

Sub-Task 4 – Best Practice and Specification for Joint Construction

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Highways England, Mineral Product Association and Eurobitume UK

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Executive Summary

It is widely recognised that joints are a point of weakness in asphalt pavements which often require maintenance in advance of the central asphalt mat. Common signs of distress at joints include loss of aggregate (fretting), ravelling and loss of bond between adjacent asphalt materials, potentially associated with the ingress of water. In addition, it is not uncommon to observe reflective cracking from joints in underlying courses which subsequently can also be prone to the same distress mechanisms associated with joints in the asphalt surface course.

It is understood that construction factors have a significant impact on the durability of asphalt joints, in particular in relation to the potential for water ingress and asphalt density/air voids at the joint. Both these points are linked to potential relative reductions in durability and mechanical performance of the asphalt in the proximity of joints. As such, there has been significant focus on the optimisation and development of joint construction methods and techniques which aim to mitigate the potential maintenance risks associated with constructing an area of relative weakness in terms of durability and mechanical performance in an asphalt surfacing.

Current specifications do not consider all factors affecting joint construction methods and technologies; therefore, they offer scope to be improved to drive more consistency in the performance of joints. For this reason, this project aims to provide an update on current best practice from the industry, recognise advancements in technologies and to make recommendations for updates to specifications. The study focuses predominantly on joints in asphalt surface course but the principles apply to other asphalt layers. To capture best practice and emerging technologies, the methodology comprised a literature review, focusing on papers and conference presentations; an industry survey; and a review of the current specification to understand which modifications are needed.

The literature review summarises joint location and planning, construction methods, focusing on side compaction wheel, cutting back, joint re-heating and rolling and compaction; performance requirements; free edges, painting of joints; joint reheaters; sealing joints and underlying joints.

- a) In terms of planning and location of joints, it is suggested to minimise the number of joints and to locate them away from sensitive areas.
- b) Laying in an echelon is recommended to provide a hot matched joint with confinement.
- c) From the joint construction methods mentioned above, cutting back or edge compaction is more commonly used.
- d) In terms of performance requirements, in the US, bonus schemes are in place which drives density at the joint to achieve combined criteria: a maximum of 2% lower density at the joint compared to the mat and a minimum of 90% of the theoretical maximum density at the joint.
- e) Best practices for sealing of joints are summarised, highlighting the importance of applying the sealant uniformly along all joints.
- f) Joint heating technologies are advancing and future trials are planned.

The industry survey focused on similar topics as the literature review. In this way, findings were easier to compare.

- i. Regarding location and planning, the industry agrees with the literature review findings and adds the necessity to submit joint patterns prior to works.

- ii. The preferred construction method is to pave in echelon, with the main joint techniques being cutting back or edge compaction, followed by sealing of the edge and then laying up against it.
- iii. For free edges, different methods are summarised. Planed joint, cut back, seal and edge compaction are the preferred methods.
- iv. For sealing, hot bitumen is generally preferred.
- v. For underlying joints, sealing the joint prior to surfacing is a recommended practice.

The industry survey also included questions about advancements in technology. These can be summarised as:

1. Electronic sensors on rollers which enable temperature measurement and better compaction temperature control.
2. High compaction screed technology delivers higher density out of the paver which aids joint construction.
3. Use of WMA additives at HMA temperatures to aid compaction, particularly on roundabouts.
4. Joint heaters for inlay work with temperature and speed monitoring.
5. Trials for optimising the angle of the chamfer on edge compaction or cutting wheel.

In terms of main challenges, training and education of operatives were highlighted. Construction methods and weather conditions as a result of site accessibility and availability are also mentioned as challenges by the industry. Finally, the review summarised the current specification requirements and highlights the lack of air voids requirement in UK highway applications for surface course.

With this information, it is suggested that the current specifications could be updated to include options for both performance and prescriptive specifications. Prescriptive specifications could improve education and training to the installers by providing a clear methodology to follow; however, it can also hinder innovation and may preclude the use of techniques which are currently established. Performance specifications are likely to drive a more consistent approach and would have direct benefits to performance at the joints. However, for small schemes and short possessions, this type of specification may not always be practical due to the requirement for testing. For this approach, it is also recommended to gather data and evaluate it to confirm which requirements should be adopted.

Additional suggestions from industry include mandating the submission of joint formation procedures, not allowing hot matched joints (unless echelon paving) and to avoid the requirement for departure for cambered pavements where the joint offset is typically 150 mm instead of the specified 300 mm.

1. Introduction

Highways England, Mineral Product Association (MPA) and Eurobitume UK jointly commissioned AECOM to undertake a review of current best practice related to the construction of asphalt joints. The review aims to provide an update on current best practice from the industry, recognise advancements in technologies and to make recommendations for updates to specifications.

This review comprises:

- Literature review of joint repair methods and techniques;
- A summary of findings from industry consultation form the basis of informing current best practice;
- Specification requirements are tabulated (see Appendix A)
- This work also makes recommendations for updates to specifications based on industry feedback and current best practice.

1.1 Background

It is widely recognised that joints are a point of weakness in asphalt pavements which often require maintenance in advance of the central asphalt mat. Common signs of distress at joints include loss of aggregate (ravelling) and loss of bond between adjacent asphalt materials, potentially associated with the ingress of water. In addition, it is not uncommon to observe reflective cracking from joints in underlying courses which subsequently can be prone to the same distress mechanisms associated with joints in the asphalt surface course. It is understood that construction factors have a significant impact on the durability of asphalt joints, in particular to the potential for water ingress and asphalt density/air voids at the joint. Both these points are linked to potential relative reductions in durability and mechanical performance of the asphalt in the proximity of joints. Inherent factors, such as lateral movement of material under the rollers at an unconfined edge potentially can result in lower density at the joint which increases the potential for water ingress which may lead to fretting and deterioration. As such, there has been significant focus on the optimisation and development of joint construction methods and techniques which aim to prevent the potential risks of water ingress and fretting. The approach and methods taken to optimise joint construction are discussed in this report.

1.2 Scope

The Collaborative Research project scope states: “*The Project should review the different techniques and make recommendations for improving the construction of asphalt joints.*” The study focuses on the construction of asphalt vertical joints for new construction, maintenance and patching works and includes joints in new material adjoining with existing surfacing. During project meetings, it was requested that the study also makes recommendations for updates to specifications related to joint construction. The study focuses predominantly on joints in asphalt surface course but the principles apply to other asphalt layers.

1.3 Methodology

To capture best practice and emerging technologies, the following approach was taken:

- Engagement with MPA members via email survey and phone
- Literature and web search study including a review of papers and conference presentations
- Summary of current specifications (presented in Appendix A)
- Consideration of recommendations for updates to specifications

Information presented in this report is structured based upon the following sub-headings which have been selected to complement the sub-headings included in Road Note 42 (Nicholls et al, 2008) which is considered to be pertinent existing industry guidance.

The sub-headings under which this report is structured are:

- Ø Joint location and planning
- Ø Method of forming joints
- Ø Performance requirements
- Ø Unsupported edges
- Ø Sealing of joints
- Ø Joints in underlying courses*

Transverse joints are covered in separate sections to longitudinal joints.

*Although not directly within the scope of this study, some interesting points were picked up during engagement with industry related to measures that may be taken to treat underlying joints to mitigate the risk of reflective cracking through the surfacing.

2. Literature Review

This section presents a literature review on asphalt joint construction. The literature study comprised a web-based search of articles, technical reports and conference papers and presentations related to construction and performance of asphalt joints. Findings and concepts of asphalt joint construction are presented taking into account experiences in the United Kingdom and the United States. The major aim of this review is to identify key joint construction methods and identify any new techniques.

The literature search yielded a significant volume of papers. Of these, findings from most pertinent documents are summarised within this literature review under the sub-headings outlined in the Methodology Section 1.3.

2.1 Longitudinal Joints

2.1.1 Location and Planning of Joints

The durability of the surface course and underlying pavement can be extended by limiting the number of longitudinal and transverse joints. Careful planning of the paving works should always be undertaken in order to limit the number of joints, considering the complexities of sites and areas of high stress, as explained in Figure 1.

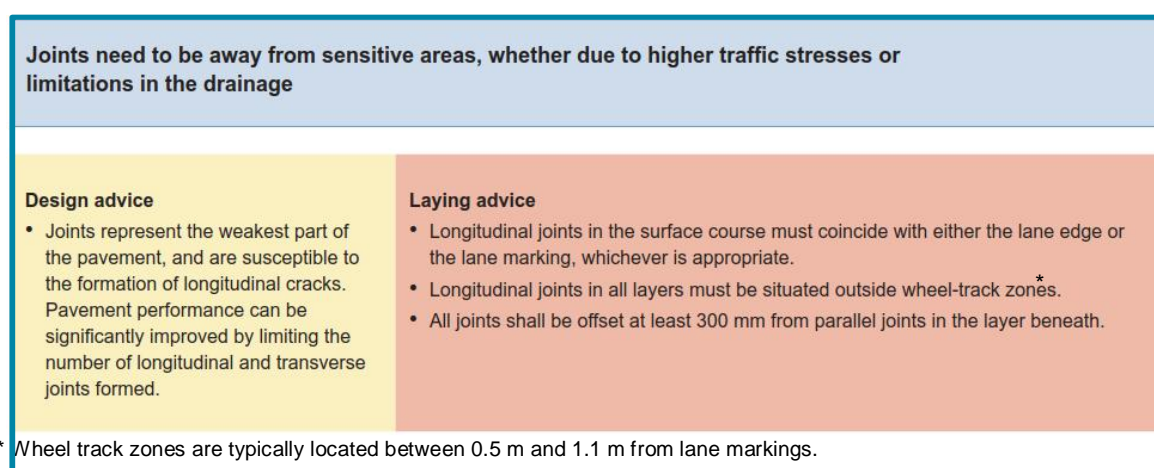


Figure 1: Joint Location Advice (Nichols et al, 2008)

