

## Technical Report

# Best Practice for the Preparation of New Granular Pavements for Thin Bituminous Surfacing

**Technical Report No. TR 209**  
**March 2010**

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**BEST PRACTICE FOR THE PREPARATION  
OF NEW GRANULAR PAVEMENTS FOR  
THIN BITUMINOUS SURFACING**

**by**

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**This report was presented to the 13<sup>th</sup> International Flexible Pavements Conference held in Surfers Paradise, Queensland on 11 - 14 October 2009. The permission of the Australian Asphalt Pavement Association has been obtained to re-issue the paper as a VicRoads Technical Report.**

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**ISBN 978-0-7311-9148-1**

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**Summary of Main Characteristics of Class 1 Crushed Rock**

# BEST PRACTICE FOR THE PREPARATION OF NEW GRANULAR PAVEMENTS FOR THIN BITUMINOUS SURFACING

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## ABSTRACT

The preparation of a granular pavement prior to the application of a sprayed bituminous or thin asphalt surfacing is a critical ingredient in achieving its expected service life of at least 10 years. Not only is the fundamental requirement of achieving pavement dry-back an essential ingredient in the preparation phase, other construction aspects such as texture, homogeneity of material, free of ravelling and laminations and a surface which is hard, dense and tight, capable of withstanding hard sweeping with a rotary broom without removal of embedded fines are also essential ingredients. VicRoads has recently issued an amended version of its Standard Specification *Section 310 - Preparation of Granular Pavements for Bituminous Surfacing* and this paper discusses the content and provides a technical basis for the requirements included in the revised specification.

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## 1. INTRODUCTION

As sprayed bituminous seals or a thin layer of asphalt form the surfacing on over 30% of the Australian road network, their performance is crucial to the sustainability of that network which is currently estimated to have a value of about \$100 billion. In Victoria, about 85% or 19,000 km of the declared road network, which is managed by VicRoads, is surfaced with a sprayed seal. A survey of State Road Authorities and Local Government in 1998 (ARRB 1999) showed that in Victoria, average seal life varied between 7 years for 7 mm seals and 12 years for 14 mm seals. Over the past decade, it had been noted that roads within the Victorian arterial network were being resealed 2-3 years earlier than would have been expected based on their historical performance.

Various forums held over the last few years have identified that the condition of the pavement at the time of initial sealing is a key factor in performance of the surfacing over its service life (Midgley and Mangan 2007). These forums revealed that the July 1993 version of VicRoads Standard Specification *Section 310 - Preparation of Pavement for Sprayed Bituminous Surfacing* was lacking in requirements which allowed poor construction practices to be permitted, resulting in many examples of reduced service life of such thin surfacings.

In partnership with the Australian Asphalt Pavement Association, VicRoads reviewed the requirements of Specification Section 310 and issued a revised version in July 2009. This paper describes the content of this revised specification and is considered to be current best practice for the preparation of granular pavements where a thin bituminous surfacing is to be applied.

It should be noted that the requirements for dry-back and ball embedment have substantially been based on results obtained during the preparation of pavements for sealing incorporating high quality Class 1 crushed rock complying with VicRoads Specifications (Sections 812 and 304). A summary of the main characteristics of Class 1 crushed rock is given in Appendix A. Notwithstanding this limitation, these existing and new requirements should still be applied to other materials at this stage until further evidence is produced to warrant amendment. It is possible however that a slight relaxation of the requirements for ball embedment could be tolerated for lighter trafficked rural roads incorporating softer fine grained naturally occurring roadmaking materials commonly used on these roads.

## 2. COMMON CAUSES FOR POOR PERFORMANCE

Some of the common causes for poor performance of thin bituminous surfacing which are directly attributable to the pavement are (TB 45):

- (a) Use of unsuitable pavement material;
- (b) Insufficient pavement thickness;
- (c) Thin layers of pavement material not bonded to the base;
- (d) Poorly finished pavement surface due to lack of constant checking of shape and/or poor preparation;
- (e) Lack of, or uneven, compaction particularly along the edges of the pavement and on the high sides of curves;
- (f) Poor surface drainage, particularly leaving the shouldering above the edge of the pavement and poor cross sectional shape;
- (g) Poor subgrade drainage;
- (h) Dragging or grading of a poor quality material from the shoulders or non-removal of excess fines from the surface;
- (i) Failure to remove patches of clay worked into the surface and foreign material carried on by the traffic from earth foundations, side roads, shoulders and side tracks;
- (j) Failure to remove layers or patches of fine slurry from the surface of a limestone pavement;
- (k) Not properly removing accumulation of fines and/or clay from the surface brought to the top of certain gravels and sands by excessive water;
- (l) Priming or primersealing the pavement when the pavement materials are too wet.

