INVESTIGATION INTO THE HIGH INCIDENCE OF PAVEMENT CHIP LOSS

Transit New Zealand Research Report No. 25

INVESTIGATION INTO THE HIGH INCIDENCE OF PAVEMENT CHIP LOSS

NORMAN G MAJOR, FIPENZ
Roading Consultant, Wellington

Transit New Zealand Research Report No. 25

AN IMPORTANT NOTE FOR THE READER

ACKNOWLEDGMENT

The extent to which people made their experiences and time available, and were prepared to openly expose their failures as well as their successes deserves commendation. During the course of the investigation over 60 people were contacted, and their courtesy and support bode well for the exchange of information in New Zealand, even in our increasingly competitive environment.

CONTENTS

EXECUTIVE SUMMARY

A high incidence of unexplained chip loss on New Zealand roads was reported following the 1989/90 to 1991/92 sealing seasons. Research, published in 1993, concluded that binder quality was unlikely to be the cause.

During investigations carried out from January to March 1993 the current condition of some 90 cases was investigated in the field. These quantified observations were analysed, using design and materials test data, and construction records, for each case. Some 80 of those cases were recorded in detail.

It is concluded that avoidable chip loss is occurring to a significant degree. Most cases of unexpected chip loss were associated with high chip application rates. Other cases of chip loss appeared to derive from a lack of adjustment of design to local circumstances (like chip shape, and local microclimate). Some over-optimistic performance expectations were noted.

Recommendations are made for immediate action to reduce chip loss. They are aimed at use of better chip spread rates, and development of local calibration data for standard design methods. No immediate change is recommended in the standard design procedure.
The recommendations are as follows:

1. Use seal design algorithm RD286 (from Transit New Zealand *Bituminous Sealing Manual*, 1993) as the benchmark.
2. Recognise the manner in which road designers and supervisors get experience, and develop a feedback mechanism.
3. Publicise the problems resulting from overchipping and provide support material for road supervisors and contractors.
4. Emphasise the need to distinguish between void filling and texturising seal coats.
5. Emphasise the need to recognise that a standard conventional coat seal is not always the appropriate treatment to follow a standard first coat seal.
6. Indicate where current good practice is sufficient.
7. Identify the traffic changes that now make some past sealing choices inappropriate.
8. Develop training material for sealing gangs to recognise grossly inappropriate application rates.
9. Publicise these conclusions in full.

ABSTRACT

A high incidence of unexplained chip loss occurred on New Zealand roads following the 1989/90 to 1991/92 sealing seasons. Data based on detailed interviews followed by site inspections covering over 80 cases from Auckland to Invercargill are analysed. Principal causes are identified. Recommendations for immediate action to reduce chip loss are made.

1. BACKGROUND

Following the 1989/90 and 1990/91 sealing seasons, a number of reports of chip loss were received by Transit New Zealand and the New Zealand Bitumen Contractors' Association. The reports were countrywide and ranged from chip loss sites on local roads and streets with low traffic volumes to sites on state highways. Since most of the reports threw doubts on the bitumen properties, chemical analyses were used to detect any differences between bitumens produced between 1986 and 1991. However, no obvious differences were detected in this research (Herrington 1993).

Reports of apparently unexplained chip loss[1] (occurring more than a month after the end of the contract maintenance period, including extensions) were later received relating to the 1991/92 sealing season as well. A sample of these incidents was investigated and reported by Curran (1992), who ranked the possible causes of chip loss in an order of importance.

The project recorded in this report comprised five tasks:

Task 1	Questionnaire design,
Task 2	Interviews,
Task 3	Site visits,
Task 4	Analysis, and
Task 5	Reporting.

---

[1] "Unexplained" chip loss is defined for this research as chip loss which is not attributable to excessive traffic stresses, omission of adhesion agents, or other identified phenomena.

2. ISSUES INVESTIGATED

Six principal issues relating to chip loss identified for consideration were investigated:

- the chipseal design algorithm
- bitumen penetration grade
- compatibility of chip size (and shape) with the underlying surface texture and the resulting effects on binder rise
- chip application rate
- chip shape
- binder suitability, e.g. adhesion agent, diluent, bitumen.

Essentially this survey was a review of pavement performance in general, and so issues that could also be considered with little extra effort during the discussions included:

- type of adhesion agent and whether it had been tested by Vialit procedure,
- effects of addition of latex and polymers,
- whether chip loss was related to binder application rates varying by more than the tolerance allowed in the contract specification.

Some issues showed up that are also being examined by roading authorities in other countries:

- voids in the seal coat (a function of packing of chip),
- effect of seal aggregate breakdown and wear.

Of more importance, trends disclosed by the survey included:

- unexpected trends in packing of the sealing chip layer,
- an increasing tendency for the person who makes the decision on the final binder spray rate, not to be aware of the true condition or (except in cases of early distress) the current performance of seal coats constructed over the preceding two seasons (see further comment in Section 5).

3. INTERVIEWS AND INSPECTIONS

The response from the road authorities contacted for interviews and inspections ranged from co-operative to enthusiastic. Many of them were also keen to recommend further issues (such as dampness of chip when spread) for consideration in the survey.

The survey was originally envisaged to be an office exercise of identifying performance from locally held records and knowledge of pavement condition, supported by inspections of two or three sites to ensure that the researcher and local contact[2] were using the same language to describe the same performance.

---

[2] Local contact: The person in a selected area who had access to sealing and road condition records, and provided detailed information from them. This person was usually the seal coat designer and/or supervisor.

In practice (as indicated in Section 5 below), it was found that even the best site supervisors[3] and designers[4] had only a general appreciation of the quantitative condition of their seal coats, and therefore all data sites had to be inspected. Over 80% of the inspections were carried out in the company of a local escort[5].

4. DETERMINING PROCEDURE FOR SITES

Given the large number of variables, it is clear that within the scope envisaged for the project the investigation could only be quasi-experimental in nature, as the observation pattern could not be pre-designed, and suitable sites had to be selected from those available for observation.

Experience in the first surveyed area, of state highways in Taranaki about New Plymouth, indicated that all sites would have to be visited to achieve consistency in observations, and that data extraction from the different sites would require some time.

In practice, depending on how far apart the sites were, it was sensible to select not more than six or seven sites in an area for detailed examination in one full day's work.

The objective then was to identify sites where nearly all factors were the same, but differences in performance had been observed. As an example, sealing jobs using the same chip size, same chip source, carried out in the same week, on high volume and low volume trafficked roads, with resulting good and poor performance for each traffic volume, would provide a suitable set of four sites.

Often the condition upon arrival at a site was somewhat different (always worse) than the local escort's recollection, so that the pattern of obtained information varied somewhat from the expected.

---

3 Site supervisor: The person on site during sealing operations with responsibility for contract supervision.

4 Designer: The person who finally determines what binder application rate should be used. Sometimes they are the supervisor, sometimes not.

5 Local escort: The person accompanying the researcher during site inspections. Usually the local contact. Also usually the person who had carried out site supervision on the jobs inspected or, in their absence, another person familiar with the jobs and who had supervised like jobs in the same area.

5. DETERMINING CONDITION OF SITES

Apart from one or two "failed" sites, none of the selected sites had been examined in detail by the local contact (contractor, consultant or road authority). For most of these people, who had knowledge of the site design and actual as-built quantities and properties, it was the first time in more than three years that they had spent some time at a specific site examining its condition in detail.

Separation between road owner, designer/supervisor, and contractor has taken place in the past four years (1989-1993), with the substantial application of Competition Pricing Policies. This separation has resulted in considering the examination and monitoring of completed jobs, other than for contractual purposes (e.g. for payment), as a non-productive overhead.