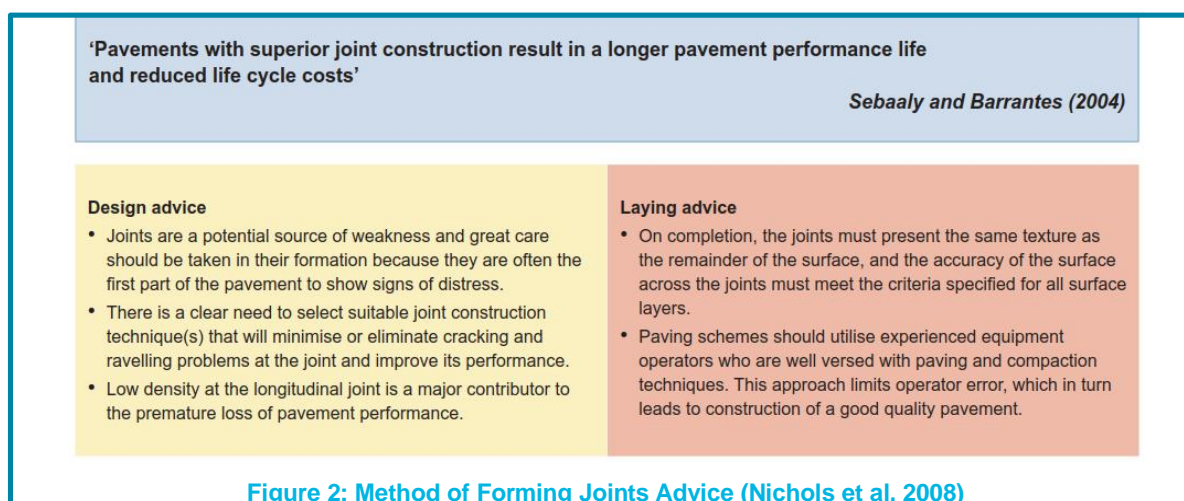
Recommendations developed for a Longitudinal Best Practices Workshop by Buncher et al (2012) consider measures which should be taken during planning and design stage. Recommendations are summarised below:

- Evaluation of traffic management to see if echelon paving could be utilised to minimise the number of traditional cold joints.
- A paver capable of paving multiple lanes in one pass is another option for reducing longitudinal joints.
- For resurfacing schemes, evaluate traffic management to mill and fill one lane at a time, eliminating unconfined edges.
- Offset the longitudinal joints by at least 150 mm, when placing multiple lifts (this does not apply when placing asphalt over concrete whereby it is better to align the joints) However, UK best practice is to offset by 300 mm.
- Plan the location of the longitudinal joint in the surface lift to avoid paths, recessed pavement markings and striping wherever possible.

- Assure there are well defined specifications for the placement and quality assurance for testing the longitudinal joints.
- Adequate layer thickness will facilitate compaction for better density.
- Consider use of less permeable surfacing mixtures.
- Consider using warm mix asphalt as a compaction aid, especially in late season paving.
- Consider the use of notch wedge joint (versus the traditional vertical edge of butt) for lift thicknesses between 40 to 75 mm. Several agencies found that the notch wedge joint provides on average higher densities than the butt joint.
- Procure bond coat as a separate item (as opposed to being an incidental requirement) to facilitate application of a sufficient amount.
- Include items related to the longitudinal joint as discussion topics for pre-paving meetings.
- Plan the lane sequence from low to high surface geometry. This will prevent the overlapped joint from impeding water flow on the surface.

2.1.2 Method of Forming Joints

In Figure 2, high-level advice from Road Note 42 (Nichols et al, 2008) is presented regarding joint formation. More detailed advice and recommendations related to construction methods are outlined in Sections 2.1.3 to 2.1.7.



2.1.3 Construction

The first lane paved is often referred to as the cold lane because the hot asphalt cools off by the time the second lane or hot lane is being paved. In addition to the fact that it will remain cold when the hot lane is laid, the unconfined edge of the cold lane tends to have a lower density than at the centre of the lane joint. The techniques described below have been used to improve the construction of an unconfined edge prior to the adjacent laying of material.

2.1.4 Side Compaction Wheel

The use of an edge compaction technique to construct a longitudinal joint is popular in Germany. It consists of a hydraulically-powered wheel, which rolls alongside the compactors drum. The wheel pinches the unconfined edge of the first lane towards the drum. The method is believed to increase the density of the unconfined edge and improve the overall density at the joint. The edge-restraining wheel is bevelled up toward the roller at a range of angles dependent on the thickness and type of material.

The bevelled edge produced by the technique provides a longer jointing surface which is thought to improve the adhesion and quality of the joint between lanes. It should be noted that the technique described above produces a slightly raised profile which can be removed by using the tandem roller in crab-steer mode, i.e. with the rear drum offset by approximately 100 mm. In TS2010 the side compaction wheel is preferred.

2.1.5 Cutting Back

In the UK, a common method of treating material at the edge of the cold lane's surface course is to carefully cut it back to its full depth. TS2010 states that this technique '*removes material that is not sufficiently compacted and ensures that the hot lane is laid and compacted against a firm and uniform material. The quality of the joint is dependent upon the skill of the cutting wheel operator. After cutting back, the exposed vertical edge must be thoroughly cleaned of all loose material and be sealed with an approved bituminous joint sealant in accordance with BS 594987. The painting of joints is intended to aid adhesion and minimise the ingress of water at the joint. It is therefore vitally important that the vertical face of the cut and the cleaned joint is completely coated with the chosen sealant*'

2.1.6 Joint Re-Heating

The quality of longitudinal joints may be aided by heating the joint with a joint heater, as shown in Figure 3. The concept is to re-heat the edge of the cold lane and bring it up to a plastic state prior to the new, adjacent hot mat being laid. The heater must raise the temperature of the full depth of the surface course to the specified range of minimum and maximum rolling temperatures for a width of not less than 75 mm (TS2010, 2015).

Joint heaters can also be used to improve the continuity of joints. It should be noted that, if the process is not carried out in a controlled manner, there is a danger that the pre-heated asphalt may be damaged, which can result in premature ageing of the material (Heslop et al, 2013). Advancements in joint heater technology are described in Section 3.3, which include fully automated joint heater technology which provides continuous temperature measurement and informs the paver operator of the optimum paving speed to achieve the desired heating. This technology can also adjust according to the paving speed which aims to limit risk of over or under heating of joints.

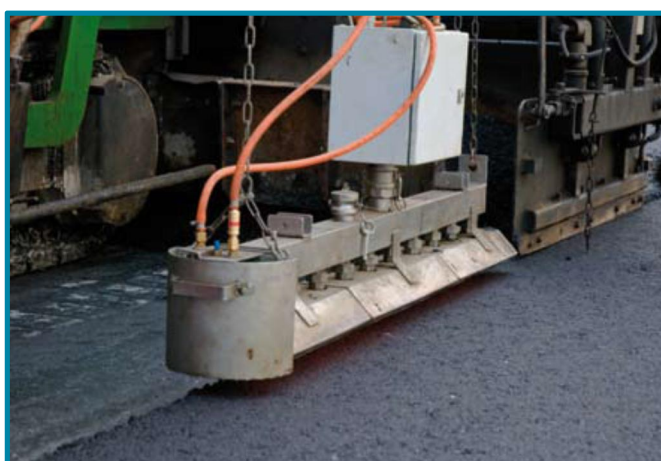


Figure 3: Example of an Infra-Red Joint Heater, Which Automatically Cuts out When Paver Stops (Heslop et al, 2013)

Paver mounted heater trials were carried out in Area 9 on the Westbound A45 between the A452 and M42. The existing surfacing was HRA and the replacement material 14 mm Clause 942 thin surface course. The works were completed on a plane out and re-lay basis to 8 patches varying in length from 5 m to 25 m (Holmes, 2016).

The heater is mounted on the side of the paver and heats the existing material to a temperature of 130°C or greater, to enable a hot joint to be formed between the new and existing surfacing.

Trials were undertaken at varying laying speeds between 5 m and 8 m per minute. The joint temperature at the rear of the screed was maintained which ensured compaction was undertaken at a far more desirable temperature. Over the range of laying speeds a good consistency for the new joint was achieved. This was evident as the heater was fitted to one side of the paver and the results showed a difference between the joint on the heater side and non-heater side.



Figure 4: Joint Treated with Paver Mounted Heater (left) and Joint Untreated (right) - Area 9 Paver Mounted Heater Trials, 2016

Feedback reported from surfacing suppliers suggests that paving speeds reported are reduced compared with the normal laying speeds which significantly reduces outputs. Further concerns related to the unknown impact of heating the existing surfacing and the potential to overheat.

The following recommendations were made following a review of the trial findings: *“The idea of heating the longitudinal joint is not a new one, however, the technology is currently not available to heat the adjacent surfacing to enable the joint to be formed at the normal operating speeds of the paver. It is therefore recommended that the use of paver mounted heaters is not an efficient way of forming the joint between new and old material, due to the impact of reducing the output of the surfacing operation.”*

Studies in the US reported that joint heaters can improve joint density by 1-2% (Buncher et al, 2012). The same studies suggest that equipment improvements include longer and more efficient infrared heaters and automation of paver speed to minimise over-heating or under-heating.

2.1.7 Rolling and Compaction

Sebaaly et al (2005) report findings from two field trials undertaken in the US which trialled two methods of the rolling pattern. Statistical analysis, conducted to identify any interaction between joint geometry and rolling pattern, indicated that the rolling pattern does not have a significant impact on the joint density if either of the two rolling patterns is used. The rolling patterns trialled were:

Rolling Pattern I – rolling from the hot side with 150mm (6 inches) overlap on the cold side (shown in Figure 5). The first pass started from the hot side of the joint with this overlap.

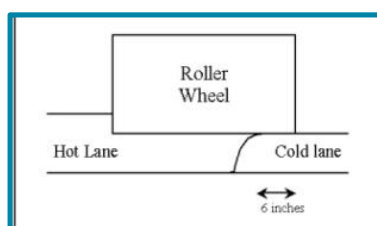


Figure 5: Rolling Pattern I (Sebaaly et al, 2005)

Rolling Pattern II – rolling from the hot side with the first pass 150mm away from the joint on the hot side (shown in Figure 6). This rolling procedure tends to push loose material towards the joint.

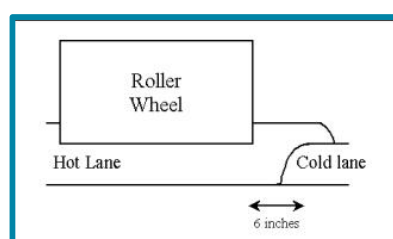


Figure 6: Rolling Pattern II (Sebaaly et al, 2005)

Rolling patterns I and II shown above were also adopted by Buncher et al (2012), in the best practices workshop. Buncher et al recommend compaction of the hot side with the first pass 150 mm to 200 mm away from the joint, with the second pass then overlapping the joint onto the cold mat by 150 mm (i.e. similar to rolling pattern II). An alternative is to follow rolling pattern I but a concern raised with this method is that if an insufficient depth of asphalt is placed on the hot side, then the roller may bridge the joint and not compact the hot material.

