# TOWARDS IMPROVED PERFORMANCE OF THIN BITUMINOUS SURFACINGS

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**Abstract**
During a recent study in Ethiopia, several problems influencing the performance of thin bituminous surfacings have been recorded. The study incorporated interviews with twenty experienced practitioners, a limited field study and a workshop on surfacing performance. Opinions of local practitioners and observations by the study team highlighted construction practices as one of the main reasons for poor performance. The paper summarises the key findings of the study, discusses aspects of construction and shows the impact of not adhering to specifications. It is concluded that the majority of construction related problems could be eliminated by understanding and applying existing specifications. Recommendations include theoretical and practical training to ensure good performance of bituminous surfacings.

## 1 INTRODUCTION

The performance of thin bituminous surfacings is rated according to its ability to protect the pavement structure from traffic wear and vertical moisture ingress while providing appropriate skid resistance. Aggregate loss and excessive bleeding are often the reasons recorded for poor performance.

During a recent study in Ethiopia (1), requested by the Ethiopian Roads Authority (ERA) and sponsored by the African Community Access Program (AFCAP), several problems influencing the performance of thin bituminous surfacings have been recorded. The study incorporated interviews with twenty experienced practitioners, a limited field study and a workshop on surfacingl performance.

The authors have selected a few examples of poor surfacing construction, elaborated on the effects, included some guidelines to prove that proper training could drastically improve the performance of bituminous surfacings in Ethiopia.

The paper first summarises the key findings from the study and then focuses on construction related problems and how these problems could be resolved.

The paper is concluded with recommendations towards improved performance focussing on training related to seal design and construction.

At the recent 2nd International Sprayed Seal Conference, held in Melbourne, Australia, similar concerns were raised by representatives of other countries. Therefore, problems and solutions discussed in this paper are universal and should be of value to any road authority using thin bituminous surfacings.

## 2 KEY FINDINGS

### 2.1 Interviews

Opinion and comments of practitioners and stakeholders regarding Surface Dressings identified the following as major concerns namely:

- Aggregate quality
- Poor workmanship of current contractors
- Poor quality control on sites
- Surface dressings require experience and skill
- Surface dressings sensitive to errors
- Surface dressings require high maintenance
- Ethiopia has lost the required skills
- Difficult to determine the cause of failures
- Bitumen quality
- Fogsprays on Surface Dressings are essential and should form part of a maintenance strategy

### 2.2 Field inspections

Defects observed during field inspections are mainly related to:

- Workmanship and knowledge
- Equipment quality
- Quality assurance
- Design – Interpretation and assumptions with no adjustments due to varying conditions
- Appropriateness of specifications

## 3 CONSTRUCTION RELATED PROBLEMS

### 3.1 General

The quality of seal construction was identified as one of the main causes for poor seal performance in Ethiopia. Even though there are some improvements required to the specifications, the majority of problems occur due to non-conformance to existing specifications.

Even though examples of excellent performing surfacing were found, observations during field inspections confirmed the opinions of local practitioners and are discussed in this section under the following headings namely:

- Binder application
- Aggregate application

It should be noted that all these problems could have been eliminated if attention was given to the existing specifications. Extracts of the existing relevant ERA specifications (2) are provided to prove this point.

### 3.2 Binder application

Typical problems observed and reported are:

- Poor transverse distribution
- Poor joint construction

### 3.3 Transverse distribution

**Error! Reference source not found.** and **Error! Reference source not found.** show evidence of poor binder transverse distribution, commonly referred to as tramlining.

**Photograph 1: Poor transverse distribution – low application rate**

**Photograph 2: Poor transverse distribution - high application rate**

Reasons for poor transverse distribution and/or tramlining could be as a result of:

- Uneven binder flow through nozzles
  The ERA Specification related to transverse distribution is provided as Extract 1

*"Tests for uniformity of transverse distribution of binder shall be carried out according to the Depot Spray Test (described below) before the commencement of binder spraying works and at such other times as directed by the Engineer, without cost to the Employer. Road tray tests shall be carried out, to check the longitudinal and transverse distribution of the binder. In the event of the results of the tests being unsatisfactory the distributor shall be adjusted and satisfactorily retested before the spraying works may proceed;*
*The distributor shall carry a card showing the registration number, the date tested, the test pressure and temperature, height of spray bar and the type and viscosity of binder used in the test. It shall also carry a charts relating road speed to rate of application of binder so that the driver can accurately determine the speed required for the rate of application specified;"*

**Extract 1: ERA Specification Clause 6104 (a)**

The depot tray test is done by spraying binder in trays, 50mm wide, and measuring the depth of binder in each tray. A maximum deviation in any tray of 5% to the mean of all the trays is allowed.

