



Guidance on Specification of Polymer Modified Emulsion - EnviroPlus Seal

This document provides guidance on the specification and appropriate use of polymer modified emulsions (PMEs) for chip seal surfacings, with specific reference to [EnviroPlus Seal](#), an SBR latex polymer modified emulsion supplied by Road Science.

The guidance is intended to support asset owners, designers, and consultants by:

- Explaining the performance benefits of polymer modification in chip seal binders
- Identifying where polymer modified binders should be specified, based on climate and traffic stress
- Providing a clear, performance based decision framework consistent with New Zealand practice
- Clarifying quality assurance expectations and construction implications

The document is not a specification, but a technical guide to support consistent and defensible binder selection.

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Why Polymer Modification Is Used in Chip Seals

Chip seals are thin surfacings whose long-term performance is strongly influenced by binder behaviour under traffic. In low-stress environments, straight-run penetration grade binders (e.g. 130/150, 80/100) can perform satisfactorily. However, as traffic stress increases, dominant failure mechanisms include:

- Binder shear deformation at elevated pavement temperatures
- Chip rollover and lateral displacement
- Progressive embedment and early flushing

These mechanisms are governed primarily by binder rheology at service temperature, not by penetration at 25 °C. Polymer modification is therefore used to improve resistance to shear deformation and reduce temperature susceptibility across the typical New Zealand pavement temperature range (approximately minus 10 °C to 55 °C).

In practical terms, standard penetration grade binders provide adequate seal performance in low stress environments where pavement temperatures remain below approximately 45 °C. However, once sustained pavement temperatures exceed this threshold — particularly under traffic stress — the risk of shear deformation and chip loss increases, and polymer modified binders become necessary.

In addition, higher binder viscosity at service temperature provides practical benefits in urban sealing environments, where minimising early chip loss and loose chip generation is critical for safety, customer care, and network performance. In these locations, warm pavement temperatures combined with early trafficking can lead to chip instability when standard binders soften rapidly. Polymer modified emulsions with higher viscosity retain stronger chip restraint during the early life of the seal, reducing the likelihood of chip movement, loss, and tracking under traffic.

High Temperature Performance Evidence – CAST Testing

The technical basis for polymer modified binders in chip sealing is strongly supported by research using the Circular Accelerated Surfacing Tester (CAST), documented in *Circular Accelerated Surfacing Tester (CAST) for Evaluating Chip Sealing Binders*, Herrington, et al (2022).

CAST testing is designed to replicate the primary failure mechanisms observed in chip seals under traffic, particularly at elevated pavement temperatures and stress. The test subjects chip seal specimens to repeated tyre loading under controlled temperature and shear conditions representative of in-service performance.

Figure 1 shows the CAST test apparatus used to apply repeated pneumatic tyre loading to chip seal samples.



Figure 1: CAST machine used to apply repeated loading to chip seal test samples
(Reproduced from *Circular Accelerated Surfacing Tester (CAST) for Evaluating Chip Sealing Binders*).

The test specimens are scanned before and after trafficking using stereo photography to generate detailed 3D surface models of the seal.

These surface models allow changes in the seal surface to be quantified over time. In particular, CAST measures “volume change”, which represents the increase in void space within the seal as chips move, rotate, or are lost.

Figure 2 Illustrates how volume change is defined.