For unconfined edges, Buncher et al recommend compaction of the uncompacted mat with the drum extending over the edge of the mat by 152.4 mm. This study also recommended the use of rubber tyre rollers for intermediate rolling (not finishing) of the hot side of the joint to knead the loose material into the joint. The edge of the outside rubber tyre should run on the inside edge of the joint and the back outside tyre can straddle the joint. Rubber tyre rollers should not be operated close to unsupported edges due to excessive lateral movement.

2.1.8 Performance Requirements

Sebaaly et al (2005) report findings from two field trials undertaken in the US which aimed to establish the knowledge base for the development and implementation of a longitudinal joint specification for the Nevada Department of Transportation (NDOT). A field-testing program was carried out to evaluate the effectiveness of the various joint geometries and compaction techniques in increasing the joint density. The field-test projects carried out in the summer of 2004, evaluated five joint geometries and two joint rolling techniques. The field-test project carried out in the summer of 2005 evaluated the three most promising joint geometries as identified from the previous program. Based on the analysis of the data generated from all the field-testing programs, it recommended that NDOT implement the following joint density specification:

- a) The density at the joint should be a maximum of 2% less than the corresponding mat density, and
- b) The density at the joint should be a minimum of 90% of the theoretical maximum density (TMD).

Review of the data from the summer 2005 project on the joint densities and the differences between the mat and joint densities leads to the following conclusion: All three joint geometries: natural slope, cut edge with rubberized tack coat, and tapered joint at 3:1 will meet the recommended joint density specification.

Research undertaken by Buncher et al concluded that for the in-place air voids need to be less than 7-8% to avoid interconnecting voids with most surface mixture types. Yet, good joint construction practices typically achieve between 8-10% air voids. This is the reason why the area around the longitudinal joint will often deteriorate before the rest of the mat, and why achieving the highest possible in-place joint density is critical.

Some US states have a pay scale bonus scheme and penalty scheme based on compaction performance for mat density and also for longitudinal joint density performance. Buncher et al (2012), report the pay scale for longitudinal joints (including surface course) to be:

- ≥90% of TMD earns 100% pay
- ≥92% of TMD earns maximum bonus
- Between 92 and 90% TMD: pro-rated bonus
- <90% of TMD reduced payment and seal by either overbanding (with PG binder) or surface seal product
- For joint densities <92%: if knowing the joint is still likely permeable, consider sealing by either overbanding or use of a surface seal product.

In the UK, performance requirements are in place for Specification for Highway Works performance binder and base course mixtures Clause 929 and 930 which are summarised in Section 4.1.3. There are no requirements in place in the UK to measure surface course density on Highways in order to avoid coring of the surface course. For airfield projects including runways it is standard practice to core and monitor density of compacted Marshall Asphalt material close to the joint (requirements are summarised in Section A.4).

2.1.9 Unsupported Edges

In Figure 7 a summary of advice for construction at unsupported edges from Road Note 42 is presented.

<p>'Maintaining continuity of density across the joint is generally considered a key factor in maintaining durability'</p> <p style="text-align: right;"><i>Toepel (2003)</i></p>	
<p>Design advice</p> <ul style="list-style-type: none"> • Request method statements to ensure the contractor has thought about how to minimise the increase in air voids content at joints. 	<p>Laying advice</p> <ul style="list-style-type: none"> • Lay in echelon whenever practicable. • Consider possible means of providing a secure side against which to compact free edges that will be site specific. If there are no viable options (which will be a common case), consider how far the edge will need to be cut back to ensure continuity.

Figure 7: Unsupported Edges Advice (Nichols et al, 2008)

There are several methods to improve compaction at unsupported edges, including the use of temporary restrains and cutting back on the less well-compacted materials. Whichever method or combination of methods is used, the increase in the air void content at joints should be limited, as suggested in the previous section (Nichols et al, 2008).

2.1.10 Sealing of Joints

In Figure 8 and Figure 9 a summary of advice from Road Note 42 is presented regarding the sealing of joints.

All vertical existing faces need to be painted with binder to enhance the adhesion with the new asphalt	
<p>Design advice</p> <ul style="list-style-type: none"> Vertical or near-vertical faces of existing construction, including ironwork, kerbs and asphalt or concrete pavement, should be required to have an application of bituminous material to enhance adhesion to newly laid asphalt. In the specific case of porous asphalt, a painted joint can prevent the horizontal movement of water. Therefore, the thickness of the bituminous paint should be limited to avoid such sealing because it will affect the drainage. 	<p>Laying advice</p> <ul style="list-style-type: none"> The bituminous material used to paint surfaces should be applied uniformly to the whole of the surface.

Figure 8: Painting of joints advice (Nichols et al, 2008)

Joints need to be sealed, not only because of the discontinuity but also because of potentially inferior compaction	
<p>Design advice</p> <ul style="list-style-type: none"> Joints, other than in the surface course, should be sealed with a thin film of bituminous sealer. 	<p>Laying advice</p> <ul style="list-style-type: none"> The sealant should be increased at locations where the joint is not tight or where the asphalt on one or both sides of the joint has a particularly high air voids content. Elsewhere, it should be applied uniformly along all joints.

Figure 9: Sealing of Joints Advice (Nichols et al, 2008)

The materials being used for sealing of vertical joints range from 40/60 paving grade bitumen applied hot to polymer modified bituminous emulsion binders with the cohesion of Class 6. Polymer modified binders are to be preferred for joints in surface courses. Only the joints in layers below the surface course are painted on the horizontal surface; the surface course joint should not be so painted, and much more care applied to providing sufficient binder to the vertical faces, as shown in Figure 10. With the exception of porous asphalt, vertical joints in all materials should be coated with a suitable bituminous material designed for use in joints. The aim is to keep water from percolation through joints (Heslop et al, 2013)

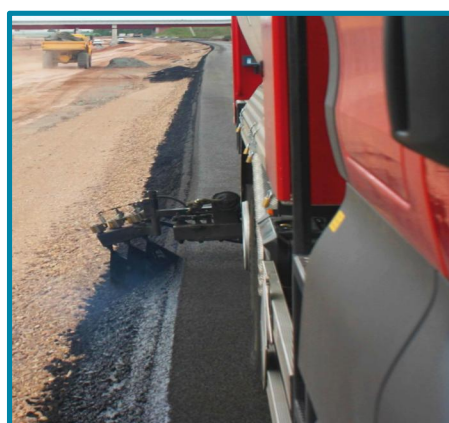


Figure 10: Side Jet Spray on Modified Bond Coat Sprayer to Seal Vertical Joints and Edges (Heslop et al, 2013)

In the US, as a minimum, the face of the joint is sprayed with the same bond/tack coat material used over the whole mat. Where emulsions are used, the face should be double treated. Penetration grade bitumen and joint adhesives are also used and are preferred, although more expensive. The use of hot-applied rubberised asphalt sealant applied to the open face of the longitudinal joint is a growing technique in the US, as agencies believe it seals and improves the durability of the joint (Buncher et al, 2012).

2.1.11 Joints in Underlying Courses

Hot material is often laid against existing cold material on the side of the joint, which results in rapid cooling of adjacent material, reducing the compactability of the asphalt at the joint. This may make the material more prone to fretting. In addition to this, reflective cracks from the underlying binder course joint are frequently observed and identified as longitudinal cracks approximately 300 mm offset from the surface course (Jones et al, 2013-14). An example is shown in Figure 11. The material between the surface course joint and the reflective crack has been observed to fret requiring repair.

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.

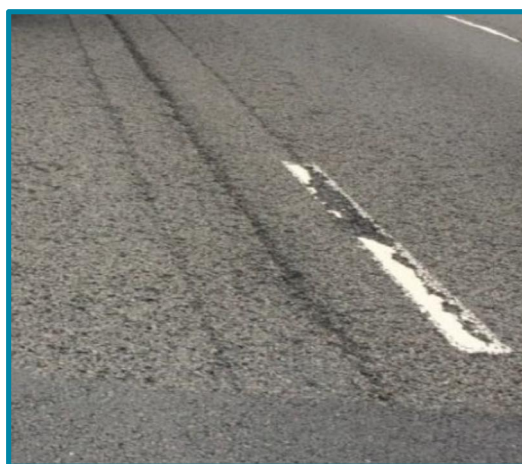


Figure 11: Reflective Cracking from Underlying Joints

2.2 Transverse Joints

Careful planning and continuous material supply can reduce the requirement for transverse joints resulting from interruptions to paving.

TS2010 (2015) states that *'transverse joints are made as a consequence of an interruption to the paving works. Such joints create a local weakness in the pavement... Careful planning can reduce the number of stoppages. Transverse joints often disrupt the smoothness of the longitudinal profile; hence, ride quality of the pavement surface. In some instances, the poor longitudinal profile created in the area of transverse joints can result in additional dynamic loading that is damaging to the pavement'*.

3. Industry Feedback

To capture industry best practice, feedback was requested from MPA members via email survey and phone. The following request was sent to MPA members by Malcolm Simms (MPA) in February 2017:

MPA is a partner in Collaborative research projects with Highways England and Eurobitume UK.

Part of this research aims to share best practice in asphalt joint construction methods and associated technologies.

MPA members are requested to provide information on joint construction. Information received will feed into a best practice document outlining different methods and equipment used and may be made available.

The scope of the study: The study focusses on asphalt joint construction for new construction, maintenance and patching works for all asphalt pavement layers and includes joints in new material and adjoining with existing surfacing.

Feedback on the following topics would be appreciated:

- 1. Methods of joint formation (method statements are requested, if available) for new construction, maintenance and patching work. Do these methods vary with different asphalt materials?*
- 2. Have different systems or techniques been trialled and what are the merits/downfalls of each? Are there methods which have not worked well?*
- 3. What are the main challenges related to joint construction*
- 4. Have there been advancements in equipment technologies which are beneficial*
- 5. Please provide any other information*
- 6. Research, publications and photographs would help, if available, please*

Please respond to me before 20th March 2017. If you have any questions or prefer to discuss over the phone then please give me a call.

Kind Regards

Malcolm

The email survey yielded one initial direct response and a number of expressions of interest for a phone discussion.

On this basis, some key contacts were identified by MPA who were contacted directly and 30-minute telephone appointments were arranged. The telephone discussions were based on the topics outlined in the email survey and discussion focussed on best practice, techniques, experience and innovation. Members were also asked whether they have any recommendations for updates to specifications. Following the telephone discussions, notes were typed up and sent to the industry member to confirm accuracy and add any additional notes they may think of following the discussion.