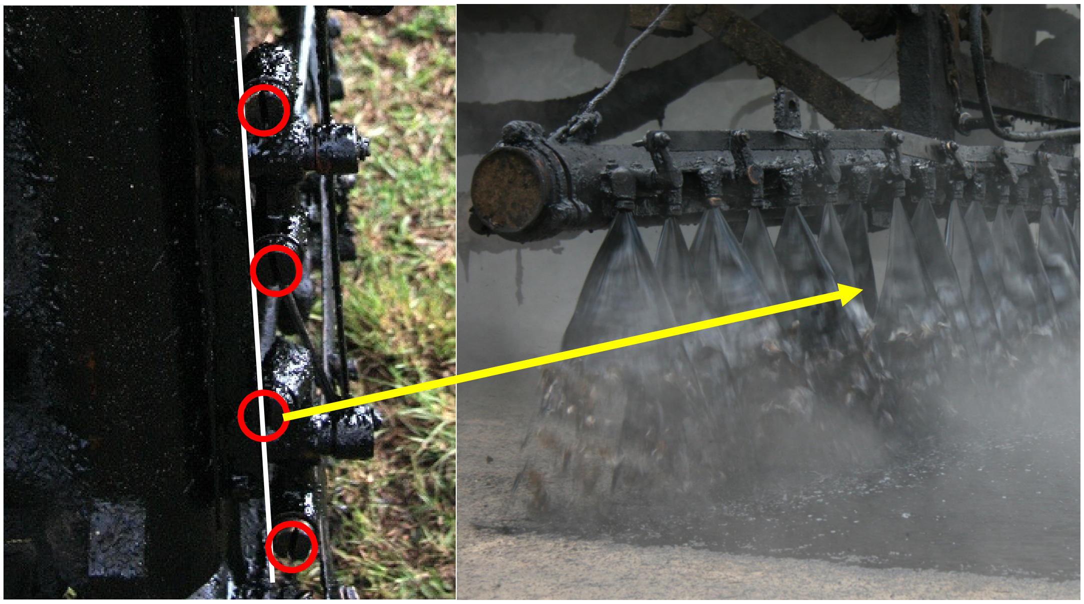
**Note:** A similar approach is followed in other countries to ensure good transverse distribution. However, experience with higher viscosity binders has resulted in relaxed specifications for these binders. The current South African specifications, using wider trays for on-site testing, are as follows:

- Emulsions, cut back bitumen and penetration grade bitumen – 5%
- Homogeneous polymer modified binders – 7%
- Non homogeneous binders (Bitumen rubber) – 10%
  (For more information see TRH 3, 2007, Appendix J)

During spray operations, nozzles could still get blocked. Therefore, it is essential that the supervisor walk behind the sprayer and continuously monitor the binder flow.

- Poor equipment (nozzles not aligned or set at correct angles)
  Photograph 3 and Photograph 4 show the effect of poor nozzle settings resulting in the spray flairs interfering and not distributing the binder evenly on the road surface.

**Photograph 3 Flair interference due to wrong angle settings**



**Photograph 4  Effect of poor nozzle alignment**

- Spray bar too high or too low

The relevant section of the ERA Specification Clause 6104 (a) is provided as

> *"Before each separate application of binder, the spray bar shall be reset to the height required to ensure the necessary uniformity of nozzle spray overlap (double or triple) and distribution is maintained. For this purpose the distributor shall be fitted with accurately calibrated and easily read means of rapidly checking the spray bar height above the road. The spray bar shall be articulated to facilitate setting parallel to the road camber;"*

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**Extract 2  ERA Specification Clause 6104 (a)**

**Notes:**

- Modified hot binders are normally sprayed to obtain a uniform triple or even a quadruple overlap
- Lower viscosity binders could be applied to obtain only a double overlap

Incorrect bar heights will result in uneven distribution of the binder on the surface as shown in Figure 1, with the effect as shown in Photograph 5.

