Minimising traffic delays during resealing
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Abbreviations and acronyms

AADT	Annual average daily traffic
AAPA	Australian Asphalt Paving Association
SCR	Seal compaction rig
TNZ	Transit New Zealand (now NZ Transport Agency)

Contents

Executive summary

The objective of this research was to demonstrate that through the appropriate choice of seal type and binder a chipseal could be constructed and opened to unrestricted traffic flow within one working day.

After resealing there is a traffic speed restriction. This is typically for a period of 48 hours at a speed limit of 30km/h and in areas with higher traffic volumes can result in significant queuing and traffic delay. Most of the traffic disruption is due to traffic slowing down to avoid flying stone chips which can cause damage to paintwork on vehicles and windscreens, and to the requirement to allow the chipseal to bed down and gain strength before opening the road to unrestricted traffic.

The 48-hour time frame, which is documented in *TNZ P/4* (Transit NZ 1995), is to allow enough time for the seal to set and for the contractor to hand over responsibility for the seal to the client. The 48-hour time frame does not have any scientific basis and appears to have evolved from field experience. Sealing supervisors are concerned that if they opened the road to unrestricted traffic too early then damage would occur to the seal. Road controlling authorities have to balance the need for a good seal with the aspirations of the travelling public who want no restrictions and no damage to their cars.

The needs of the motorist have become of paramount importance to the roading industry which is reflected in the move towards low-noise and high skid-resistant surfaces. In the early 1990s neither of these requirements were a high priority to road controlling authorities.

Changes to the levels of service requirements in areas with higher traffic volumes mean that traffic disruption caused by traditional chipseal techniques is now unacceptable. The alternative has been to use a hot-mix asphalt surfacing treatment but this costs at least four times more than traditional chipseal.

Since the early 1990s there have been significant changes in the materials and seal types used on the network. Multi-coat seals which use a small chip to lock a larger chip in place have gained popularity. These types of seals (two-coat, sandwich and racked-in) have been found to withstand higher traffic stress and resist flushing over binder rich surfaces. There has also been the introduction of a range of polymer modified binders which have the potential to increase the shear strength of the chipseal.

The research team believed that by applying the optimum choice of seal type and binder coupled with the implementation of effective traffic control in the first few hours after sealing, the seal could be opened much sooner than the traditional 48 hours used for single-coat seals.

This research demonstrated that:

- racked-in seals can handle the stress of high-volume traffic
- racked-in seals can be constructed in an eight-hour working period including sweeping (if required) and road marking
- closely controlled chip application rates result in minimal loose chip on the completed chipseal surface
- minimal loose chip results in minimal chip being flicked by vehicle tyres
- speed restrictions can be lifted to 50–70km/h at the completion of the line marking
- unrestricted traffic can be placed on the seal the morning after resealing

- having no bitumen exposed to tyres reduces the chip pick up and flick and minimises the risk of bitumen tracking.

The requirement for a newly sealed chipseal road to be opened to traffic speeds of at least 70km/h for peak evening traffic could be included in construction specifications. This would assist in minimising motorists' frustration at the traffic delays caused by road sealing.

Abstract

This research demonstrated that:

- racked-in seals can handle the stress of high-volume traffic
- racked-in seals can be constructed in an eight-hour working period including any sweeping and road marking
- closely controlled chip application rates result in minimal loose chip on surface
- minimal loose chip results in minimal chip being flicked by vehicle tyres
- speed restrictions can be lifted to 50–70km/h at the completion of the line marking
- unrestricted traffic can be placed on the seal the morning after resealing.

The requirement for a newly sealed chipseal road to be opened to traffic speeds of at least 70km/h for peak evening traffic could be included in the construction specifications. This would assist in minimising motorists' frustration at the traffic delays caused by road sealing.

1 Introduction

The objective of this research was to develop guidelines on the choice of seal type and traffic control methods that would allow the opening of traffic to normal operating speeds as quickly as possible (within 12 hours) after resealing.

After chipseal construction there is a requirement for a traffic speed restriction to be in place until the site is swept and all markings are in place. This is typically for a period of 48 hrs at a speed limit of 30km/h and can result in significant queuing and traffic delays, especially in areas with higher traffic volumes. Most of the traffic disruption is due to traffic slowing down to avoid flying stone chips which can cause damage to paintwork on vehicles and broken windscreens, and because of the requirement to allow the chipseal to bed down and gain strength before opening the road to unrestricted traffic.

The 48-hour restriction does not have any scientific basis and appears to have evolved from field experience. Sealing contractors are concerned that if they opened the road to unrestrictive traffic too early then damage would occur to the seal. Road controlling authorities have to balance the need for a good seal with the aspirations of the travelling public who want no restrictions and no damage to their cars.

The needs of the motorist have become of paramount importance to the roading industry which is reflected in the move towards low-noise and high skid-resistant surfaces. In the early 1990s neither of these requirements were a high priority to the road controlling authorities.

Changes to the levels of service requirements in areas with higher traffic volumes mean that traffic disruption caused by traditional chipseal techniques are now unacceptable. The alternative treatment using hot mix asphalt is at least four times more expensive. A solution is urgently required.

Since the early 1990s there have been significant changes in the materials and seal types used on the network. Multi-coat seals which use a small chip to lock a larger chip in place have gained popularity. These types of seals (two-coat and racked-in) have been found to withstand higher traffic stress. There has also been the introduction of a range of polymer modified binders which have the potential to increase the shear strength.

The research team believed that a combination of the optimum choice of seal type and binder coupled with effective traffic control in the first few hours after sealing would enable the seal to be opened much sooner than the traditional 48 hours applied for single-coat seals.

It was hypothesised that the traffic embedment of the chip (for a particular seal type) was the most significant variable and therefore if a road with 1000 annual average daily traffic (AADT) could be opened to normal traffic after 48 hours then a road with 10,000 AADT could be opened in 4.8 hours.

This report presents the results of trials using the racked-in sealing technique which demonstrate new chipseals can be constructed and opened to unrestricted traffic flow within a time window of 9.00am to 4.30pm.

2 Literature search

A search of the literature and direct contact with authorities in Australia, South Africa and Britain failed to find any currently enforced specifications that included clauses on the time to open a new seal to unrestricted traffic.