The following people (MPA members) were consulted:

- Ø Tim Smith (Tarmac)
- Ø Frank Haughey (Tarmac)
- Ø Martin Ashfield (CEMEX)
- Ø Adrian Hadley (Hanson)
- Ø Neil Leake (Aggregate Industries)
- Ø David Jones (Eurovia)

Feedback received is summarised factually and anonymously following the topic headings.

3.1 Longitudinal Joints

3.1.1 Location and Planning of Joints

The industry survey regarding location and planning of joints highlighted the importance of having the joint pattern prior to work commencement, paying attention to bell mouth areas. The Specification for Highways Works requires longitudinal joints to be offset by 300 mm from parallel joints in the layer beneath. Some respondents commented that *'joints should have a minimal of 150 mm but desirable 300 mm offset between each layer.'* *'This is to allow roller compaction and a brick work effect and not to have joint on the joint as this is the weakest part of any mat'*. There was general agreement that joints in the surface course should coincide with lane markings where possible.

3.1.2 Method of Forming Joints

All consulted specialists agreed that the best method of joint formation is to pave in echelon. It was also commented by one respondent that, where possible, *'it is best to avoid joints by paving full width (provided there is a sufficient rate of material supply)'*. All parties focussed their feedback on joint construction of the free edge and achieving a good seal. The main techniques were cutting back or edge compaction, followed by sealing of the edge and then laying up against it. Feedback is detailed in the sections below.

For inlays and patching works (i.e. laying on an existing surface) all parties layup against a clean vertical edge that has been sprayed with sealant. The planed edge is generally tidied by cutting but some respondents advised that a planed joint performs well without the need for cutting back.

Use of a high compaction screed is understood to aid joint construction as a higher density can be achieved which one respondent advised can reduce the amount of cutting back required.

3.1.3 Unsupported Edges

When compacting a free (unsupported) edge, the mat spreads laterally and results in lower density. It was reported by a respondent that *'it is sometimes possible to identify which side of the joint was the unconfined edge as fretting at the joint on that side can become apparent'*. This section focuses on treatment at the unsupported edge at the edge of the pavement.

Two main methods for construction at unsupported edges were highlighted during the survey.

- a) Cutting back
- b) Edge compaction

All parties agreed that the method of cutting back material at an unsupported edge improves the final joint and three respondents commented that this is the only method which is used as a best practice at roundabouts. A number of techniques are adapted for cutting back which include the use of a cutting wheel on a roller, use of a floor saw, use of a jackhammer and use of a planing machine. For base and binder course material it was generally considered that any of these techniques work. Some materials must be cut back or paved in echelon, such as Marshall Asphalt to meet density requirement on cores across the joint on airfields.

There were some conflicting opinions regarding the use of a cutting wheel for high stone mixes, such as surface courses as one supplier commented that *'the technique had been observed to 'rip' material rather than produce a clean cut'*. In contrast, other recipients use the cutting wheel technique and find it to be effective and one recipient noted development trials in this area using a chamfered cutting wheelset at 60° (see Section 3.3).

Marking out the joint location is preferred to assist the operatives in producing a straight joint which is beneficial when installing the next rip. Generally, the amount of material that is cut back was not defined as it can vary depending on material and course thickness. One respondent quoted 50-75 mm of cut back is required.

Using a planing machine to cut back the longitudinal joint is the preferred technique for one supplier. They suggested that *'planing the joint first thing in the morning and then painting the joint prior to installation of the next lane is very effective. This method may cost more depending on the scheme and program but is found to be quicker than using a floor saw and is reported to lock in better than a sawn joint, especially with smaller aggregates'*. Conversely, another supplier advised that they have *'sometimes found issues if the planer teeth are worn and the pick spacing is greater which can result in a ragged joint'*.

One supplier advised that *'edge compaction is (their) preferred method for joint construction of surface and binder courses (base courses may be too thick for this technique to be effective)'*. Edge compaction has been used as a standard by this supplier for 2 years. The chamfered wheel is lowered hydraulically to suit the course thickness. The edge compaction wheels are typically fitted to a Bomag 161 (for binder/base compaction) and Bomag 131 for surface course. Development focusing on angles of the edge confinement found that 45° chamfered wheel works well. Additional development to assess 30° angle from vertical for the surface course is ongoing. Evaluation is based on visual assessment and on larger schemes cores are also taken. Density and core data will be beneficial in the long term.

Edge compaction was found to be most effective *'after 3-4 roller passes as material must be hot for edge compaction to be effective. If edge compaction is carried out too early then the material has more movement and is less stable'*. There was some opinion that edge compaction was not the most effective method of joint construction. However, it was noted that suppliers have invested development in different areas.

Cutting back is not preferred by one supplier due to time and material waste; however, it was noted that it is considered best practice for TSCS and on roundabouts as it is not effective on a curve. One respondent advised that *'the outer edge of a roundabout is cut back by a minimum of 100 mm'*. It was also noted that scheme-specific specifications often require joints to be cut back.

The material type has an effect on the joint, for example, finer graded materials *'close up better'*. It was also noted that *'smaller aggregate sizes will also form better joints (that said you can achieve good joints with 14 mm TSCS)'*. Material immediately adjacent to the joint should have a *'full surcharge to ensure that the correct thickness of the material is achieved to allow for the compaction effect of the roller to produce a neat durable joint'*.

It was also found by one respondent who consulted with their experienced operatives, that *'3 pin rollers 'knit' the joint better than using twin drum rollers. Compaction of the joint is targeted straightaway behind the back of the machine to knit in, provide a quicker bond and a better seal. Material cools quickly at the edge of the mat and it is very important that compaction is carried out efficiently'*.

3.1.4 Sealing of Joints

All respondents apply joint sealant to the clean, vertical (or chamfered) face. The major aim of the joint sealant is to prevent ingress of water and provide a good bond between the asphalt at the joint. Cold applied joint sealants have been found to run off the joint face, however, one supplier reports success with a cold thixotropic bituminous sealant which is 'glupey', and able to hold sealant on the joint. Cold pour joint sealants were also reported by one respondent not to provide the necessary seal and bond. They advised that *'in the North when the weather may be cold and damp, hot applied sealants appear to provide a better bond than cold-applied sealants. In the South with the dry weather they found cold sealants to work but prefer hot bitumen'*.

Use of hot applied bitumen or hot applied polymer modified bond coat is considered to provide the best seal and bond. However, some clients prohibit the use of hot bitumen for health and safety reasons as it requires bitumen boilers and hand applied sprayer. Most parties reported that full coverage of the joint face is targeted, with one respondent targeting half to two-thirds coverage.

Most respondents reported that application of bond coat using a bond coat spray tanker with a *'specialist nozzle for joint sealing provides the best and most consistent coverage and allows heating of the bond coat'*. One supplier quoted *'hot applied Colbond 50 (>0.35 kg/m² residual binder) works well'*. Most suppliers reported that combi spray tankers work best which have two tanks, one for bond coat and one for bitumen for the joints and a joint painter attachment. It was reported by most that this method gives the best coverage. Conversely, one supplier found that the use of a bond coat sprayer 'spray arm' is *'not preferred due to insufficient coverage ('mist spray')*. They use hand sprayers to apply hot bitumen which others suggest *'is not always the best as it may not cover the full depth of the joint face'*. Hand sprayers to apply hot bitumen to the joint face are considered best practice on smaller schemes. Respondents raised some health and safety considerations with hand application of hot bitumen and advised that some clients do not allow this operation but hot applied methods are understood to be preferable in terms of joint performance.

It was reported that all faces of cold upstanding edges including kerbs and ironwork are painted with hot PMB bitumen and all base and binder course joints should be overbanded and sealed using hot applied PMB bitumen to prevent in the ingress of water.

3.1.5 Joints in Underlying Courses

Where there may be old binder course materials that were installed before requirements came in to seal joints, the joints may be in poor condition. An option reported for preventing reflective cracking was to seal the underlying joint prior to surfacing.

3.2 Transverse joints

Best practice for transverse joints is to cut back. The preferred method of cutting back transverse joints is to *'remove material using a planing machine, trim to vertical and paint. This is to remove the end of load material which may have cooled or segregated in the paver hopper'*.

Experience from one respondent during Clause 942 research suggests that sometimes there are issues in this area. They advised that cutting back by '1 m (as opposed to 0.5 m) provides a safeguard' and is the adopted approach for their company.

For transverse joints, a floor saw or jackhammer is most commonly used, or the asphalt planing machine followed by a saw to vertical.

One respondent advised the importance of having 'all transverse joints, where possible, with a stagger between layers of a least 5 m. This is to allow a paver length as when tying in if the paver is going up or down across lower joints, might have some effect on level control'.

3.3 Advancements in Technology and Areas under Development

Advancements in equipment and technology include:

- Use of edge compactors on rollers and Bomag type rollers fitted with cutting wheels.
- Automated paving which includes continuous monitoring of material in the paver hopper and real-time information for the roller driver related to compaction temperature and a number of passes is a significant advancement. This technology helps to monitor temperature at the joint and ensure compaction is timely.
- Joint heaters for inlay works, to heat up adjoining material to 'knit' them together and initial trials have indicated promising results in terms of the joint. The joint heating operation may compromise paving speed and one respondent noted that significant energy is required to sufficiently heat 20-25 mm of material which may burn bitumen on the joint. One supplier commented that the proximity of the joint heaters to the paver tyres has been an issue in the past as it needs to be as close to the back end as possible without obstructing the augers. It is understood that further advancements in joint heater technology are due to be trialled and there are options to increase paving speed. Joint heater technology is now available which is fully automated and provides continuous temperature measurement and informs the paver operator of the optimum paving speed to achieve the desired heating. This technology can also adjust according to the paving speed which aims to limit risk of over or under heating of joints.
- High compaction screed pavers which can improve initial density which can reduce cut back.
- Use of WMA additives at HMA temperatures to aid compaction, particularly on roundabouts. Operatives have a longer working window for compaction as they offer an extra 30 – 40°C workability window. This is also reported to be a good option in winter. In addition, additives are also thought to offer adhesion benefits which could benefit sealing at joints. One supplier reported an economic balance between costs of additive vs the amount of cut back and risk of complaints.
- Development is in progress to evaluate 30° chamfer angle of edge compaction for surface course.
- Bespoke SMA mix design (based on German SMA approach) was found to produce a good joint with one supplier.
- Chamfered wheel to cut back surface course to the 60° angle (Figure 12) has been trialled at a County Council scheme. The joint sealant was reported to be easier to apply at this angle and the resulting joint looked good.
- One supplier has trialled a wedge joint with a 45° chamfer (comprises a shield on the side of the paving machine approx. 100-150 mm wide, depending on thickness). The wedge goes from full depth to zero. However, it was found that this method was not effective due to the second lane overlap where it effectively tapers to zero.