Over the same time, the opportunity to observe and use performance information has changed markedly. Now the person who does the maintenance, and sees how the seal performs, very seldom has contact with the seal designer or supervisor.

While recent changes no doubt have improved time use efficiencies and defined responsibilities more clearly, they have reduced the opportunity for gaining experience in a local area with local materials.

As well, both contractors and consultants have become more "mobile", they are less likely to operate continually in the same area, and so less likely to build up a knowledge of local pavement seal behaviour.

6. AREAS AND TIME OF SURVEY

The survey included 13 areas for inspection (listed in Appendix 1), and originally it was expected to occupy 13 days of observations. However, some of the areas took more than one day to inspect and collect data, so that inspections and interviews in total took about 17 days, plus travel. Areas, dates and local contacts are listed in Appendix 1.

One area (state highways in Otago region, about Dunedin) was omitted as further discussion indicated that it had few cases of a useful pattern. Another area (state highways in the Wanganui Region) though inspected is not reported in detail.

7. GETTING THE DATA

The general procedure that was adopted to collect the data for each selected site was:

(a) Identify the design quantities that were originally intended from site sealing records, or their equivalent.

(b) Record traffic, chip test information and all other design inputs while researching the sealing records.

(c) Determine where the individual sprayer runs started and stopped, so that a site that would not cause confusion between runs could be selected.

(d) Obtain data of the original surface, including sand circle measurements where available.

(e) At the site, stop at the selected point, walk 30 to 50 m against the traffic and return, to obtain an overview.

(f) Inspect surface texture in detail, count chip loss, and examine chip embedment.

(g) Take photos as appropriate, and complete records.

An example of a field inspection sheet, showing how it was filled in on site but transcribed enough to obtain clarity for reproduction, is included as Appendix 2.

8. ANALYSIS OF DATA

In the course of the interviews, it became clear that variations in the design procedure as outlined in Transit New Zealand *Bituminous Sealing Manual* (1993) had the potential to cause confusion.

For analysis, a design using the seal design algorithm RD286, as cited in the current (1993) *Bituminous Sealing Manual*, was carried out. All input data and key output data were recorded on the Processed Data records for each inspected site, and are reproduced in their original format in Appendix 3. The key indicator used for base comparisons is the ratio of application rates for residual binder as actually applied, versus design residual binder rate.

A brief record of condition is given on each processed data sheet. For most areas, the sheet is accompanied by a summary indicating the basis of site selection and direct conclusions, if any. The records are included so that practitioners wishing to review the data or carry out local investigations do not have to seek copies of the original records (lodged with Transit New Zealand Research and Development Section). These summaries show how they were filled in on site and have been transcribed only enough to obtain clarity for reproduction.

9. CHIP PACKING AND BINDER DEMAND

9.1 Observations of High Chip Application Rates

It is clear from the field observations that the volume of voids in a chip layer depends upon more than just the average least dimension (ALD). Substantial differences can exist in the packing characteristics of chips with the same nominal characteristics. Variations in flakiness (or ratio of average greatest dimension to average least dimension, i.e. AGD/ALD) will heighten these differences. As well chips that break down in service into small grit-size particles, will result in a further change (reduction) in void space.

At most sites, the binder rise was less than expected. This appeared to be caused by excessive chip application rates that prevented the chips bedding down with their least dimensions vertical.

A number of influences are believed to have led to this situation, including :

(a) Acceptance and approval of a coarse texture without recognising that the coarse texture may be the result of limited embedment caused by overchipping.

(b) In many cases, a deliberate choice by consultant or client to have substantial chip present at the stage that rolling is completed and the contractor plant leaves the site.

(c) Absence from sealing specifications of quantitative measures that discourage overchipping.

(d) Limited responsibility/maintenance periods (seven days to three months) on many contracts, so that overchipping is contractually acceptable.

(e) Reduction in specified rolling, so that initial uncontrolled speed trafficking takes place earlier. Overchipping seems more likely to initially survive than under-chipping with limited rolling.

(f) When using chip spreaders which do not have a reliably uniform discharge, a tendency is to apply "enough so that we don't have any deficient areas".

(g) Near total absence of the use of "hand spotting" on areas that have been identified as having initial under application of chip.

9.2 Evidence of High Chip Application Rates

Chip application rates appear to have increased over the past four years. While difficult to quantify, the proportion of overchipping (or chip "crowding") on recent seals appears to be significantly higher than on adjacent older seals. Only a small proportion of seals inspected in this survey did not have a significant proportion of overlapping chips. As well both contractors and consultants expressed concern over the prevalence of high chip spread rates.

The photos in Appendix 7 of this report and both examples of chip loss in the Transit New Zealand *Bituminous Sealing Manual* (1993 edition, Plates 1.3 and 1.4) illustrate the phenomenon of chip crowding.

10. SURPLUS BINDER

Incidences of "spot bleeding" (bubbles and small patches of bitumen squeezing up to the surface between chips) were seen on sites from Auckland to Invercargill while carrying out this survey (see first photo in Appendix 7). An explanation for this kind of bleeding is considered to be binder rise induced by high water vapour pressure in the basecourse. Spot bleeding occurs without embedment of chips into the substrate, and is distinguished from "bleeding" caused by excess binder, in which binder flows on the road surface.

Vapour pressure-induced binder rise is caused by high water vapour pressure in dense and relatively impermeable basecourse with low voids within the mineral aggregate which, after prolonged wet periods, can become near-saturated. A rapid onset of hot weather can produce a significant rise in water vapour pressure. (For example, an increase in basecourse temperature from 20° to 30°C results in an increase in water vapour pressure of about 170mm water gauge.)

Such a combination of conditions occurred in parts of New Zealand in 1992. That year was generally considered to have had a prolonged wet winter and a cool spring which did not allow the pavements to dry out until late summer, by which time the temperatures were higher.

It is important that the cause of bleeding is identified because, if the two kinds of bleeding are confused, the mistaken reaction may be to reduce bitumen application rates. Thus if the cause for the bleeding is vapour pressure-induced binder rise, decreased bitumen application could lead to chip loss.

11. OTHER FACTORS INVESTIGATED

11.1 Changes in Recommended Design Procedures

From about 1966, National Roads Board (now Transit New Zealand) provided for guidance a "Spray Rate Chart" (a combination of graph and nomograph) for determining target binder application rate for second coat seals and reseals. After successive amendments the chart was metricated and became drawing number RD238 (June 1975), in the National Roads Board *Manual of Sealing and Paving Practice* (1975 edition).

In 1984 the spray rate chart was replaced by an "outcome equivalent" formula, referred to as seal design algorithm RD286. (The formula and associated factors are formally filed by Transit New Zealand as drawing number RD286.) This latter design procedure gave similar application rates at 4000 vehicles per lane per day (vplpd)[6], but higher spray rate quantities at lower traffic volumes (about 10% higher at 700 vplpd). In a revision to RD286 promulgated in the 1993 Transit New Zealand *Bituminous Sealing Manual*, application rates were progressively increased for traffic volumes below 2000 vplpd (Appendix 5), in which the increase at 700 vplpd was about 5% and at 100 vplpd about 15%.

When using the earlier chart procedure, the sensitivity of the resulting application rate to changes in input variables was quite evident. Further the chart included an indication of the allowances to be made for chip shape and varying degrees of flushing of the existing surface (in addition to measured texture depth).