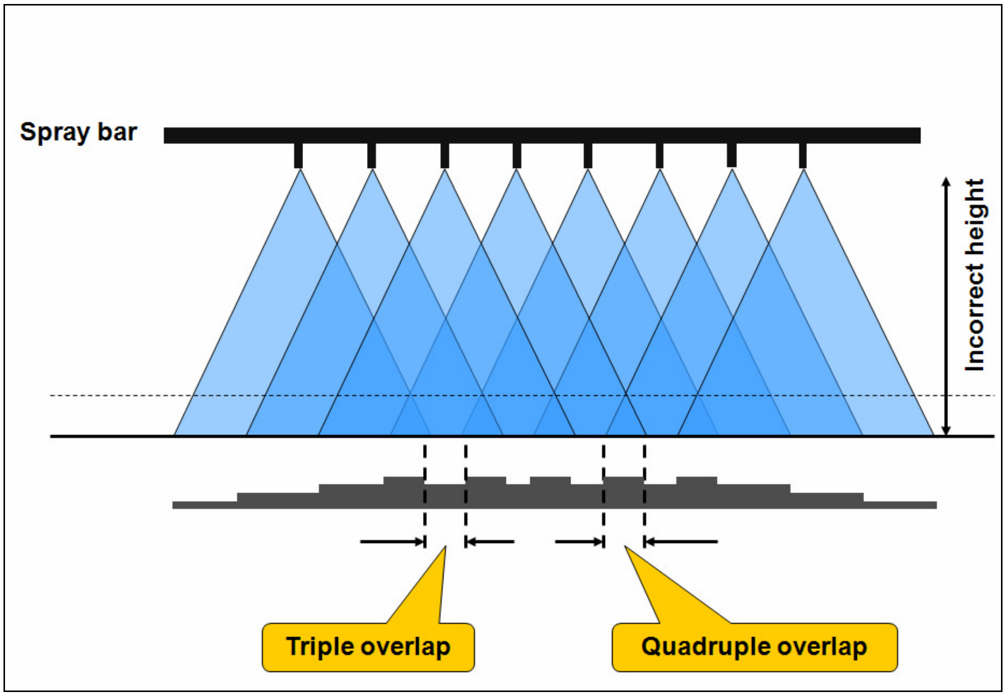
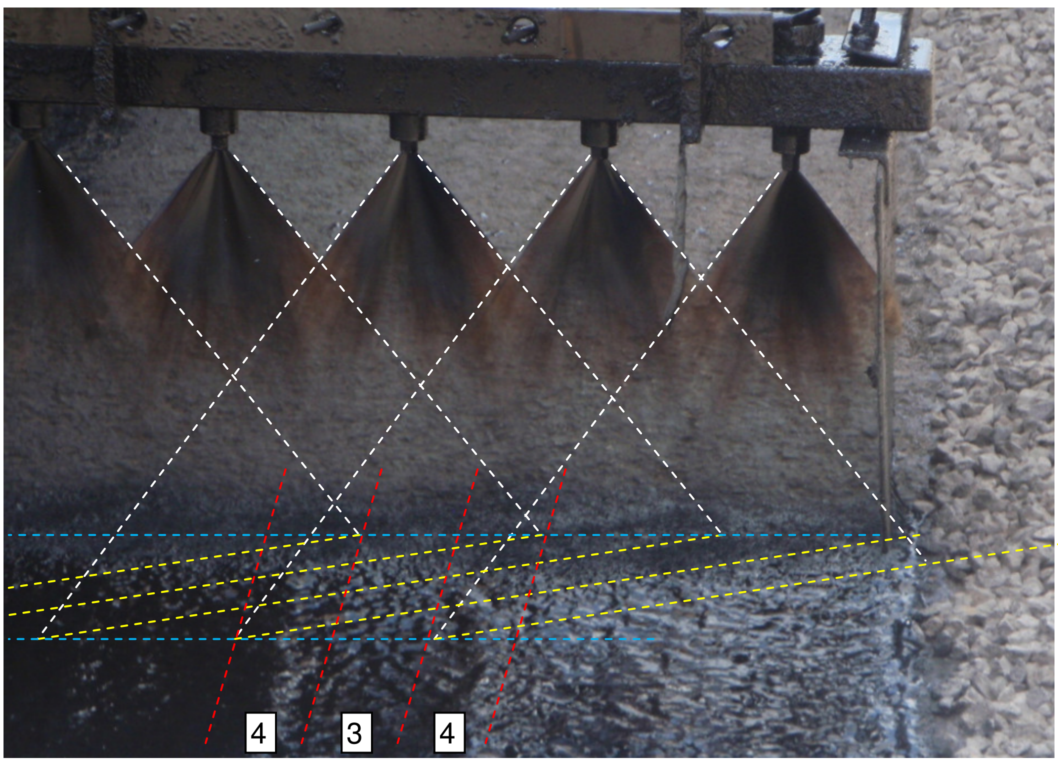



**Figure 1 Poor transverse distribution due to incorrect bar height**




**Photograph 5  Effect of too high spray bar setting**

**Note:**

Although the height could be calculated mathematically taking into account the nozzle spacing, nozzle angle and the flair angle, the pressure at which the product is sprayed, the viscosity and the nozzle design could influence the flair angle and, therefore, the calculated "correct" bar height.

The best way to ensure an accurate overlap is to close two nozzles (one in case of a double overlap) and adjust the bar height to ensure that the two adjacent flairs just meet, as shown in Figure 2.

