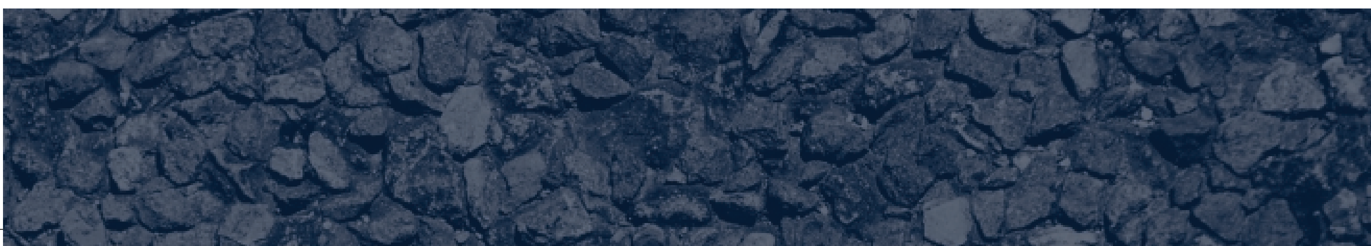
CHAPTER ELEVEN

Chipseal Construction Practices



Previous page: In the 1920s, hand spraying was the norm and application rates for bitumen and chip were less accurate than are expected and achieved today. Rules for no smoking and wearing protective clothing were unknown or not enforced, and so the job was more hazardous then.

Photo courtesy of John Matthews, Technix Group Ltd

Chapter 11 Chipseal Construction Practices

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11.1 Preparation before Sealing Day

The preparation of the road in readiness for sealing is important to do properly and thoroughly as it is basic to the quality of the final chipseal. Before programming and organising the sealing work, many tasks must be carried out, and they may include:

- Specification and contract preparation;
- Site assessment;
- Treatment selection;
- Preliminary design;
- Pre-reseal repairs;
- Traffic management plan (not necessarily for each site but for a contract or series of sites), and associated safety equipment;
- Planning to reduce environmental impacts, to provide safe work sites and to prevent accidents by preparing for:
  - environmental emergencies such as spillages (provision of spillage kits),
  - run-off control (provision of bunds around stormwater drains),
  - fire (provision of fire extinguishers and other firefighting gear on site);
- Quality plan (not necessarily for each site but for a contract or series of sites);
- Binder selection;
- Chip stockpiling and testing;
- Notification to affected stakeholders and neighbours (short-term), and community liaison (long-term);
- Plan to reinstate road marking (possibly including recording of existing roadmarking);
- Confirmation of application rate with actual chip sizes determined from testing.

These tasks have been discussed in detail in previous chapters.

11.2 Programming and Organising for Sealing

With these tasks completed or at least in progress, planning the actual seal construction process can begin in detail. To organise for the sealing day the following aspects must be considered.

11.2.1 Specification or Contract Requirements

It is important to be aware of and understand the requirements of the contract. The contract specification will detail who is responsible for different parts of the sealing process and the end result required, though it is often left to the constructor to determine whether the proposed seal will actually meet specified performance criteria.

It is therefore crucial that the person responsible for sealing on the day clearly understands the 'defects liability' and 'performance' requirements that apply under the contract.

In many circumstances the most practical treatment giving best value will in fact not meet the specification and the constructor can be left with the task of meeting requirements which cannot be achieved. This situation can often show up after the seal has been constructed and after the end of the 'defects liability' period, e.g. after the 12-month defects liability period in a TNZ P/17 Performance-based Contract has passed, and the texture is found to not meet the minimum performance criteria.

While these issues should have been considered and resolved during treatment selection stages, it is important for seal constructors to be aware of these requirements. If necessary, they should discuss any areas of uncertainty they may have with the engineer, consultant or client, in order to reach agreement before starting the sealing operations.

11.2.2 Site Assessment

Safety and environmental issues concerning the site need to considered in the planning process. For example, traffic safety (e.g. narrow shoulders, banks, limited passing), fire hazards (e.g. flammable vegetation on the berms), noise impacts (e.g. houses very close to road), possible pollution of stormwater and air (e.g. lack of catchpits in drains, open streams, spray drift into gardens), spillages of bitumen, diesel, and other chemicals.

The plan should therefore ensure that the following will be on site: firefighting equipment, fire extinguishers in easily accessible places, adequate first aid kits, bitumen burns cards, spillage kits containing sand to cover the spill, portable textile dams to block off drains, a suitably enclosed catch tank to carry away any bitumen or oily residues and a solids waste bin.

While many of the following items should have been addressed in the site assessment, treatment selection and design stages, circumstances can change and checking these items before sealing is sound practice and helps to avoid costly mistakes.

11.2.2.1 Location and Size

It is important to make sure the site is located correctly and well marked. Also make sure the sealing crew can find the site and that they do seal the correct section of road.

The site size needs to be known accurately to make sure that the volumes of materials are correct and adequate. Make sure that the limits of the site have been established with regard to entranceways, intersections, extra widening, parking bays, etc. Discuss with the client or engineer to check the location of the limits and that the treatment selection and design have considered all the site and not just the carriageway.

11.2.2.2 Community Liaison

Close and early consultation with the contractor, Road Controlling Authorities (RCAs), road user groups, directly affected neighbours and the wider community is important to minimise and manage the impacts, especially disruption, that chipsealing has on the local community and the general public.

Sealing activities have the potential to create a range of positive and negative effects for the natural environment and neighbouring communities. However, costly remedial work and unwanted negative publicity can be avoided by considering environmental and community effects early when planning sealing works.

Noise effects associated with maintenance activities and operation of road works, as well as the possibly increased traffic noise following an improvement to a road, warrant consideration when scheduling, planning and designing sealing works. The noise guidelines of the local RCA, and the input from community groups, will give guidance to mitigating the noise caused by sealing construction. Sealing at night to avoid peak traffic on motorways is common practice which, if near residential areas, may need to be restricted to certain hours.

New seals are 'tender' and can be damaged easily while they are curing and loose chip is present. The timing of sealing on a particular site is therefore important as there are occasions when the construction process can be hindered, quality affected, unnecessary nuisance caused and safety compromised because of other circumstances.

Examples could be:

- *Special events*
  The engineer and the client should be able to help sealing crews to establish if any special events will coincide with the programmed sealing. These can be events which will damage the new seal during use (such as cycle races, motor races, and marathons). Other events in the vicinity of the new chipseal can also affect the traffic flow over the new seal such as show days, concerts, parades, etc.
- *Site location and surrounding land use*
  The location and surrounding land use must be considered in treatment selection and design but also must be taken into consideration when planning to seal. Examples of locations and surrounding uses which can effect the planning and timing of sealing are:
  - *Schools:* It can be unsafe and create unnecessary nuisance to seal near schools during class times and especially at school start and finish times.
  - *Shops and businesses:* The effect on business customers should be considered, businesses can be affected by the construction and, conversely, seal construction can be hindered by business movements.
  - *Stock:* Stock crossing or using the road will seriously disrupt construction and affect quality. Sealing in the vicinity of stock saleyards and near sale days not only affects the new seal through increased traffic movements but also through effluent contamination.
  - *Forest operations and Crop harvesting:* Short-term events, sometimes one-off or annual such as the harvest of crops (maize or tomatoes for example) and of small forest lots, can cause substantial damage to new seal coats. Not only are the seals subjected to traffic stresses and heavy equipment, but often the surface is contaminated with debris from the harvest site. In these cases it is wise to complete the work far enough in advance to allow the new seal to cure, or to wait until after the harvest, if this timing will not compromise the seal construction and performance.

11.2.3 Design Assessment

Check that the supplied chipseal design does take all the site into consideration and that nothing has changed since the original assessment.

11.2.4 Plant and Equipment

11.2.4.1 Construction Plant

Plan the number of rollers required, the number of chip trucks and spreading equipment, sprayer size, supply tankers and sweeping requirements (Figure 11-1).