When using the formula plus tabulation of algorithm RD286 the calculation produces a single value. Hence deliberate repeated calculations with varied input parameters are required to assess sensitivity of binder application rate to the input parameters of ALD, existing surface texture (measured by sand circle diameter), and average daily traffic. Examples showing the general degree of sensitivity of design spray rates are given in Appendix 4.

While the current design procedures are more consistent and numerical, the seal design procedure introduced for State Highways in 1984 has led to designers simply measuring and recording the sand circle sizes along the sealing job length, and proceeding through a systematic sequence of steps, to determine a target binder application rate. But its very code-like nature has discouraged local site observation and judgement.

When such a systematic design method exists, seal designers at the desk or in the field on the day have to have (or be able to access) substantial field performance information (experience) to justify any departure from the standard method. This applies whether design responsibility lies with consultant or contractor.

---

[6] Note the use of vehicles **per lane** per day (vplpd) for assessment of binder application rate. Not to be confused with vehicles per day (vpd) total traffic on all lanes.

11.2 Alternative Design Procedures

Given that most unexpected chip loss derives from insufficient chip embedment in the binder at the time of distress, a new seal coat needs enough time after construction to become bedded to a stable condition. The traditional way to promote embedment was to carry out construction before summer, to give opportunity for traffic-derived embedment before seasonal winter cooling. Substantially increased rolling by construction plant, or by an extended period of traffic control, also have been used.

The alternative design procedure outlined by Houghton and Hallett (1987), and currently used as an alternative to algorithm RD286 by some designers, takes account of the "first winter" problem by estimating the amounts of binder required both as minimum for first winter (based on progressive embedment in the time from sealing until "winter starts") and as a maximum to avoid flushing at the end of the intended service life. Such considerations could help improve a designer's prediction of performance.

11.3 Changes in Vehicles

Deregulation of the land transport industry (in 1989) has led to substantial increases in the tonnage of goods transported by road, with particularly marked changes in line haul situations. This change means that we now expect to use chipseals under loadings that are higher than those before deregulation.

Further, changes in the configuration of larger line haul vehicles have resulted in higher shear stresses being applied on curves. In February 1989, new weight and dimension limits for heavy vehicles took effect. Regulations[7] introduced then increased gross (and in some cases axle) limits, and varied the construction and length limits.

The new regulations tend to discourage use of semi-trailer plus full trailer, and truck plus full trailer combinations, and to encourage the semi-trailer behind semi-trailer "B-train" configuration. The most effective (from the operator's point of view) semi-trailer rig has become one with a non-steering 3 axle set under the semi-trailer; a spacing of 2.8 metres from front to back axles of this group is common. Similarly, triple tandem axles are not uncommon on B-trains.

The increased side shear resulting from the changes relating to axle sets does require a more durable seal coat. In many cases a change to drylocked or two coat seals may be required.

---

[7] Amendments No. 4, 5, 6 (1989) updated the Heavy Motor Vehicle Regulations 1974.

11.4 Changes in Rolling Requirements

The rolling requirement in the 1989 edition of specification TNZ P/4 Resealing was reduced to about half the original and became effective for the 1989/90 season.

Reported research on the effect of alternative rolling practices is limited. The reports that are available are *Rolling of Chipseals* (Hudson et al. 1986) which reports local trials carried out from 1982 to 1984, and National Roads Board Road Research Unit Project AB/13 *Chipseal Rolling Investigation* (Sheppard and Petrie 1989, 1990) which reports a detailed site trial on SH26 east of Hamilton in the 1988/89 season.

The first of these reports concluded that little measurable improvement occurred beyond six passes of rubber-tyred rolling, and that initial traffic had a marked effect in wheelpaths. The second report concluded that rubber banded vibratory rollers were likely to be as effective as conventional plant but, for reasons of chip spread rate, it was inconclusive about an optimum number of rubber-tyred roller passes. Controlled traffic (represented by rolling by truck), like the rubber banded roller, was clearly still effective between six and nine passes. It should however be noted that the Grade 3 reseal of Project AB/13 was carried out on a somewhat special site with sand circle diameters ranging from 150 to 170mm over the nine subsections, at a traffic volume of about 3200 vplpd. Both reports recorded substantial compaction under subsequent traffic.

12. CONCLUSIONS

Conclusions were derived from most sites, and these are set out with minimum amendment in the Processed Data schedules given in Appendix 3, and in the attachments to each schedule. The individual conclusions in terms of the issues identified for the project are set out below, in increasing order of importance. (Some further conclusions, not related to the project but worth noting, are included in Appendix 6.)

12.1 Effects of Choice of Adhesion Agent Relative to Binder and Chip Stone Type

Although only a portion of the local contacts had records of Vialit testing for adhesion agent compatibility and design content that were readily available, it appeared that contract requirements for this matter were being complied with.

12.2 Effects of Binder Application Rates Outside Contract Tolerances

Developments in the technology for, and the regular testing of, bitumen distributors over the past five years have resulted in their application rates usually being accurate. Only one of over 200 records of individual spray runs examined in the course of this project was outside contract tolerances for uniform width cases. Varying width cases applied by spraybar appeared to all be within contract tolerance. Hand-sprayed areas were of lesser uniformity. No cases of chip loss in trafficked lanes were found that could be attributed to departure from contract-specified accuracy.

12.3 Correlation With Use of Latex or Polymers

Only two of the inspected sites used polymer, which is an insufficient sample size to arrive at a sustainable conclusion. It was however noted that the viscosity and resilience of polymer-modified binders (even with the extra temporary diluent that is usually added) requires greater compactive effort to obtain full bedding of the chips. Contract requirements or practice do not appear to lead to significantly greater field rolling than for the unmodified binder.

12.4 Choice of Bitumen Penetration Grade

With one exception, all areas were using the normally accepted bitumen penetration grade, and no clear reason was evident that change should be made. The exception, in the Auckland region, was to shift from 80/100 to 180/200 penetration grade for lower trafficked rural roads, in the expectation of better development of a close bedded chip layer. There was no detectable association of poor chip retention performance with penetration grade.

12.5 Suitability of Flux and Cutback Proportions for Intended Service

Additions of AGO (automotive gas oil) as flux were modest and in no case was the addition of more than 2 parts per hundred (pph) found to have been used.

Generally the amounts of kerosine used appeared to vary to about 2 pph lower than that recommended in the Transit New Zealand *Bituminous Sealing Manual* (1993). An unforeseen change in weather, with a resulting drop in temperature from 28°C at 10am to 19°C at 6pm, without adjustment of kerosine content contributed to poor performance at one site. (The manual would indicate an extra requirement of about 6 pph for such a temperature change.) It must be noted however that records of actual site temperatures were scanty.

Fluxing and cutting back are not significant issues in unexplained chip loss.

12.6 Compatibility of Chip with Existing Surface Textures, and Effects of Chip on Binder Rise

The binder applied in a chipseal is used in two ways:

1. To fill up the voids in the existing surface which will be bridged by the chips being applied, and
2. To supply the binder that will produce chip adhesion, mainly by partially filling the voids within the applied layer of chips.

Generally seal designers are concerned to get their design application rate accurate to within 3 to 5%, and sprayers can consistently apply binder to within 1% of target across the full spraybar width. (Within the full spraybar width, nozzle to nozzle variation complying with specification BCA E/2 (1992) may produce variations of up to 12% from mean on a 200mm wide strip).

Therefore variations in existing surface texture that would cause a change of +10% to – 10% from average application rate, while tolerable if all other factors have been accurately assessed, use up a large proportion of the available tolerances of the whole chipsealing process.

