NZTA P18 Notes: 2025

Notes to the Specification for the Design of Chip Seals

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1 Introduction

NZTA P18: 2025 is a new specification. It sets out the default processes for the design of chip seals. P18 is a method based, Principal risk document.

The algorithms and guidelines are based on those published in *Chipsealing in New Zealand*, and its predecessor, the *Bituminous Sealing Manual.*

The purposes in developing P18 include:

(a) Updating design guidelines and processes in line with current knowledge and best practice.

(b) The creation and publication of a document that is more easily revised and updated on an as-needed basis.

(c) The development of a design document as a technical specification that better fits a contractual environment.

While P18 provides explicit tools and processes for chip seal designs, it does not remove the need for engineering judgement and consideration of local practice and experience by seal designers. The design and construction of chip seals continues to have some associated “art” and hence adjustments to design and construction must be considered by the designer and the chip sealing contractor.

2 Materials

2.1 Bitumen

Until a performance-based specification for chip sealing binders is developed, P18 continues to specify M01 compliant penetration grade bitumen as the base binder for chip seals. The grade of bitumen is selected based on Winter climate conditions, with softer bitumen used for the colder Winters, and vice versa.

2.2 Diluents

The use of flux oil diluents in the binder is recommended for many locations. This is to provide more softening for Winter conditions and minimise chip loss by brittle failure of the binder.

Recommendations for the dosage rates of cutter oil (kerosene in the form of Jet A-1 aviation turbine fuel) are provided. Cutter oil contents are elevated for first coat seals to aid wetting and binding to granular basecourse pavements.

The flux oil recommended dosages are required for all binder delivery media – i.e. for cutback bitumens and bitumen emulsions as the intent is to provide long term softening for the binder. In contrast, the cutter oil dosages are recommended for cutback bitumen, but contractor optional where bitumen emulsion are used as the cutter oil serves more as a construction aid.

However note that the **flux and cutter oil dosages are recommendations and are not mandatory. The seal designer must consider the site climatic conditions, loading, local practice and historical precedent when determining the diluent content for the chip seal.**

2.3 Modified Binders

P18 allows the use of modified binders with the agreement of the Principal following a recommendation from the contractor or binder supplier. Modifiers can include elastomeric polymers (SBS, SBR), binder stiffeners (reactive terpolymer), extenders (tall oil, lignin) and other materials.

There are a wide range of bitumen modifiers used to treat specific chip seal surfacing problems. Such modifiers can add benefits, but there should be a logical basis for the use of a modifier, and the rheological properties of the modified binder should be linked to the specific problem identified.

2.4 Aggregate

2.4.1 General

Chip aggregate must be compliant with NZTA M06 specification which has been normal practice for many years.

However P18 specifically requires chip stockpiles to be constructed at or adjacent to the work site unless prior agreement has been reached with the Principal. Samples must be drawn from the stockpile specifically allocated for the job site and the ALD of the chip determined. This ALD is then used to calculate the residual binder application rate. The intention is to ensure that the ALD used for the application rate calculation is representative of the chip actually used.

2.4.2 Two Coat Seals

The two chip grades used for two coat seals must be size compatible. *Chipsealing in New Zealand* publishes a chart that can be used to determine compatibility, but some commonly used sealing practices, such as Grade 2/4 two coat seals sometimes may not comply with the compatibility chart. The *Bituminous Sealing Manual* published a similar chart that better represents two coat sealing practice so this was adopted for P18.

3 Design

3.1 First Coat Seals

The design algorithm for calculating the residual binder application rate for single coat and racked-in first coat seals uses the algorithm first published in *Chipsealing in New Zealand* in 2005 (equation 9-11), except that an additional 0.2L/m² of binder is added to the calculation. The intent of the extra 0.2L/m² is to allow for some absorption into granular basecourse layers and also enhance the waterproofness of the first coat seal.

The design algorithm for calculating the residual binder application rate for two-coat first coat seals uses the algorithm published in the *Bituminous Sealing Manual* published by Transit New Zealand in 1993. The effect of this algorithm is to lift the residual binder application rate by about 0.2L/m² for reasons as above. See Figure 1 for a graphical comparison of some design algorithms.

3.2 Reseals

Reseals, which include “second coat” seals and subsequent chip seal layers continue to use the *Chipsealing in New Zealand* algorithm (equation 9-11).