Clause 25.1 of *TNZ P/4* (Transit NZ 1995) (which is not contractually binding) notes:

> *The contractor is responsible for the protection of the sealcoat, from the completion of the contractual rolling of each section of construction carried out within the day for a period of 48 hours, until the removal of temporary speed restrictions. The standard to be achieved at the end of the 48 hours is primarily that the "take" of chip is satisfactory so that there is no evidence of remaining windows or of chip loss and that surplus chips have been removed. The inspection and testing are to be carried out at the end of the protection period after the removal of surplus chip and immediately prior to the removal of the temporary speed restriction.*
>
> *Providing the standard complies, the contractor is to be released from maintenance responsibility for the new surfacing. Thereafter any damage to the sealcoat is to be deemed to be fair wear and tear.*

The Australian *National sprayed sealing specification* (AAPA 2004) includes guidance on sweeping excess aggregate off new seals as follows:

> *Removal of loose aggregate can generally commence when initial aggregate adhesion and interlock has been completed by rolling and traffic, the binder has hardened to a state where no more aggregate can be pressed into it, and the seal is less prone to damage by sweeping.*
>
> *Factors that influence the timing of aggregate removal include:*
>
> - *Traffic volume/road class*
> - *Type of binder*
> - *Aggregate size*
> - *Ambient temperature/pavement temperature.*
>
> *High traffic volumes will rapidly fix aggregates into the binder so that removal of surplus stones may commence within a few hours of spreading. High traffic volumes are also often associated with roads in urban areas and other situations where it is important to minimise risks associated with loose aggregate, so that removal is often undertaken within about 12 hours of spreading.*
>
> *On lighter trafficked roads, a period of up to 48 hours may be allowed to elapse before completing the removal of excess aggregate, provided the safety of the travelling public is appropriately considered.*
>
> *Polymer modified binders develop cohesion more rapidly, particularly at higher ambient temperatures, so that aggregate removal can often be undertaken on the same day. Emulsion binders develop cohesion more slowly. Up to 48 hours curing may be necessary, in some circumstances, before sweeping can be undertaken without a high risk of damage to the seal.*

AAPA (2004) also proposes the following maximum time limits for sweeping.

Table 2.1 Time limit for removal of loose aggregate (*National sprayed sealing specification* (AAPA 2004))

Traffic volume (vehicles/lane/day)	Maximum time limits
> 2000 and all freeways	Within 8 hours of sealing
> 1000 to 2000	Within 24 hours of sealing
> 250 to 1000	Within 48 hours of sealing
< 250	Within 5 days of sealing

It is not clear in the specifications if the road must be opened to unrestricted traffic after removal of the loose chip.

3 Chipseal background

In order for a seal to be opened to traffic it must have gained sufficient strength to resist the plucking and turning stresses of vehicle tyres.

The strength of a seal is a function of:

- the binder strength in climatic conditions during and after construction
- the extent of binder coverage
- aggregate interlock
- adhesion of the chip to the binder and the binder to the substrate.

3.1 Binder strength

In a new seal the binder strength is low. With normal sealing binders the strength is directly related to the viscosity. A relatively low binder viscosity is required to 'wet' the chips and allow adhesion to occur. If a high viscosity binder is used then the time for the chip to adhere and re-orient, and the stone mastic to form can be significantly increased.

3.2 Binder coverage

The binder rises up around the chip as compaction and orientation occur under the roller and traffic. As the binder rises the surface area of the chip in contact with binder increases, resulting in greater chip retention, chip strength and resistance to seal damage.

3.3 Chip interlock

The compaction process, helped by rolling and trafficking, moves and re-orients the chips, and the strength increases as the interlocked chip mosaic forms. The process is illustrated conceptually in figures 3.1, 3.2 and 3.3.