Reduction of variation in existing surface texture, by use of a void filling seal coat treatment, has long been accepted as a normal procedure in a sequence of sealing treatments. Since the middle 1980s a treatment using Grade 5 or 6 chips, now called a "texturising seal coat", has come to be regarded as a treatment with significant useful life - say two to five years - with a preference for using Grade 5 chips to extend the time until a further treatment is needed.

Sand circle data, for the original surface and for the surface after sealing, show substantially greater texture depth between wheelpaths and along the centreline than in the general wheelpath zone. This difference is emphasised most on relatively narrow seals (6.0 to 6.6 m total seal width) which have high quality centreline paint marking or raised pavement markers. Trafficking of the centreline area is much reduced on lengths that have raised pavement markers.

The expectation of a texturising seal coat is that in coarse textured areas the relatively small chip used should fit into the surface voids rather than bridge them, and at the same time should adhere on top of the smooth wheelpath sections. But in such treatments it must be accepted that between coarse and smooth underlying textures there must be medium texture where the binder will end up in the medium voids with insufficient binder left to retain the new chips.

A complete take and uniform resulting surface is unlikely when applying a texturising seal coat to a surface that is too variable for say a conventional Grade 3 reseal. Although such lack of uniformity may be acceptable if waterproofing is the dominant requirement, such a resurfacing can develop a very low (large sand circle) surface texture fairly quickly in the areas that do not retain chip.

Historically a true void filling seal coat, where no significant increase in texture depth was expected on smooth areas, was usually carried out with a Grade 6 chip. Such treatments were not expected to have a significant service life as they were left under traffic only long enough to mature to produce a surface suitable for the next routine treatment.

It is the author's belief that current concerns about maximum coverage for a given budget have diverted people from the use of void filling seal coats as a pretreatment, toward immediate application of a Grade 4 or Grade 3 reseal, with frequent attempts to cover surfaces with quite high texture and texture variability. Such treatments are proving to be a high risk choice. Assessment of the compatibility of chosen chip size with the range of textures of the pavement to be sealed should temper these concerns for coverage. Compatibility is rated as a significant factor in seal coat survival probability.

The extent to which the chosen chip size is compatible with the variations in binder demand arising from the variations in texture depth of the substrate also needs to temper these concerns. Substantial texture variation may make it impracticable to achieve an application rate that is high enough to retain the applied chip in local areas of large substrate texture depth, but low enough to avoid flushing in areas of small substrate texture. Matching chip size to existing texture depth (whether by choice of chip size, or pretreatment of the existing surface) is rated as a significant factor in seal coat survival.

12.7 Voids in Seal Coat and Chip Packing

Voids in seal coat as a function of the pattern of packing of the specific chip that results from chip shape and amount is an important consideration. Three factors lead to significant variations in the effective voids in the layer of chips in a single seal coat when it reaches its final bedded state under trafficking:

1. Chip application rate and chip shape in all cases,
2. Chip breakdown (or wear) in service occasionally, and
3. Chip absorbency.

In this project, the most prominent contributor to unexpected chip loss was application of too much chip. The result of this was threefold:

- the layer depth increased,
- the proportion of voids within that (thicker) layer tended to increase, and
- the chips standing on end were much more prone to dislodgement by traffic stress.

The effect of chip shape (particularly as measured by AGD/ALD) is believed to have a significant effect on required binder application rate, but this was masked on most of the 80 sites by chip application rate. In some cases (8 of the 80), chip breakdown under traffic occurred, leading to a reduction in binder required.

Application of too much chip is rated as a significant factor in a large proportion (about 70%) of the observed cases of unexpected chip loss, and about half the seals rated as good had more chip than desirable.

12.8 Accuracy of Seal Design Algorithm RD286

Given that the seal design algorithm RD286 (from Transit New Zealand *Bituminous Sealing Manual*, 1993) does not take account of chip shape, chip breakdown, the way the applied chip nests into the underlying surface texture, and assumes uniform single layer placement of the covering chip, it is surprisingly accurate. It behaved appropriately in the cases in which only one variable (application rate, chip size, underlying surface texture, traffic intensity) varied at a time.

It is concluded that the algorithm should not be changed, but that deliberate adjustments based on observations for each local area, traffic intensity, and chip type combination should be used more generally (noting that this pre-supposes examination of sites in as much detail as undertaken for this project). Note that the reduced application rates for high traffic volumes (say over 2000 vplpd) assume that the date of sealing, and the rolling, traffic control and relative binder hardness during the time leading up to the first winter, are such that allow the applied chips to reach a condition of stable interlock.

Insufficient cases could be categorised in the survey to determine how effective the change of algorithm RD286 from its original version to the 1993 version has been. The change was effective only for traffic loadings of below 1000 vplpd, where there is more tolerance to variation in application rate.

12.9 Application of Design Procedure and Execution of Sealing Work

Briefly, shortfalls in design arise from lack of experience (related to the current work environment that makes experience hard to get) and from a system of awarding design commissions that encourages minimum site inspections (i.e. the substantial effect of price determining which designer will be engaged).

Though inspections during construction were not part of this project, it appears that in the execution of the work chip application tends to be regarded as a matter of getting over the ground quickly. The shortened duration of rolling seems to result in chip spreading being regarded as just an incidental process, rather than one requiring skill and accuracy. While the predominant shortfall is in determination of binder application rate, choice of treatment is also a problem.

13. RECOMMENDATIONS

Recommendation 1. Use Seal Design Algorithm RD286 as the benchmark.

No change should be made to seal design algorithm RD286 as printed in the 1993 edition of Transit New Zealand *Bituminous Sealing Manual.* The industry should be advised to use it as a benchmark, applying a local calibration factor based on quantitative observations in which they have confidence. Industry should be advised that the change to be applied to the application rate appears to range from -5% to +20% but with quite good consistency for a specific climate/stone-type/chip size combination. Use of local calibration should be regarded as part of the design process.

Attention should be drawn to the need for the chips to be sufficiently bedded into the binder at the onset of the first prolonged cold spell if they are not to be lost. To achieve this under high traffic (and reduced application rate) conditions, the seal may require to be constructed early in the season, to allow enough pre-winter traffic compaction. In such high traffic conditions consideration at the design stage should also be given to the traffic pattern within lanes and hence to the effectiveness of in-service traffic compaction on lane lines and shoulders.

Recommendation 2. Recognise the manner in which road designers and supervisors get experience, and develop a feedback mechanism.

As discussed in Section 5, the separation of responsibilities and "turnover" in designers and site supervisors (whether contactor or consultant) has resulted in less feedback over the past four years.

Road owners[8] should be advised to develop a pool of performance records for their own areas. Observation procedures and data reduction procedures as used in this survey would be satisfactory.

Road owners are the most appropriate holders of, and the principal beneficiaries from such information. The estimated cost per road owner to obtain minimum records under such a system would be four technician days per season. This is about the same cost (as in 1993) as 500 lane metres needing stripping repair.

---

[8] Road owner: The territorial local authority with long term ownership responsibility for the road or street.

Recommendation 3. Publicise the problems resulting from overchipping and provide support material for road supervisors and contractors.

In part as a reaction against loss of skid resistance, and shortening of a surfacing's service life by flushing, road owners, designers and some contractors have come to rate a high voids layer of chips as desirable. Where this occurs because the chips are crowded and not bedding down with their ALD vertical, binder demand is higher and resistance of the chips to shear displacement is lost.