Figure 12 County Council Innovation Scheme Trials of 30° Chamfered Cutting Wheel- Painted Joint (provided by an MPA member)

3.4 Suggestions for Improvement

The survey emphasised that educating operatives in best practice is very important. Toolbox talks were highlighted as a good method of training operatives. In particular, training of foremen and supervisors was considered to be very important in communicating best practice. A challenge raised was the adoption and understanding of specifications by the operators. On this basis, it was suggested by one supplier that prescriptive specifications could provide clarity and assurance. There are a lot of options within the current specifications.

Regarding the placement of joints, contractors are required to submit joint pattern before work commences, however, this is rarely done. It was suggested that submission of joint patterns and methods should be mandatory.

The ideal is to lay in 2 rips but often there are bell mouths to contend with which are frequently hand laid and hot matched. The nature of these locations means they are often high stress areas. It was also recommended by one respondent that hot matching is banned, but this is challenging in practice.

For cambered roads, a 300 mm joint offset is reported to be impractical. 150 mm works better to achieve a good embedded joint. Current specifications do not allow for this.

The tie-in with concrete presents practical challenges with joint offsetting as concrete and strong CBGM's cannot be planed out. This has resulted in departures being required.

Weather is a challenge which affects joints. Contractors are expected to lay in adverse conditions. Winter working and drizzly damp conditions have an adverse effect. The rate of cooling is impacted and adds an element of risk. Weather is expected to have a greater effect on thin layers (25-50 mm) which should not be underestimated. Adequate road space is required to allow traffic management, for example, to enable joint offsetting and cutting back. Having a limited window of possession can be a challenge as staged planing is required for joint offsetting, instead of cutting full specified depth in one goes. Construction is simpler on new build/full construction type works than maintenance works.

4. Current Specifications

4.1 Key Specifications Covering Asphalt Joint Construction

The key UK specifications which cover the requirements for asphalt joint formation include:

- Series 700, Series 900, BS 594987, IAN154, IAN157, HD27

Specification requirements are presented in tables in Appendix A.

4.1.1 Joint Location and Planning

In general, current specifications require joint locations to be planned such that the joints are not located within the wheel paths. Vertical joints in asphalt layers shall be offset by 300 mm.

Joint formation procedures for each layer are required to be submitted by the contractor to the Overseeing Organisation, along with the location of joints and methods of treating upstanding edges.

Specification requirements for joint location and planning are detailed in Appendix A, Section A.1.

4.1.2 Method of Forming Joints

Appendix A, Section A.2 details specification requirements related to joint construction methods.

The specifications name the following methods which are permitted methods for preparation before the adjacent lane width is laid;

- Echelon paving
- Cutting back
- Edge compaction
- Use of joint heaters

Specifications also detail requirements for bond coat application overlap at joints, with maximum 300 mm overlap.

4.1.3 Performance Requirements

Appendix A, Section A.4 details specification requirements related to performance requirements at joints.

Joints in binder and base courses have a maximum permitted air voids content measured from core pairs whose centres are not more than 100 mm from the final joint, not greater than 2% above the maximum limit for core pairs in the body of the mat.

For AC dense base and binder course design mixtures (Clause 929), there are requirements for the air void content of cores adjacent to the joint to not exceed 9%.

There is no air void performance requirement for surface course materials in the mat or at joints for Highways. Cores are not taken from the surface course in the UK, with the exception of airfield Marshall Asphalt (requirements are presented in Section A.4).

4.1.4 Unsupported Edges

Appendix A, Section A.5 details specification requirements for unsupported edges which require sealing of the pavement edges for the high side of elevation. Sealing of the low side is conditional on whether it is necessary to let water out or stop water getting into the pavement.

4.1.5 Sealing of Joints

Appendix A, Section A.6 details specification requirements related to sealing of joint faces. Specifications require a binder to be applied to all vertical faces prior to laying the adjacent mat. The type of binder used for sealing joints is not specified.

4.1.6 Surface Sealing Joints

The top surface of all base and binder courses are required to be sealed with not less than 0.50 kg/m² residual bitumen 75 mm either side of the joint. The sealant shall be one of the following: (i) hot elastomeric polymer-modified bituminous binder complying with BS EN 14023 with a penetration of not less than 40 pen; (ii) bitumen emulsion with a cohesion by pendulum of Class 4 or above in accordance with BS EN 13808; (iii) slurry surfacing complying with Clause 918. 25.

Specification requirements for surface sealing joints are detailed in Appendix A, Section A.7.

4.1.7 Underlying joints

Specification requirements for the treatment of underlying joints are detailed in Appendix A, Section A.8. In general, joints are required to be made good by flushing out and refilling with the joint-filling material.

5. Recommendations for Updates to Specifications

The industry feedback recognises the importance of good construction at the joints and each contractor has guidelines in place to deliver good workmanship.

There is a difference of opinion as to what the best methods are for constructing and sealing joints and as such the current approach is not consistent across the industry.

Two alternative approaches can be considered for increased consistency in joint construction:

1. Make specifications more prescriptive.
2. Consider performance-based specifications.

Prescriptive Specifications

Part of the feedback received during industry consultation suggested that more prescriptive specifications would improve consistency and performance of joints. It was also noted that prescriptive specifications can provide benefits to installers and make education and training easier for contractors. In the US, some states having a prescriptive specification choose to randomly test the density at joints. Conversely, prescriptive method based specifications may hinder innovation and may preclude the use of techniques which are currently established.

Performance Specifications

Performance specifications are likely to drive a more consistent approach and would have direct benefits to performance at the joints. Currently, there are performance requirements for Clause 929 performance base and binder courses and Clause 930 for EME2. However, there are no performance requirements for air voids content in the surface course mat or joints (with the exception of Marshall Asphalt for airfields, DIO Specification 13). Parts of the US have adopted a performance-based approach (see Section 2.1.8) which is based on achieving a maximum of 2% less than the corresponding mat density and a minimum of 90% of the theoretical maximum density. Where the density is not achieved, the contractor is required to seal the joints. These requirements were developed on the basis of extensive field trials to ensure that joints prevent ingress of water (i.e. voids are not interconnected and joints are well sealed). As part of the research in the US, both joint density and permeability were evaluated.

For this approach to be considered in the UK it is recommended that data is gathered and evaluated to confirm whether these requirements are achieved by UK asphalt materials and to understand what level of air voids is appropriate to provide material which prohibits water ingress.

For small schemes and short possessions, measuring density is not always practical. Specifications should take into account such scenarios.

Specific recommendations from industry

Consultation with industry raised the following suggestions

1. Require submission of joint formation procedures. Clause 903.5 requires the joint formation procedures for each layer – including the location of longitudinal and transverse joints; and the method(s) of treating upstanding edges to be detailed and submitted to the Overseeing Organisation. It is suspected that this information is not always requested or considered in relation to scheme design, resulting in potential conflicting requirements.
2. Do not allow hot matched joints. Hot matched joint refers to a joint where the paving machine lays one rip and then pulls back to lay up against it (note that this is not the same as echelon paving). Feedback from industry suggests that hot matched joints are not effective. This practice generally occurs at bell mouths and junctions which are considered to be high-stress areas. It is recommended that this practice is specifically not allowed by the specifications and that joints should be formed following best practice.
3. Current specifications require 300 mm offset of vertical joints in pavement courses. For cambered pavements, this offset is not always practical to construct and as such departures are required to reduce the offset to typically 150 mm. Specification updates could eliminate the requirement for departure in this instance.

6. Next Steps

Current specifications can be improved to drive more consistency in the performance of joints. A review of the effectiveness of current methods should be undertaken which should build on the learning from the US and focus on joint density and seal (the US assessed air voids and permeability as the basis of their research). Consideration of advancements in technologies would also be valuable, including continued collaboration with the work undertaken by Highways England Efficiencies Committee which assesses the effectiveness of joint heaters. In addition, the notch wedge joint has found to be effective in the US which has not been developed in the UK.

7. Acknowledgements

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Appendix A Current Specification Requirements

Specification requirements related to asphalt joints are summarised in Sections A.1 to A.8 below.

A.1 Joint location and Planning of Joints

Table 1: Summary of Specification Requirements: Joint Location and Planning

Specification	Clause	Requirement
BS 594987:2015	6.8	When the information is available, all joints shall be offset by at least 300 mm from parallel joints in the layer beneath.
MCHW Series 900	903.5 (ii)	(08/08) Before work commences, the contractor shall submit a method statement to the Overseeing Organisation that includes: (i) Laying and compaction procedures for each layer – including paving speed and paved width; size, type and number of rollers; and a number of roller passes. (ii) <u>The joint formation procedures for each layer – including the location of longitudinal and transverse joints; and the method(s) of treating upstanding edges.</u>
MCHW Series 900	903.21	(08/08) Unless otherwise specified in Appendix 7/1, longitudinal joints in all layers shall be situated outside wheel-track zones. For the purposes of this Clause, the wheel-track zones shall be taken to be between 0.5 m and 1.1 m and between 2.55 m and 3.15 m from the centre of the nearside lane markings for each traffic lane (or, in the absence of lane markings, lane edges). All joints shall be offset at least 300 mm from parallel joints in the layer beneath. Joints in the surface course shall coincide with either the lane edge or the lane marking, whichever is appropriate.
MCHW Series 900	918.19	(08/08) Unless otherwise agreed with the Overseeing Organisation, longitudinal joints, where the material is laid on a road, shall coincide with lane markings.
NG Series 900	NG (iii)(v) 903.2	(08/08) Certain key factors are important in maximising the durability of the finished pavement and should be reviewed before work commences. These are: (i) Mechanical laying wherever practicable. (ii) Bonding of layers. (iii) <u>Good compaction, particularly at joints.</u> (iv) Pre-planning of the compaction process. <u>Sealing of edges and joints to prevent water ingress.</u>
NG Series 900	NG 903.12	(08/08) However, a joint in a bituminous layer is constructed, it will always be the weakest part of the pavement. Therefore, it is good practice, wherever possible, to minimise the number of cold joints by, for example, using wide screeds and/or paving in echelon. (08/08) Joints should be located in low stressed areas of the pavement wherever practicable, as indicated in sub-Clause 903.21.
MCHW Series 900	948.25	(08/08) A method for the making of longitudinal and transverse joints, appropriate to the type of CRBM being laid shall be provided.
IAN 154/12	1	This IAN gives revised requirements for the locations of longitudinal joints in highway re-surfacing and the initial and retained texture depth of thin surface course systems. It also gives requirements for cold applied ultra thin surfacing.
IAN 154/12	903.21SR	The following shall be included in contract specific Appendix 0/2 Part A 903.21SR For new pavement construction, all longitudinal joints in all layers shall be situated outside wheel-track zones. Where an existing road pavement is resurfaced, joints in the surface course shall coincide with either the lane edge, the lane marking, or the middle of a traffic lane, whichever is appropriate. Joints shall not coincide with the wheel path. For the purposes of this Clause, the wheel-track zones shall be taken to be between 0.5 m and 1.1 m and between 2.55 m and 3.15 m from the centre of the nearside lane markings for each traffic lane (or, in the absence of lane markings, lane edges). All joints shall be offset at least 300 mm from parallel joints in the layer beneath.
IAN 154/12	NG 903.12SR	The following alteration to Clause NG 903 is to be used for all appropriate schemes and included in contract specific Appendix 0/2 Part B when necessary. NG 903.12SR Joints should always be located in low-stress areas of the pavement wherever practicable, as indicated in sub-Clause 903.21. However, where an existing road surface is being replaced, it is permitted to locate the longitudinal joints within the surfacing material in the middle of a traffic lane. This position should only be selected if positioning the joint under the lane edge or lane marking would result in significant areas of sound surface course material being unnecessarily replaced. Joints should never be placed in the wheel-track zones.


