieving good joint density.
- The quality control plan should include all current standard FDOT sampling and testing of materials in the roadway construction, as well as additional sampling and testing recommended in the "Guidebook for Lane Widening Projects on Flexible Pavement Roadways in Florida."
- Construct a test strip.
- Determine the optimum rolling pattern for density at the joint.
- Monitor density in the field with a nuclear density gauge correlated to cores. It is recommended that the gauge be placed parallel to the joint and offset 2 inches from the joint to ensure the gauge is seated. Take an average of two to four 1-minute readings. Rotate the gauge 180 degrees between each reading.
- Take 6-inch core samples adjacent to the longitudinal joint and compare with the density samples taken 2 feet away from the joint.

The existing FDOT design manual, specifications, and other documents should be revised to reflect the recommended changes to lane widening. These items include prepared guidance documents, design and construction procedures, and policies that apply to the placement of the widened lane and construction of the longitudinal joint between the widened and existing lane. The documents to be updated include:

- Flexible Pavement Design Manual, Florida Department of Transportation, Tallahassee, FL, 2008.
- Add sections to chapter 6 for widening site investigation, removal of existing materials, widened structure joint types, and HMA joint location procedures.

- FDOT Plans and Preparations Manual Vol 2, Florida Department of Transportation, Tallahassee, FL, 2015.
- Update typical widening section in chapter 6 (pp.107-108) to show minimum 6-inch offset joint detail between layers.

- Include typical cross-section in chapter 6 that highlights widening with full depth reclamation.
- Include typical cross-section in chapter 6 that illustrates widening a pavement through reworking the existing base.

- FDOT Manual of Uniform Minimum Standards for Design, Construction and Maintenance for Streets and Highways (2013 Florida Green Book), Florida Department of Transportation, Tallahassee FL, Revised September 3, 2015.
- Add statement to chapter 5; section B.2, “For widening flexible pavements, refer to the state flexible pavement design manual.”

- FDOT Materials Manual, Florida Department of Transportation, Tallahassee FL, Revised October 16, 2014.
- Add to chapter 3 (Bituminous Materials) an updated procedure for utilizing nuclear gauge measurements in widening projects. This guidance would potentially benefit any type of HMA construction project).

- FDOT Standard Specifications for Road and Bridge Construction 2016, Florida Department of Transportation, Tallahassee FL, 2016.
- Add a “Widening” section under Division II Construction Details/General Construction Operations/Bituminous Treatments, Surfaces Courses and Concrete Pavement to include:
    - Optional flexible pavement joint types
    - Approved practices for removing existing materials
    - Approved joint treatments
    - Pay for widening of the joint
    - Recommendations for best construction practices

DISTRIBUTION OF GUIDEBOOK

The expected audience for the new guidance on lane widening will be the FDOT design and construction engineers, consultants, and contractors required to implement the design and construction recommendations. In addition, recommendations in the guidebook will include documentation on how the results can be used to increase the service life of these widened lanes.

The guidebook can be distributed electronically through the FDOT website or by e-mail to all appropriate users.

A PowerPoint presentation should be developed and presented via a webinar to transfer the new technology to all interested users.

After completion of the pilot project and demonstration projects discussed below, a follow-up webinar can be used to show actual construction of the projects and describe lessons learned.

DEMONSTRATION PROJECTS

It is recommended that FDOT conduct a pilot project to ensure all design and construction details have been considered and addressed. FDOT should then conduct at least two additional demonstration projects that follow the recommendations in the guidebook and incorporate any lessons learned from the pilot study. The pilot project can be used to evaluate methods for removal of existing pavement along the edge to be widened, best equipment and methods to develop the stair-step edge, ability of different rollers to achieve density of all pavement layers, and to fine-tune the quality control/quality assurance procedures.

Each project should focus on meeting specifications to the 100 percent level with no acceptance of reduced quality work (i.e., no reduction in quality based on penalty provisions). This is important for the demonstration projects to show that good performance can be achieved with the correct design and construction. Emphasis should be placed on the longitudinal joint construction because it has been the area of early failure and maintenance needs in past lane widening projects.

Some specific recommendations for the design and construction of the demonstration projects include the following.