In the long term, development of quantitative means of defining chip spread rates (m^2/m^3) should be investigated, but in the shorter term full size photographs of standard chip spread rates immediately after spreading should be made widely available[9], and publicised. (Copies of such photos, first made available at the introductory courses for the Transit New Zealand *Bituminous Sealing Manual* (1993), are well used in those offices that have them.)

Recommendation 4. Emphasise the need to distinguish between void filling and texturising seal coats.

The attention of both road owners and designers should be drawn to the problems arising when attempting a seal treatment on a coarse texture with a grade 4 or grade 5 chip. The appropriateness of the use of emulsion for void filling seal coats should be highlighted.

Recommendation 5. Emphasise the need to recognise that a standard conventional coat seal is not always the appropriate treatment to follow a standard first coat seal.

The need for special consideration for sand circles of below 175mm diameter should be emphasised - even if it means using a general void filling seal coat with an immediate service life of only one year, instead of a conventional second coat seal.

Recommendation 6. Indicate where current good practice is sufficient.

Benefits will be gained by focusing attention on significant factors, such as those indicated in this report, rather than by trying to solve every perceived problem.

---

9 A set of four photos for each chip size, Grades 2 to 5 would be satisfactory. Each set of four would illustrate correct chip spread rate, and rates which vary from correct, to -10%, +10%, and +20%. An example is given in Appendix 2, Transit New Zealand *Bituminous Sealing Manual* (1993).

Recommendation 7. Identify the traffic changes that now make some past sealing choices inappropriate.

Identify the changes in loading and vehicle configurations that have occurred since traffic deregulation and point out that in some turning and some traction situations, and in some locations, a single coat seal is no longer suitable.

Recommendation 8. Develop training material for sealing gangs to recognise grossly inappropriate application rates.

In one or two cases it appeared that binder application rates were simply wrong for the site. A simple guide which shows sealing gangs what to look for after the first four passes of the roller would help to reduce the incidence of such mistakes. Such a guide could well accompany sets of chip application rate photos.

Recommendation 9. Publicise these conclusions in full.

The appropriate medium for publicising these recommendations should be considered by Transit New Zealand to ensure that road practitioners are fully informed of the results of this project on chip loss.

14. REFERENCES

Curran, J.M. 1992. Investigation into chip loss causes. *Proceedings National One Day Forum on Bitumen Surfacings*. Chip Sealing Session. 4pp. New Zealand Bitumen Contractors' Association.

Herrington, P.R. 1993. Safaniya bitumen - verification of chemical properties. *Transit New Zealand Research Report 22*.

Houghton, L.D., Hallett, J.E. 1987. An analysis of single coat seal designs. *Proceedings 1987 NZ Roading Symposium* Vol.2: 249-263.

Hudson, K.C., Saunders, L.R., Hambleton, P.H. 1986. Rolling of chip seals. *Proceedings 13th ARRB/5th REAAA Conference* 13: 173-186.

National Roads Board 1968 (updates 1971, 1975). *Manual of Sealing and Paving Practice*. National Roads Board, Wellington. 159pp.

NZ Bitumen Contractors' Association. 1992. *BCA E/2 Specification for Performance of Bitumen Distributors (provisional)*, (previous edition, NRB E/2 1987).

NZ Government. 1974. Heavy motor vehicle regulations. 1989 Amendments.

Sheppard, J., Petrie, D.D. 1989. Road Research Project AB/13. Chip seal rolling investigation. Report on Stages 1 and 2. Transit New Zealand, Wellington. 33pp. plus 35 pp. appendices.

Sheppard, J., Petrie, D.D. 1990. Road Research Project AB/13. Chip seal rolling investigation. Stages 1 and 2. Review of Performance over First 12 Months. Transit New Zealand, Wellington. 20pp. plus 5pp. appendices.

Transit New Zealand. 1993. *Bituminous Sealing Manual*. Transit New Zealand, Wellington. 201pp.

Transit New Zealand. 1989. *Specification TNZ P/4 Resealing*. Transit New Zealand, Wellington.

APPENDICES

APPENDIX 1 SCHEDULE OF FIELD INTERVIEWS AND INSPECTIONS

Road Area	Principal Discussions with	Date
Waitakere City	Auckland Asphalts, G Pugh	27 Jan & 15 Mar
Manukau City	Manukau, J Smith & G Smith	26 Jan
Clutha District	Royds Garden, R Scherp	2 Mar
Queenstown-Lakes District	Royds Garden, R Scherp	11 Feb & 3 Mar
Southland District	SDC, G Clarke	5 Mar
SH Region 2, Auckland	Transit, R Smith WCS, R Watkins	27, 28 Jan
SH Region 5, Gisborne	WCS, T Boyle	20, 21 Jan
SH Region 6, Hawke's Bay	Transit, Hart, Harkness WCS, Somerville	19, 20 Jan
SH Region 7, Taranaki	BCHF, M Kennard	8, 10 Jan
SH Region 8, Wanganui	Transit, Barnes, O'Hara WCS, R Tutty	11 Jan
SH Region 10, Nelson	WCS, K Manson	26 Feb
SH Region 13, Otago	Fulton Hogan at Dunedin, only minor SH inspection	1 Mar
SH Region 14 Southland	WCS, Stuart McLeod	4 Mar

APPENDIX 2 SAMPLE INTERVIEW RECORD FIELD SHEET

INTERVIEW RECORD 4/3/93 at INV DATA FROM Stuart McLeod of WCS 14/1

#3 Try 6400 (spray 6340 1.683)

1. Site AWARUA
   - Reference giving exact location and extent: SH 1 933/S.87-7.01
   - Traffic volume vpd (and how determined): 2400 vpd '91 counts
   - Traffic % hcv (and how determined): 20% '91 counts
   - Stress factors? (Tight turns, braking etc.): V large radius curve, —— n.c.
   - Other site factors? (eg contamination): Some Phosphate Cartage
2. Substrate
   - Nominal chip size: Grade 5 2nd coat appx 4yr old.
   - Texture (sand circle or other estimate):

	6200	6400	6600
L	205	180	190
C	165	155	155
R	200	195	200

   - Uniformity of texture
   - Old chip loss? (specify): Nil
   - Pretreatment. (Type & Age): Nil - apart from std maint
3. Equipment
   - Type of sprayer: Fulton Hogan (then Sthld Constn) 4.5m bar
   - Certified? (cert date): Serial 28 Exp 21/8/92 PF 1081
   - Type of chipspreader: Flaherty (type) self prop chipspd
   - Type of roller(s): 2off, 1off 9 tyred, 1off Hahn vib drum
4. Materials

ALD 9.25 9.07 9.82
Shape 2.23 1.96 2.01
% 75 76 71
clean 93 95 95
BF 100 100 100

   - Chip. size 9.86 Aparima & test ref INV WCS #92/277
   - shape 2.02 % within 68%
   - cleanness 93 * and geol type BFes 100
   - Bitumen. pengrade
   - flux (pph of pengrade) 18/200 with 2pph AGO

Rest in tern(?) Tender said

   - cutter (type and pph) 3 kero
   - adhesion agent (type & brand, pph, vialit tested Y/N) SIKA EX3747 0.8 Y
   - polymer (type and brand, mix method, hold time) —
   - how long binder at tanker temp (6, 12, 24etc hrs) 3 mins
5. Design intention
   - Residual spray rate. 1.69 reqd
   - general design procedure New manual
   - local modifications Nil
   - Chip spread rate Not meas - "to spec"
   - Other (e.g. drylock, special rolling) No

Chiploss Questionnaire Sheet 1 of 2.