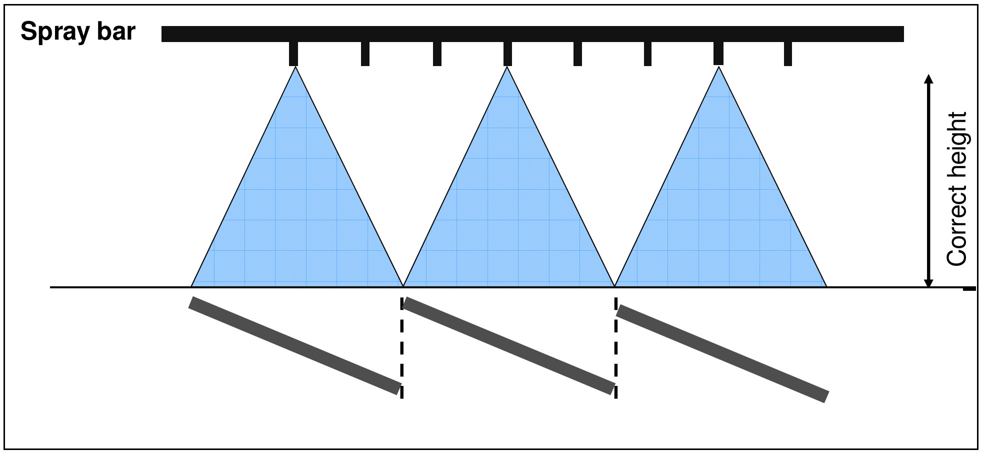



**Figure 2: Adjusting spray bar to correct height**

- Insufficient pressure in the spray bar

Even though transverse distribution test results are acceptable and the height of the bar is correctly adjusted, poor transverse distribution could still occur as a result of too high viscosity/ too low pressure in the bar. Refer to Figure 3. Each binder has its own temperature/ viscosity relationship with a recommended temperature range at which it should be sprayed. Should the binder be too cold, the viscosity will be too high for the applied pressure to ensure a proper flair.

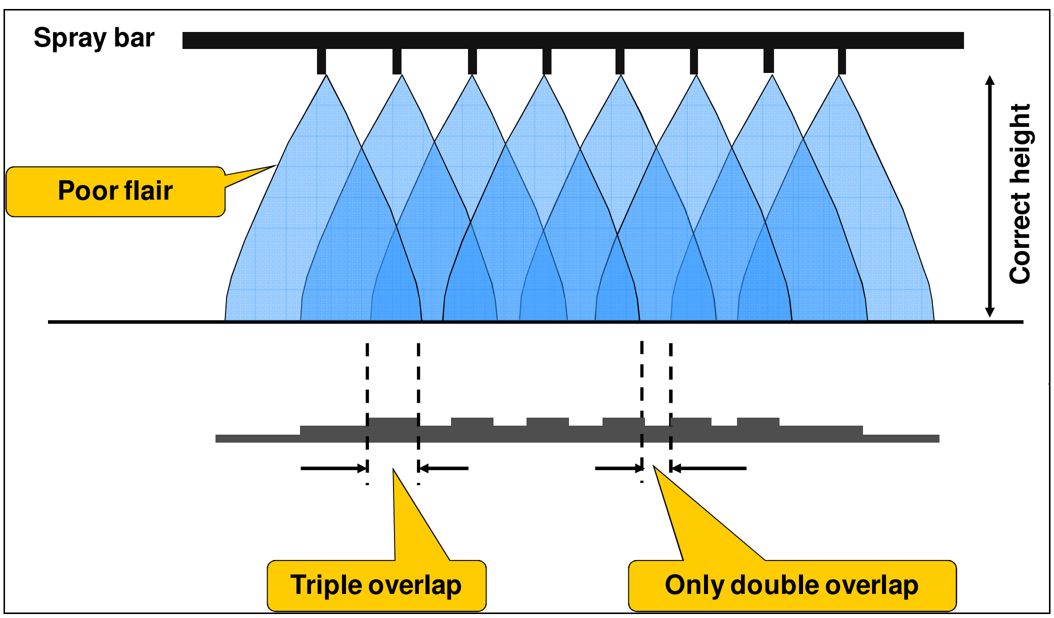



**Figure 3 Poor distribution due to low bar pressure**

### 3.4 Longitudinal joint construction using stringlines

Existing specifications emphasise the use of stringlines to prevent poor longitudinal joints. (Refer Extract 3)

> (a) New Construction
>
> The Contractor shall demarcate the area of the primed roadbase to be surfaced by means of setting out wire, or string lines down each edge of the proposed surfaced width. The control intervals for the setting out of horizontal curves shall be as agreed by the Engineer.
>
> (b) Existing surfaces that are to be resurfaced
> The centerline of the road or other reference setting out line, as agreed by the Engineer, shall be established immediately before the tack coat or bituminous binder is sprayed.

**Extract 3 ERA Specification Clause 63A08 Demarcation of Working Area**

**Notes:**

- It is recommended that string lines are held down in place with steel nails at 15 meter intervals on straight sections and at 3 meter intervals on curves
- Preferably, joints should be constructed on the centre line and definitely not in the wheel tracks

Keeping the guide marker on the stringline assists the spray tanker operator to spray the correct line (Refer Photograph 6)

**Photograph 6 Stringline and guide marker**

Photograph 7 shows a situation where no stringline was used to guide the distributor driver". In this case it would be very difficult to construct a proper joint.