Stagger Joints between Pavement Layers

Many states stagger the joints between pavement layers; most states offset joints 6 inches between successive layers. Some states use a 12-inch key, as shown in Figure 1, but only in the top layer. The potential for reflective cracking along the longitudinal joint can be reduced by milling the pavement adjacent to a widened section to a depth of at least 1.5 inches, then surfacing both the widening and existing pavement. Some districts in Florida have included offsetting joints in widened section designs.

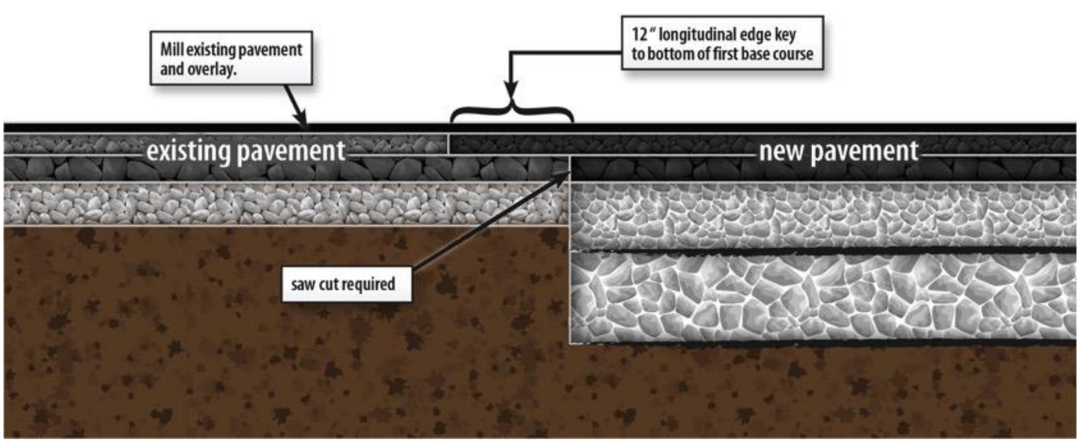

Figure 1. Notched edge cross-section (Kentucky Transportation Cabinet).

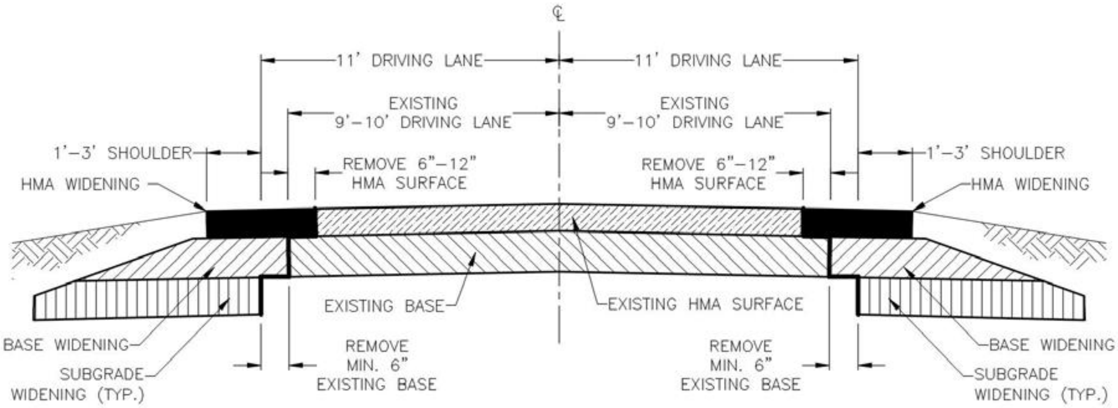

Figure 2. Cross-section of widened lanes illustrating stair-step design.

Vertical Joint Face

Neat vertical faces along the edge of the existing pavement must be free of dirt and debris in order to provide for uniform tack coat adhesion and for achieving proper compaction along joints. Both milling machines and saws can be used successfully to create vertical cuts. Uneven cut lines and joint faces have been experienced on projects that use a grader blade to widen the pavement, and poor compaction has been identified in these "sluffed" areas.