LOW FAIR BINDER + PATCH

6 **Intention on site on the day**

Did it differ from design? If so how?
(include binder formulation) 2.10 l/m² hot

7. **Construction**

Date and Time of sprayrun (within half hour) Sat am 28 Mar 92

Cleanness after brooming

Actual binder spray rate (residual or total) 2.10 l/m² @ 158 °C

Chip spread rate (at least estimate over or under) Acceptable

Chip time to dry? <10 minutes recalled

Rolling (passes or time per unit area) Specified

Traffic control (method, duration till depart site) Normal

8. **Weather**
Temperature, precipitation, wind, and other. High cloud, warm 20°C
Drizzle 10 min after sealing

9. **After care or deliberate supplementary treatments.** No but emul + G5 on ℄ later

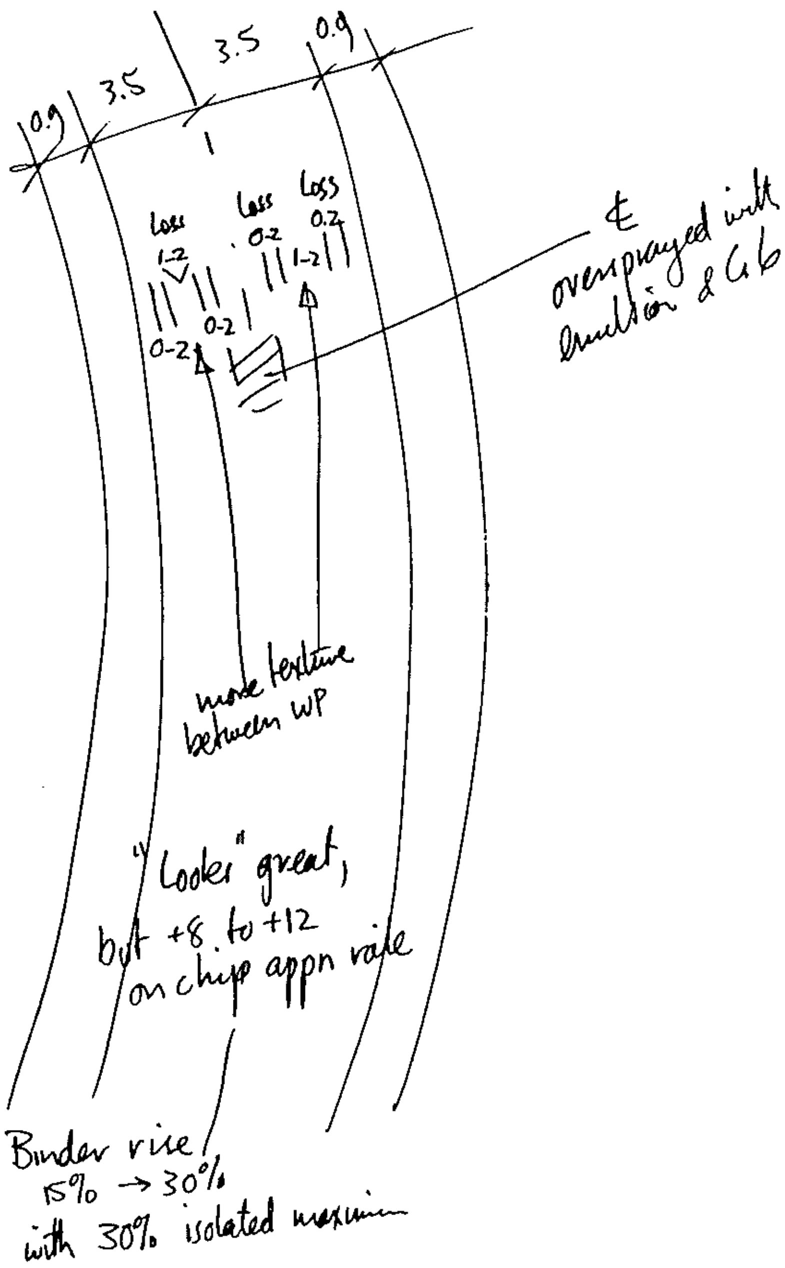
10. **If this is a stripping site**
Chip loss extent and location See →

Conditions change markedly after sealing.
(eg doubling in logging traffic)

When did it go wrong, and how. (Narrative,
quantified if possible)

What is the local opinion on the cause.

11. **Other observations**



Chiploss Questionairre Sheet 2 of 2

APPENDIX 3 PROCESSED DATA AND COMMENTARY FOR ELEVEN INSPECTION AREAS

Inspection areas are filed in the order:

Waitakere City

Manukau City

Clutha District

Queenstown-Lakes District

Southland District

SH Region 2, Auckland

SH Region 5, Gisborne

SH Region 6, Hawke's Bay

SH Region 7, Taranaki

SH Region 10, Nelson

SH Region 14, Southland

Notes on the schedules of processed data:

Section no. - identifies the field survey sheet for each observation.
Type - uses a letter, number code. **R** indicates reseal, **S** second coat seal,
number indicates the nominal grade of chip.
Modifiers sometimes follow the number:
- **P** - pre-coated,
- **L** - locked (void filled) using binder,
- **D** - drylocked without binder.

Des (l/sm) - design application using Bituminous Sealing Manual (1993) design procedure, unmodified.
Ratio act/des - the ratio of actual site application rate to design application rate in terms of residual binder at 15°C. It applies to both cutbacks and emulsions.
Loss % - average percentage of chips missing on reported section:
W0-2/B8-15 means 0 to 2% missing in **W**heelpaths,
8 to 15% missing **B**etween wheelpaths.

PROCESSED DATA FOR WAITAKERE inspns 27 Jan, 15 Mar 93

Section Name	Sectn no.	Type	Tfc (vplpd) W	SS dia (mm)	ALD (mm)	Des (l/sm)	All 80/100 Other (pph) AGO	Ker	Adh	Application Hot	Temp	ResCold	Ratio act/des	Loss% W/B
Karekare #1	W/1	R4	350 *	230	7.50	1.516	2	2	0.7	1.60	170	1.42	0.94	All 8-10
Karekare #2	W/2	R3	118 ?	200	8.60	2.080	2	2	0.7	2.45	170	2.18	1.05	See note
Lone Kauri	W/3	R3	200 *	230	8.60	1.839	2	2	0.7	1.51	170	1.34	0.73	80% patched
Simpson	W/4	R3	950	230	8.60	1.492	2	3	0.7	1.82	170	1.60	1.07	W0-2/B8-15
Coulter, from Drower to Vineyard	W/5	R3	650	250	8.60	1.530	2	2	0.7	2.35	175	2.08	1.36	W0-10/B10-40
Candida, from Pooks to Coulter	W/6	R3	1000	200	8.60	1.562	2	3	0.7	2.56	170	2.26	1.44	Extensive
Millbrook	W/7	R4	3000	300	7.50	1.049	2	4	0.7	1.53	175	1.33	1.27	Scab areas.
Abbotleigh	W/8	R4	300	200	7.50	1.642	2	5	0.7	1.64	170	1.42	0.86	20% patched
Potts Ave	W/13	R4	50	275	7.50	1.857	2	4	0.7	1.97	165	1.73	0.93	Extensive

An asterisk in W column * indicates narrow width, both directions assigned as one lane.
Also reviewed and inspected, but with missing data, Beach, Pringle, Cornwall, Devon, W/9 to W/12.
Overchipping rated as common on many sections by contractor.
W/1 Overchip 8-10% Chiploss obs 3, 5, 4, 8%
Serviceable as speeds held to 20kph by speedhumps.
W/2 Fair. Design shown is for curves where operate 2 lane. Chip crowded. Insufficient binder on curves.
W/3 Poor. Error in application rate. And 10% overchip. Embedment nowhere more than 10%
W/4 Fair. would be good if the +15% chip reduced.
W/5 Fair. Embed 10-20% Rated as ok at contract review. Looks good at speed, apart from minor patches.
10% overchip now in nil loss areas, up to 10% "underchip" following loss in wheelpaths.
W/6 Poor. Rated OK at contract inspection, >10% total ares now Grade 5 locked/patched, both
half width and centerline. All a bit ovechipped, embed 20-30% in survive areas.
Use of Grade 3 on Grade 3 a likely contributor.
W/7 Fair. 5-10% overchip. No chips at 50% embed, all 20-40%
"Patches" of 50% loss reflect underlying texture.
W/8 Poor. Contract comment Lack of binder, light stripping over reseal repairs.
Research comment Low binder, clearly overchipped with many chips at 14 mths still standing up on end.
W/13 Poor. 20-40% chiploss on areas not patched out.