Specification	Clause	Requirement
IAN 157/11	6.42-46	<p>6.42 It has been observed, from examples of thin surfacing approaching the limit of serviceability that the longitudinal joint may begin to fail before the pavement surface. The failure mechanism begins with localised fretting of aggregate at the joint, which rapidly progresses. This highlights the need to pay attention to the detail of the joint when the thin surfacing is being laid.</p> <p>6.43 Wherever possible the number and length of transverse and longitudinal joints should be minimised to reduce possible areas of vulnerability.</p> <p>6.44 ...where laying in an echelon is not possible, joints should be placed as far as possible from the wheel track zones. Where surfacing joints are placed in the wheel track zones, the durability of the surfacing will be adversely affected.</p> <p>6.46 Information on the jointing of rips is given in individual products HAPAS Certificates, Quality Plans and Installation Method Statements. Those specifying works incorporating TSCS must ensure that they take account of these.</p>
IAN 157/11	6.50	<p>Damage to the surface from turning heavy vehicles can be a significant problem on roundabouts and invariably starts at joints. This can be mitigated by carefully planning the laying to avoid joints if possible and to place essential joints in lower stress areas.</p> <p>Consideration should be given to closing roundabouts completely to enable continuous surfacing. The main traffic flow of heavy vehicles should be examined and paver runs planned to follow the same tracks, to minimise scrubbing of heavy vehicle tyres across joints.</p> <p>Thin surfacings with a small nominal aggregate size, laid to the maximum permissible thickness general give a more durable result. These thicker surfacing layers would also be more tolerant of adverse working conditions. There is less need to achieve high texture on a roundabout as traffic speeds are generally low.</p>
MCHW Series 700	714.3	(02/16) All joints, arises and temporary repairs shall be checked and repaired in accordance with contract specific Appendix 7/14.
HD 27/04	2.26	Asymmetrical widening should be designed so that longitudinal joints between old and new are mid- lane or near lane divisions so avoiding wheel tracks. Short lengths crossing a lane diagonally, which may be dictated by realignment, may be acceptable.
HD 27/04	2.28	Where widening asphalt pavements in similar construction, layers should be cut back and benched to key into the old construction to comply with Clause 901 of the Specification (MCHW 1) (see Figure 2.2 for minimum widths). Joints into sub-base or capping layer should be made where there is clean material. If necessary the minimum dimension should be increased until the clean material is encountered. Special care is required during compaction of any granular layers to ensure a sound joint between the two materials.
IAN 161	2.2.21	<p>Maintenance renewal integration 2.2.21 SM interventions on the network present opportunities to undertake maintenance renewal activities resulting in an overall cost saving for Highways England and minimising disruption to the customer. The intent is to provide a period of 5 years free of major renewal following completion of the SM works.</p> <p>The residual life of all existing assets retained in a scheme at the opening year of that scheme should be no less than 5 years to avoid significant customer disruption soon after completion of the SM scheme. SM schemes should include the re-surfacing of the pavement within the scheme limits where there are less than 5 years residual life after the opening of the scheme or a change to ALR lane configuration is expected to erode the residual life to less than five years due to <u>revised wheel track positions aligning with existing longitudinal joints</u>. The impact of TTM layouts required for SM construction should also be included in the determination of the residual life assessment of pavement.</p>
IAN 161	2.5.7	<p>The hierarchy for increasing lane widths is to allocate additional width to Lane 2, then Lane 3 and finally Lane 4. This supersedes IAN 149/11 paragraph 4.6.4.</p> <p>Re-locating the lane lines (without resurfacing) may result in the proposed wheel tracks moving over the existing longitudinal joints in the final solution. The impact on the joints in both the surface and the binder course and mitigations shall be recorded in the DSR (design strategy record). Refer to paragraph 2.2.21 regarding residual life requirements. The longitudinal joints being located within the wheel track does not require a departure from the standard. Where lane widths below 3.65m are used the wheel track zones shall be 600mm wide at 2050mm centres, centred in the lane. Re-locating the lane lines (with resurfacing) shall be in accordance with the requirements of SHW Clause 903.21SR identified in IAN 154/12.</p>

A.2 Method of Forming Joints

Method of Forming Joints: General

Table 2. Summary of Specification Requirements: Method of Forming Joints

Specification	Clause	Requirement
BS 594987:2015	6.8	<p>Surface course joints:</p> <p>All longitudinal and transverse joints in surface courses shall be made flush.</p> <p>Before the adjacent width is laid, surface course joints shall be made by:</p> <p>a) cutting back the edge to a vertical face that exposes the full thickness of the layer; and</p> <p>b) Discarding all loosened material and painting or spraying the vertical face completely with a thin uniform coating of hot applied 40/60 or 70/100 paving grade bitumen, or cold applied thixotropic bituminous emulsion of similar grade or polymer modified bitumen emulsion bond coat.</p> <p>Surface course joints made in this way shall be:</p> <ul style="list-style-type: none"> • all transverse joints that have not been formed to a specific profile; • Joints where the asphalt abuts an existing surface; and all longitudinal joints. <p>NOTE 1 Two or more pavers may be operated in echelon where this is practicable and in sufficient proximity for adjacent widths to be fully compacted by continuous rolling.</p> <p>NOTE 2 Longitudinal joints in the surface course may also be formed by use of an edge compactor creating a chamfered edge during the laying process. Cutting back of the longitudinal joint is not necessary for this instance.</p> <p>NOTE 3 Surplus bitumen on the surface after the joint is made should be avoided. The surface of the finished joint should not be painted because of the risk of skidding and slipping.</p> <p>Joints in other courses (e.g. base and binder course) shall be treated in such a way as to enhance compaction and bonding.</p> <p>NOTE For example:</p> <ul style="list-style-type: none"> • as in 6.8.2a); • where two or more pavers are being operated in echelon, where this is practicable and in sufficient proximity for adjacent widths to be fully compacted by continuous rolling; and where edge compactors being used are fitted to rollers.
BS 594987:2015	9.2.3.4	<p>NOTE 3 Rolling should normally be in a longitudinal direction, with the driven rolls nearest to the paver. The roller should first compact the asphalt adjacent to the joints and then work from the lower to the upper side of the layer overlapping on successive roller passes. To achieve uniform compaction, at least half of the roller passes should be along the edges of the layer. The positions at which the roller reverses should be staggered.</p>
MCHW Series 900	903.9 (iv)	<p>(08/08) Hand placing of hot bituminous mixtures shall be restricted to the following circumstances:</p> <p>(i) For laying regulating courses of irregular shape and varying thickness.</p> <p>(ii) In confined spaces where it is impracticable for a paver to operate.</p> <p>(iii) For footways.</p> <p>(iv) <u>At the approaches to expansion joints at bridges, viaducts or other structures.</u></p> <p>(v) For laying mastic asphalt.</p>
MCHW Series 900	903.10 (ii)	<p>(08/08) Hand-raking of surface course material or the addition of such material by hand-spreading to the paved area, for adjustment of level, shall be restricted to the following circumstances:</p> <p>(i) At the edges of the layers of material and at gullies, manholes and other ironwork.</p> <p>(ii) <u>At the approaches to expansion joints at bridges, viaducts or other structures.</u></p>
MCHW Series 900	903.22	<p>22 (08/08) Unless otherwise specified in Appendix 7/1, the faces of all cold upstanding edges, including previously laid asphalt, against which hot bituminous mixtures are to be laid to form joints shall be treated with one of the following: (i) hot bituminous binder with a penetration of not less than 40 pen; (ii) hot elastomeric polymer-modified bituminous binder complying with BS EN 14023 with a penetration of not less than 40 pen; (iii) cold applied thixotropic bituminous compound of similar bitumen or polymer modified bitumen grade; (iv) polymer-modified adhesive bitumen strip with a minimum thickness of 2 mm. This operation shall be done so that the binder adheres to both the cold and the warm upstanding edges when the asphalt is placed.</p>
MCHW Series 900	918.18-19	<p>(08/08) Transverse joints shall be formed with spreading starting and finishing on a protective strip not less than 100 mm wide at each end of the lane length or area being treated or such other method as defined in the Contractor's Method Statement to produce an equivalent standard. Transverse joints shall be formed such that there shall be no ridges or bare strips.</p> <p>19 (08/08) Unless otherwise agreed with the Overseeing Organisation, longitudinal joints,</p>