Figure 11-1 A 1920s road sealing team ready for work, with their steam roller, the tar kettle stoked up with the distributor nearby, rotary broom, and chip spreading trucks, in Cook County, Gisborne.

Photo courtesy of John Matthews, Technix Group Ltd

11.2.4.2 Traffic Management

Ensure the correct type and number of traffic management materials are available, e.g. the correct signs and enough of them to do the job. Check with Transit's COPTTM (2004 and amendments) for information, and that everything is available to comply with the site traffic management plan.

11.2.5 Consumables

Consumables include items and materials to be used during construction which can include the obvious hand tools and cans of spray paint etc. However consideration should also be given to include: Raised Pavement Marker covers (if appropriate), tags to assist with line marking reinstatement, and masking paper used to protect road-side furniture and for spray run starts and stops.

11.2.6 Materials

11.2.6.1 Chip

The volume of chip ordered and stockpiled should be checked against the site area to ensure enough is available to complete the project. Volumes stockpiled must allow for some 'wastage'. The amount of waste will depend on factors such as stockpile location, overall volume and the surface the stockpile sits on. Test results should be available to confirm compliance with specifications and enable final design application rate calculations.

11.2.6.2 Precoated Chip

When handling hot precoated chips, they must be covered during transport and spreading to minimise heat loss and prevent contamination.

If precoated chips are to be stockpiled before use, great care must be taken to avoid contamination with dust or other contaminants. Dust will adhere all too readily, counteracting some of the advantages gained by precoating.

Safety procedures: These must be followed, as always, because precoating materials can contain a high proportion of distillate oil and/or volatile cutter, which increases flammability risk during blending and use. The advice for the use of bitumen cutbacks contained in RNZ's COP BCA 9904 (2000) should be followed as well as the additional precautions listed below.

- If heating is required to reach the desired viscosity, this should be carried out under carefully controlled conditions at a blending plant before the precoat is transferred to a job site.
- Flame-tube heaters should not be used.
- On-site blending should not be used.
- If precoating on site, use materials only below 60°C.
- A special safety plan must be developed and put in place covering blending, storage, transport, and use of precoating materials.

Environmental issues: Although much of the volatile cutter evaporates into the atmosphere during and soon after the precoating process, the actual quantities involved are very small.

If rain occurs before full coating and absorption has taken place, a significant risk is that the precoat will wash off the surface and contaminate the environment. Once coating and absorption is complete however, a well-designed precoat is remarkably water-resistant.

Traffic issues: Traffic can pick up precoated chip that has too thick an adhesive coating and spread it far and wide.

11.2.6.3 Binder

The volume of binder needs to be checked and matched to tanker requirements. Adhesion agent and cutback volumes should be assessed and planned for. Spray temperatures should be estimated.

11.2.7 Construction Checklist

With the above items actioned, the actual construction methodology should be finalised. In this process an experienced practitioner will consider:

- Safety measures and any safety issues specific to the site.
- Notification of affected parties.
- Site size.
- Traffic volumes and traffic management requirements.
- Site characteristics and physical features and hazards which will affect the construction process such as: steep gradients, narrow carriageways, parked vehicles, overhead services, over-hanging trees and obstructions.
- Seal design type.
- Chip spread rates and how they match spreading equipment capacity, e.g. the area that a truck load of chip will cover, and if two chip sizes are being used, the order and timing of delivery onto site that will be required.
- Spray sequence and spray run size.
- Binder volumes, tankers and safe heating levels need to be considered: e.g. at the design application rate the length and width that a spray run will cover and best suit traffic use of the carriageway, chip spread rate, tanker capacity, safe heating levels, transfer times and rolling requirements.
- Spray runs and volumes must be planned to avoid the situation where tankers are left with binder below allowable spray temperatures, and cannot be re-heated because the quantity of binder is below the safe heating level for the tank.
- Longitudinal laps should be planned to ensure they do not coincide with traffic wheelpaths.
- Rolling method: e.g. type of rollers and number that are necessary, along with the pattern of rolling to suit traffic conditions: e.g. in the case of a two coat seal, one of the techniques can involve the use of a light steel-wheeled roller.
- More rolling is required on low traffic volume roads because on high traffic volume roads traffic can be diverted, if managed correctly, to roll the new seal.

- Sweeping requirements both before- and after-sealing: e.g. check if materials need to be removed from site; and from kerb and channel (K&C).
- Plant and people/staff required.

11.3 Preparation for Chipseal Construction

11.3.1 Chipsealing Techniques

The performance of all seal types is directly affected by the techniques used during chipseal construction. Quite different seal performance characteristics can be achieved with the same seal type but different sealing technique. This is not to say there is a right or wrong way to construct a seal, but merely that different results can be achieved depending on the construction methods used.

For example two coat seals are very dependent on the chip size compatibility, the chip spread rate achieved, and the rolling technique used, as outlined here (Figure 11-2):

- A two coat with very high spread rates used for the bottom coat will result in large 'windows' which allow the small chip to fall in beside the large chip and be in contact with the bottom layer of binder. This will result in a two coat which looks a little like a racked-in seal. This can reduce the overall binder volumes required, and achieve high texture but may not be as stress-resistant as a two coat with more chip interlock.
- A two coat constructed with less space between the larger chips than described above, with the small chip locking into the large chip with little contact with the underlying surface, will look quite different to the above seal.
- If the bottom coat of chip is rolled before the second spray of bitumen is applied, this will produce a different looking seal to a two coat which is not rolled between coats.
- In some situations the bottom coat is rolled with one pass of a light steel-wheeled roller. This has the effect of pushing the large stone flat onto its AGD, and the resultant seal can be more smooth, very tough, and quieter, but with less overall texture.

Construction techniques therefore must be considered and discussed with the engineer or client to make sure the end result is what is expected and needed, and is the best engineering solution for each site.

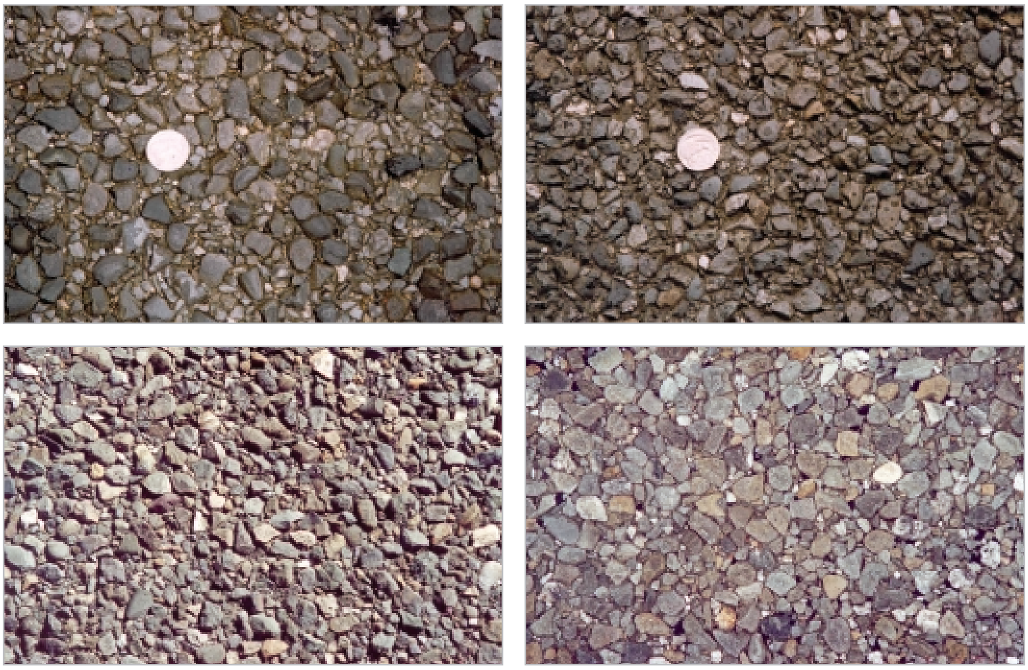

Figure 11-2 As with two coat seals, a wide variety of finishes can be achieved with racked-in seals. (The coin is about 3cm diameter.) Photos courtesy of Les McKenzie, Opus

11.3.2 Cutter

Binders are cut back to increase their wetting ability and adhesion to chip (Section 4.2.1). The choice of cutter type and amount of cutter by volume depends on the local climatic conditions and, in particular, on the temperatures of sealing day (Table 11-1) and the following few days and nights (as explained in Section 4.7.4.1, Figure 4-17).