As at 27,28Apr93
Filed as
CASE_WAI.ENC
& CASE_WAI.PRN
Ccn on 4 May 93

Preliminary selection at Auckland Asphalts from their performance review schedule.

Good	Marginal	Poor
G3 Coulter 400-800 vplpd	G3 Simpson 950 vplpd some good, some bad	
G3 Karekare 350 vpd total (actually coast end of Lone Kauri)	G3 Lone Kauri near Piha 200 vplpd all problem possible chip total emuls Jan 93	Actual inspn shows poor
	G3 Candida part fixed, part not 1000 vplpd est (interp 1400, 1382)	G4 Potts Low binder part emuls patch
Chip all v. good greywacke ex Hunthy Quarries, nil breakdown, cubical, harder to sweep	G3 ONeills emuls on part early 92 500 - 1000 vplpd	G4 Bedford, Devon Cornwall all bad, emuls treated
	G4 Abbotleigh 200-400 vplpd a little chip loss some fat bubble up.	

PROCESSED DATA FOR MANUKAU   inspns 26 Jan 93

Section Name	Sectn no.	Tfc (vplpd)	SS dia (mm)	ALD (mm)	Des (l/sm)	Bit Pen	Other (pph) AGO	Ker	Adh	Application Hot	Temp	ResCold	Ratio act/des	Loss% W/B
Roscommon, Wiri Stn South	M/1	5000	230	12.50	1.666	80/100	0	0	0.5	1.96	184	1.77	1.06	Total repair
Roscommon, Browns southwd	M/2	8970	163	12.50	1.723	80/100	0	0	0.5	2.21	175	2.00	1.16	Patched then wetlocked.
Everglades, Crail to rndabout	M/3	1800	250	9.50	1.460	80/100	0	4	0.5	2.18	170	1.90	1.30	Two sections, one drylocked
Smails, Noname (at tip) eastward	M/4	4200	300	11.75	1.528	180/200	0	3	0.5	2.13	165	1.88	1.23	W1-3/B1-3
Arakotinga	M/5	555	160	11.75	2.400	180/200	0	6	0.5	2.92	173	2.49	1.04	See note
Twilight, Kemptons-PapCleve	M/6	530	190	12.00	2.294	180/200	0	4	0.5	2.75	180	2.38	1.04	W1-3/B1-3 CL loss to 40
Monument, frm Tourist,sthwd	M/7	395	175	12.00	2.460	80/100	0	4	0.5	2.92	175	2.54	1.03	

Overchipping tendencies evident generally. Some breakdown selflocking chip.

M/1 Poor. Feb92 "Fell apart" in 2 days. Problem of getting high tfc retained to start.

M/2 Poor. Feb92 Substantial but lesser loss at same time as M/2. Still has 250mm loss areas.

M/3 Fair. Oct91 Drylocked section near nill loss. Underlying high air voids asphmix surface probably very absorbent. Chip very crowded.

M/4 Fair. Oct92 High CV %ge. Initially appeared underchipped, so rechipped with hot chip. Chip appn probably about right now, 2% loss general, local linear loss on CL.

M/5 Poor. Apr92 Low HCV. Binder rise low and o'chip 10-15% Near complete G5 and binder o'spray.

M/6 Fair/Good. Apr92 Clear traffic damage repaired, rest shows about 2% chiploss. Clear 10% o'chip. Chip breakdown, and stray chip from tfc damage repairs, has helped lock up, see photos.

M/7 Fair. Mar92 Overchipping, spot popouts, and lots of cracking chip. Spray repiars on CL. Broken chip and G6 spreasd across from CL repair have stabilised balance.

As at 28Apr93
Filed as
CASE_MAN.ENC
& CASE_MAN.PRN

Examined recent seals only - i.e. 91/92 & 92/93

Lessons: 1. Overchip problems
2. Grade 2 ineffective on top of "toothy" G3. Conclude that even with light traffic its wrong to try & put even a big chip on open texture
3. Breakdown of chip like East Tamaki "fragile" basalts can fill in areas of chip loss.

To get comparisons, selected
3 high volume, Poor through to Fair } all Grade 2
3 low volume, Poor to Fair }

Plus
1 medium volume fair Grade 3

Conclude: 1. Overchipping rife
2. Insufficient prepn before reseals
3. The textures of the seven (substrates) showed no clear correlation

290-320	250	230	190	175	163	150
Fair	F G3	Total Repair G3	Poor	F	Over sprayed P	P

Inspections: Tuesday 26 January 1993

Schedule of sites:

Section No.	Section Name	Traffic (vplpd)	Condition
Grade 2 second coats and reseals			
High volume			
M/4	Smails	4200	Fair/Good
M/2	Roscommon, Browns, southward	8970	Poor/Fair
M/1	Roscommon, Wiri Stn southward	5000	Poor
Low volume			
M/7	Monument	395	Fair
M/5	Arakotinga	555	Poor
M/6	Twilight	530	Poor
Grade 3 reseal			
M/3	Everglades	1800	Fair

Conclusions:
- See detailed comments on Processed Data sheet (p.36).

- Note that, at very high traffic volumes, there has to be enough binder to handle initial uncontrolled traffic. It may not be practicable to apply the "correct" application rate for the traffic density, without extensive controlled rolling by plant or managed traffic.

PROCESSED DATA FOR CLUTHA inspns 2 Mar 93

Section Name	Sectn no.	Type	Tfc (vplpd)	SS dia (mm)	ALD (mm)	Des (l/sm)	All 180/200 Other (pph) AGO	Ker	Adh	Application Hot	Temp	ResCold	Ratio act/des	Loss% W/B
SECOND COAT SEALS GRADE 3														
Same Harewood chip ALD value suspect														
Clutha-Clydevale														
Sec 3.20 RP 2.450	C/6	S3	400	170	9.00	1.976	2	6	0.5	2.25	154	1.95	0.99	Nil
Clutha-Clydevale														
Sec 3.21 RP 11.70	C/5	S3	360	160	9.00	2.071	2	4	0.5	2.25	150	1.99	0.96	W2-3/B5-6
Same Palmers chip. Good test data.														
Clifton-TeHouka														
Sec 3.23 RP 1.770	C/1	S3	100	190	9.19	2.295	2	6	0.5	2.39	155	2.07	0.90	W1-2/B4-6
Pannets Road														
Sec 3.10 RP 1.130	C/2	S3	50	150	9.19	2.845	2	4	0.7	2.58	152	2.28	0.80	See note
(south from Beaumont-Rong Rd)														
RESEALS GRADE 3														
Chips not matching														
Clutha-Clydevale (Gore gravel)														
Sec 4.17 RP 15.820	C/3	R3	400	230	8.97	1.739	2	4	0.7	1.90	147	1.68	0.97	W0-1/B0-3
Clutha-Clydevale (Harewood)														
Sec 4.16 RP 9.79	C/4	R3	400	240	9.00	1.721	2	6	0.5	1.90	160	1.64	0.95	W0-1/B0-2