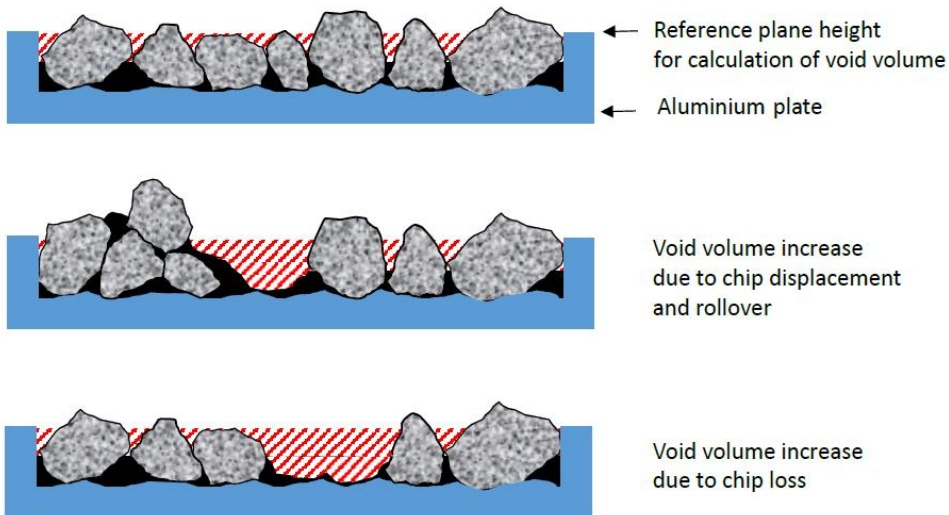


Figure 2: Schematic diagram illustrating void volume (in red) used to determine seal damage (Reproduced from *Circular Accelerated Surfacing Tester (CAST) for Evaluating Chip Sealing Binders*).

Volume change occurs due to:

- Chip displacement and roll over under traffic loading
- Binder shear deformation, allowing chips to reorient
- Loss of aggregate, increasing void space and reducing surface integrity

An increase in void volume corresponds directly to increased seal damage, including loss of texture, chip instability, and eventual binder tracking or chip loss.

CAST testing accelerates these processes under controlled conditions and demonstrates that:

- At elevated temperatures (45 °C), seal damage is dominated by permanent shear deformation of the binder
- Seal damage correlates strongly with binder viscosity at service temperature and low shear rate
- Increasing binder hardness alone does not reliably prevent high temperature seal failure

Figure 3 illustrates the relationship identified through CAST testing between binder viscosity at 45 °C and measured seal damage (where higher volume change corresponds to more seal damage). The data demonstrates a clear reduction in seal damage as binder viscosity increases, confirming viscosity at service temperature as the key factor for high-temperature chip seal performance.

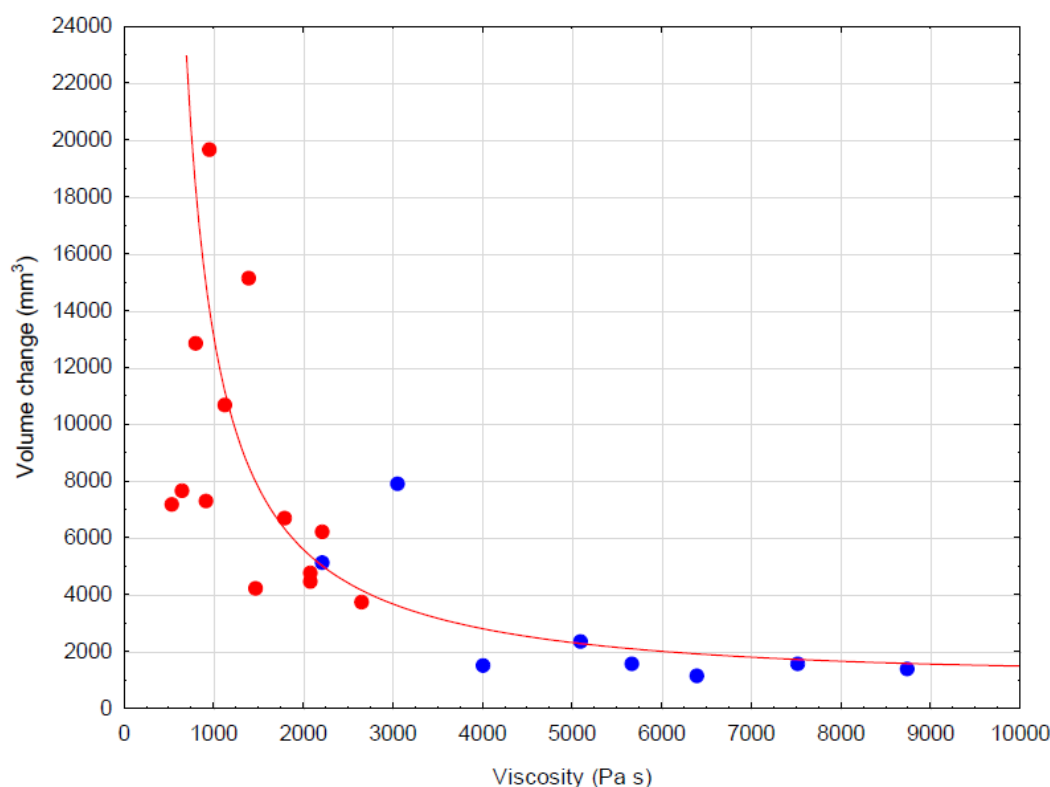


Figure 3: Correlation between the viscosity at 45°C (1.58 s⁻¹) and seal volume change (Reproduced from *Circular Accelerated Surfacing Tester (CAST) for Evaluating Chip Sealing Binders*).