As is normal practice, the binder for two coat seals is applied in two passes, with 50% - 60% applied in the first spray, and the balance in the second. It is considered that two coat seals are less waterproof than similar single coat or racked-in seals, hence the recommendation to apply a slightly greater proportion of the binder in the first application to enhance the waterproofness.

3.3 Winter Climate Conditions

P18 bases bitumen grade selection, flux oil content and first coat cutter oil content on the lowest temperature experienced by the binder. The intent is to minimise the risk of chip loss due to brittle failure of the binder in Winter.

The designated climate conditions are empirical and chip seal designers must use their judgement to determine which category applies to the job site.

Winter Climate Category	Climate Conditions
Very Cold	Subject to snow, frosts and no/minimal daytime thawing. Icing common.
Cold	Frosts experienced but generally thaw during the day. Icing rare.
Cool	Minimal/no frosts. No risk of icing.

Table 1: Site Winter climate conditions

Factors including local best practice, precedent, local microclimates and the like should be considered when allocating the Winter climate category.

3.4 Site-Specific Adjustments

3.4.1 General

The design algorithms use chip ALD, texture depth and traffic loading to calculate a basic binder application rate V_b. This basic rate must be adjusted to compensate for specific site conditions as follows, to derive the final residual binder application rate *R*.

3.4.2 Soft Substrate (Ss)

Soft substrates can be caused by layers of multiple chip seals or asphalt or pavement repairs that have not fully cured or hardened. The objective is to apply sufficient binder to initially hold the chip and not lose it during the following winter before it is fully cured, yet not apply too much that will cause premature flushing to occur as embedment takes place.

The Ball Penetration Test, Austroads AGPT T251 can be used to measure substrate hardness. This test, which originated in South Africa consists of measuring the penetration that a 19mm ball bearing makes in a sample of the substrate when it is struck by one blow of a Marshall hot mix-compaction hammer. Typical ball penetration values for reseal surfacings in New Zealand are in the range of 2mm to 3mm. For penetration values greater than 3mm the application rate should be reduced to compensate for the chip ALD lost by embedment.

3.4.3 Absorptive Surfaces (As)

On some surfaces binder can be absorbed, meaning that the binder ‘disappears’ into the surface and in effect results in a low application rate. Surfaces that may exhibit this condition are open graded porous asphalt (OGPA), an open-graded emulsion mix (OGEM), or asphaltic concrete.

As no method is available for assessing the degree of absorption, the preferred procedure is to seal the surface first with a small chip. If this is not possible, the basic application rate could be increased in the order of 0.1L/m² to 0.2L/m².

3.4.4 Steep Grades (Gs)

On steep uphill grades, slow moving heavy vehicles can cause premature flushing of the surface. The Heavy Traffic Factor adjustment can be used for the application rates for crawler lanes (when these are provided), so the pavement can cope with the slow heavy vehicles.

A reduction of 0.1L/m² to 0.15L/m² in binder application rate for these areas is commonly used to minimise the chance of binder pick-up from the truck tyres, which causes tracking and potential for flushing.

3.4.5 Chip Shape (Cs)

Chip shape is controlled by a maximum ratio of ALD:AGD of 1:2.25, although typical ratios of 1:2 have been found in practice. These shapes are preferred as they pack in with maximum shoulder-to-shoulder contact.

Some aggregate crushing systems can result in more cubical chip with ratios less than 1:2.0. The volume of voids, with this more cubical shape of chip, is higher than the voids between chips having the 1:2 cubical shape. Subsequently the binder application rate needs to be increased. Typically, the application requires up to 10% extra binder for chips with more cubical shape.

3.4.6 Urban and Low Traffic Volume Reseals (Us)

A significant number of urban Road Controlling Authorities (RCAs) and contractors are of the opinion that urban streets sealed with normal application rates suffer from chip loss along centrelines and in parking lanes.

A number of ways are available for dealing with this problem. Generally, chip loss will be solved by increasing binder application rates from 10% up to 20%. However, apply this solution with caution especially in areas with higher traffic volumes, otherwise shortened seal life caused by flushing in the wheel paths may result.