**Photograph 7  Impact of no stringline placement**

Photograph 8 shows the result of poor joint construction.

**Photograph 8  Poor longitudinal joint (not on centre line)**

Figure 4, Figure 5 and Figure 6 are provided to assist in the understanding of string line positioning and calculation of the effective spray width.

***Note:***
*The application rate is calculated by dividing the volume of binder sprayed by the effective area of full coverage. The effective width takes into account the reduced binder due to the flair of the end nozzles.*

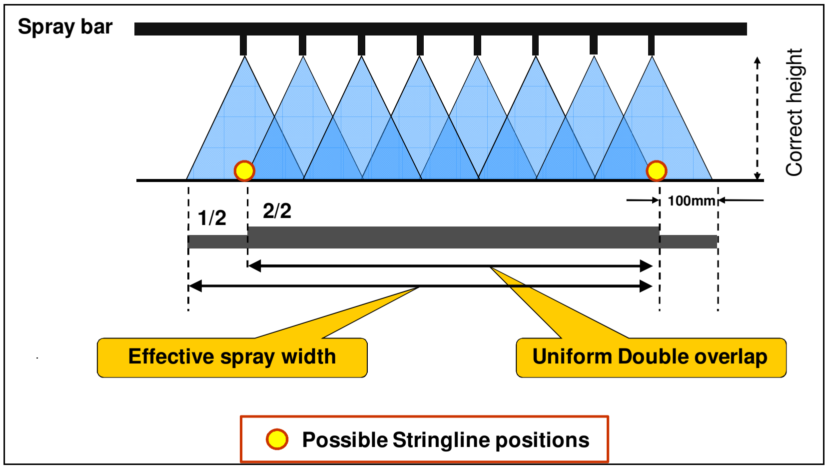


**Figure 4 Double overlap**

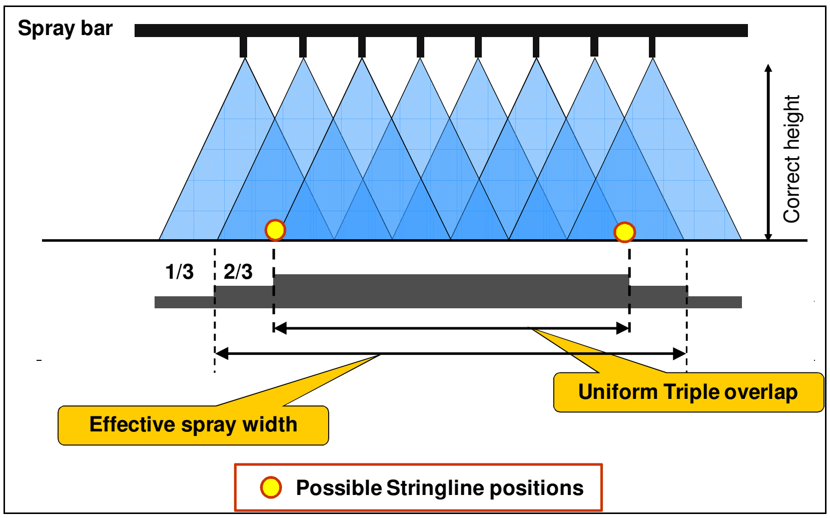


**Figure 5  Triple overlap**

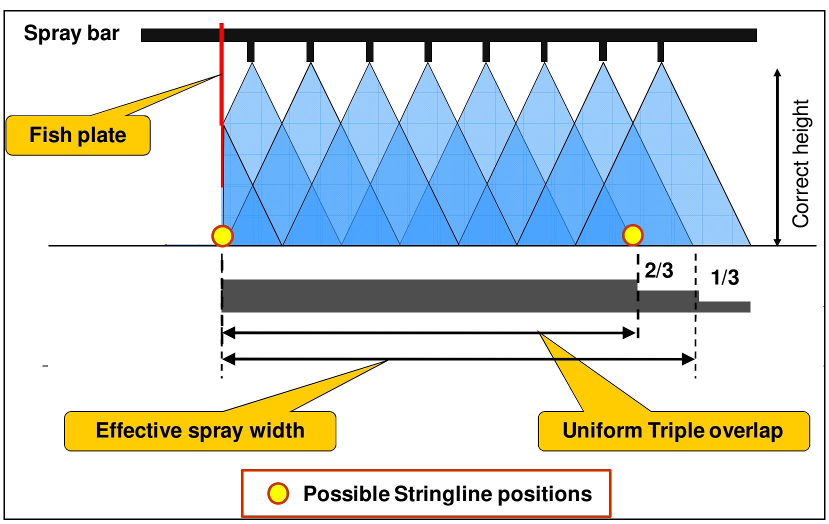


**Figure 6  Triple overlap with fish plate**

The chippings should only be applied onto the area of full binder application. The stringline demarcates the area of full binder application and therefore, also assists with the application of the chippings (Refer Photograph 9)