Figure 3.1 Binder applied followed by chip

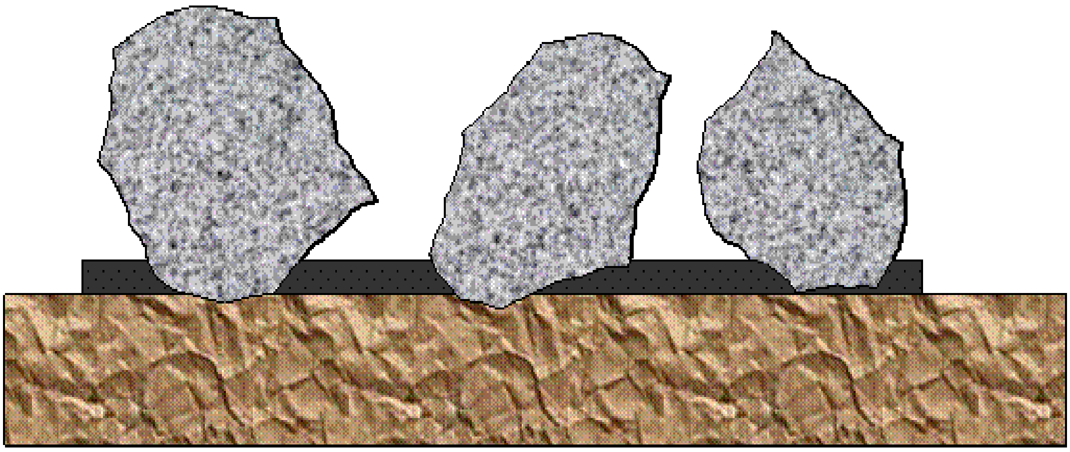


Figure 3.2 Chip movement and binder adhesion after rolling

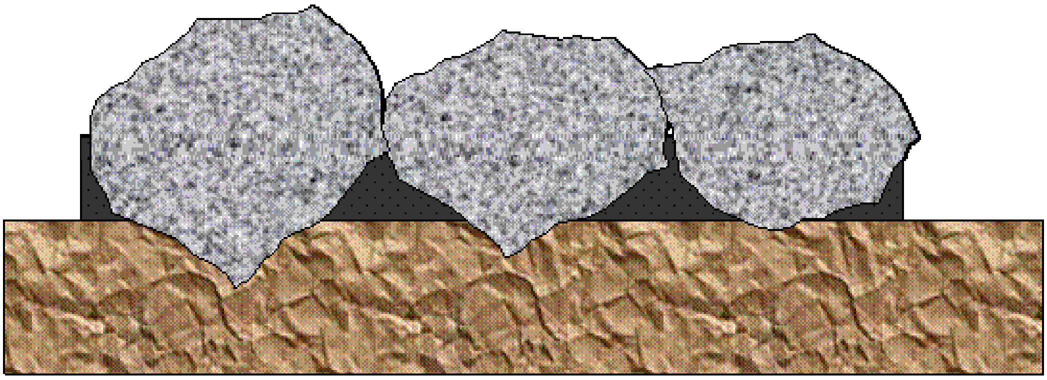
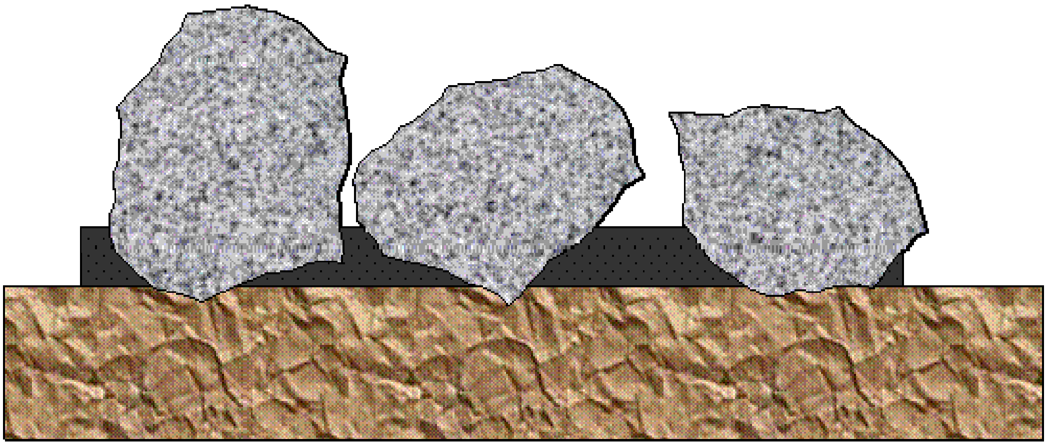


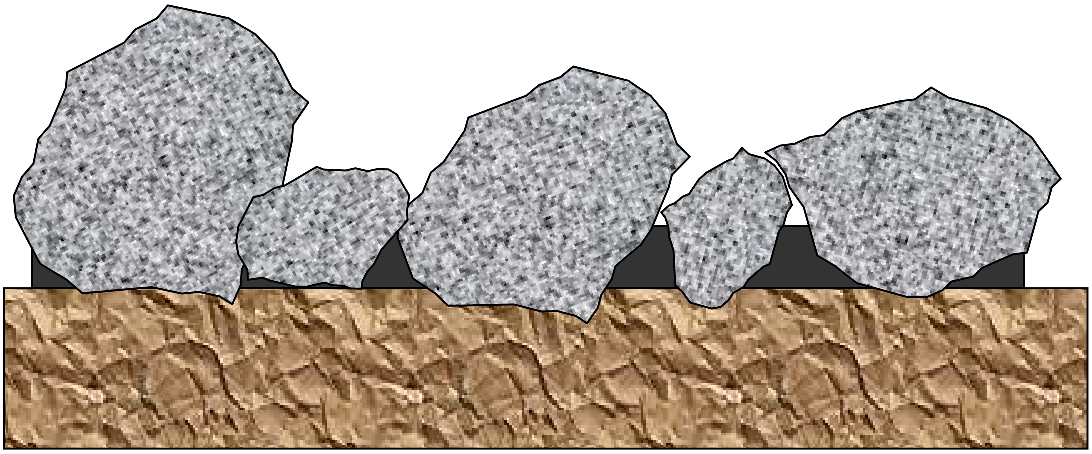
Figure 3.3 Chip interlock and binder rise after trafficking



In a single-coat reseal as illustrated in figures 3.1, 3.2 and 3.3, the interlock that occurs under rolling is relatively minimal and traffic is the main method by which interlock and therefore strength is obtained.

The interlock can be increased by using two chip sizes in a 'racked-in' seal. This is illustrated below. In a racked-in seal the binder is applied followed by a relatively light application of the big chip. A smaller chip is then applied that sits between the larger chips and effectively locks them in place. As most of the traffic load is carried by the bigger chip the total effect is a stronger seal. A racked-in seal is not so dependent on traffic compaction to obtain strength.

Figure 3.4 Racked-in seal



A racked-in seal is considered the most appropriate for producing a seal with minimal loose chip and binder tracking. This seal type is the preferred treatment in Wellington City, Hutt City and Tauranga City rather than two-coat or single-coat seals; as the racked-in seal has been found to minimise complaints from residents about loose chips and binder tracking.

4 Laboratory testing programme

Laboratory testing was the first step in this research. The main focus for the laboratory trials was to gather information and an understanding on how two different grades of sealing chip interacted under trafficking.

With the use of Opus Central Laboratories' seal compaction rig (SCR) and moulds, a racked-in seal could be constructed.

4.1 Seal compaction equipment overview

This apparatus is used to compact racked-in seal specimens that have been constructed in a laboratory. Figures 4.1, 4.2 and 4.3 show an overall view of the apparatus, with the pneumatic cylinder on the right and the rolling wheel to the left. The wheel support was constructed from 100 x 50mm channel section steel, welded into a hollow rectangle. A 25mm diameter shaft, on which the wheel rotated, was bolted on a wheel support using U-bolts. The wheel was prevented from moving sideways on the axle with 10mm thick washers which were attached to the axel grub screws.

The tyre is a standard item purchased from a materials handling outlet. This particular tyre was chosen as the tread was similar to that of a car tyre, was pneumatic and had the load capacity required to carry the weights attached to the wheel support. The tyre was moved longitudinally using a pneumatic cylinder 1m in length controlled by its associated control equipment.

Longitudinal travel was achieved using a pneumatic cylinder with a stroke of 1m and with its associated control equipment .Transverse travel was achieved using a speed-controlled gear box which ran the 12mm threaded rod attached to the specimen plate. The motor/gearbox providing the transverse movement was a 37 watt permanent magnet DC variable speed motor linked to a 90:1 reduction gearbox. The output shaft from the gearbox rotated a 12mm threaded rod which turned in a threaded lug welded onto the underside of the sample table. Limit switches were bolted to the model's strong floor and provided signals to the motor controller to reverse the travel of the motor after the wheel had traversed the specimen plates.

This movement allowed the specimen to get complete compaction over the entire surface simulating traffic movement.