Typical straight run binders used in chip sealing, such as 80/100 and 130/150 penetration grade bitumens, exhibit viscosities of approximately 1000 mPa·s or less at 45 °C. These binders correspond to the red data points located in the upper left region of Figure 3, where high levels of seal damage (volume change) are observed. This indicates that under elevated temperature conditions, standard binders operate in a regime where binder shear deformation and chip instability dominate.

A distinct change in behaviour is evident at approximately 2000 mPa·s, where the gradients of the standard binder data (red dots) and polymer modified binder data (blue dots) intersect. Below this level, seal damage increases rapidly with decreasing viscosity, reflecting a regime dominated by binder shear deformation and chip instability. Above this level, the rate of seal damage reduces significantly, indicating that higher binder viscosity improves resistance to shear and enhances chip retention.

This transition should not be interpreted as a fixed minimum requirement, but rather as an indication of the performance benefit associated with increasing binder viscosity at service temperature. It demonstrates that binders with higher viscosity at elevated temperature are more effective in reducing seal damage under combined thermal and traffic loading.

These results confirm that binder selection must be based on viscosity at service temperature. In practical terms, binders with lower viscosity at operating temperature are significantly more susceptible to stress-related seal damage, while higher viscosity binders provide improved performance as pavement temperatures and traffic stress increase. This aligns with field conditions where standard binders become increasingly unsuitable once pavement temperatures approach or exceed 45 °C under sustained loading.

Defining High-Stress Binder Performance

Interpretation of CAST results shows a clear improvement in seal performance as recovered binder viscosity at approximately 45 °C increases, with a marked reduction in seal damage observed as viscosity approaches and exceeds approximately 2000 mPa.s. This provides a useful reference point for distinguishing lower and higher performance binder behaviour under elevated temperature and stress conditions, rather than a fixed minimum requirement.

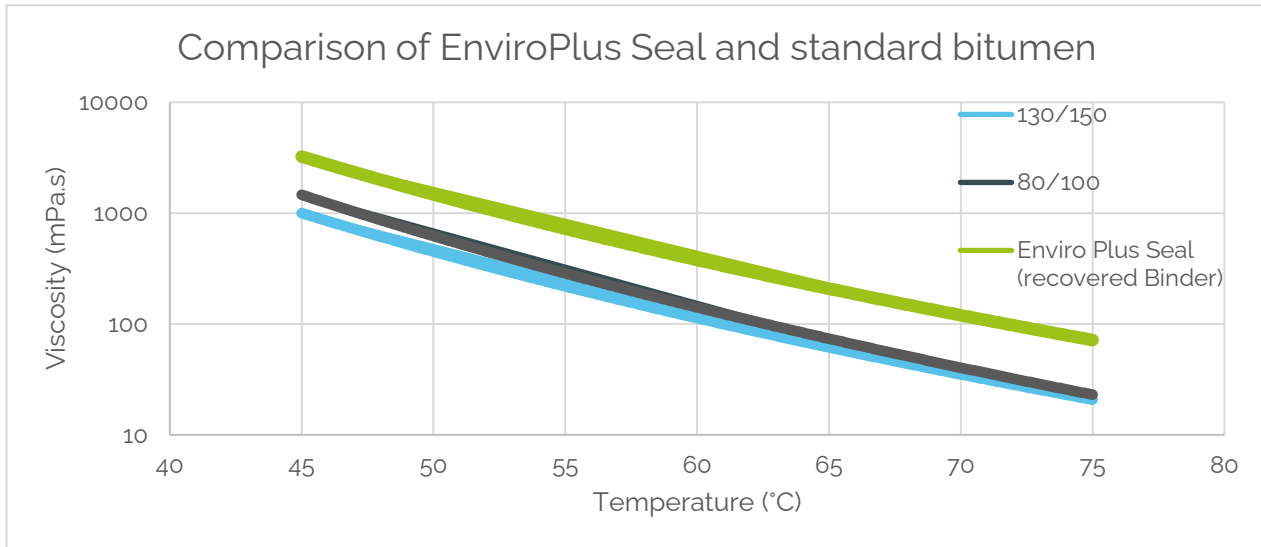


Figure 4: Comparison of recovered binder viscosity for EnviroPlus Seal and standard penetration grade binders (80/100 and 130/150) at elevated temperatures (45–75 °C).