To reduce this risk of flushing using high binder application rates, two further options can be considered:

- Dry-lock or wet-lock the centreline and parking lanes; and
- Spray higher binder application rates on the centreline and parking lanes on their own. This option is

- more easily used on very wide streets.

With traffic volumes around 100 v/l/d or less, then increases of 15% may be considered.

3.4.7 Shaded Areas

Binder application rates should be increased for areas that are heavily shaded. Increases should be in the order of 10% - 15% for the shaded areas.

4 Treatment Selection

4.1 General

NZTA P03 and P04 specifications require the Principal to determine the chip seal treatment for the site. Single coat seals are preferred although they can not be used in every application for reasons of traffic stress or variable substrate surface texture.

Multiple layers of two-coat seals are prone to flushing as the traffic compacts the layers of seals and reduces the available voids to the extent that the bitumen is forced to the surface. Consequently, the preferred hierarchy of seal treatments are:

- Single coat seals
- Racked-in seals
- Two coat seals.

As noted above, site conditions will mean that not every seal option can be used for every application. Seal designers must carefully consider the site characteristics and loading and select the seal type most appropriate for the location.

4.2 Traffic Stress

Stresses imposed by traffic can cause early failure of chip seals. Stresses can arise from:

- High HCV loading
- Steep gradients
- Tortuous alignments
- Braking arising from intersections, railway or pedestrian crossing and intersections.

The stress resistance of seal types are (from best to worst):

- Two-coat seals
- Racked-in seals
- Single coat seals.

Seal designers must carefully consider the site stress environment and select the seal type most appropriate for the location.

Chip seals can be successfully used for sites with traffic loading greater than 20,000 ELV per lane per day in low stress alignments.

Table 2 lists a number of treatment selections and rates their appropriateness against a series of arbitrarily numbered stress factors.

Table 3 gives examples of site scenarios for the stress factors.

These tables are not absolute nor exhaustive so the seal designer must treat them as advisory and use good judgement to decide on the appropriateness of the treatment selection under consideration.

Treatment Selection	Stress Factors					
	1	2	3	4	5	6
Single coat seal						
Single coat + active traffic control						
Single coat + active traffic control + premium binder						
Racked-in seal						
Racked-in + active traffic control						
Racked-in + active traffic control + premium binder						
Two-coat seal						
Two-coat seal + active traffic control						
Two-coat seal + active traffic control + premium binder						

Key

Should perform satisfactorily	
Should be considered, especially at lower traffic volumes	
Marginal	
Not recommended unless traffic volume and speed are low	

Table 2: Seal treatments and Stress Factor designations

Stress Factors					
1	2	3	4	5	6
Gradient <5%	Gradient 5-10%	Gradient >10%	Trucks braking (intersections including traffic signals, stop and give way) >50 HCV/l/day	Rural curves 250–400m radius and >10% gradient	Rural and urban curves <250m radius and > 10% gradient
One-lane bridge decks (Note: One-lane bridges have < 4000 vpd)	Curvature (advisory speed >70km/h)	Curvature (advisory speed >70km/h) and >10% gradient	Approaches to Railway level crossings (high volume roads)	Rural and urban curves (advisory speed 50 – 70 km/h) and >10% gradient	Rural and urban curves (advisory speed 0 – 50 km/h) and >10% gradient
Undivided carriage-ways (event-free).	Rural curves >400m radius	Rural curves 250–400m radius	Railway Crossing 20 – 50 HCV/l/day	Rural and urban curves <250m radius	Approaches to and the circular section of roundabouts >50 HCV/l/day
Divided carriage-ways (event-free).		Rural curves 400m - 800m radius and >10% gradient	Trucks turning (intersection) 20 – 50 HCV/l/day	Rural and urban curves (advisory speed 0 - 50km/h)	
		Rural and urban curves (advisory speed 50 – 70 km/h)	Pedestrian Crossing 20 – 50 HCV/l/day	Approaches to and circular section of roundabouts <50 HCV/l/day	
		Trucks braking (intersections including traffic signals, stop and give way) <50 HCV/l/day		Trucks braking (Pedestrian and Railway Crossings) >50 HCV/l/day	
		Approaches to one-lane bridges (Note: One-lane bridges have < 4000 vpd)		Trucks turning (intersection) >50 HCV/l/day	
		Approaches to intersections and on ramps with ramp metering.			
		Trucks braking (Pedestrian and Railway Crossings) <20 HCV/l/day			
		Trucks turning (intersections, commercial driveways) <20 HCV/l/day			
		Motorway junction area (including on/off ramps)			

Table 3: Site Examples and Stress Factors

4.3 "Holding" Seals

Holding seals are generally a last resort treatment prior to rehabilitation of a pavement. They can sometimes be successfully used to eke out more life from a flushed surface, or a surfacing with highly variable texture, but they are unlikely to have a long life as a consequence. Experienced judgement is needed for the selection and design of such surfacings.