**Photograph 9  Stringline position and chip application (double overlap)**

### 3.5 Longitudinal joint overlap

Extract 4 provides the ERA specification related to joints between binder sprays

> *"If in the opinion of the Engineer, the Contractor is unable to apply surfacing to the entire width specified in a single pass, the Contractor shall apply the surfacing in strips. Adjacent sprays shall overlap by 100mm. Chippings shall not be placed on the 100mm overlap before the adjacent strip has been sprayed. The adjacent strip may not be sprayed before the preceding strip, excluding the 100mm overlap, has been covered satisfactorily with chippings in compliance with the specifications. As far as is practicable, the contractor shall so place the strips that the joint between two adjacent chipping applications shall fall on the centre line of the road".*

**Extract 4   ERA Specification 63A11 (c) Joints between binder sprays**

**Note:**
This ERA specification implies a double overlap. For this reason, the overlap on adjacent sprays is specified as 100mm. A tripple flair configuration is more common at this time, resulting in the need for adjusted project specifications. Provided no fishplates are used, the overlap, in case of a triple overlap should be 200 mm

Figure 7 first shows the intended joint spray in the case of a triple overlap to ensure full binder coverage. Due to the risks involved with joint construction, the centre line joint is often over sprayed by 100 mm, resulting in 25% more binder on the 300 mm joint. Unless the road is narrow, this practice seldom creates flushing of the binder as the traffic tends to stay within the driving lane. Cognisance should be taken that additional binder is sprayed and that the contractor should be compensated accordingly.

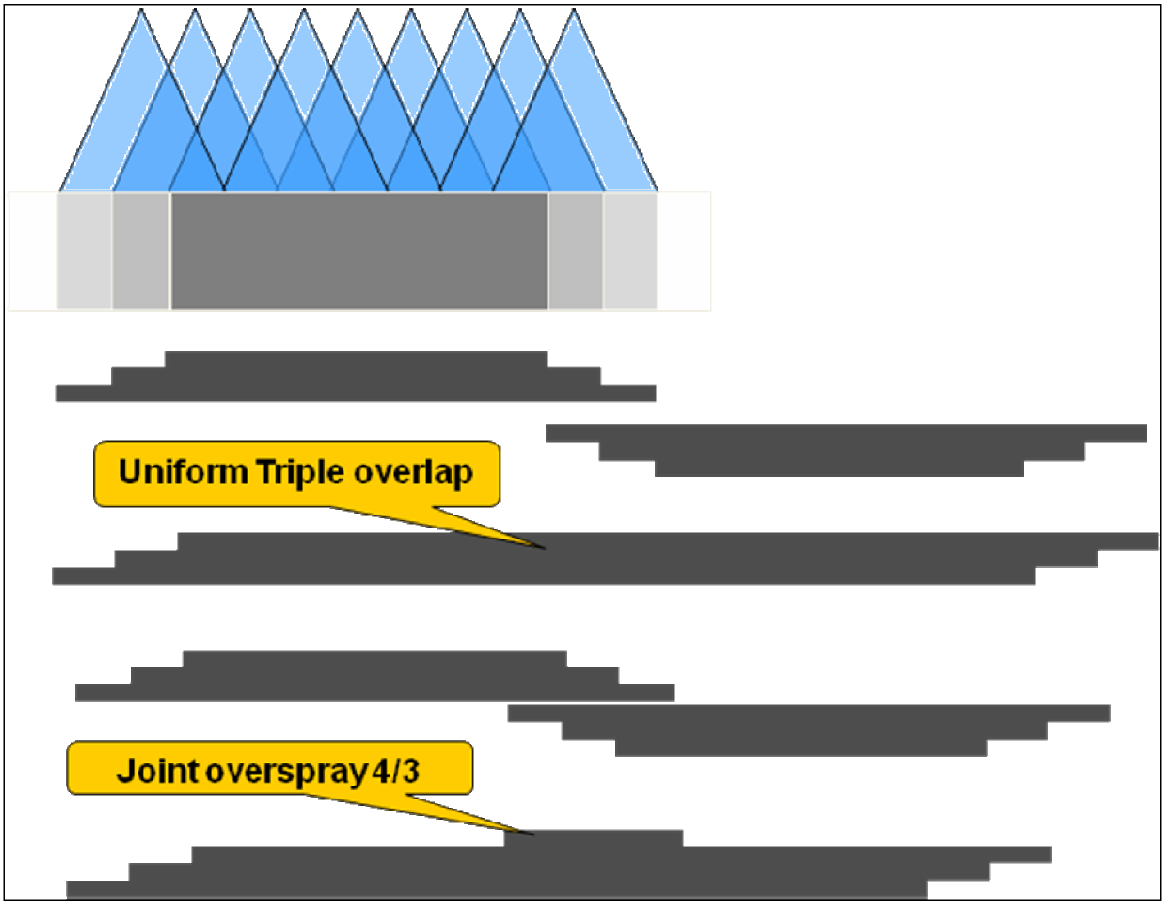



**Figure 7 Longitudinal joint - binder overlap**

### 3.6 Transverse Joints

The ERA Specification related to transverse joints is provided as Extract 5.