Figure 4 compares the recovered binder viscosity of the polymer modified EnviroPlus Seal binder with standard penetration grade binders (80/100 and 130/150) over the temperature range 45–75 °C.

At 45 °C, EnviroPlus Seal binder exhibits a viscosity of approximately 3000–3100 mPa.s, placing it well within the higher performance regime identified by CAST-validated behaviour. In contrast, both 80/100 and 130/150 binders exhibit substantially lower viscosity at this temperature.

Importantly, Figure 4 shows that EnviroPlus Seal maintains significantly higher viscosity than standard binders across all elevated temperatures tested, whereas the viscosity of straight run binders reduces rapidly as temperature increases. This indicates lower temperature susceptibility and greater resistance to permanent shear deformation under traffic loading.

Figure 4 also indicates that EnviroPlus Seal reaches viscosity levels equivalent to standard penetration grade binders at temperatures approximately 10 °C higher. In practical terms, this means that EnviroPlus Seal at around 55 °C exhibits similar viscosity to that of standard binders at approximately 45 °C. This shift reflects a meaningful extension of the effective operating temperature range achieved through polymer modification and provides a practical basis for selecting EnviroPlus Seal where higher pavement temperatures are anticipated.

Relating Binder Performance to Traffic Stress

Binder performance requirements must be selected based on the traffic stress environment, not traffic volume alone. New Zealand practice uses a stress factor framework (1–6) to characterise traffic-induced surfacing stress. This framework is documented in NOC Appendix 6.4 – Selecting Surfacing Treatments and includes both:

- A risk table linking seal type and stress, and
- A curve and gradient stress table defining how stress factors are assigned.

Risk Table – Seal Type Stress Factors

(Reproduced from NOC Appendix 6.4 – Selecting Surfacing Treatments)

SEAL TYPE	1	2	3	4	5	6
Single coat	✓✓✓	✓✓	✓	X	X	X
Single coat + active traffic control	✓✓✓	✓✓✓	✓✓	X	X	X
Single coat + active traffic control + PMB	✓✓✓	✓✓✓	✓✓✓	✓✓	X	X
Racked-in	✓✓✓	✓✓✓	✓✓✓	✓✓	X	X
Racked-in + active traffic control	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	X
Racked-in + active traffic control + PMB	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	X
Two-coat	✓✓✓	✓✓✓	✓✓✓	✓✓	X	X
Two-coat + active traffic control	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	X
Two-coat + active traffic control + PMB	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	X

✓✓✓ = Should perform satisfactorily

✓✓ = Should be considered

✓ = Marginal

X = Not recommended

This table demonstrates that as stress increases, polymer modified binders are required to maintain acceptable seal risk, particularly for single-coat and racked-in seals.

Curve and Gradient Stress Factors

(Reproduced from NOC Appendix 6.4 – Selecting Surfacing Treatments) are as follows:

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 250–400 m radius and > 10% gradient	Rural and urban curves < 250 m radius and > 10% gradient
One-lane bridge decks (Note: one-lane bridges have < 4000 vpd)	Curvature (advisory speed > 70 km/h)	Curvature (advisory speed > 70 km/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 carriageways (event-free)	Rural curves > 400 m radius	Rural curves 250–400 m radius	Railway Crossing 20–50 HCV/L/day	Rural and urban curves < 250 m radius	Approaches to and the circular section of roundabouts > 50 HCV/L/day
Divided carriageways (event-free)		Rural curves 400–800 m radius and > 10% gradient	Trucks turning (intersection) 20–50 HCV/L/day	Rural and urban curves (advisory speed 0–50 km/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 (intersection 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	

Climate Considerations

In many regions of New Zealand, pavement surface temperatures can approach or exceed 45 °C during summer, while some locations experience peak temperatures exceeding 55 °C, particularly on exposed, dark surfacings or low-speed urban roads.