Specification	Clause	Requirement
		where the material is laid on a road, shall coincide with lane markings. Longitudinal joints shall be formed such that there shall be no ridges or bare strips.
MCHW Series 900	947.18	All longitudinal and transverse joints shall be clean cut and vertical. Where work continues adjacent to the previously recycled material, transverse joints shall be reformed a minimum 0.5 m into the previously treated construction. Where a layer of material for stabilisation is placed over a layer previously stabilised, the depth of pulverisation/stabilisation of the upper layer shall be set to cut into the underlying stabilised layer by at least 20 mm.
NG Series 900	NG 903.13	(08/08) Compaction at joints with unsupported edges will never be as good as in the body of the mat. This is recognised in the air void content requirements in sub-Clauses 903.24, 929.15 and 930.15.
NG Series 900	NG 903.14	(08/08) To guard against ingress of water at joints, Sub-Clause 903.22 requires a binder to be applied to the vertical face prior to laying the adjacent mat in order to improve bond and Sub-Clause 903.25 requires overbanding to seal the surface of the joint.
IAN 157/11	6.44	6.44 Echelon paving is the use of multiple paving machines laying the bituminous mat in adjacent rips concurrently. The material in all the rips is compacted at the same time after the last paving machine has passed.
 <p>Figure 6.1. The second of two paving machines laying the second rip of a TSCS so that both rips can be compacted simultaneously whilst hot.</p>		
<p>The use of multiple paving machines laying in echelon should be the preferred laying method as there is no discernible longitudinal joint once compaction is complete. Where laying in an echelon is not possible, joints should be placed as far as possible from the wheel track zones. Where surfacing joints are placed in the wheel track zones, the durability of the surfacing will be adversely affected.</p> <p>6.46 Information on the jointing of rips is given in individual products HAPAS Certificates, Quality Plans and Installation Method Statements. Those specifying works incorporating TSCS must ensure that they take account of these.</p>		
MCHW Series 700	702.10 (iv)	Areas to be removed shall be delineated both longitudinally and transversely by saw cutting prior to the material being removed. Joints shall be formed either by coating the exposed sawn face with hot bitumen or heating by a suitable heater. The heater shall raise the temperature of the full depth of the course immediately before laying the new material to a figure within the range of minimum rolling temperature and maximum temperature at any stage specified for the material and for a width of not less than 75 mm.
MCHW Series 700	706.7	(02/16) Immediately before bituminous layers are reinstated, the edges of the existing material shall be cleaned of all loose material and be coated with an appropriate hot bituminous binder, or equivalent treatment. Where joints in concrete slabs are affected by the excavation they shall be reinstated by cutting back to at least 0.5 m on each side of a transverse joint and forming an expansion joint on one side of the excavation and a contraction joint on the other and provide longitudinal joints where necessary in the same line before reinstatement in compliance with Series 1000 to match the existing construction.
MCHW Series 700	702NI.10 (iv)	Areas to be removed shall be delineated both longitudinally and transversely by saw cutting prior to the material being removed. Joints shall be formed either by coating the exposed sawn face with hot bitumen or heating by the suitable heater. The heater shall raise the temperature of the full depth of the course immediately before laying the new material to a

Specification	Clause	Requirement
		figure within the range of minimum rolling temperature and maximum temperature at any stage specified for the material and for a width of not less than 75 mm.
MCHW Series 700	702NI.10 (iv)	Areas to be removed shall be delineated both longitudinally and transversely by saw cutting prior to the material being removed. Joints shall be formed either by coating the exposed sawn face with hot bitumen or heating by the suitable heater. The heater shall raise the temperature of the full depth of the course immediately before laying the new material to a figure within the range of minimum rolling temperature and maximum temperature at any stage specified for the material and for a width of not less than 75 mm.
HD 27/04	2.30	Where sufficient space is available asphalt materials can be laid quickly with pavers in echelon to avoid longitudinal joints which need cutting back when cold. In winter, successive layers can be placed in rapid succession, but both this and echelon work will depend on sufficient compaction plant being available to ensure adequate compaction can be achieved. Information on laying of asphalt surface course is given in HD 37.
HD 27/04	2.32	Where asphalt material is to be laid against an existing pavement, drainage channels, kerbs, bridge parapets etc., suitable preformed sealing strips should be considered for application to the vertical surface of the existing pavement, after cutting back. This could avoid the need to overband the longitudinal joint or to cut a sealing groove and apply a poured sealant.
IAN 157/11	6.42	It has been observed, from examples of thin surfacing approaching the limit of serviceability that the longitudinal joint may begin to fail before the pavement surface. The failure mechanism begins with localised fretting of aggregate at the joint, which rapidly progresses. This highlights the need to pay attention to the detail of the joint when the thin surfacing is being laid.
Defence Infrastructure Organisation Specification 13, Marshall Asphalt for Airfields	5.25	<p><u>Longitudinal joints</u> in surfacing materials shall be constructed in such a position that they are at least 600 mm horizontally away from any longitudinal joints in the underlying material. The longitudinal lane joints shall be vertical in straight lines which are continuous for the full length of the pavement, or in smooth curves around bends.</p> <p>The exposed vertical edges of the longitudinal lane joints in the Marshall Asphalt surfacing materials shall be carefully cut back and trimmed to firm material in the compacted lane, or for a minimum of one and a half times the layer thickness, whichever is the greater, and all loose material arising from this operation shall be removed from the pavement before the cut edge is painted.</p> <p>Edge rolling shall only be used as an alternative to cutting back if it can be demonstrated during the trials to the Project Manager that satisfactory standards of compaction, surface/joint finish and adhesion can be achieved.</p> <p>(NOTE. Cores should be taken for the test at these joints to demonstrate good adhesion and bulk density within the specified limits.)</p> <p>Cutting back and trimming will not be required when two or more spreading units operate in echelon in close proximity, permitting adjacent lanes to be continuously compacted before the material around the joint between the lanes falls below the compaction temperature specified in Clause 5.7.</p> <p>After cutting back and trimming, the exposed vertical edges of the longitudinal lane joints shall be thoroughly cleaned of all adherent material and shall then be painted with a uniform thickness of bitumen just ahead of the spreading unit laying the adjacent lane. Painting shall completely and uniformly cover the exposed edge for its full depth. Excess material to the top and base of the joints, streakiness and blobs shall be avoided.</p> <p>On completion, the joints shall present the same texture as the remainder of the surface and the accuracy of the surface across the joints shall meet the criteria specified in Clause 5.31.</p> <p>When laying in cool windy weather, a joint heater may be used subject to the discretion of the Project Manager.</p>
Defence Infrastructure Organisation Specification 13, Marshall Asphalt for Airfields	5.26	<p><u>Transverse joints</u> are required at the end of a day's work and following any interruption in laying which prevents continuity of rolling at, or above, the specified minimum temperature. Transverse joints shall be formed at right angles to the longitudinal joints and shall be vertical.</p> <p>The exposed vertical edges of the transverse joints of all layers shall be cut back to at least 300 mm and trimmed. All loose material arising from this operation shall be removed from the pavement and the underlying surface cleaned. The exposed joint edges shall then be cleaned and painted with bitumen as specified in Clause 5.25 immediately before the laying of the lane continues.</p> <p>On completion, the joints shall present the same texture as the remainder of the surface and the accuracy of the surface across the joints shall meet the criteria specified in Clause 5.31.</p>
Defence Infrastructure Organisation Specification 13, Marshall Asphalt for Airfields	5.27	<p><u>Joints between new surfacing and existing pavements</u></p> <p>Existing asphalt surfacing against which new surfacing is to be laid shall be cut back as necessary to a line removing all loose or weathered material and shall be finished with a vertical edge. Immediately prior to the laying of new material, either:</p> <ul style="list-style-type: none"> • a thin uniform coating of 40/60 or 70/100 paving grade bitumen; or • an approved joint seal in accordance with the manufacturer's instructions, shall be applied

Specification	Clause	Requirement
		<p>over the complete face.</p> <p>Where asphalt resurfacing is ramped into an existing asphalt surface and the ramp ends at a point abutting an existing concrete surface, the exposed vertical face of the concrete shall be cleaned thoroughly and either:</p> <ul style="list-style-type: none"> • a thin uniform coating of 40/60 or 70/100 paving grade bitumen; or • an approved joint seal in accordance with the manufacturer's instructions, shall be applied over the complete face within 2 h prior to laying the asphalt surfacing. <p>The edge of existing concrete surfacing against which a completely new asphalt surfacing is to be laid shall be exposed and thoroughly cleaned to its full depth and for the appropriate length.</p> <p>Unless shown otherwise in the drawings, an expansion joint shall then be formed below the new surfacing by:</p> <ul style="list-style-type: none"> • placing a joint filler of non-extruding, heat and rot-proof board against the bottom of the exposed concrete face that is 25 mm thick and of a height equal to the depth of the concrete slab less the greater of: <ul style="list-style-type: none"> 100 mm and the total thickness of the new surfacing; • installing an approved joint sealing material in accordance with the manufacturer's instructions to the upper margin of the exposed face; and • carrying the new surfacing over the top of the joint filler within 2 h of installing the joint sealing material. <p>The new surfacing at the junction shall be a minimum of 100 mm thick for a distance of at least 3 m back from the junction, laid in a minimum of two layers.</p>

A.3 Method of Forming Joints: Bond Coat Application

Table 3. Summary of Specification Requirements: Bond Coat Application

Specification	Clause	Requirement
BS 594987:2015	5.5.2	<p>Transverse joints shall have an overlap not wider than 300 mm.</p> <p>Longitudinal joints shall have an overlap to ensure that the minimum permitted rate of spread is achieved across the joint.</p> <p>NOTE 4 For quartering (using part of the spraybar) the longitudinal joint overlap width may be extended to a maximum of 300 mm.</p> <p>Paver integral sprayers shall provide a wet edge to ensure spray overlap under adjacent overlays such that the minimum permitted rate of spread is achieved across the longitudinal joint.</p>
MCHW Series 900	920.10	<p>(08/08) There shall be no bare strips or areas having less than the minimum permitted rate of spread. Transverse joints shall have an overlap not wider than 300 mm. Longitudinal joints shall have an overlap to ensure that the minimum permitted rate of spread is achieved across the joint. For quartering (using part of the spraybar) the longitudinal joint overlap width may be extended to a maximum of 300 mm. Paver integral sprayers shall provide a wet edge to ensure spray overlap under adjacent overlays such that the minimum permitted rate of spread is achieved across the longitudinal joint. Where the longitudinal spray overlap causes the effective rate of spread to be increased by more than 50% of the specified rate, then the width of overlap shall not be greater than 100 mm and shall be outside the location of the wheel tracks for the lane.</p>

A.4 Performance Requirements

Table 4. Summary of Specification Requirements: Performance

Specification	Clause	Requirement
MCHW Series 900	903.23	<p>23 (08/08) Unless otherwise specified in Appendix 7/1, joints in binder courses and bases shall be compacted such that the air voids content measured from core pairs whose centres are not more than 100 mm from the final joint is not greater than 2% above the maximum permitted limit for core pairs in the body of the mat. The air voids content shall be calculated in accordance with BS EN 12697-8 using the relevant bulk and maximum densities defined in Appendix B of BS EN 13108-20 for the relevant mixture type.</p>