> *"In order to prevent overlapping at transverse junctions of separate binder applications, the previous work along the joint shall be covered with twine-reinforced building paper for a sufficient distance back from the joint to ensure that the spray bar of the bitumen distributor is operating at the required rate before the untreated surface is reached, and also to prevent additional binder application onto the previously treated section. The same method shall be used to ensure a neat joint at the end of the run."*

**Extract 5 ERA Specification Clause 63A11 (c)**

The intention of the specific clause is shown in Photograph 10.

**Photograph 10  Correct application of transverse joint paper**

Observations during construction and on existing surfacings show that this specification is not always adhered to (Refer Photograph 11 and Photograph 12

**Photograph 11  No transverse joint protection**

**Photograph 12  Impact of no joint protection**

### 3.7 Aggregate spread

Important aspects in the ERA specification related to application of chippings is highlighted in Extract 6.

> *"Chippings shall be applied by means of chip spreaders as described in Clause 63A03 (c). Chip spreaders shall commence spreading the chippings as closely as possible behind the distributor. The chip spreader shall be operated in such a manner that the binder shall be covered with chippings and the <u>wheels of the chip spreader or truck do not pass over the uncovered binder</u>. All chippings shall be spread as soon as possible but no later than ten (10) minutes after the binder has been sprayed.*
> *Any areas deficient in chippings shall have additional material added to leave the carpet with a single layer of chippings lying shoulder to shoulder. <u>It is essential to ensure that only one layer of chippings is applied and every care shall be taken to avoid over-application of chippings</u>".*

**Extract 6 ERA Specification 63A11 (d) Application of chippings**

The result of a chip spreader passing over uncovered binder results in damage to the base and a poor joint as shown in Photograph 13

**Photograph 13 Chip spreader driving on sprayed binder**

This particular clause further warns against over application of the chippings. In this regard it should be noted that:

- Design application rates for single and double seals are based on single sized aggregate, normally spread to obtain a shoulder to shoulder matrix after rolling.
- The bond strength between the aggregate and binder is directly related to the surface area in contact with the binder.

Over application of aggregate could therefore, result in the following:

- Insufficient adhesion to the bituminous binder
    - The aggregate is packed so close together that it cannot orientate during rolling to the largest area in contact with the binder.
    - Increase in the wetted surface area due to the rocking motion during pneumatic tyred rolling cannot take place

- Due to friction between the aggregate particles, less embedment will occur during construction

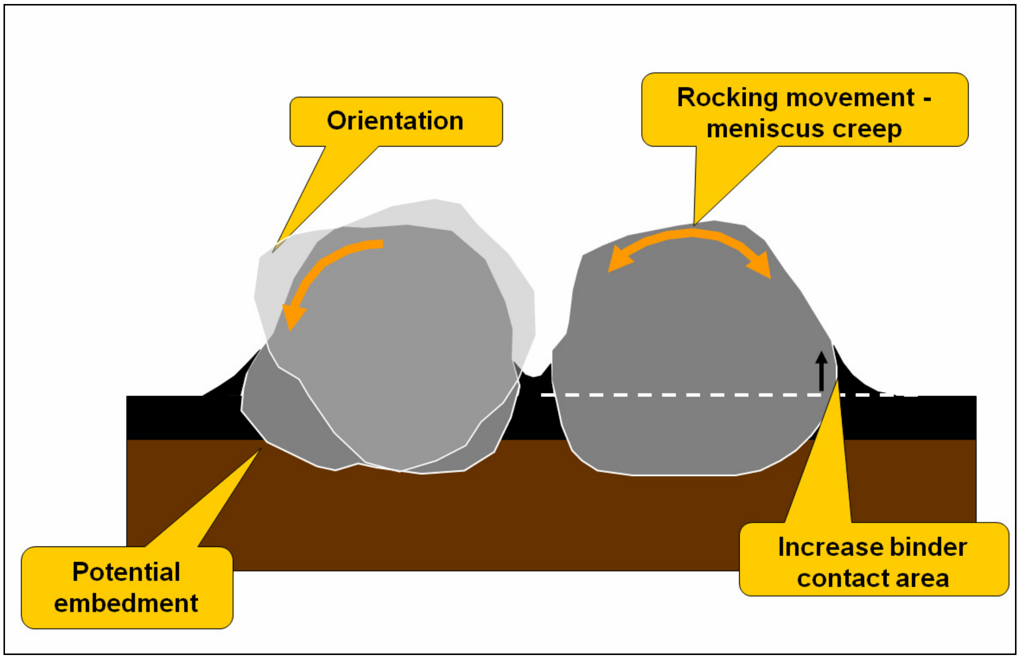



**Figure 8 Effects of rolling**

- Design application rates not sufficient
  Experience indicates that approximately 30% of the height of the aggregate should be filled with binder to prevent whip-off. High aggregate spread rates result in a higher effective layer thickness (ELT), which requires more binder to hold the stone. The principle is shown in Figure 9.