Figure 4.1 Overview of the seal compaction equipment

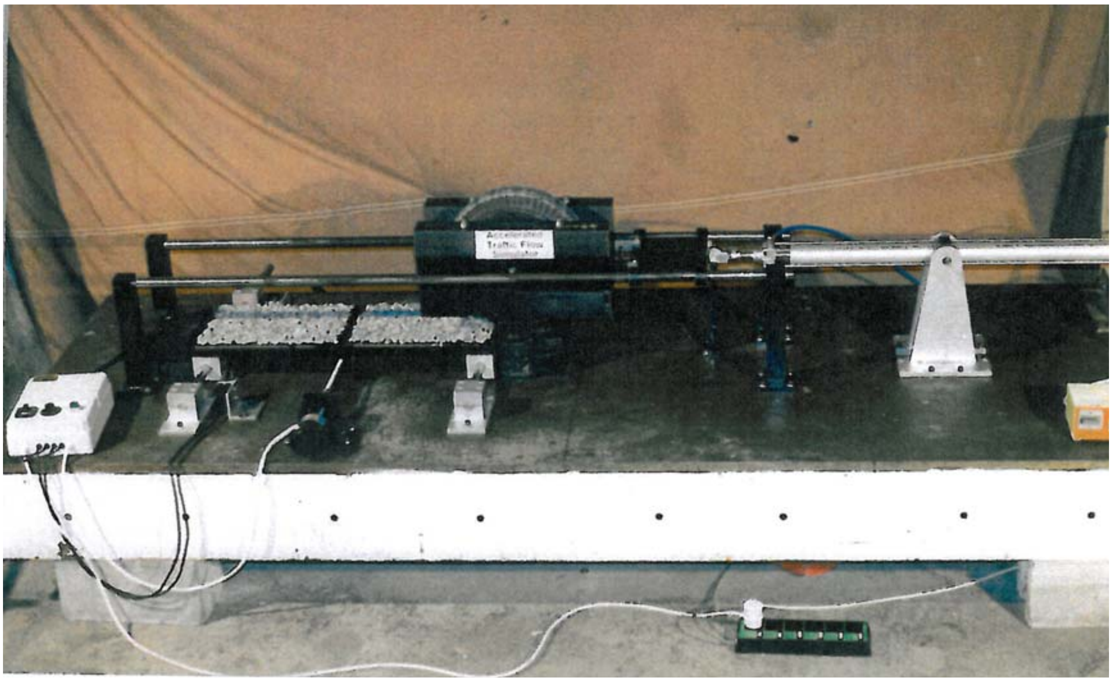


Figure 4.2 Close up of the pneumatic cylinder for longitudinal movement

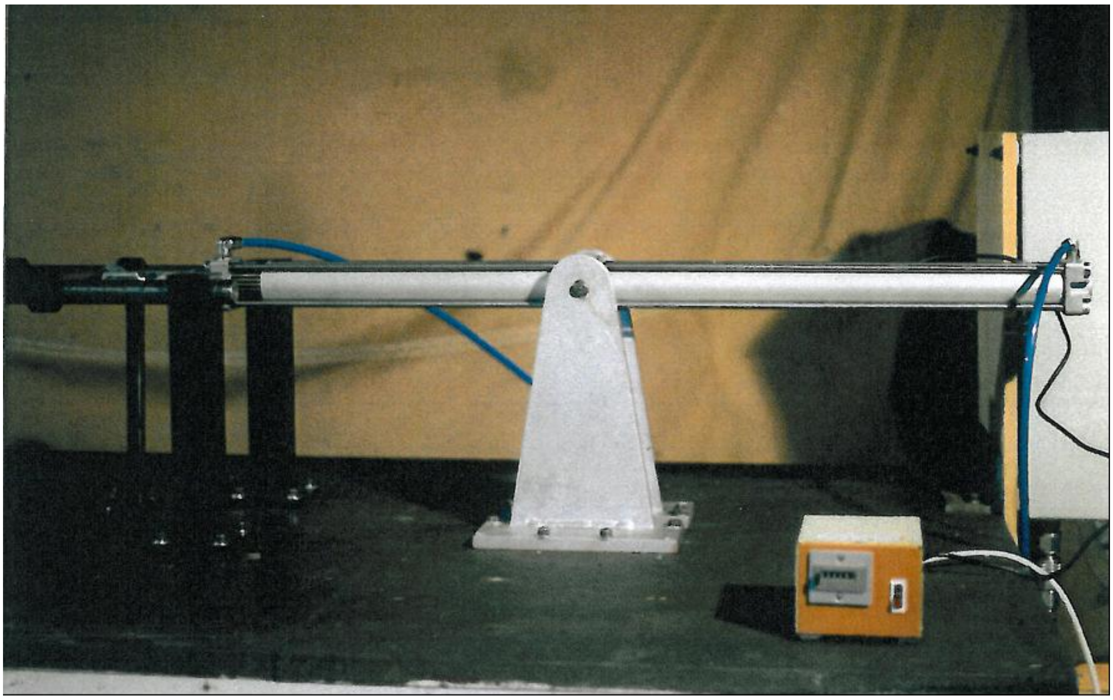
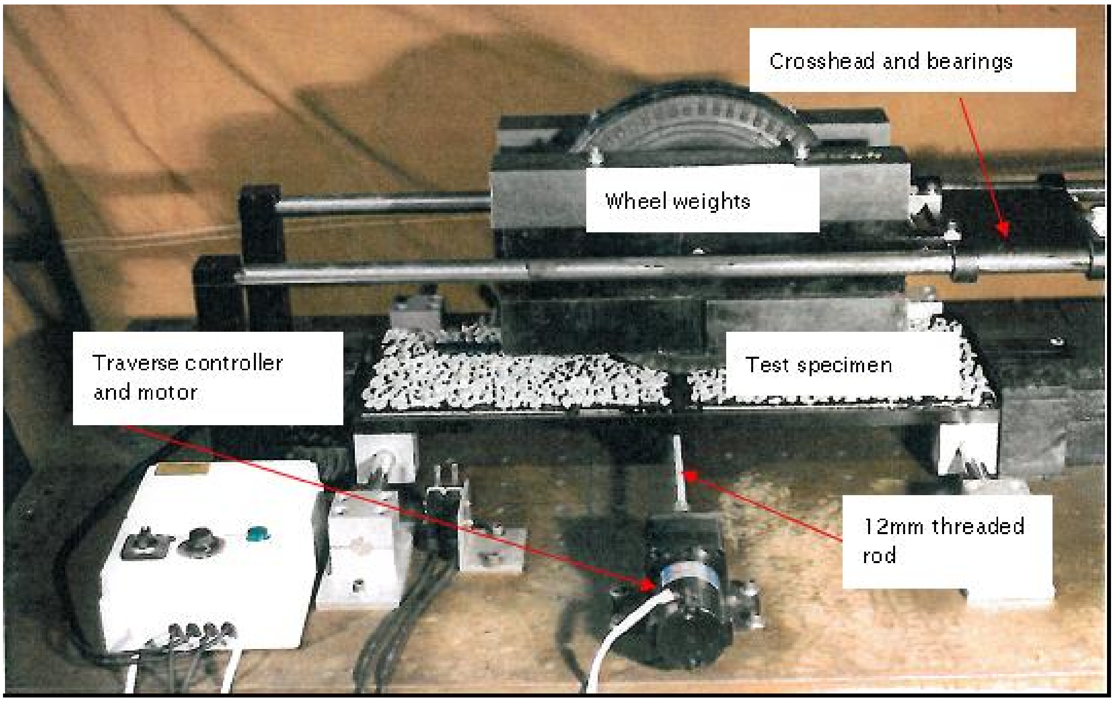