Not enough cutter can result in a binder which is too stiff and, in cold conditions, this can cause stripping. But too much cutter can result in a binder which is too soft and will not hold chip in place, or will become soft in hot weather and cause stripping, bleeding or flushing.

The volume of cutter to be blended with the bitumen is part of chipseal design (Chapter 9) and should be decided before arriving on site because cutter needs to be blended at a central blending plant. Adding cutter to a binder is an extremely dangerous operation, and is not recommended to be carried out on-site (Chapter 2). Whether on-site or in a blending plant, cutter must never be added through the bitumen-tank top onto a hot load of bitumen. RNZ's COP BCA 9904 lists the procedures for bleeding and cutting.

Table 11-1 A guide to the recommended diluent content in relation to bitumen grade and average shade air temperature.

Average Shade Air Temperature (°C) for sealing period	Recommended Diluent Content			
	Bitumen: 180/200		130/150	80/100
	First Coat	Reseals	Reseals	Reseals
	Diluent (pph)		Diluent (pph)	Diluent (pph)
12.5	11	8	10	12
15.0	10	6	8	10
17.5	9	4	6	8
20.0	7	2	4	6
22.5	5	0	2	4
25.0	3	0	0	2
27.5	2	0	0	0
30.0	2	0	0	0
32.5 & over	2	0	0	0

Note: Up to 4 parts extra may be added for late season sealing or for other anticipated adhesion difficulties.

11.3.3 Flux

As explained in Sections 4.2.1 and 8.2.1, fluxing is usually achieved by the addition of AGO to permanently soften a binder. The amount of flux will be determined in the binder determination and design. The addition of the flux and calculating the volume to be added is part of the preparation and construction process.

11.3.4 Adhesion Agent

Adhesion agents are added to assist with chip–binder adhesion and to prevent stripping in wet weather. This does not mean that adding an adhesion agent allows sealing to be carried out in wet weather but it does help prevent failure if wet conditions are experienced shortly after sealing.

In some situations, even in dry conditions, a particular aggregate type may require the addition of an adhesion agent to promote good adhesion.

11.3.5 Calculating Binder Constituents

To calculate the constituents (bitumen, cutter, flux, adhesion agent) of a binder we consider them in terms of parts per hundred (pph). A worked example showing how to calculate volumes is on pages 429-431.

Note: calculating by 'parts per hundred' is not the same as calculating by 'percentages'.

Worked Example

To Calculate the 'Parts' of a Bitumen Binder

Volume of kerosene in the binder	=	'one part' multiplied by the number of parts of kerosene
Volume of adhesion agent in the binder	=	'one part' multiplied by the number of parts of adhesion agent
Volume of AGO in the binder	=	'one part' multiplied by the number of parts of AGO
Volume of bitumen in the binder	=	'one part' multiplied by 100 (number of parts of bitumen)
Volume of 'one part'	=	Total binder divided by total number of parts

Example 1: To convert pph to ℓ

Binder at 15°C	6450 ℓ	=	100 pph		
Kerosene		=	5 pph		
AGO		=	2 pph		
Adhesion agent		=	0.7 pph		
	total parts	=	**107.7 pph**		

$$\textit{Volume of 'one part'} = \frac{\textit{Total binder}}{\textit{Total number of parts}}$$

$$\text{'one part'} = \frac{6450\ \ell}{107.7}$$

$$= \mathbf{59.89}\ \ell$$

Volume of kerosene in binder = *'one part' multiplied by number of parts kerosene*

Kerosene = $5 \times 59.89\ \ell$ = $299\ \ell$

Volume of AGO in binder = *'one part' multiplied by number of parts AGO*

AGO = $2 \times 59.89\ \ell$ = $120\ \ell$

Volume of adhesion agent in binder = *'one part' multiplied by number of parts adhesion agent*

Adhesion agent = $0.7 \times 59.89\ \ell$ = $42\ \ell$

Volume of bitumen in binder	= *'one part' multiplied by 100 (number of parts bitumen)*	
Bitumen	= 100 × 59.89 ℓ	= 5,989 ℓ
Total volume	= **6,450 ℓ**	

Example 2: To convert ℓ to pph

Binder at 15°C	= 7600 ℓ
Kerosene	= 220 ℓ
Adhesion agent	= 4 bags (40 kg)

To calculate parts of adhesion agent and kerosene in the binder

Volume of bitumen / 100	= Volume of 'one part'	
Total binder	= 7600 ℓ	
– less kerosene	= 220 ℓ	
Binder less kerosene	= 7380 ℓ	
– less adhesion agent	= 40 ℓ	
Volume of bitumen	= 7,340 ℓ	
Volume of bitumen in binder	= *'one part' multiplied by 100 (number of parts bitumen)*	
Volume of 'one part'	= 7340 ℓ/ 100	
therefore Volume of 'one part'	= **73.4 ℓ**	
Volume of kerosene	= **220 ℓ/ 73.4**	= **3.0 pph**
Volume of adhesion agent	= **40 ℓ/ 73.4**	= **0.5 pp**

The formulae are expressed in words rather than symbols, ready for use while on the job

To calculate the changes required to make one binder into another binder (e.g. 'left over')

Step 1	Calculate the components of the final binder
Step 2	Calculate the components of the existing binder
Step 3	Subtract 'step 2' from 'step 1' to give the components to make up the new binder

Example 3: To convert one binder to another

We have 5,000 ℓ of 180/200, with 2pph AGO and 3pph kerosene, i.e. 105 total parts
We want 12,000 ℓ of 180/200, with 2pph AGO and 5pph kerosene, i.e. 107 total parts

Step 1 Calculate the components of the final binder

Final Binder

Volume of one part	= 12000 ℓ/107		
	= 112.15 ℓ		
Kerosene	= 112.15 ℓ × 5	=	560.8 ℓ
AGO	= 112.15 ℓ × 2	=	224.3 ℓ
Bitumen	= 112.15 ℓ × 100	=	11,215.0 ℓ
	Total	=	**12,000.0 ℓ**

Step 2 Calculate the components of the existing binder

Existing binder

Volume of one part	= 5000 ℓ/105		
	= 47.62 ℓ		
Kerosene	= 47.62 ℓ × 3	=	142.9 ℓ
AGO	= 47.62 ℓ × 2	=	95.2 ℓ
Bitumen	= 47.62 ℓ × 100	=	4,762.0 ℓ
	Total	=	**5,000.0 ℓ**

Step 3 To convert the existing binder to the final binder, you need to add:

Kerosene	= 560.8 – 142.9 ℓ	=	417.9 ℓ
AGO	= 224.3 – 95.2 ℓ	=	129.1 ℓ
Bitumen	= 11215 – 4762 ℓ	=	6,453.0 ℓ
	Total	=	**7,000.0 ℓ**

11.3.6 Binder Spray Temperature

To ensure even distribution, binders must be sprayed within a specific temperature range. Once the final make up of the binder has been decided, the spray temperature is then calculated. The seal design process will calculate a residual spray rate (litres/m^2) which is 'cold' and without cutter, flux or adhesion agent. It is the task of the sealing constructor or sealing crew to calculate the final binder constituents and the final hot spray rate including or excluding cutter, flux and adhesion agent (in litres/m^2).

Spraying cold binder (i.e. binder not heated to within the recommended spray temperature range) can result in poor distribution, streaking and chip loss.

The process to calculate the final spray rate from the residual spray rate is as follows:

1. Spray temperatures are established (from Table 11-2 which indicates the recommended spray temperatures for binders based on the three most commonly used penetration grades of bitumen: 180/200, 130/150 and 80/100);
2. Then a conversion heating factor from cold to hot binder is used (from Table 11-3).