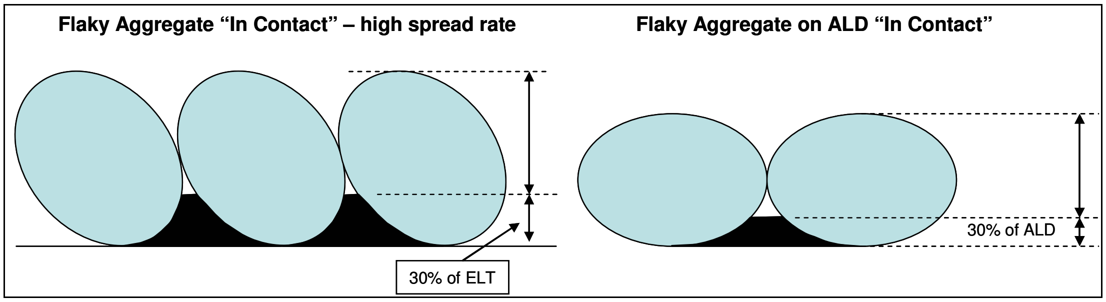



**Figure 9 Increased binder requirement**

The effect on the 19.0 mm plus 9.5mm double seal, as often applied in Ethiopia, is shown in **Figure 10** and **Figure 11**. The situation as shown in **Figure 11** requires much more binder than the situation displayed in **Figure 10.**

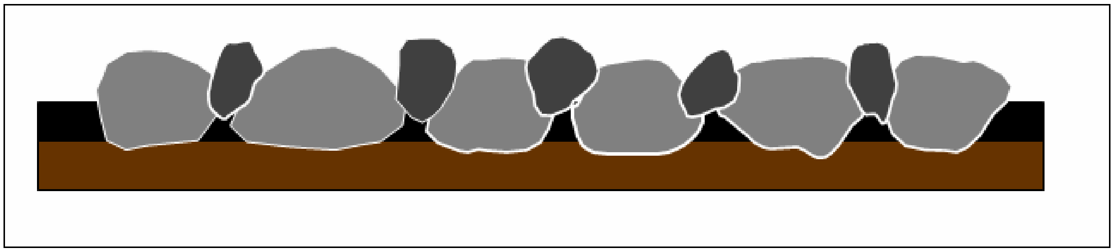


**Figure 10 Spread rate allowing orientation**

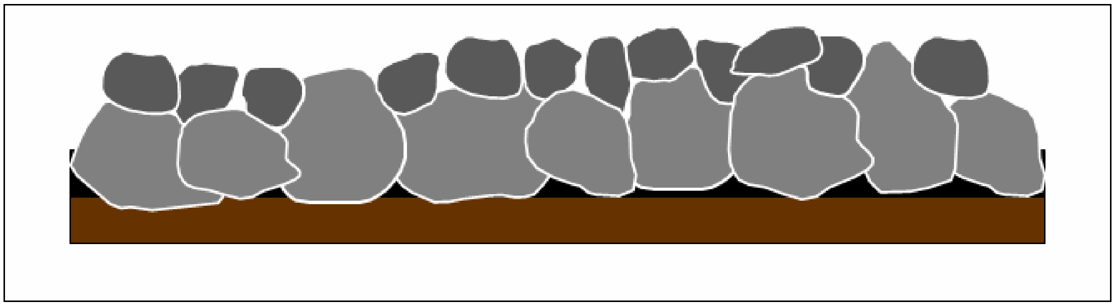


**Figure 11 High spread rate of large aggregate**

Therefore, even if design application rates are calculated according to standard acknowledged procedures, the method of construction could result in too little binder and subsequent chip loss.

## 4 CONCLUSIONS AND RECOMMENDATIONS

Concerns of local practitioners regarding poor performance of surface dressings in Ethiopia were confirmed through a recent study. Although examples of excellent construction and good performing surfacings were found, non-adherence to existing specifications is evident and result in several cases of poor performance.

The paper highlights the importance of specifications and shows, from observations made, the impact of non-adherence.

It is concluded that training in the design and construction of surface dressings could largely eliminate poor construction practices, which will result in much better performance. Recommended training should incorporate theoretical sessions to improve the understanding of surface dressings and the purpose of existing specifications, as well as practical sessions with designers, contractors and supervisors to provide guidance with the construction and control phase.

## REFERENCES


1) Neaylon, K and Van Zyl, G. 2010. Review of Surface dressing practice in Ethiopia – Contract Report AFCAP/ETH/021.
2) Ethiopian Roads Authority. 2002. Standard Technical Specifications.


## KEY WORDS


Surface dressing, performance, construction