On review of VicRoads Standard Specification Section 310 - *Preparation of Pavement for Sprayed Bituminous Surfacing* dated July 1993, some of these deficiencies were not being adequately addressed during the pavement construction phase. It was during this 1990 period that VicRoads had moved from undertaking the pavement construction and sealing operations using in-house resources (direct labour form of construction) to more use of contractors to carry out the work. Clearly the expertise built up over past generations in preparing unbound flexible pavements had not been adequately transferred to the current generation.

VicRoads Technical Report 207 (TR 207) *Ingredients of an Unbound Granular Pavement for a Successful Sprayed Seal* provided good advice on how to overcome these deficiencies but did not address the inadequacies of the July 1993 version of the specification being used in contracts involving the preparation of unbound pavement for bituminous surfacing. Other advice on preparing pavements for initial sealing treatments can be found in the Austroads *Sprayed Sealing Guide* (AP-G76/04).

### 3. PAVEMENT PREPARATION BEST PRACTICE

The preparation of a granular pavement for sprayed bituminous or asphalt surfacing requires attention to the following :

**(i) Shape and Level**

In order to provide a smooth ride and for the efficient run-off of surface water during rain, the granular pavement must be constructed to the specified shape and level as the thin bituminous surfacing will not correct irregularities. Regular checking of line and level is essential during the spreading and compaction process. Once compaction is completed and depending upon the importance of the road, minimum departure from design surface level should be within +/- 15 mm for minor roads to +/- 5 mm for major roads (Section 304). More recently, the spreading operation is controlled by GPS programmed machines which do not require level pegs for achieving the required shape and level (pegless survey). In these situations, independent spot checks of line and level needs to be undertaken to ensure the specified requirements are being met.

**(ii) Homogenous Surface and Pavement Material**

In order for the required pavement performance to be achieved, it is necessary for the pavement material to be homogenous in nature throughout the layer depth. Any change to the grading of the pavement material near the surface of the layer due to segregation at time of construction (refer Figure 1), addition of fine material to the surface (refer Figure 2), or excess material being swept from the compacted layer (refer Figure 3) is likely to result in a poor ride quality and/or a weakening of the inherent pavement strength. Pavement material that is durable (resists mechanical breakdown during compaction) and has good cohesion (avoid non-plastic products but not excessively plastic that will affect strength) is recommended.



**Figure 1 : Boney Segregated Areas - Lacking Homogeneity**



**Figure 2 : Layer of Fine Material on Top of Crushed Rock**



**Figure 3 : Excess Material Swept from Compacted Layer**

**(iii) Uniform in Texture**

The pavement surface must be prepared to achieve uniform texture (refer Figure 4). This is an important condition in achieving a uniform and strong bond between the pavement and the bituminous prime or primerseal surfacing. A surface that is patchy in nature will respond differently to the application of bituminous material. Different penetration rates will occur

depending upon whether the surface is coarse and hungry or fine and fatty. Such variations in bond are likely to lead to future loss of seal or seal flushing.



**Figure 4 : Well Prepared Surface - Uniform Texture**

**(iv) Free from Tearing and Scabbing**

Tearing (refer Figure 5) and scabbing can occur during the preparation phase often due to lack of cohesion in the pavement material when subjected to brooming or when a thin laminated layer exists at the surface. Both faults lead to poor ride quality and reduced service life in the surfacing.



**Figure 5 : Tearing of Pavement - Ravelling**

**(v) Free from Laminations**

Laminations generally occur where it is discovered that the required finished surface level has not been achieved during or following the compaction process. By subsequently adding a thin layer of additional pavement material without tying in the additional material will not achieve the necessary mechanical interlock between the two layers (refer Figure 6). Tearing is the likely consequence of this poor practice. Another common poor practice is to add a thin layer of fine material to the compacted layer in an attempt to overcome poor texture. Again, this practice often produces a laminated layer with the inevitable consequences.