Figure 4.3 Wheel section with longitudinal and transverse setup



4.1.1 Testing procedure

Several test specimens of a racked-in seal were constructed using a standard 180/200 bitumen with no adhesion agents or kerosene added. Grades 3 and 5 chip sizes, supplied by Winstone Aggregates, Belmont, Lower Hutt, were used as the two sealing materials and put in an oven at 105ºC overnight to dry out the aggregate. The bitumen was stored in a 500ml sample tin and heated in an oven to 165ºC. The sample plate was heated in an oven at a temperature of 40ºC. One hundred and sixteen grams of hot bitumen was poured onto the specimen plate and spread with a spatula to get an even coverage. The grade 3 chip (dry) was applied by hand to the sealing binder, making sure to leave open 'windows'. The second chip application of the grade 5 (dry) was applied by hand covering all open areas of bitumen.

The test specimen was put into the seal compaction box at a temperature of 25ºC and allowed to come to temperature for 35 minutes. The tyre was then rolled over the chip of the seal, along with the transverse motor moving the specimen table, allowing the tyre to move over the entire test specimen and compacting the two grades of chip.

Figure 4.4 shows a test specimen with two application rates of a grade 3 sealing chip with the left side having higher chip coverage (smaller bitumen windows) than the right side. Figure 4.5 shows the plate after the application of the grade 5 chip.

Figure 4.4 Two application rates of grade 3 chip and open bitumen windows

Figure4.5 Second application using a grade 5 sealing chip

After 200 passes on the SCR, it was observed that significantly more loose chips were on the seal surface with the higher application rate of grade 3 chip than on the surface with the lower application rate (figure 4.6). It was also observed that when the bitumen windows were larger, the grade 5 chips fitted more easily into the space creating better interlocking, allowing the stone mosaic to form earlier and the seal to gain strength at a faster rate. Figure 4.6 illustrates the need not only to match chip sizes but also to match the chip selection with the construction technique.

Figure 4.6 Close up of the interlocking of the two grades of chip after 200 passes of the SCR

The laboratory trials demonstrated the importance of the correct chip selection and application rate and although seal strength could not be physically measured it was visibly obvious that seal strength build up was rapid. It was also evident that the formation of the aggregate mosaic and the consequent build up of strength was much faster than occurred with a single-coat seal. The same apparatus was used for compacting single-coat seals in previous research (Ball and Patrick 1998).

5 Field trials: urban

With the findings gathered from the laboratory testing and the excellent cooperation of Hutt City Council and Higgins Contractors Limited, a number of racked-in seals were chosen and observed to gather information on the contractor's current practice of laying a racked-in seal and on the build up of seal strength.

Observations were carried out in Cuba Street and Cudby Street, Lower Hutt. These pavements were constructed using a polymer modified emulsion and grades 3 and 5 sealing chip.

Figures 5.1 to 5.4 illustrate the process.

It was noted on inspecting the two locations that there was still a moderate amount of loose chip on the surface after the sweeping process. The contractor acknowledged that the application rate of the grade 5 chip was high and also deliberate as he was concerned that vehicle tyres could touch the very sticky polymer modified binder. He considered that excess chip protected the underlying seal until it had developed strength and that this was common practice. It was also noted that the application rate of the grade 3 chip was higher than that used in the laboratory trials.

To check the seal strength, a garden broom was used to sweep away the loose surface chip from a 30cm x 30cm section of seal while looking for any movement of the chip. This test was a good indication of how well the two grades of sealing chip interlocked and how strong the seal was after construction. There was some small movement, but no loss of the chip in the seal while doing this test. After one hour of the seal being open to the public the broom test was repeated in the same section. This time there was no movement at all in the seal and with no loss of chip showing it had built up good shear strength.

These findings determined that the more trafficking the new seal had, the quicker its strength developed. From a traffic management perspective this was much more effective than just rolling the seal and not allowing the traffic on it for a few hours after construction.

There were some areas where bitumen tracking appeared on the surface due to vehicles picking it up from open areas in the new seal.

Figure 5.1 Spraying of the polymer modified emulsion in Cuba Street

Figure 5.2 Application of the grade 3 chip

Figure 5.3 Open 'windows' ready for the small grade 5 chip

Figure 5.4 Application of the grade 5 chip

While watching the application of the grade 5 chip it was obvious when it was right or not. In a good application the smaller grade 5 chip slotted straight into the windows between the grade 3 chip and locked it together.

Areas that had extra chip applied resulted in a build up of chip outside the wheel tracks as illustrated in figures 5.5, 5.6 and 5.7. The excess chip was moved by the vehicle tyre but due to the speed restrictions this was not enough to damage vehicles.

Figure 5.5 Photo showing build up of loose chip on seal surface and on road shoulder

Figure 5.6 Photo showing the polymer modified emulsion being tracked over the seal surface

The Petone Esplanade was the next trial which used straight 180/200 standard bitumen (no polymer) with the grades 3 and 5 chip. The construction of the seal was closely monitored and again there was an excess amount of grade 5 chip applied to the seal and some flicking of the loose chip while traffic was passing over it. After a two-hour period of trafficking, the excess chip on the seal was flicked to the side and the seal seemed to have settled down and developed good strength.

Figure 5.7 Photo illustrating the excess chip flicked to the outer of the wheel tracks

5.1 Results from urban trials

Having monitored the construction of the racked-in seals on three sites and observed how the seal reacted when vehicles were allowed to travel on it immediately after the racked-in seal was constructed it was clear that the seal did build up a good early strength. The only concern from these urban trials was the amount of excess chip left on the seal surface on the three sites and that this wasted material would be dumped.