Figure 5 presents the distribution of three-day maximum pavement temperatures across New Zealand. The data represents the average of the highest three-day consecutive pavement temperatures, calculated over a 10-year period. This provides an estimate of the peak pavement temperatures that a seal is likely to experience during sustained heat events in each region.

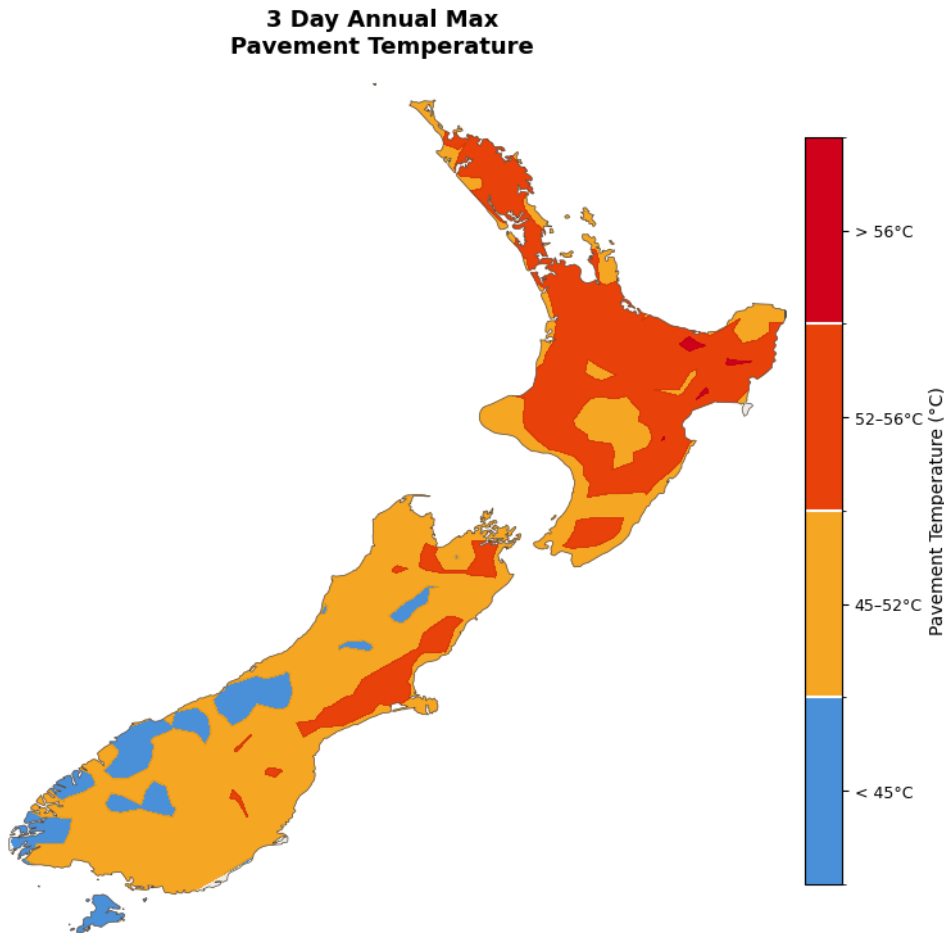


Figure 5: 10-year average of maximum three-day consecutive pavement temperatures across New Zealand

These conditions are critical, as chip seals are most vulnerable when elevated temperatures persist over multiple days with limited opportunity for cooling between daily heating cycles. Under such sustained thermal loading, binder softening becomes cumulative, significantly increasing the risk of chip movement, embedment, binder tracking and early seal damage.

Where three-day pavement temperatures remain below approximately 45 °C, standard penetration grade binders are generally suitable, even in high-stress environments, as they retain sufficient viscosity to resist shear deformation and chip loss.

However, once three-day pavement temperatures exceed approximately 45 °C, standard binders enter a higher-risk performance regime. In these conditions, particularly under high-stress loading, they are more likely to soften excessively, resulting in increased susceptibility to chip loss and shear-related deformation.

The data indicates that a significant proportion of the network regularly experiences pavement temperatures exceeding 45 °C, with some regions reaching 52–56 °C. In these environments, polymer-modified binders such as EnviroPlus Seal are required for high-stress applications to maintain adequate stability and performance.