**Figure 6 : Laminated Layer**

**(vi) Level with Adjacent Sealed Areas and Edgings**

Notwithstanding the requirements to achieve the specified line and level, it is obvious that matching in with existing sealed areas and edgings at the joins is essential to ensure smooth ride, good drainage and comfortable alignment of traffic lanes. In some circumstances, this may mean a transition from design requirements to existing requirements over an agreed length or width.

**(vii) Hard, Dense, Tight Surface Capable of Brooming**

The prepared pavement surface needs to be hard to resist any subsequent embedment of sealing aggregate into the pavement under trafficking. It needs to be dense to provide the required strength to withstand the applied traffic loadings. It must be tight to withstand sweeping with a rotary broom or similar equipment to remove surface dust and to provide a surface with the larger stones in the pavement exposed but not loose or dislodged. Care must be exercised to ensure that the force applied by the rotary broom is sufficient to remove the dust and loose aggregate without damaging the pavement surface. If excessive force is used, the result is usually a scabbled or ravelled surface with excess fine material windrowed to the side (refer Figure 3).

**(viii) Free from Loose and Foreign Material**

Loose and foreign material (refer Figure 7) if not removed from the prepared surface prior to sealing can result in poor bonding with the bituminous surfacing leading to early failure of the surfacing. Any hardened mud or embedded vegetation needs to be removed, by hand shovel if necessary.



**Figure 7 : Loose and Foreign Material at Surface**

**(ix) Avoid Excessive Slurring**

The achievement of a uniform surface texture that is tight and dense can be assisted by minor wetting up of the surface followed by pneumatic multi wheeled rolling. This action will knead any loose stones remaining at the surface after the compaction process. However care must be exercised to avoid excessive slurring up (refer Figure 8) which under rolling draws too many fines to the surface. Such a practice can lead to a glassy appearance being produced, adversely affecting the ability of the prime or primerseal to adhere to the granular surface. There is also a risk that premature rutting may occur due to the loss of mechanical interlock between pavement particles weakening the pavement structure.

Care also needs to be exercised to ensure that the quality of water used in pavement construction including any slurring up of the pavement surface during the preparation phase is clean and substantially free from detrimental impurities such as oils, salts, acids, alkalis and vegetable substances. Such impurities can lead to the primer debonding from the pavement.



**Figure 8 : Excessive Slurring of Fines**

## **4. PAVEMENT DRY-BACK**

One of the most critical elements in the whole process of preparing a granular pavement for bituminous surfacing is the achievement of dry-back. While water must be added to the pavement material to assist in achieving the specified density during the compaction process, the pavement must then be allowed to dry to a condition that resists premature failure of the granular pavement due to traffic compaction in the wheel path or flushing in the seal due to embedment of the sealing aggregate into the moist “green” pavement.

Across Australia and New Zealand, various methods exist for assessing whether a pavement has dried back sufficiently before the application of bituminous surfacing. They are:

- **Queensland** use Degree of Saturation (DoS). Where the DoS is less than 65% for crushed rock, there is reasonable expectation that the pavement should perform adequately. Where the DoS is greater than 70% for crushed rock, the pavement should be allowed to further dry back to less than 65% (TN7).
- **New South Wales** requires dry-back to 70% of Optimum Moisture Content (OMC) based on standard compaction immediately prior to placement of wearing course surfacing (RTA R71).
- **South Australia** specifies that priming and/or primer sealing shall not be commenced until the moisture content of the top 20 mm of the base course is less than 60% of OMC. Areas to be sealed shall be tested for moisture content. The location of tests shall be selected by the Contractor for each lot on a stratified random basis in accordance with Australian Standard AS 1289.1.4.2. The number of strata shall be equal to the number of tests required for a given lot.
- **Tasmania** requires the Contractor to inspect the base and ensure that it is of uniform moisture content and free of local damp and wet spots and demonstrate that the moisture content of the base course is not more than 70% of OMC (R40).

Where the number of test sites for moisture content is 4 or less, the assessment shall be based on the maximum moisture content measured in those samples. Where the number of test sites is greater than 4, the assessment shall be based on the average plus one standard deviation of the test results for that lot.

The sampling depth shall be 75 mm or greater. The moisture contents determined by the use of an appropriately calibrated nuclear density meter will be acceptable. In addition to the above moisture content requirements, the surface of the base may have to meet ball penetration test criteria (embedment) as defined in DIER Standard Specification R51.