The rate of gained strength gave confidence that if the loose chip had not been present the seals could have been opened to unrestricted traffic flow without the danger of flying chips.

6 Field trials: open road

The opportunity to trial the concept of allowing unrestricted traffic on a newly constructed chipseal open road in less than 48 hours was established with the excellent cooperation of Fulton Hogan.

Three open-road trials were constructed on state highways in the Wairarapa and in Wellington. The main focus of the research project was on constructing a new racked-in seal, having it opened to the public straight after completion and increasing the speed restrictions as soon as possible to prevent traffic delays and queuing as had happened previously on high trafficked roads on the network. The decision was taken to trial the concept on lower trafficked sections of the state highway before attempting it on a high trafficked section.

6.1 Martinborough, SH53

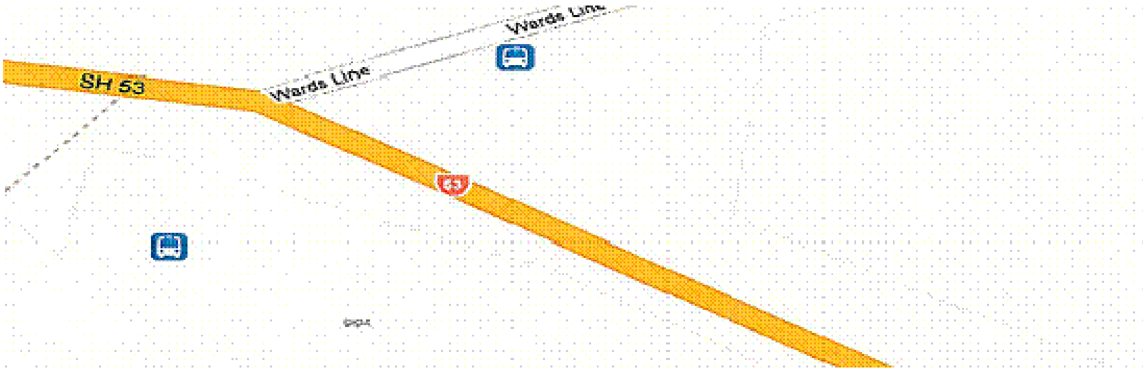


Figure 6.1 Location of first racked-in seal trial

Table 6.1 Site details SH53 Martinborough

AADT	2231 vpd (6%)
Date sealed	24/2/09
Length	400m
Bitumen grade	180/200
Kerosene content	2.0pph
Application rate @ 15C	2.1 l/m^2
1st chip	Grade 3
2nd chip	Grade 5
Weather	Fine, showers
1st bitumen spray	10.15am
Time traffic control lifted	5.05pm 70km/h

The first trial using a racked-in seal was constructed at the intersection of Wards Line and SH53 from RP10.750 to RP11.073. Figures 6.2, 6.3 and 6.4 illustrate the construction.

To get a complete picture of how long it would take to lay a new racked-in seal, a time line was produced for the start of each process until traffic was allowed onto the seal.

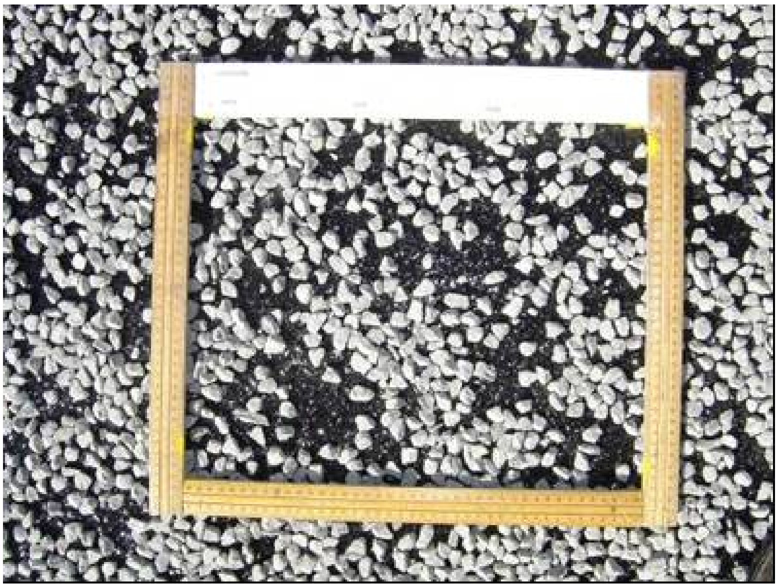
9.30am Traffic control was set up with the traffic being diverted through the use of cones.

10.15am Spraying of the sealing binder began in the northbound lane. The design of the sealing binder was a standard 180/200, mixed with 2.0pph kerosene and 0.6pph adhesion agent. The spray temperature was 164ºC with a total spray run of 325m.

Figure 6.2 Spraying the 180/200 sealing binder

10.45am The application of the grade 3 sealing chip was completed, making sure there were open bitumen windows for the subsequent application of grade 5 chip. The grade 3 chip was then rolled.

Figure 6.3 Grade 3 chip application with open bitumen windows



10.59am The smaller grade 5 chip was applied and immediately rolled with a rubber tyre roller which moved the grade 5 chip into the open windows left by the grade 3. A total of six passes from the roller interlocked the sealing chip well and created strong seal strength immediately with a very small amount of excess chip on the surface.