11.3.7 Sealing Chip Spread Rates

In an effort to continually improve the performance and cost-effectiveness of our chipsealing operations chip coverage rates are reviewed as follows.

Earlier designs were based on this basic formula:

$$\text{Spread Rate} = \frac{630}{\text{ALD}}\ \text{m}^2/\text{m}^3 \qquad \text{Equation 11-1}$$

For average chip sizes this provided target rates[1] of 58, 72, 93 and 126 m^2/m^3 (assuming an ALD of 5 mm for Grade 5 chip) for Grades 2, 3, 4 and 5 chips respectively (Figure 11-3).

The revised target spread rates are based on a change in the formula to:

$$\text{Rate} = \frac{750}{\text{ALD}}\ \text{m}^2/\text{m}^3 \qquad \text{Equation 11-2}$$

This represents a considerable increase in spread rates,[1] i.e. 92, 114, 147 and 200 m^2/m^3 for Grades 2, 3, 4 and 5 (Figure 11-4). Because of the size of the increase, the suggestion is that sealing crews move cautiously towards these new target rates, while considering the following points:

[1] Assumes average ALD from TNZ M/6:2004 tables.

Table 11-2 Recommended spraying temperatures for hot bitumen binders, based on the 3 most commonly used penetration grade bitumens.

(i) For Binders Based on 180/200 grade Bitumen

Total Diluent	Temp. °C	Total Diluent	Temp. °C
0	160-180	8	141-161
1	157-177	9	139-159
2	155-175	10	136-156
3	153-173	11	134-154
4	150-170	12	132-152
5	148-168	13	129-149
6	146-166	14	127-147
7	143-163	15	125-145

(ii) For Binders Based on 130/150 grade Bitumen

Total Diluent	Temp. °C	Total Diluent	Temp. °C
0	167-187	8	147-167
1	164-184	9	145-165
2	162-182	10	142-162
3	160-180	11	140-160
4	157-177	12	138-158
5	155-175	13	135-155
6	153-173	14	132-152
7	150-170	15	130-150

(iii) For Binders Based on 80/100 grade Bitumen

Total Diluent	Temp. °C	Total Diluent	Temp. °C
0	175-195	8	154-174
1	172-192	9	152-172
2	170-190	10	149-169
3	167-187	11	147-167
4	165-185	12	144-164
5	162-182	13	141-161
6	160-180	14	138-158
7	157-177	15	136-158

Table 11-3 Heating factor (H_{fh}) for hot bitumen binders.

Temp °C	Multiplier	Temp °C	Multiplier	Temp °C	Multiplier
15	1.0000	76	1.0393	138	1.0813
16	1.0006	78	1.0407	140	1.0827
18	1.0019	80	1.0420	142	1.0841
20	1.0031	82	1.0433	144	1.0854
22	1.0044	84	1.0446	146	1.0868
24	1.0057	86	1.0459	148	1.0883
26	1.0066	88	1.0473	150	1.0897
28	1.0083	90	1.0487	152	1.0911
30	1.0095	92	1.0500	154	1.0924
32	1.0107	94	1.0513	156	1.0939
34	1.0120	96	1.0526	158	1.0953
36	1.0133	98	1.0540	160	1.0967
38	1.0146	100	1.0553	162	1.0982
40	1.0158	102	1.0566	164	1.0995
42	1.0171	104	1.0580	166	1.1010
44	1.0184	106	1.0593	168	1.1023
46	1.0197	108	1.0607	170	1.1038
48	1.0210	110	1.0620	172	1.1052
50	1.0223	112	1.0634	174	1.1066
52	1.0235	114	1.0648	176	1.1080
54	1.0249	116	1.0662	178	1.1094
56	1.0262	118	1.0675	180	1.1109
58	1.0275	120	1.0688	182	1.1123
60	1.0288	122	1.0702	184	1.1137
62	1.0301	124	1.0716	186	1.1152
64	1.0315	126	1.0730	188	1.1166
66	1.0327	128	1.0743	190	1.1181
68	1.0341	130	1.0757	192	1.1196
70	1.0452	132	1.0771	194	1.1210
72	1.0367	134	1.0785	196	1.1225
74	1.0380	136	1.0800	198	1.1238
				200	1.1254

Source: ASTM D4311-83, Table 2

1. **No changes** in current spread rates should be attempted until they have been confirmed, i.e. find out what the present spread rate is before making any changes.
2. Increase the rates slowly. If the previous rate for a grade 4 chip was 90 m^2/m^3, the next target should be 100 to 105 m^2/m^3.
3. When assessing spread rates, the volume (m^3) of chip on the truck must be known to a reasonable degree of accuracy, e.g. if the truck's expected load is 10 m^3, then the actual volume of chip must be calculated to within 0.5 m^3 or so.

Note: Weight to volume conversions (i.e. weight per 1 m^3 of chip) for each grade of chip to use will be available from the supplier. Calculating the volume of the truck load from the weighbridge docket then becomes a simple calculation, i.e.:

$$\text{Volume of load} = \frac{\text{Weighbridge docket}}{\text{Weight of 1m}^3\text{ of Grade 4 chip}}$$

Weight of 1 m^3 of grade 4 chip = 1.52 tonnes
Weighbridge docket = 11.24 tonnes

$$\text{Volume of Load} \quad \frac{11.24}{1.52} = 7.40\ \text{m}^3$$

If the target spread rate is 110m^2/m^3 then:

$$\begin{aligned}\text{Area the load will cover} &= \text{Volume of load} \times \text{Spread rate}\\ &= 7.4 \times 110\\ &= \mathbf{814\ m^2}\end{aligned}$$

When working from stockpiles, assessing the volume of the load will obviously be more difficult but may be achieved with reasonable accuracy if the volume of the loader bucket is known. Another method would be to check the application rate of the first truck by measuring the volume of the tray and striking the load off flat with the top of the tray. Calculate the spread rate using the formula shown above, re-arranged as shown:

$$\textbf{spread rate} = \frac{\textbf{area the load covers (m}^2\textbf{)}}{\textbf{volume of load (m}^3\textbf{)}}$$

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Figure 11-3 Previously advice was to aim for a chip spread-target rate as shown at the top of this page. This is now considered as over-chipping. The image at the bottom of the page shows a very over-chipped seal. Photos courtesy of Shirley Potter, Opus

Figure 11-4 Now advice is to aim for a chip spread-target rate as shown at the top of this page. This was previously considered as under-chipped. The image at the bottom of this page shows a chip spread rate suitable for use in the first layer of a racked-in chipseal. Note the large 'windows' where smaller chip in the second layer can adhere to the binder. Photos courtesy of Shirley Potter and Les McKenzie, Opus

4. The ability to achieve the new target rates will depend greatly on the type of sealing that is required. For example, when sealing a long straight section of State Highway 1, the chances of achieving target rates of sealing chip application will be far better than if the job is on a busy street in Auckland City with many intersections and roundabouts, etc.
5. However, irrespective of the actual rates achieved, significant savings can be made in all sealing situations if the process is properly controlled.
6. Ways in which savings can be made on volume of chip used include:
   i. Consider hand spreading of chip around the 'wings' of intersections rather than using the spreader.
   ii. As chip is usually spread to a 2.4 m width, and the bitumen sprayer sprays at 3 m width, usually a second pass of the chip spreader is made with some of its tail gates closed. Despite the best care, this often ends up with double-applied chip in some areas. Where weather conditions and seal type allow, it can be acceptable to leave a narrow length of unchipped seal for short periods, until the next spray run has been completed, and then complete the chip spreading.
   iii. Consider reducing the number of runs to reduce the number of overlaps (i.e. use the spraybar at its widest practical setting).

The aim is to apply the same level of control into the spreading of chip that is put into the spraying of binder.

> Ultimately the 'best' spread rate will be that which provides the most economic use of sealing chip while providing the required interlock of the individual chips.