- **Western Australia** has dry-back requirements for all pavement layers prior to the application of bituminous binder or constructing the overlying layer. For base course layers, the requirements vary from a maximum Dry-back Characteristic Moisture Content of 85% for gravel to 60% for crushed rock. The number of tests per lot for pavement layers is 9.
- **Northern Territory** requires the pavement to dry back to a DoS equal or less than 65% for fine crushed rock and 70% for natural gravel before priming/primer seal. Frequency of testing is 1 in 5,000m<sup>2</sup>.
- **Australian Capital Territory** only specifies moisture content in the range of 60% - 90% of the laboratory optimum maximum moisture content as determined by Australian Standard AS 1289.5.2.1 (modified compaction) when tested for compaction. For projects where there is a likelihood of a problem, the requirement to produce a surface that is hard, dense, tight and capable of being swept with a rotary broom is used.
- **New Zealand** specifies DoS (B/02). Testing shall be carried out in lots. A lot is defined as a section where the pavement layer appears homogeneous and evenly compacted. The area of a lot shall not exceed 1000m<sup>2</sup>. The DoS for each lot shall be determined by testing at least five randomly selected areas.

The seal coat shall not be applied unless the water content at each test point of the basecourse layer is such that the DoS is less than 80%.

**Note:** Recent research noted improved rut resistance with decreasing DoS. Pavements with a design traffic loading in excess of 5x10<sup>6</sup> ESA's (approximately equivalent to 500 heavy vehicles per day) improve significantly with a DoS of less than 60% prior to sealing, for other roads a maximum DoS of 65% would be suitable.

## 5. NEW DRY- BACK REQUIREMENTS IN VICTORIA

In partnership with the Australian Asphalt Pavement Association, VicRoads has adopted new requirements relating to dry-back for the uppermost pavement layer after preparation of the granular surface and prior to priming or primersealing (Section 310). In the past there was no specific requirement for dry-back other than the surface being hard, dense, tight and capable of being swept with a rotary broom. The previous successfully used method of thumping the head of a mattock pick (refer Figure 9) onto the prepared surface to produce a distinctive ring was never incorporated into specifications. If a dull sound was heard, it was apparent the pavement had not dried out sufficiently and sealing did not proceed.



**Figure 9 : Mattock Pick used to Test Hardness**

The new requirements are as follows :

- (i) Pavement layers shall be compacted to the required density at a moisture content of not less than 85% of modified optimum. After completion of compaction of a layer, the moisture content of the material in the layer shall be maintained at a moisture content of not less than 85% of optimum until test rolling has been completed (Section 304). Compliance with the test rolling requirements shall be when an area withstands test rolling without visible deformation or springing (Section 173).
- (ii) Following acceptance for compaction and test rolling, the uppermost layer after preparation of the surface and prior to priming or primersealing shall be dried back in moisture content such that the mean Moisture Ratio as determined from six randomly selected sites is less than 60% of the optimum moisture content based on modified compactive effort, with an individual result not exceeding 70%.
- (iii) The mean Moisture Ratio shall be determined in accordance with VicRoads Test Method - Moisture Ratio Determination for Assessment of Dry-back of Granular Pavement Materials, using Nuclear Gauge (RC 316.14). The OMC used in compaction acceptance testing shall be adopted as the OMC used in dry-back testing. This avoids the need to take field samples for determination of the OMC of the material being assessed for dry-back. It also allows for result of testing being determined on site allowing the immediate assessment of the dry-back condition.
- (iv) The maximum lot size to be presented for testing under this provision shall be 4,000m<sup>2</sup>, and testing shall be undertaken no more than 24 hours before priming or primersealing.

- (v) Should the mean Moisture Ratio be more than 60% and less than 65% and providing that no individual result is more than 70, the lot may be accepted by the Superintendent subject to Ball Embedment testing (refer Figure 10) in accordance with Austroads Test Method AG:PT/T251 being undertaken at six randomly selected sites. No individual result from such Ball Embedment testing shall be more than 3.0 mm.



**Figure 10 : Ball Embedment Penetrometer**

- (vi) Where in the opinion of the Superintendent, the pavement moisture content has increased during the period between dry-back testing and the time of proposed bituminous surfacing, the Superintendent may require retesting for Moisture Ratio and Ball Embedment testing.