The binder viscosity data indicates that EnviroPlus Seal reaches viscosity levels comparable to standard penetration grade binders at approximately 10 °C higher pavement temperature. Standard binders are generally suitable for low-shear environments where pavement temperatures remain below approximately 45 °C, while EnviroPlus Seal provides equivalent performance in similar environments where temperatures reach or exceed 55 °C.

This is particularly relevant in New Zealand, where much of the North Island experiences sustained three-day pavement temperatures of 52–56 °C. Under these conditions, standard binders operate well beyond their effective performance range, whereas EnviroPlus Seal maintains sufficient viscosity to resist shear deformation and retain aggregate.

As temperatures rise above 45 °C, the performance gap increases, with EnviroPlus Seal providing progressively greater resistance to shear-related deformation and chip loss, extending reliable seal performance into temperature regimes that exceed the capability of standard binders.

In addition to high temperature performance, polymer modification also improves binder flexibility at lower temperatures, reducing the risk of scabbing and embrittlement in high altitude or frost-prone environments.

Guidance on When to Specify EnviroPlus Seal

Combining the two stress tables above with CAST-validated binder performance and pavement temperature considerations leads to a clear guidance position:

Stress Factors 1–2:

Low stress environments where straight run binders may be appropriate, provided pavement temperatures remain below approximately 45 °C

Stress Factor 3:

Moderate stress environments where polymer modification should be actively considered, particularly where three-day pavement temperatures are likely to approach or exceed 45 °C

Stress Factors 4–6:

High stress environments dominated by braking, turning, curvature and heavy vehicle shear forces, where a high-stress polymer modified binder is required when pavement temperatures exceed approximately 45 °C

The suitability of standard binders within these stress categories is conditional on pavement temperature.

Where three-day pavement temperatures remain below approximately 45 °C, standard penetration grade binders are generally suitable, even in higher stress environments. However, once pavement temperatures

exceed this threshold, binder viscosity reduces to a level where resistance to shear deformation is significantly diminished.

In these conditions, particularly for Stress Factors 3 and above, polymer modified binders such as EnviroPlus Seal should be specified and are required for Stress Factors 4–6 to ensure reliable performance.

EnviroPlus Seal is specifically suited to Stress Factors 3 and above and strongly recommended for Stress Factors 4 to 6, particularly in regions subject to sustained elevated pavement temperatures.

Stress Factors 4–5 environments are particularly susceptible to chip roll-over, binder tracking, and chip loss, especially where traffic involves braking or turning movements. These effects are most pronounced during the early life of the seal while the aggregate is still orientating, and during periods of sustained elevated pavement temperature.

In such situations, loss of aggregate and binder displacement can also compromise surface texture and SCRIM (T10) performance, increasing safety risk. The use of a higher viscosity polymer modified binder improves resistance to these effects by maintaining binder stability and chip embedment under combined thermal and traffic loading.

Quality Assurance Expectations

Quality assurance for EnviroPlus Seal should align with established Road Science product control practices and include:

- Verification of emulsion and binder properties against the product data sheet
- Control of polymer dosage during manufacture
- Routine sampling and testing of supplied material
- Periodic confirmation of recovered binder properties where appropriate

Recovered binder testing provides confidence that polymer modification has been effectively incorporated and that high-stress performance is being delivered.

Seal Design and Construction

EnviroPlus Seal is intended for use within standard chip seal design and construction practices.

- No changes to normal seal design are required
- No changes to spray rates, chip selection or rolling procedures are required
- Standard traffic management and curing practices apply

As with all seals, good construction practice remains essential to achieve the intended performance.

Summary Guidance Statement

Traffic and geometric features defined in the risk and stress tables above identify environments where chip seal performance is governed by shear deformation at elevated pavement temperatures. In these environments, polymer modification provides demonstrable performance benefits.

EnviroPlus Seal should be specified for chip seal applications subject to moderate to high traffic stress, particularly where standard penetration grade binders are unlikely to provide durable performance.

This guidance is intended to support binder selection only and must be applied alongside a robust and site-specific seal design process. Chip seal performance is influenced by multiple factors including seal type, aggregate selection, application rates, and construction practice. The use of polymer modified binders does not replace the need for appropriate design and does not eliminate performance risk in challenging environments.

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