11.4 Seal Construction on the Day

11.4.1 Rolling

Rolling can begin as soon as the chip has been applied and has been satisfactorily spread on the binder (Figure 11-5). Current rolling practice varies from seal type to seal type but is usually carried out by bedding in the chip with a pneumatic-tyred roller (PTR) travelling at around 8 km/h for about five roller passes. See discussion on the effects of rolling in Section 4.2.2.

The number of passes, the speed of the rollers, the number and type of rollers required will depend on site conditions, seal type and traffic count. They should be considered as part of the site planning in conjunction with the site traffic management plans (see TNZ COPTTM, 2004 and amendments).

Figure 11-5 Once the planning has been done, seal construction can begin.
Clockwise from top left: Spraying the binder. Top right: Spreading the chip. Bottom right: Rolling underway while waiting for the chip-spreading operation to complete the second run. Bottom left: Rolling underway on the almost completed seal. Photos courtesy of David Ashby, Opus

Because rolling plant can create significant traffic hazards and add to the dangers of sealing very busy sections, traffic can be used on site to assist with rolling. In these cases, the rollers can be used for the initial passes to push the chip into place and then be replaced by traffic. If managed correctly and moved across the sealing site, traffic can continue to bed the chip into the binder.

The construction crew should set up rolling patterns that concentrate on the areas which only receive intermittent traffic, e.g. parking bays, shoulders and centrelines.

Special attention should also be paid to the site if a cold front is predicted or arrives during seal construction. The arrival of a cold front causes a rapid drop in pavement temperature which will interfere with the formation of the bond between binder and chip (Pollard 1967). Shaded areas can also cause bitumen to cool too rapidly for good adhesion to occur. See discussion in Section 11.4.5.

If temperatures drop suddenly or a chipseal is to be constructed in a shaded area, extra rolling and low-speed trafficking can help prevent chip loss. These measures work because the effect of rolling and traffic on the development of a good bond can be considered to be similar to a pressure-sensitive adhesive. As the viscosity of bitumen is stress-dependent, the stress from vehicle tyres causes the binder to have lower viscosity and also increases the rate of wetting. The rate of wetting will be directly proportional to the stress imposed (Forbes et al. 2000).

11.4.2 Drum Rollers

Drum rollers, also called flat drum rollers because they have no tread, are either steel or rubber coated. The use of a flat drum roller can produce a very flat seal coat as the drum has the effect of pushing the chip onto its flat (i.e. its AGD is embedded in the binder, and its ALD is the vertical dimension).

This technique can be used on most seal types and especially for single coats, two coats and racked-in seals. In constructing racked-in or two coat seals, if the first layer of chip is rolled with this kind of roller, the finished result will be a smoother flatter seal with less macrotexture than a seal which has been rolled with only a PTR.

Care is required however to prevent chip crushing, especially with steel drum rollers. Usually only one pass is required to make the chip lie flat.

Road shape should also be considered when using flat drum rollers as many pavements have some rutting (often shallow, and generally in the wheelpaths) and this will result in the drum bridging the ruts and not making contact with the chip in them. If traffic is not well managed during the initial compaction period, the seal in the ruts in the wheelpaths does not get rolled enough, and is at risk of early stripping.

11.4.3 Heating Binder

Binders must be heated to reach the appropriate viscosity to ensure even spraying and distribution. This procedure requires care when heating to carry it out safely and to avoid binder degradation. BCA 9904 must be followed when heating and only experienced trained staff should be involved.

When tankers are heating bitumen on site:

- Binder levels must be checked to make sure they are above safe heating levels.
- The tanker must be on level ground.
- The tanker must be attended at all times unless the unit is specifically designed to be heated while unattended.
- Rise in temperature must be controlled (this varies for different binder types).
- Certain binders, e.g. PMBs, are particularly sensitive to heating rate.
- The tanker must not be moved for 15 minutes after heating has been stopped.

11.4.4 Spraying

11.4.4.1 Spraybar Height

Correct spraybar height is crucial to achieving accurate spray rates and correct distribution across the spray area. As part of the E/2 certification (NZ BCA 1992) of a sprayer, the spray bar height will be noted and this should be checked regularly and corrected on site. Spraybars at an incorrect height can be a leading cause of streaking of binder (or stripes) on the road surface. When operating at the wrong height binder streaking will occur with corresponding chip loss.

11.4.4.2 Spraybar End Nozzles

A spraybar end nozzle is designed to prevent the last spray nozzle from 'fanning' at the outer edge, and to allow the full application rate right up to the outer edge of the spray run. It can provide a defined line at the outer edge of the sprayed area. Because the correct binder application rate is only achieved with a triple overlap of nozzles, the outside edges of the spray area will not receive the full design spray rate if an end nozzle is not used.

Some clients however prefer not to apply the full rate at the outer edge as this can cause run-off where the road surface drops off into the kerb and channel, or onto an unsealed shoulder. Instead they prefer to allow the last nozzle to fan at the outer edge. Often the reason for this is that usually traffic does not use the edge, and chip loss caused by a lighter application over the last few millimetres of the road edge may not be a problem.

The use of end nozzles is not always specified. Therefore if it is not clearly defined in the specification, it is wise to discuss the issue with the client to decide which method is best for their road.

11.4.4.3 Variable Rate Spraybars

In more recent years variable rate spraybars have made it possible to spray more than one application rate over a single spray run. This can be useful for applying more binder to shoulders or coarse textured areas while applying a different rate to wheelpaths in the same pass.

As technology develops, spray systems will become more sophisticated. To assist with their development, practitioners, engineers, consultants and clients should all be open to new improvements and allow trials to be carried out during their particular works.

11.4.4.4 Spray Runs

As discussed above, spray runs should be carefully planned to match the site conditions, the seal type, the design, chip and the plant on site.

When planning the spray run an approximate layout is developed, based on initial test results gathered during the programming and pavement check phase. Road geometry, variations and gradients, etc., are taken into account on a visual examination of the road.

Run start / stops

The start and end positions, widths and tapers need to be planned and documented in advance in all but the very simplest situations. It is essential that the appropriate application rates are designed in advance for different parts of the pavement to be sealed, and that the field construction personnel are absolutely in no doubt where each change in rate is to occur.

Strong paper should be used at spray run starts and stops to ensure that clean straight lines are achieved (Figure 11-6).

Figure 11-6 A spray run about to start. Note the paper spread in place so that an accurate start line can be achieved.

Photo courtesy of Les McKenzie, Opus

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Laps

To achieve full application rates, longitudinal joints need to overlap (distance of which is specified in the distributor's BCA E/2 certificate) to achieve the triple overlap of spray nozzles. Longitudinal laps between spray runs should, as far as is possible, be planned to be on lane boundaries, and not in the wheelpaths.

Tapping on and off

The width of seals will often vary along the length of a spray run. To cater for the variation in width, spraybars usually have the ability to traverse sideways a short distance and extra taps are turned on or off while spraying.

In the past the practice of 'tapping on or off' was frowned on by some, because adding or reducing taps during a spray run can have the effect of changing the spray application rate. Usually though, an experienced sprayer operator adjusted the spray pump output to compensate for the changing number of nozzles during the spray run.

More modern sprayers have the ability to automatically adjust and maintain a constant application rate when spray nozzles are turned on or off during a spray run. Telescopic spray bars allow the overall bar width to vary without altering the application rate across the bar.

11.4.4.5 Spraying on Difficult Areas

On sharp bends

> While often very little can be done to avoid them, sharp bends will have an effect on application rate across the road. Because the end of the spraybar on the inside of the bend travels slower than the outer end, the application rate will be lighter at the outside than the inside of the bend.

Experienced practitioners will be aware of this and will attempt to minimise the effect as best they can by reducing the spray width. However reducing the spray width down to narrow strips is not always practical. It also introduces more possibility for error by increasing the number of joints, in a position where a quality joint is difficult to construct. In extreme cases a chipseal may not be the best treatment anyway, and a realistic practical approach is required and alternatives should be discussed with the client.