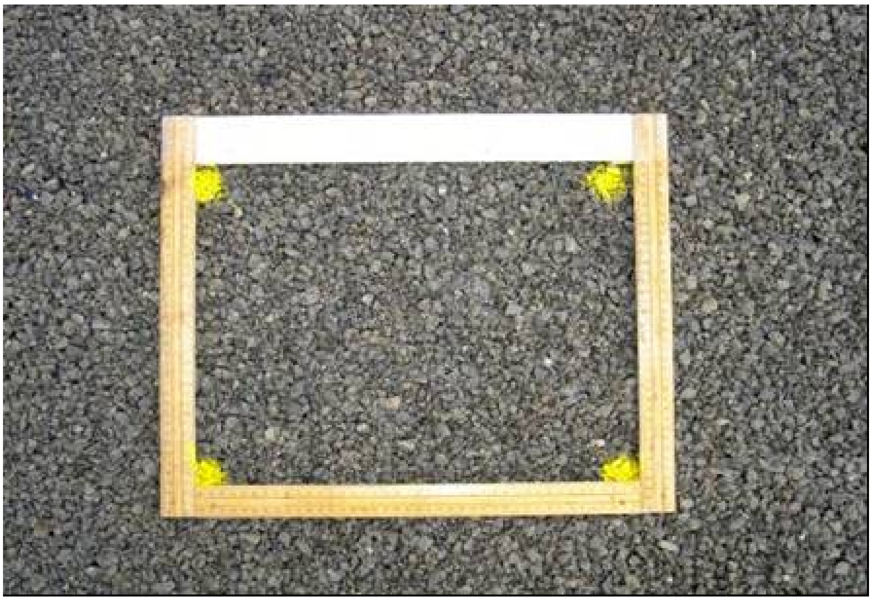


Figure 6.4 Grade 5 chip application after being rolled

11.35am Traffic was allowed onto the newly constructed sealed section with a speed restriction of 30km/h. The movement of the traffic over the new seal improved the settling down of the sealing chips.

12.31pm Spraying of the sealing binder began in the southbound lane.

12.51pm Grade 3 chip was applied to the sealing binder and rolled.

1.13pm Grade 5 chip was applied onto the grade 3 chip and again rolled with a rubber tyre roller for a total of six passes.

1.52pm Traffic was allowed onto the new seal with a 30km/h speed restriction.

The construction process took approximately four hours before controlled traffic was opened onto the new seal with a speed restriction of 30km/h. Active traffic control took place in which traffic cones were periodically moved so that the traffic was directed over the whole site and not just in the wheel paths. The seal settled down and the construction crew were confident of the seal strength so the site was swept and the line marked at 5.00pm with the speed restriction then lifted.

A visual inspection of the trial seal was done the following day. The racked-in seal had settled down well with strong interlocking of chip and lack of loose chip on the surface. There were no visual signs of bitumen tracking on the surface of the seal. There was only minor scuffing on the seal surface which would have been caused by heavy vehicles turning at the intersection of SH53 and Wards Line and vehicles turning at an intersection in the middle of the trial.

6.2 Featherston SH 2

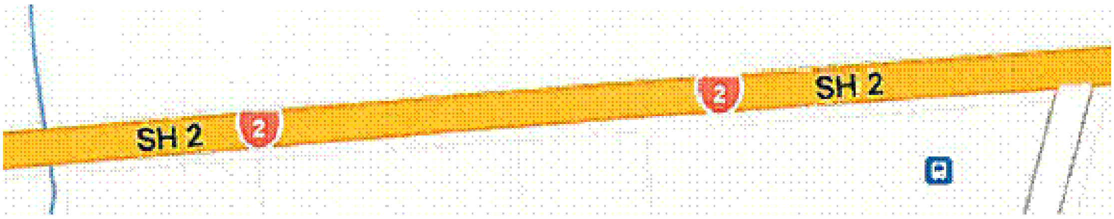


Figure 6.5 Location of second racked-in seal trial

Table 6.1 SH2 Featherston site details

AADT	5682 vpd (9%)
Date sealed	17/3/09
Length	800m
Bitumen grade	180/200
Kerosene content pph	3.0pph
Application rate @ 15°C	1.8 l/m²
1st chip	Grade 3
2nd chip	Grade 5
Weather	Fine, warm
1st bitumen spray	10:11am

Time traffic control lifted	5.30pm 50km/h

This trial used much of the same methodology as on the Wards Line site; however, there were some minor changes. The kerosene rate was increased to 3.0pph and the grade 5 chip application rate was reduced to nearly half the rate applied on the Wards Line trial.

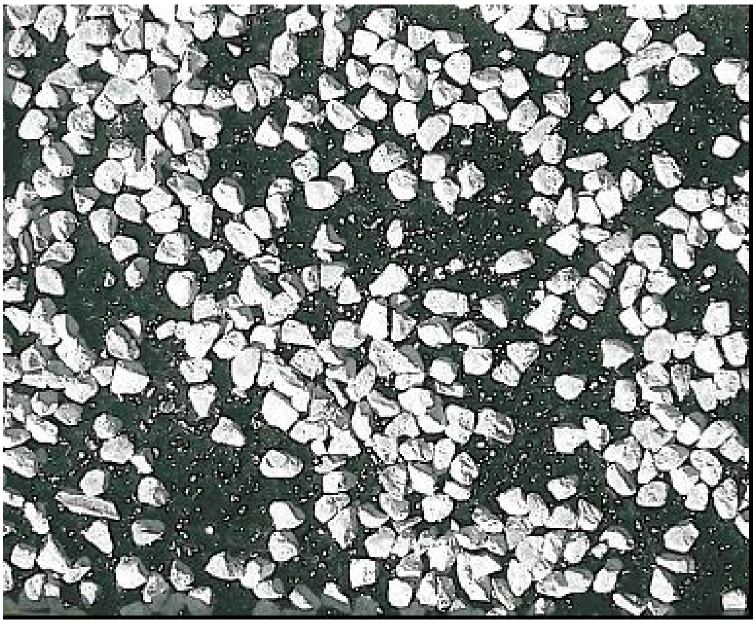
Figures 6.6 and 6.7 illustrate the chip application rates.

The time line for this trial was as follows:

10.11am Sealing binder was applied to the road surface in the northbound lane.

10.21am Grade 3 chip application began with special attention made to leaving good open bitumen windows. Rolling started immediately after application of the grade 3 chip.

Figure 6.6 Photo showing open binder windows during the grade 3 chip application



10.35am Grade 5 chip application was started, followed immediately by six passes with the rubber tyre roller.

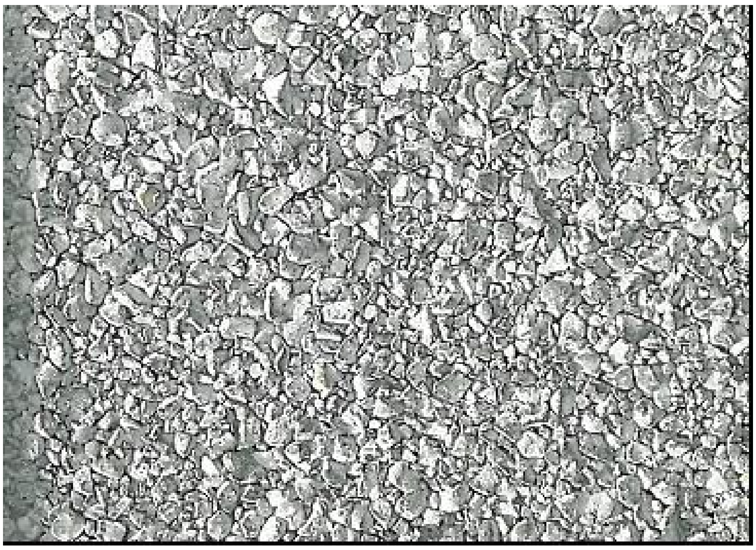
11.25am The northbound lane was opened to traffic with a speed restriction of 30km/h.