Longitudinal Joint Construction

Compacting the longitudinal joint from the hot side of the joint, by either placing the drum of a steel wheel roller 10 inches over the top of the joint or the outside tire of a pneumatic tire roller directly at the joint, is optimal. Figure 3 shows a steel wheel roller compacting longitudinal joints from both the hot side and cold side of the joint. The amount of the overlap of material onto the existing pavement should be monitored during construction, as illustrated in Figure 4.

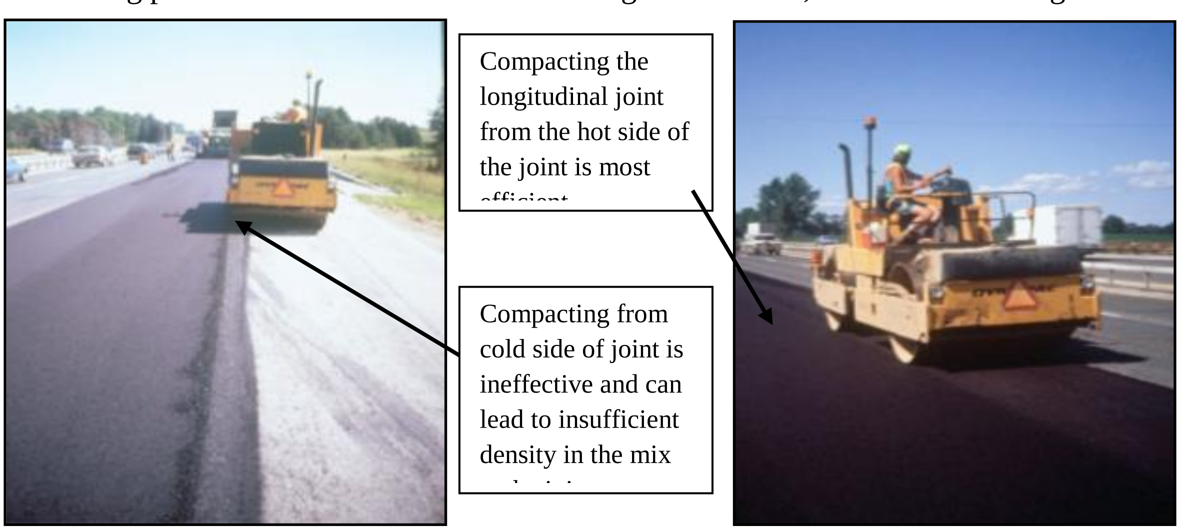

Figure 3. Techniques for compacting HMA longitudinal joints.

Overlap should be periodically monitored during paving. Raking of the joint and broadcasting the mix across the mat should not be permitted for this demonstration or any future project.

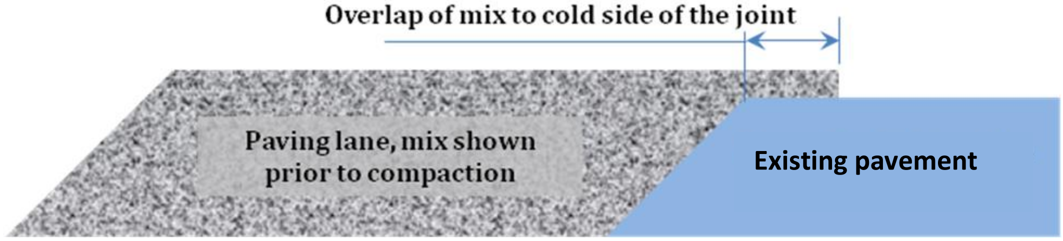

Figure 4. Illustration of overlap of mix onto existing pavement.

A clean edge along the existing pavement is best made using a milling machine or concrete saws. For newly placed cold lanes, a vertical edge can be produced with a cutting wheel, as shown in Figure 5; this has been found to greatly improve joint density when used with proper laydown and mix overlap procedures. The notched wedge joint has also been found to provide density that is greater than or equal to the vertical joint. Figure 6 illustrates the shape of the wedge joint, and Figure 7 shows modifications to equipment to accommodate the wedge joint.

The demonstration projects should consider a comparison of the joint types as part of the construction. An advantage of the notched wedge is that traffic can traverse the joint without any safety issues. Figure 8 shows the notched wedge joint.

Figure 5. Cutting wheel removing approximately 2 inches of material along cold lane.