On excessive cambers

As with sharp bends, excessive camber (where the road crossfall is steep) can affect application rates across the road. The effect is that the spraybar can come very close to the road on the low side and can be higher off the road on the high side. This alters the overlap of the spray nozzles at the point of contact with the road so that heavy rates are applied close to the road while light rates are applied when the bar is high.

In some cases the effects can be minimised by altering the bar height and/or the spray width. However not all circumstances will allow this to be completely successful. Unfortunately sharp bends are often associated with excessive camber and, when combined, these can make achieving the required residual application rate over the full spray width very difficult. As with sharp bends a chipseal may not be the best treatment and a realistic approach toward alternatives is required.

On intersections

At intersections in particular, and generally wherever the road has a complex shape, it is an important task to ensure that hand-sprayed areas are kept out of major traffic wheelpaths. Failure to do so risks flushing and tracking of excess binder over wide areas. Therefore the most desirable procedure is to prepare a plan of the intersection, showing the areas and spray rates of each run.

11.4.4.6 Hand Spraying

Hand spraying should be kept to a minimum because it is operator-dependent, and experienced persons are now rare (Figure 11-7).

Figure 11-7 In the 1920s, hand spraying was the only way to get the binder onto the road. It required highly developed skills to apply the binder evenly over the surface.

Photo courtesy of John Matthews, Technix Group Ltd

Hand spraying is carried out in difficult areas which cannot be sprayed with the spraybar because of their shape or restricted access. Usually areas such as triangles at road intersections, odd shapes, around posts and guard rails, and areas very close to buildings, are hand sprayed.

Control of application rate is very difficult and completely operator-dependent. An experienced operator is required, and even then the actual rate applied can be very difficult to determine because the small volumes sprayed are not easy to measure accurately. In many cases the inaccuracy does not affect the end result, e.g. hand spraying around the posts of guardrails.

However in important areas, such as the 'wings' of intersections and odd-shaped areas of entrance ways where traffic stress is high but space for a mechanical sprayer is limited, hand spraying has to be used despite the disadvantage of controlling the application. In many cases these problems cannot be avoided and, until more innovative construction methods are developed, operator experience and increased care are the only factors that can reduce risk.

Practitioners should rely on experience and care while clients and specification writers should be aware of the constraints and take a practical approach.

11.4.5 Weather Conditions

As touched on in Section 11.4.1, the arrival of a cold front or presence of shaded areas on the road can cause the binder to cool too rapidly for adequate binder–chip adhesion to occur. The reason behind this is that the rate of wetting of a binder on a stone is an inverse function of the binder viscosity (Forbes et al. 2000).

Forbes' research showed that the change in viscosity with temperature is exponential, i.e. viscosity increases rapidly with decrease in temperature and this increasing binder hardness has a very significant effect on the time for wetting, and therefore adhesion, to take place. (See Figures 4-4 and 4-6, and discussion in Section 4.2.3.)

This work also illustrates in part why initial adhesion problems can occur where a pavement is in the shade. The pavement in the sun could be at 35°C but in the shade below 20°C. Thus the chip in the sun-lit areas may have adhered when the construction crew leaves the site, but in the shaded area it may not have adhered and chip loss may occur overnight and over subsequent days. Seals constructed earlier in the day generally adhere and perform well.

11.4.6 Remedial Work

Remedial work is covered in Chapter 12.

11.5 Preparation for Sealing with Emulsions

11.5.1 Introduction

This section discusses issues relating to the use of and preparation required for sealing with emulsified binders (see also NZ BCA 1996).

Chipsealing emulsions are described in Section 8.3, and are simply another means of placing a bituminous binder into a chipseal surfacing. Advantages of emulsion are listed in Section 8.3.6.

11.5.2 Material Selection

Bitumen grades used for emulsion sealing should be the same as those used for cutback sealing, although harder grades can be considered.

The base bitumen may contain small volumes of diluent, e.g. kerosene, to:

- reduce settlement or upcreaming by matching density of dispersed phase to that of the continuous phase;
- improve green-strength of seals constructed under cool conditions by increasing the rate of droplet coalescence, and hence formation of a continuous binder film.

> The composition of the binder in the emulsion should be discussed with the manufacturer, taking into consideration the required break rate, site stresses, seal type, road geometry, site climatic conditions, and expected pavement temperatures during construction.

The type and quantity of emulsifier used in the emulsion is generally proprietary information. Therefore the contractor should inform the manufacturer if long distance transportation of the emulsion is required, for which adjustments to the formulation may be needed.

The type and grade of emulsion that is used for chipsealing depends on the nature of the seal coat as listed in Table 11-4. It is expected that cationic emulsions will be selected because of their active breaking characteristics and good adhesion to most aggrgeates used in New Zealand. This list is only a general guideline.

Table 11-4 Emulsion grades used for various seal types.

Seal Type	Emulsion Grades
Voidfill	CQ55, CQ60
First coat seals	CQ65, CQ70
Reseals	CQ65, CQ70
Two coat seals	CQ65, CQ70
Wet lock seals	CQ55, CQ60, CQ70

Lower viscosity emulsions, hence with lower binder content, are recommended for seals where the binder is required to collect in the surface voids of the substrate, e.g. voidfills, wet lock seals. Higher binder content emulsions with higher viscosities are recommended for reseals where there is risk of run-off, and for higher application rates for coarser seals.

Advanced emulsions that contain polymer modifiers have become available in recent years. These emulsions may be manufactured using PMBs, or have the polymer added in a latex form during manufacture. These polymer modified emulsions (PME) are proprietary materials so careful assessment should be made of the claimed material properties to allow comparisons to be made with similar or conventional emulsions. Experience has shown that these PMEs allow the use of highly modified binders but with a reduced risk of failure compared with hot-sprayed modified binders.

11.5.3 Spray Rate Calculations

The design principles of chipseals constructed using emulsified binders are the same as those using cutback bitumen and have been described previously in this book. Specific matters for consideration that relate to emulsions follow.

Calculate the normal residual binder application rates using the formula for chipseal (Equation 9-13) in Chapter 9. As emulsions comprise binder dispersed in water, spray rates must be factored upwards to allow for the water in the emulsion, using the formula below. If emulsions are sprayed at elevated temperatures, e.g. for viscous grades such as CQ70, the expansion of the emulsion caused by heating must also be accommodated by multiplying the emulsion spray rate with the Heating Factor from Table 11-5.

$$\mathbf{ESR} = \mathbf{R} \times \frac{\mathbf{100}}{\mathbf{EBC}} \times \mathbf{H_{fe}}$$

where:

ESR	=	Emulsion Spray Rate (ℓ/m^2 at 15°C)
R	=	Residual Binder Application Rate (ℓ/m^2) at 15°C, from Equation 9-13
EBC	=	Emulsion Binder Content (%)
H_{fe}	=	Heating factor to compensate for volume changes due to elevated spraying temperatures (see Table 11-5).

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Additional care must be taken for emulsion spray rates greater than approximately 1.8 ℓ/m² due to the risk of run-off. This also depends on substrate texture, road geometry and seal type. Some emulsions with binder content greater than 72% and hence higher viscosity may be sprayed at higher application rates. However, as these are generally proprietary materials they should only be used in accordance with the manufacturer's instructions.

Table 11-5 Heating factors (H_{fe}) for use with emulsions.