MCHW Series 900	929.14	(08/08) For the material from each mixing plant a pair of cores shall be taken every 250 metres laid, centred 100 mm from the final joint position at any unsupported edge and the air void shall be determined in accordance with BS 594987, clause 9.5.1.3.
MCHW Series 900	929.15	(08/08) The average in situ void content for each of these pairs shall not exceed 9%.
MCHW Series 900	930.16 & 17	(08/08) For the material from each mixing plant a pair of cores shall be taken every 250 metres laid, centred 100mm from the final joint position at any unsupported edge and the air void shall be determined in accordance with BS 594987, clause 9.5.1.3. The average in situ void content for each of these pairs shall not exceed 8%
NG Series 900	NG 903.13	08/08) Compaction at joints with unsupported edges will never be as good as in the body of the mat. This is recognised in the air void content requirements in sub-Clauses 903.24, 929.15 and 930.15.
Defence Infrastructure Organisation Specification 13, Marshall Asphalt for Airfields	5.32	After the surfacing has cooled sufficiently to allow sampling, two core samples of 150 mm diameter shall be extracted from every * m ² of surfacing laid and, in addition, twin samples shall be taken adjacent to longitudinal lane joints at not more than * m intervals in positions selected by the Project Manager and, when directed, across transverse joints. [* The Project Manager to provide value for specific job specification; advice is given in Clause Z.9 of Appendix Z.] (NOTE. Reheating a surfacing using an infra-red heater and re-compacting shall not be permitted.) The cores adjacent to lane joints shall be situated at a distance not exceeding 50 mm or nearer than 25 mm from the joint. The samples shall be used for the determination of bulk density according to BS EN 12697-6, Procedure A. Not more than three bulk density values out of any twenty consecutive results shall be below 98 % of the 'Job Standard Mixture Bulk Density' or 94 % of the 'Maximum Density', whichever is appropriate as specified in Clause 6.4. Any non-complying area shall be removed for the full width of the lane and replaced with material that shall satisfy the acceptance criteria.

Table 5. Summary of Specification Requirements: Testing

Specification	Clause	Requirement
BS 594987:2015	1.2	NOTE 2 Careful selections of test positions are required to achieve a suitable density range. This can be achieved by locating some positions at the end of the test strip or close to joints. Small areas of the trial strip may be left under-compacted; however, these would not normally be retained as part of the permanent works.
NG Series 900	NG 929.10	(08/08) A new requirement for density control close to joints has been introduced. Experience has shown that in-situ void content requirements in the wheeltracks are generally achieved. Therefore, the frequency of testing in this position has been reduced. Compaction at joints is considered to be a primary factor in affecting the durability of asphalt pavements and testing at this location has therefore been introduced. Contractors may need to adopt special measures of joint compaction in order to comply with this requirement.
NG Series 900	NG 930.7	(08/08) A new requirement for density control close to joints has been introduced. Contractors may need to adopt special measures of joint compaction in order to comply.

A.5 Unsupported Edges

Table 6. Summary of Specification Requirements: Unsupported Edges

Specification	Clause	Requirement
NG Series 900	NG 903.15	(08/08) To ensure that water does not enter the pavement from the side, sub-Clause 903.26 requires sealing the edges of the finished pavement. This is always required for the high side of the elevation. Sealing of the low side is conditional on whether it necessary to let water out or stop water getting into the pavement. The selection is a design issue and should be specified in Schedule 4 of Appendix 7/1.
Series 903	903.25	(11/08) Unless otherwise specified in Appendix 7/1, a sealant, as specified in sub-Clause 24 of this Clause, shall be applied to the whole of any freestanding edge on the outside of the finished pavement on the high side of the camber and, when specified in Appendix 7/1, on the low side

A.6 Sealing of Joints

Table 7. Summary of Specification Requirements: Painting of Joints

Specification	Clause	Requirement
MCHW Series 900	903.24	24 (08/08) Within 24 hours of the joint being formed, a sealant shall be applied to the top surface of all base and binder course joints such that there is not less than 0.50 kg/m ² of residual bitumen 75 mm either side of the joint, unless otherwise specified in Appendix 7/1. The sealant, which may contain mineral filler to BS EN 13043, shall be one of the following: (i) hot elastomeric polymer-modified bituminous binder complying with BS EN 14023 with a penetration of not less than 40 pen; (ii) bitumen emulsion with a cohesion by pendulum of Class 4 or above in accordance with BS EN 13808; (iii) slurry surfacing complying with Clause 918. 25 (11/08) Unless otherwise specified in Appendix 7/1, a sealant, as specified in sub-Clause 24 of this Clause, shall be applied to the whole of any freestanding edge on the outside of the finished pavement on the high side of the camber and, when specified in Appendix 7/1, on the low side.
MCHW Series 900	918.18-19	(08/08) Transverse joints shall be formed with spreading starting and finishing on a protective strip not less than 100 mm wide at each end of the lane length or area being treated or such other method as defined in the Contractor's Method Statement to produce an equivalent standard. <u>Transverse joints shall be formed such that there shall be no ridges or bare strips.</u> 19 (08/08) Unless otherwise agreed with the Overseeing Organisation, longitudinal joints, where the material is laid on a road, shall coincide with lane markings. <u>Longitudinal joints shall be formed such that there shall be no ridges or bare strips.</u>
NG Series 900	NG 903.14	(08/08) To guard against ingress of water at joints, Sub-Clause 903.22 requires a binder to be applied to the vertical face prior to laying the adjacent mat in order to improve bond and Sub-Clause 903.25 requires overbanding to seal the surface of the joint.

A.7 Surface Sealing Joints

Table 8. Summary of Specification Requirements: Surface Sealing

Specification	Clause	Requirement
NG Series 900	NG 903.14	(08/08) To guard against ingress of water at joints, Sub-Clause 903.22 requires a binder to be applied to the vertical face prior to laying the adjacent mat in order to improve bond and <u>Sub-Clause 903.25 requires overbanding to seal the surface of the joint.</u>
Series 900	903.24	(08/08) Within 24 hours of the joint being formed, a sealant shall be applied to the top surface of all base and binder course joints such that there is not less than 0.50 kg/m ² of residual bitumen 75 mm either side of the joint, unless otherwise specified in Appendix 7/1. The sealant, which may contain mineral filler to BS EN 13043, shall be one of the following: hot elastomeric polymer-modified bituminous binder complying with BS EN 14023 with a penetration of not less than 40 pen; bitumen emulsion with a cohesion by the pendulum of Class 4 or above in accordance with BS EN 13808; slurry surfacing complying with Clause 918. 25

A.8 Underlying Joints

Table 9. Summary of Specification Requirements: Treatment of Underlying Joints

Specification	Clause	Requirement
BS 594987:2015	5.3.3	Where asphalt is to be laid on existing concrete pavements with defective joints, in addition to the measures specified in 5.3.1 and 5.3.2, the joints shall be made good by cleaning out and refilling with a joint-filling material. This material shall be compacted flush with the surface. The jointing material used shall not be adversely affected by, or itself adversely affect, the surfacing
IAN 157/11	6.7	Thin surfacings are not generally designed to treat pavements where structural deterioration or cracking is present in the underlying layer (whether this is asphalt, hydraulically bound material, or pavement quality concrete). Generally, structural deterioration, cracking or open joints already present in the layer directly beneath the TSCS will rapidly propagate to the surface. Such defects in the surfacing mat tend to disrupt the integrity of the TSCS resulting in a local loss of aggregate interlock. Consequently, surface disintegration (fretting) occurs, and reduced life of the surfacing is the likely outcome.
IAN 157/11	6.52	Thin surface course systems are generally suitable for application to both old and new continuously reinforced concrete (CRCP) surfaces. When laying on concrete it is likely that a polymer modified bond coat will be required. Surfacing directly over jointed concrete is not generally recommended. However, if undertaken, joint sealants in the concrete substrate should be replaced by Type N2 hard sealants to BS 2499, brought up almost flush to the surface, and expanded polythene backing strips should not be used. These tend to be compressed by the roller and then recover, cracking the surface course.
Defence Infrastructure Organisation Specification 13, Marshall Asphalt for Airfields	5.15	<p>Ravelled joints, ravelled cracks and potholes shall be made good before the new surfacing is laid.</p> <p>Trenches shall be formed by carefully cutting out the existing asphalt surfacing on either side of the joints or cracks to the full depth of the surface course and, if directed, to the underside of the binder course or to the top of the underlying concrete or pavement base. The new material shall be bonded into the old surfacing.</p> <p>The cross section of the trench shall be a minimum of 200 mm wide. The side walls of the trench shall be clean vertical cuts and shall be stepped-back a minimum of 50 mm on each side at a convenient plane of separation between any two courses of the existing surfacing. When the existing pavement level is not to be raised, the edges of the trench or patch shall be defined by means of saw cuts extending to the full depth of the surface course.</p> <p>All loose and crumbling fractions shall be removed from the bottom and sides of the trench. The bottom and sides shall be completely painted with tack coat.</p> <p>The defective surfacing shall be replaced with the specified surface course material. It shall be placed in the trenches in lifts of about 50 mm each which shall be compacted separately with approved mechanical or hand tampers as specified in Clauses 5.23 and/or 5.24.</p> <p>At the time of compaction, the mixture shall be at the specified temperature. The final layer shall be laid so as not to leave a concave finish below the general surface after thorough compaction by rolling.</p> <p>All loose material shall be removed from any potholes, the bottom and sides of the depressions painted with tack coat and then the potholes backfilled, compacted and finished in accordance with sub-Clauses 5.15.5 and 5.15.6.</p>

A.9 Joints Over Concrete

Table 10. Summary of Specification Requirements: Treatment of Underlying Joints

Specification	Clause	Requirement
MCHW Series 700	713.1	(02/16) Where shown on the drawings listed in contract specific Appendix 7/13, a bituminous overlay or inlay, as specified in contract specific Appendix 7/1, shall be laid over the existing concrete pavement which has been either treated or prepared as specified in Clause 714. The overlay or inlay shall then be saw-cut and sealed above existing transverse joints.
MCHW Series 700	713.3-4	<p>(02/16) Preparatory work to the existing concrete pavement including joints shall comply with Clause 714.</p> <p>(02/16) Before any tack or bond coating commences, the Contractor shall ensure that there are adequate stable accurate reference marks delineating all existing transverse</p>

pavement joints or saw-cuts and that they have been clearly marked and agreed with the Overseeing Organisation for purposes of accurately locating the positions of saw-cuts after overlaying to sub-Clause 5 of this Clause. The marking procedure and the nature and location of offsets and the means of their establishment shall be agreed in advance with the Overseeing Organisation in a method statement. The accuracy of such markings shall be compatible with the specified accuracy of subsequent saw-cutting operations to this Clause.