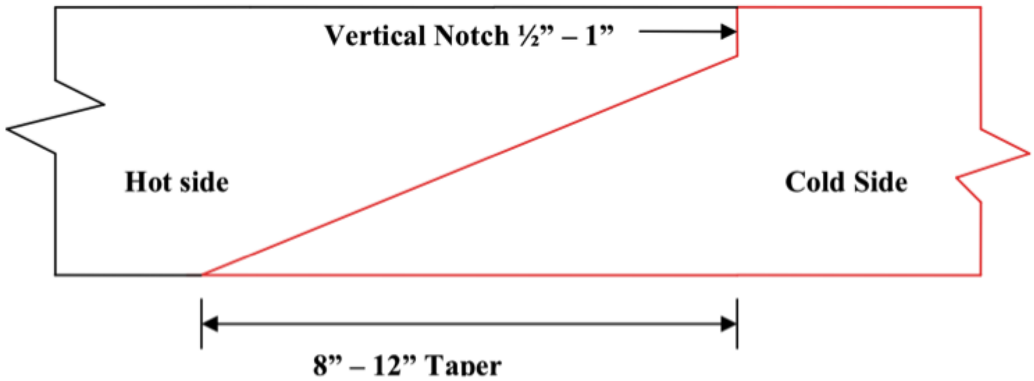

Figure 6. Alternative notched wedge joint.

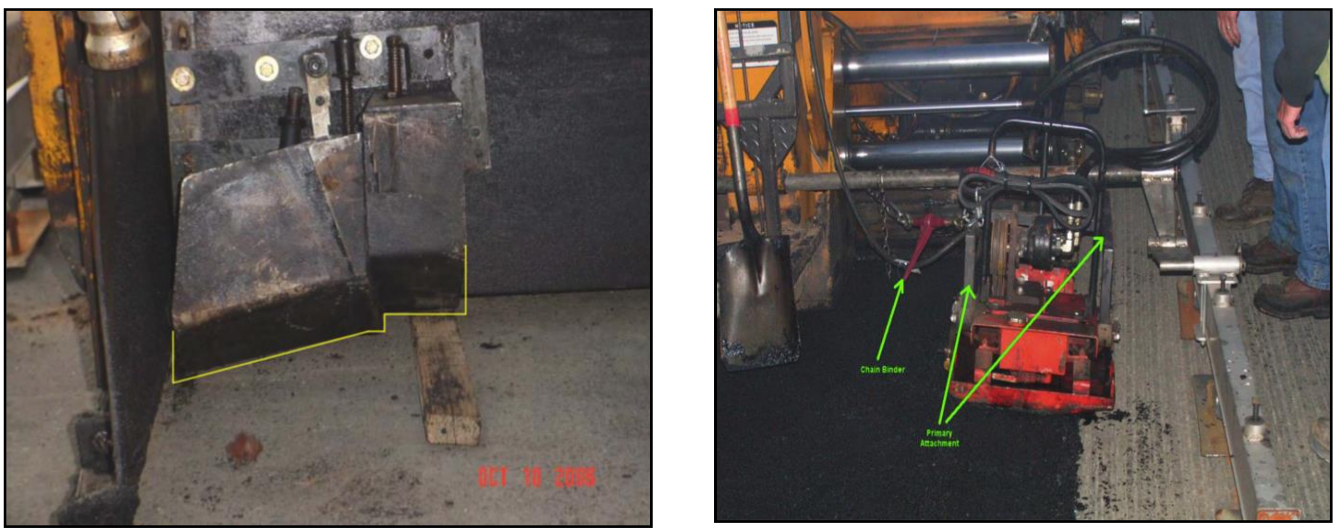

Figure 7. Modifications to paver for notch wedge forming and compaction.

Figure 8. Notched wedge joint.

Location of Longitudinal Joint

The location of the joint between the existing and new widened pavement structure may vary due to the condition of the pavement edge. Placing the widening joint at least 12 inches inside the existing pavement is recommended. However, it is important to keep the longitudinal joint away from the traffic wheel paths.