Temperature (°C)	Multiplier H_{fe}	Temperature (°C)	Multiplier H_{fe}	Temperature (°C)	Multiplier H_{fe}	Temperature (°C)	Multiplier H_{fe}
15	1.0000	35	1.0094	55	1.0189	75	1.0286
16	1.0005	36	1.0098	56	1.0194	76	1.0291
17	1.0009	37	1.0103	57	1.0199	77	1.0296
18	1.0014	38	1.0108	58	1.0204	78	1.0301
19	1.0019	39	1.0113	59	1.0208	79	1.0306
20	1.0023	40	1.0117	60	1.0213	80	1.0311
21	1.0028	41	1.0122	61	1.0218	81	1.0316
22	1.0033	42	1.0127	62	1.0223	82	1.0321
23	1.0037	43	1.0132	63	1.0228	83	1.0326
24	1.0042	44	1.0136	64	1.0233	84	1.0331
25	1.0047	45	1.0141	65	1.0237	85	1.0336
26	1.0051	46	1.0146	66	1.0242	86	1.0341
27	1.0056	47	1.0151	67	1.0247	87	1.0346
28	1.0061	48	1.0155	68	1.0252	88	1.0350
29	1.0065	49	1.0160	69	1.0257	89	1.0355
30	1.0070	50	1.0165	70	1.0262	90	1.0360
31	1.0075	51	1.0170	71	1.0267	91	1.0365
32	1.0079	52	1.0175	72	1.0272	92	1.0370
33	1.0084	53	1.0179	73	1.0276	93	1.0375
34	1.0089	54	1.0184	74	1.0281	94	1.0380
–	–	–	–	–	–	95	1.0385

11.5.4 Emulsion Binder Spray Temperature

The recommendation is that emulsions with binder contents greater than about 65% should be sprayed hot, usually in the range of 80°– 95°C. Two reasons are given for this recommendation.

- The elevated temperature reduces the emulsion viscosity, thus aiding pumping and distribution through the spray nozzle.

- The heat of the emulsion accelerates evaporation of the water during spraying.

Emulsions with lower binder contents may be sprayed from ambient temperatures up to 95°C.

While some chipsealing emulsions may contain small volumes (≤5 pph) of diluents such as kerosene in the binder, the suggestion is that adjustment of the application rate to compensate for the evaporation of the diluent may be neglected because volume changes are gradual and negligible. As emulsions are sprayed at relatively cool temperatures, diluents will evaporate slowly after the emulsion has broken and the seal has been constructed. Consideration should be given to the upward adjustment of application rates to compensate for diluent loss if more than (say) 5 pph of diluent is present in the emulsified binder.

11.5.5 Plant and Handling

Emulsions are sprayed using bitumen distributors complying with the BCA E/2 specification. Consideration must be given to the following:

- Tanks should be cool before loading with emulsions.
- As emulsions are water-based, they will boil if heated to 100°C. Therefore the recommendation is that temperatures do not exceed 95°C.
- When heating emulsions it is preferable to use electric elements that have lower and evenly distributed surface temperatures compared with flame tubes. If flame tubes are used, the heating rate should be reduced enough to prevent high flame-tube surface temperatures that could cause localised boiling.
- Excessive circulation through the pump will cause coalescence of the binder droplets in the emulsion, and eventually the emulsion can break. It is recommended that circulation is minimised.
- Emulsions will not remove binder residues in pipework. If pipework is partly or fully blocked, flushing and cleaning with hot bitumen is necessary before introducing emulsions.
- Spraybar height, or nozzle type or nozzle angle, may need to be changed because emulsion spray characteristics are different to cutback bitumen. This is shown by streaking, visible in sprayed surfaces.

Sprayers that have previously contained emulsion often have small volumes of emulsion or water remaining, either trapped under a skin of binder, or in pipework. This is a significant hazard if hot binders with temperatures over 100°C are introduced. The water will boil on contact with the hot binder, flash into steam, and the consequent expansion will cause the binder to foam. If the volume in the tank is sufficient, it will be violently ejected. Tanks must be carefully de-watered by adding small volumes of hot binder and allowing the water to boil off under controlled conditions. Refer to the Bitumen Safety Book (NZ PBCA 2001), and the Code of Practice BCA 9904 (2000) available from Roading NZ for more information and advice.

11.5.6 Construction

There are some specific differences in practice when constructing chipseals using emulsified binders:

- The sealing chip must be clean. Emulsions will break and adhere to any dust on the surface of sealing chip but not penetrate the dust layer and bond with the chip surface. The use of dirty chip increases the risk of early chip loss.
- Sealing chip must not be excessively wet, as the excess moisture will dilute the sprayed emulsion causing delayed seal curing times and possible run-off. However damp chip assists the emulsion to wet and flow over the chip surface.
- Chip must be applied as soon as possible after the emulsion has been sprayed and before the sprayed film changes colour from brown (unbroken emulsion) to black (binder from the broken emulsion). The emulsion should break after the sealing chip has been applied, thus ensuring a good bond to the chip aggregates and effectively 'casting' them in place.
- Cold ambient temperatures, high humidity and light wind conditions or combinations of these three can significantly extend breaking times and lengthen curing, by slowing evaporation of the water from the emulsion. Sealing should be programmed to avoid these conditions. However specific formulations and care in construction may allow work to proceed.
- High ambient temperatures, low humidity, light wind conditions, moderate to steep road gradients, high traffic flows, or a combination of these factors can cause chip aggregates to adhere to tyres and be dislodged. Application of a light mist of water to the completed seal can prevent the chips from adhering to tyres and being lost.

11.5.7 Breaking and Curing

The two distinct processes that must take place before an emulsion seal attains full strength are breaking and curing.

Breaking is the process in which the binder droplets in an emulsion separate from the emulsion and coalesce to form a continuous binder film.

Curing is the development of strength in an emulsion seal as the water from the broken emulsion evaporates. The seal does not achieve full strength until all the water has evaporated.

New emulsion seals where the emulsion has broken but curing is not fully complete may be trafficked provided traffic speed is kept below 30 km/hour. The kneading action of the vehicle tyres will assist the loss of water, and hence develop strength in the seal.

First coat seals may be constructed using emulsions, but suitable basecourse preparation is essential for success. As emulsions break on contact with dust or fines, newly constructed basecourse layers must have a visible clean mosaic of coarse aggregate particles and be slightly damp for good adhesion to be achieved. The water in the emulsion will also swell any fines on the surface of the basecourse, preventing penetration of the emulsion.

Early rain, particularly if sprayed emulsions have not broken, can cause catastrophic failure of the seal by washing the emulsion away. Spill kits should be carried and used to prevent possible pollution of waterways should such an event occur.

High ambient temperatures can cause skinning of the sprayed emulsion, trapping the water and slowing rates of cure. Slow traffic and rolling will help release the trapped water and accelerate the curing process.

11.6 Preparation for Sealing with PMBs

11.6.1 Introduction

Sealing using polymer modified binders (PMBs) requires that all the normal good practices relating to conventional sealing are to be followed and, as well, a number of extra precautions are to be undertaken to ensure a good PMB seal.

PMBs are used in chipsealing to provide enhanced properties to the final seal. These improved properties can include:

- The ability to withstand increased levels of shear stress;
- Improved performance over wider temperature range;
- Improved resistance to crack propagation.

To obtain these improved properties requires increased care and skill during the sealing operation because polymer sealing uses materials which are more susceptible to many influences such as weather, pavement temperature, shade from trees, air and binder temperature, kind of aggregate, and sealing technique. To ensure high levels of success with hot-applied PMB, it is preferable to spray during the ideal sealing period of December through to March (summer months).

11.6.2 Material Selection

As described in Section 8.4, the range of polymers available today for use in polymer sealing is extensive and they vary greatly in their performance characteristics and more importantly in their application techniques. Because of this extensive range, only an outline can be provided here to the character of this extensive range of products. Thus in all cases, direct advice should be obtained from the polymer manufacturer before undertaking any polymer sealing to ensure that any specific properties or application techniques are thoroughly understood. As well, the reason for using a PMB should be clear before commencing sealing so that the additional cost inherent in using a PMB can be fully justified.

Unless special techniques such as SAMs or SAMIs (see Section 8.4.7) are being applied, most polymers used in sealing are used at polymer concentrations of less than 5% (by weight) in bitumen.

Because of the many additives used in producing PMBs, the grade of bitumen used in their manufacture does not have as significant an effect as the grade of bitumen has in straight bitumen sealing. Viscosity, which with straight bitumen is normally closely related to the respective grade of bitumen, can be changed by the large number of additives that are incorporated into a PMB. Once again, advice should be taken from the PMB manufacturer.