The above requirements have primarily been based on the performance of high quality crushed rock pavements. The value of 60% of modified OMC was selected because it was achievable and produced a hard surface. This condition ensured good resistance to any embedment of sealing aggregate into the pavement surface under the action of traffic after opening. Note the requirements for good surface texture mentioned in Section 3 above should not be overlooked.

The Ball Embedment test has been adopted in marginal cases which should still give reasonable confidence of minimising aggregate embedment. This test was adopted as the equipment is being introduced for use in the design procedure for resealing over existing sprayed sealed pavements. The specified 3 mm limit for embedment was adopted as being within the range permitted for seal design purposes (AP-T68/06).

Based on evidence collected over the past 12 months, dry-back from the compaction moisture content of greater than 85% OMC to the required 60% OMC can be achieved over a period of 1 to 3 days depending on weather conditions at the time. Obviously in colder months or wet

periods, the dry-back time will be much longer. In any event, any proposal to proceed with bituminous sealing while the uppermost pavement layer is still in a “green condition” (i.e. has not dried-back to meet specified requirements) will risk longer term embedment of the sealing aggregate resulting in flushing problems in seals or rutting in a thin asphalt surfacing.

At this stage, no distinction between crushed rock and other pavement material has been made in the specification. As more information becomes available, review of requirements for these other materials may be considered.

## 6. REFERENCES

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R71: *Unbound and Modified Pavement Course*; Specification R71; April 2007, Roads & Traffic Authority, Sydney, New South Wales, Australia.

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Section 310: *Preparation of Granular Pavements for Bituminous Surfacing*, Standard Specification Section 310, July 2009, VicRoads, Kew, Victoria, Australia.

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## 7. ACKNOWLEDGEMENTS

The author wishes to acknowledge Walter Holtrop, Australian Asphalt Pavement Association, for his technical review of this paper and to John Esnouf, VicRoads' Principal Engineer - Spray Seal Technology, for his assistance in developing the new Section 310 specification.

## 8. AUTHOR BIOGRAPHY

Lance commenced with VicRoads in 1967 and over his 40 year career with that organisation, he has worked in most parts of Victoria, gaining experience in the construction and maintenance of roads. He has worked on a number of major road projects including upgrading a section of the Hume Highway to freeway standard, the South Eastern Arterial (now Monash Freeway) and the Western Freeway Bypass at Melton.



He is also a leader in the field of pavement technology with over 18 years experience in pavement research, investigation, testing and design including managing VicRoads' GeoPave Department for 4 years. He has been recognised by Austroads for his outstanding achievement of major national significance in the delivery of Austroads objectives in the field of pavement research.

In 2000, he was appointed to his current position as VicRoads' Regional Director for Western Victoria where he is responsible for the management and delivery of VicRoads' \$60 million roads and services program in Western Victoria.

Lance has worked closely with industry in the fields of asphalt and bituminous surfacing technology and has made valuable contributions to the production of various guides, specifications and work tips.

## APPENDIX A

### Summary of Main Characteristics of Class 1 Crushed Rock

#### COMMONLY USED SOURCE ROCKS

Material	Test	Typical Values
1. Acid Igneous (Granite)	Hardness (Log Angeles Value)	28
	Durability (Degradation Factor)	74
2. Basic Igneous (Basalt)	Hardness (Los Angeles Value)	17
	Durability (Accelerated Soundness Index)	99 - 100
3. Metamorphic (Hornfels)	Hardness (Los Angeles Value)	11
	Durability (Degradation Factor)	75

#### TYPICAL PRODUCT VALUES

##### Grading Test

Sieve Size AS (mm)	26.5	19.0	13.2	9.5	4.75	2.36	0.425	0.075
% Passing by mass LAV <25	100	97	85	73	54	39	18	9
% Passing by mass LAV >26	100	97	85	73	54	38	17	7

##### Other Product Tests

Test	Liquid Limit (%)	Plasticity Index	Flakiness Index (%)	Unsound Stone (%)	Permeability (m/sec)
Value	20 - 30	3 - 4	15 - 25	2 - 4	$1 \times 10^{-9}$

**Note:**

Full specification requirements for all classes of crushed rock are listed in Sections 801 and 812 - refer References.