Problems can arise when saw cutting at the extreme edge of the pavement to maximize use of the existing pavement structure; this practice can lead to joint failures when the new base is compacted against the older, deteriorated and non-uniform materials that are likely found at the edge of the roadway. The existing pavement edge typically has the worst quality material and is composed of maintenance repairs and base material that is deteriorated or has vegetation growing through the pavement within about 6 inches of the edge. Placing the joint farther into a more stable and workable face will also allow more space to fit compaction equipment, as illustrated in Figure 9.

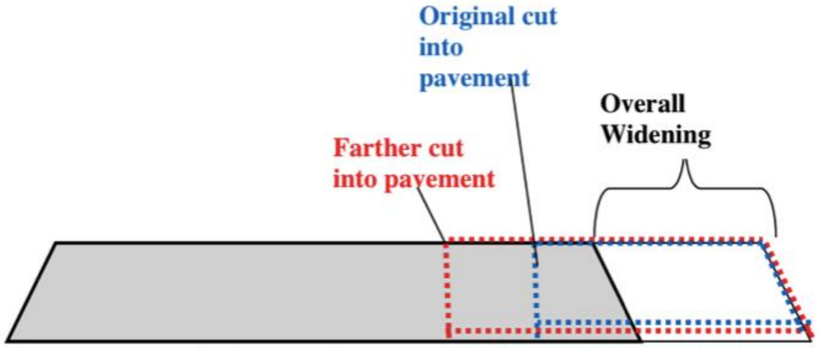

Figure 9. Locate joint in area of sound material.

Bridge Longitudinal Widening Joint with HMA Overlay

The Federal Highway Administration (FHWA), National Center for Asphalt Technology (NCAT), and others recommend placing an overlay over the entire roadway in conjunction with joint staggering to mitigate stacking of underlying joints. A number of states reported placing HMA across the entire width of travel lanes to avoid a longitudinal widening joint on the surface of the pavement.

Treatments for Widened-Section Longitudinal Joint

A number of treatments have been used successfully along the longitudinal joint. Applying tack coat to the open face of joints was the most frequently reported treatment. Treatments used by various states are:

- Tack coat joint face
- Joint adhesive/sealer
- Geotextile or grid reinforcement
- Full-depth HMA in widened section

Quality Control Testing

The current quality control procedures described in FDOT manuals and standard construction specifications should be applied to lane widening projects. State agencies reported practicing the standard state inspection quality control procedures for constructing subgrade, base, and structural asphalt materials, ensuring quality materials are placed at correct elevations, adequate density is achieved, drainage layers are aligned, and layer thicknesses are correct. Efforts should be made to ensure subgrade resilient moduli of the widened section are similar to the existing section. Proof rolling of the subgrade has been used to identify and correct soft spots on widening projects. HMA mix segregation may be an issue in widened sections. The gradation of the HMA mixture can have a significant effect on the joint density along notched wedge type joints. The surface voids and/or surface texture of the notched wedge can result in low densities that are mix dependent and not a result of the contractor's standard care and workmanship.

FDOT should execute the implementation plan outlined herein within the next construction season. The projects should be located in different districts and spaced geographically to allow FDOT engineers across the state easy access to at least one of the project sites. ARA personnel can be available to assist FDOT in the application of the implementation plan during the pilot project and/or the demonstration projects; however, that effort is not included in current project budget.

The updated specification(s) should be used in the demonstration projects during the first construction season of implementation to demonstrate and confirm the best practices and methods for rolling longitudinal construction joints to achieve the maximum density along the joint relative to the density achieved near the center of the HMA mat.

PERFORMANCE MONITORING

It is recommended that FDOT track performance by closely monitoring the pilot projects. The criteria to be used for assessing the progress and consequences of implementation will be based on Florida's transportation asset management system and data included in the pavement surface condition database. That information will be used to measure the benefit in terms of reduced deterioration of the longitudinal joint of the widened lane.

It is hypothesized that the length and severity of longitudinal centerline cracks can be reduced by including joint density in the construction specification. Reducing the length and severity of longitudinal centerline cracks will delay the occurrence of the distress value requiring some type of rehabilitation and/or preventive maintenance. Thus, density needs to be monitored during construction, and the length and severity level of centerline cracks need to be monitored over time. This density requirement will have no negative impact on International Roughness Index (IRI) values or rut depths.