5 Comparison of Design Algorithms

The following graph compares various design algorithms for a Grade 2 sealing chip (ALD = 11mm) for single coat and two coat seals. It is included here for interest.

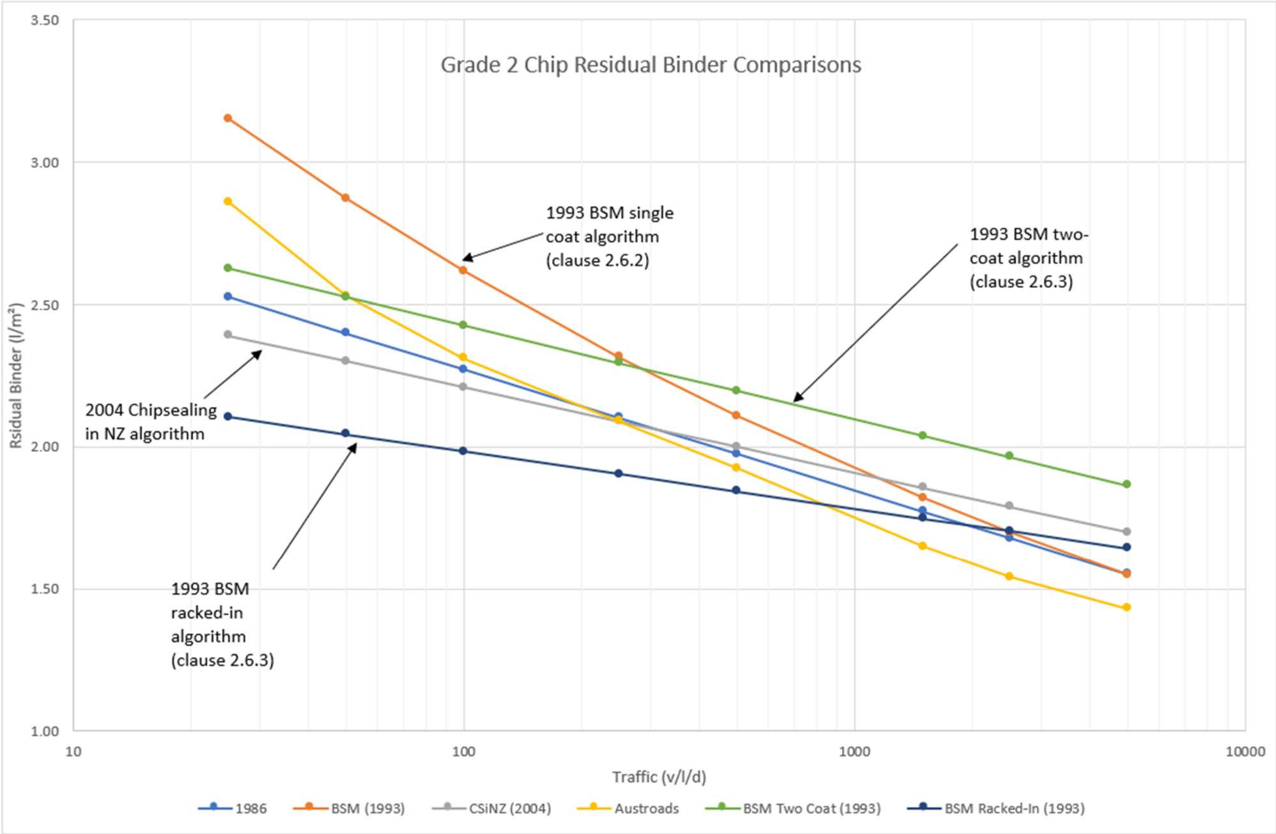

Figure 1: Comparison of design algorithms