12:15pm Binder was applied to the southbound lane.

12.26pm Grade 3 chip was applied and rolling started immediately.

12.41pm Grade 5 chip was applied, followed immediately rolling with the rubber tyre roller.

Figure 6.7 Photo showing the interlocking of the grades 3 and 5 chip



2.00pm Southbound lane was opened to traffic with a speed restriction of 30km/h.

Active traffic control was implemented for a three-hour period, moving the traffic over the entire new seal by shifting the cones.

5.00pm Line marking began.

5.30pm Speed restrictions were lifted from 30 to 50km/h and left at this speed overnight.

A visual check of the seal was observed the following morning. There was no loose chip on the surface, with the seal having good strength visually.

6.3 Te Horo SH1

Figure 6.8 Location of the third racked-in trial site at Te Horo

The location of this trial was on SH1 north of Waikanae. The site consisted of three lanes with the two southbound lanes including a passing lane.

Details are given in table 6.2.

Table 6.2 SH1 site details

AADT	18228 vpd (10%)
Date sealed	30/3/09
Length	800m
Bitumen grade	180/200
Kerosene content	3.0pph
Application rate 15°C	2.0 l/m^2
1st chip	Grade 2
2nd chip	Grade 4
Weather	Fine, warm
1st bitumen spray	10.01am
Time traffic control lifted	17.20 (50km/h)

The construction methodology for this trial was similar to the previous trial at Featherston except that the sealing chip was changed from a grade 3 and 5 combination to a grade 2 and 4 combination from a different source. The other change was a slight increase to the amount of adhesion agent from 0.6 to 0.7pph. The main difference between this site and the other two was the traffic, which was very high on this site and low to medium on the other sites.

The time line for this trial was as follows:

10.01am The sealing binder was applied at a temperature of 164ºC.

10.15am Grade 2 chip was applied to the sealing binder.

Figure 6.9 Close-up photo of the open bitumen windows in the grade 2 chip application

10.21am Grade 2 chip was rolled using the rubber tyre roller.

10.24am Grade 4 chip was applied, followed immediately by rolling with the rubber tyre roller.

Figure 6.10 Photo of grade 2/4 chip interlocking

11.57am Trafficking of the northbound lane started with a 30km/h speed restriction applied.

Figure 6.11 Photo of the active traffic control during the resealing

12.12pm Sealing binder was applied on the southbound lane.

12.26pm Grade 2 chip application began

12.40pm Rolling of the grade 2 chip.

12.51pm Grade 4 chip was applied, immediately followed by rolling with the rubber tyre roller.

1.15pm Active traffic control began to move the traffic over the entire new seal to help with the settling down time of the seal.

4.00pm Sweeping of the new seal started.

4.15pm Line marking began in the northbound lane.

5.20pm Line marking was completed.

It took seven hours to complete this 800m section of SH1 which included time for line marking and sweeping of the new seal. The time required to implement and alter the traffic management in such a high trafficked area slowed down production considerably. The speed restrictions were then increased to 50km/h and left at this speed overnight.

An estimation of the chip application rates was made based on the area covered by a truck load of chip. The grade 2 rate was estimated at $160m^2/m^3$ and the grade 4 at $240m^2/m^3$.

A visual inspection of the seal was done the following day approximately 16 hours after the construction of the seal had been completed. Speed restrictions were also removed and the speed limit returned to the normal 100km/h.

Some minor chip loss occurred along the lane line the following night and traffic management was reintroduced to slow the traffic down to 50km/h over the weekend. The repairs were completed early the following week and the speed limit returned to 100km/h without further chip loss.

7 Discussion

This research demonstrated that it was possible to construct a chipseal, apply the road marking and open the road to unrestricted traffic within an eight-hour period in most traffic conditions. The roads in these trials were only opened to traffic speeds of 50–70km/h because of the risk of opening to 100km/h speeds during the first night without onsite supervision. The excellent condition of the seals on the lower trafficked roads meant they could have been opened to unrestricted traffic flows once construction was completed.

Although the chipsealing operation can cover a large area quickly, in practice implementing and changing the traffic control, and sealing small areas associated with intersections and driveways etc takes a significant proportion of the time.

In the field trials the seal was line marked within two hours after the last spray runs were applied. This demonstrated that using a racked-in seal under active traffic control required much less time than other processes.

The trials used a racked-in system as it was considered that if a two-coat seal had been used with a low application rate of the second chip, there would have been danger of the second application of binder sticking to tyres. Although some practitioners consider that a two-coat seal is stronger than a racked-in seal most two-coat seals do have excess chip that can take weeks to settle down. This is in contrast to the SH1 trial where through using a closely controlled chip application rate, sweeping of the surface was not required and there were no loose chips to cause damage to vehicles or require removal before the road marking was applied.

The chip application rates used in the third trial were measured and found to be approximately 60% of that recommended in *Chipsealing in New Zealand* (Transit NZ 2005). Even though the chip application rates for the first two sites were not measured they were visually similar to site three and thus it appears that the application rates suggested in the text book could be reduced. The reduction would assist in ensuring that minimal loose chip was generated.

8 Conclusion

This research demonstrated that:

- racked-in seal can handle the stress of high volume traffic
- racked-in seals can be constructed in an eight-hour working period including any sweeping and line marking
- closely controlled chip application rates result in minimal loose chip on the road surface
- minimal loose chip results in minimal chip being flicked by vehicle tyres
- speed restrictions can be lifted to 50–70km/h at the completion of the line marking
- unrestricted traffic can be placed on the seal the morning after construction
- having no bitumen exposed to tyres reduces the chip pick up and flick and minimises the risk of bitumen tracking.

Also, the requirement for a resealed road to be opened to traffic speeds of at least 70km/h for peak evening traffic could be included in construction specifications. This would assist in minimising motorists' frustration at the traffic delays caused by road sealing.

9 References

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