11.6.3 Spray Rate Calculations

The design principles of chipseals are the same whether straight bitumen or PMB is used as the binder. If 3% polymer concentration (or less) is used in a seal design, no adjustment should be made to the application rate over that of conventional bitumen.

Most 3% PMBs made in New Zealand do not have greatly increased viscosity over that of conventional bitumen, hence neither the spray fan shape nor the chip orientation is greatly affected.

The greater difficulty occurs when polymer concentrations greater than 3% are used. Research work has shown that, for hot application (but not emulsion) of a number of polymer types, the spray fan shape is greatly affected, leading to possible 'tramlining'.

Also the viscosity can be increased to a level where it begins to affect the ability of aggregate to be able to orient down on to its AGD. This has major implications in terms of seal voids and affects the chipseal's ability to obtain sufficient binder rise before the onset of cooler temperatures at the end of a sealing season. As a consequence, early autumn stripping of aggregate can be a possibility. Once again, the advice of the polymer manufacturer should be taken on the specific character of the particular polymer product.

11.6.4 Spray Temperature

The objective of selecting a spray temperature for a PMB is to obtain the same viscosity of the particular product being sprayed as the bitumen for which the distributor obtained its BCA E/2 certificate. This will ensure very similar spray distribution and a similar application rate as when straight bitumen is applied.

As most PMBs have a higher viscosity than bitumen for a given temperature, this means that most PMBs need to be sprayed at higher temperatures than conventional bitumen. For example, 3% SBS-polymer sealing binders are typically sprayed at temperatures between 160 and 180°C. As not all polymers follow this trend of requiring higher temperatures than bitumen, spray temperature recommendations should be obtained from the polymer manufacturer.

Some polymer manufacturers also endorse the use of cutters to reduce the viscosity of their PMB thereby assisting in obtaining a suitable spray fan shape, improving aggregate wetting and allowing the chip to orient into its correct position. Consultation with the PMB supplier is essential before adding any cutter to a PMB.

Another highly effective way of reducing the application viscosity of a PMB without having to increase the temperature or add cutters is to emulsify the PMB and apply it as a PME.

11.6.5 Handling

Conventional bitumen distributors can be used in polymer sealing. The differences in the spraying character of the PMBs over conventional bitumen usually relate to any increase in viscosity. Normally, a satisfactory spray fan shape can be obtained with PMBs by increasing the spraying temperature, by the addition of cutter, or by using PMEs.

Some important handling characteristics specific to hot PMBs are:

- Most PMBs can be rapidly degraded by excessive heat. This means that no PMB should ever be heated above 190°C. If heating the PMB in the bitumen distributor is necessary, the heating rate should not exceed 12°C per hour.

- The high viscosity of most PMBs (especially at low temperatures) means that circulation while heating is a necessity. Circulation will enable fresh PMB to be run past the heating tubes constantly, and this will minimise any localised degradation of the PMB.

- The highly viscous nature of most PMBs means that they will adhere to fabric or skin. Burns from PMBs can be severe and extreme care should be taken at all times when handling the hot product. It is essential that full personal protection equipment is worn at all times when working with hot PMBs.

- The presence of any water in tanks (e.g. from condensation), pipework or hoses can cause localised boiling and extreme foam-over. Ensure that all tank lids are waterproof and that no emulsion residues are present before pumping hot PMB.
- Separation (or layering) of a PMB can occur if the product is left for a prolonged time at elevated temperatures without stirring. The PMB should be circulated for a number of hours before use. Contact the polymer supplier if extended elevated storage has occurred, as they will be able to give guidance on possible remedial actions.

11.6.6 Construction

The most critical aspect in constructing a polymer seal is to ensure that satisfactory chip adhesion is obtained. Therefore a number of specific actions need to be undertaken to ensure a good bond between the PMB and the aggregate:

- If hot PMB is used, then the aggregate should be precoated to maximise the bond between the PMB and the chip. Precoating is not required if PME is used.
- The aggregate should be spread immediately after the PMB is sprayed and multi-tyred rolling undertaken to maximise the contact area between the binder and the chip.
- If PME is used, good traffic control is essential to minimise chip rollover and pick-up. All normal emulsion construction practices should be followed (see Section 11.5).
- In two coat polymer seals, a conventional bitumen may be used as the binder for the second locking coat. The freshly sprayed conventional bitumen with a lower viscosity than the PMB can flow into the voids of both layers, providing an improved bond.
- Because hot-applied polymer seals have increased susceptibility to early damage from chip loss if moisture is present, increased vigilance must be taken with regard to the weather before sealing. A window of 1 to 2 days fine weather following spraying is needed to allow the seal time to build chip adhesion. This requirement is lessened if PME is used because, once it has broken and is fully set-up (in about 2 to 4 hours), the PME seal is much less sensitive to water damage.

11.7 Environmental and Community Issues

Today the public and RCAs are more conscious of environmental and social issues than ever before. The following sections list matters to consider when planning chipsealing work to help enable the chipsealing practitioners to better deliver RCA goals of environmental sustainability. See also discussion on environmental and community issues in Section 6.10.

11.7.1 Waste Minimisation

Waste minimisation includes consideration of the way waste is disposed of, reducing the amount of waste to be disposed of, e.g. at the landfill, and reducing the demand on primary sources of materials, e.g. of sealing chip.

Waste minimisation and substitution of materials are aspects to consider in the planning and selection process, and in activities such as:

- Re-using milled sealing material;
- Evaluating chip application rates to use less chip and binder;
- Substituting materials from other waste streams, such as clean fill or construction and demolition waste, for use in basecourse or subsurface pavement layers.

11.7.2 Energy Efficiency

Taking simple steps to reduce energy consumption can result in cost savings, and make a positive contribution to national energy reduction targets.

Including energy conservation practices and products, and improving vehicle fuel efficiency, e.g. by smoothing the road texture and surface, in the planning and selection process can achieve the best value of energy use.

These conservation principles can be put into practice in the following examples:

- Examining ways to maximise energy efficiency, e.g. avoiding unnecessary heating of binder before its application;
- Using products which enhance energy efficiency, e.g. insulation in binder heater tanks;
- Calculating the fuel efficiency benefits (and benefits of reduced road–tyre noise) of using smaller chip sizes;
- Using locally sourced material, to reduce haulage distance, and therefore reducing overall fuel consumption, transport costs and vehicle emissions;
- Cost-effective options to recycle loose chip should also be investigated. For example, using rotary brooms to sweep up excess chip and stockpiling it for other uses.

11.7.3 Water Management

The effects of sealing activities on the volumes of water used and impacts of water run-off on stormwater can be reduced through careful water use and sensible management practices.

Key water management objectives include:

- Reducing the volume of potable (drinking quality) water used in sealing and maintenance activities, e.g. for washing down;
- Ensuring pollutants from sealing activities do not enter waterways[2].

Good management practices include:

- Filtering and re-using water collected from high pressure water treatments;
- Avoiding spillage of binders;
- Ensuring containment devices are in place and spillage kits (of fine aggregate to cover oily spills, portable textile dams to block run-off) are available;
- Ensuring that contact with the local Fire Brigade has been made.

See Roading NZ's BCA 9904 (2000), Chapter 3.12 Emergency Precautions for Fire Control and Spillage, and Chapter 5.11, Spillage Hazards, for details.

Check list of Environmental and Community Principles relevant to chipsealing.

	Have the following environmental and community principles been considered in planning for and completing pavement sealing works?
	Have waste management and energy efficiency principles been considered? e.g. heating the bitumen tanker?
	Have all opportunities to conserve water been considered?
	Have methods to avoid discharges of sediment and other pollutants into waterways been considered and actioned?
	Have spillage kits and fire extinguishing kits been prepared?
	Have affected stakeholders (and neighbours) been consulted and advised of sealing activities?
	Have other key environmental & community considerations been identified & actioned? Noise Air quality Site safety Fire prevention Other?

2 Waterways are water bodies such as streams, rivers, coastal areas, ground water, wetlands.

11.8 References

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