C/6 Nil stripping, close in to town. High HCV count from FH quarry. Vplpd probably higher than reported.
C/5 Fair. Jan92 Not stripping grossly, but fragile. CL loss visible at 15-20%
C/1 Fair. Dec91 From OWP to OWP fair, but edge 40-55% loss. Overchip. Embedment 30-40%
C/2 Poor. Jan92 on scabbed and repaired 1st coat. Substantial patching G5 & cutback.
Overchip estimate 15-20% and embedment 25-30%
C/3 Good. Jan92 7-8% overchip but unlikely to become fragile. Embed 35-45%
C/4 Fair. Jan92 10-12% overchip, but lots of upstand on chips. Likely to become fragile. Embed 30-40%

As at 28Apr93
Filed as
CASE_CLU.ENC
& CASE_CLU.PRN
C/5 amd 4May93

DISTRICT ROADS, CLUTHA DISTRICT COUNCIL

Inspections: Tuesday 2 March 1993
Examined 11 sites for data, about half and half Grades 3 & 4.

Schedule of Sites:

Section No.	Contract Section	Traffic (vplpd)	Condition	Notes
Grade 3 second coat seals				
C/6	3.20	400	Good	same Waimakariri chip "higher" volumes
C/5	3.21	360	Fair	
C/1	3.23	100	Fair	same Palmers chip "lower" volumes
C/2	3.10	50	Poor	
Grade 3 reseals				
C/3	4.17	400	Good (as found on site)	Waimakariri chip
C/4	4.16	400	Fair	Gore Gravel chip

Conclusions:
- See detailed comments on Processed Data sheet (p.40).

- Even at these low traffic volumes, overchipping can use up the binder.

Indication is that here, for a moderate chipping rate, current algorithm RD286 is about right.

PROCESSED DATA FOR LAKES inspns 11 Feb, 3 March 93

Section Name	Sectn no.	Type	ALD (mm)	SS dia (mm)	Tfc (vplpd)	Des (l/sm)	All 180/200 Other (pph) AGO	Ker	Adh	Application Hot (l/sm)	Temp	ResCold (l/sm)	Ratio act/des	Loss% W/B	
Hertford 3.07	L/1	R3	9.35	200	50	2.501	2	4	0.5	2.30	151	2.033	0.81	0/0	40% min embedment. much chip breakdown.
Lr Shotover 4.05	L/2	R4	7.31	160	150	2.002	2	4	0.7	2.19	153	1.930	0.96	13/7	Overchip, min embed. G4 on old G2, v coarse.
ArrowJctn 4.06	L/3	R4	7.31	175	150	1.894	2	4	0.7	2.05	152	1.811	0.96	2/2	15% overchip survives.

Wynyard Cres 1.03 R3 Steep asphalt substrate (photo)
Arawhata Tce 3.01 R3V Steep reseal (photo)
Manse Road 3.09 R3 Demonstrates chip breakdown (photo)

S is secondcoat, R reseal.
L/1 Good. Even upstanding chips have 40% embedment.
Low volumes give high values of Tf. Old Tf would have ratio 0.99
L/2 Poor. 6-20% loss in WP. Grade 4 neither bridges nor nests in old 160mm texture.
L/3 Higher (tourist) traffic than authority reported, and narrow seal causing wander, gives uniform compaction so that 15% overchip survives.

Conclude Low vols very tolerant, but not of G4 on 150mm G2.

As at 25Mar93
Filed as
CASE_LAK.PRN
& CASE_LAK.ENC

Schedule from Scherp, Royds Garden, 93-3-1

Contract Section	Name	Chip size	Substrate size	Seal type	Vp/pd
2.01	Camphill Rd	3	4	2° coat	50
3.01	Arawhata Tce	~~4~~ 3	3	R	50
3.04	Lower Suburb	4	3	R	75
3.07	Hertford } Arrowtown	3	5	R	50
3.09	Manse } Arrowtown	4	2	R	40
4.10	Gorge	——	——	Tortuous	
4.05	Lower Shotover	4	2	R	150
1.03	Wynyard Cres	3	Asph		Steep
4.04	Mulligan Rd	4	2	R	
4.06	Arrow Jn Rd	4	2	R	150

Good test and site data available except sand circle.
Very substantial breakdown of chips from FH Central at Alexandra – crushed quartz gravel.

PROCESSED DATA FOR SOUTHLAND inspns 5 Mar 93

Section Name	Sectn no.	Type	Tfc (vplpd)	SS dia (mm)	ALD (mm)	Des (l/sm)	All 180/200 Other (pph) AGO	Ker	Adh	Application Hot	Temp	ResCold	Ratio act/des	Loss% W/B
SH96 RP66/10.0-13.64 RaesBush-Nightcaps	S/3	R3	350	270	9.00	1.697	2	4	0.7	2.30	155	2.03	1.19	Nil
Otautau-Tuatapere Raymonds Gap 8.33-9.41	S/2	R3	325	230	9.00	1.793	2	4	0.7	2.05	155	1.81	1.01	W0-8/B15-20
RaesBush-Mossburn RP 22.43-25.63	S/5	R3	190	230	9.00	1.927	2	4	0.7	2.35	155	2.07	1.08	See note
Centre Road RP 4.90-6.19	S/1	R4	50	230	6.00	1.632	2	4	0.7	1.83	155	1.61	0.99	W4-10/B14-16
RaesBush-Mossburn RP 21.10-22.43	S/4	R4	190	230	6.00	1.365	2	4	0.7	1.77	155	1.56	1.14	W0-10/B15-20

Most of these reseals are on 12 to 18 year old Grade 2 second coats.
S/3 Good 89/90 (Mar90) 50-60% embedment full width with slick at widening join.
S/2 Fair/Poor 90/91 (end90) chip loss but no patching. Supervisors choice +0.10 l/sm binder, -15% on chips.
S/5 Fair 89/90 (Mar90) Chip replacement required (G5 and kero) between wheelpaths and on CL
Vapour induced (wet basecourse) boils now result in 50% embed in WP. Good for another 5 yrs
S/1 "Good" 89/90 (Jan90) Has some spot vapour bleeds, but also shows 4 to 16 % chip loss, avge 7%
Rated as good since for this low vol and silty basecourse, has space for water induced bleed.
S/4 Fair 89/90 (Mar90) at RP 21.15 Some kero & G5 patch surviving. Expect min of 8 yrs life.
Ratio indicates variability of outcome from limited records.
Generally, theres lots of tolerance at volumes of under 300 vplpd,
and it used to be used, giving 15 - 20 yr life.

As at 28Apr93
Filed as
CASE_SOU.ENC
& CASE_SOU.PRN

DISTRICT ROADS, SOUTHLAND DISTRICT COUNCIL

Inspections: Friday 5 March 1993

The district carries out about 180 centreline kilometres of second coat seals and reseals per year, usually let as two separate (in time of letting) contracts. There is roughly equal use (by road length) of Grades 3, 4 and 5 chips. Very little emulsion chipsealing is used, being nearly all cutback.

Chip produced under separate contracts is used from roadside stockpile areas.

Centreline marking is a separate contract, and so roads get 6 to 10 workdays without markings, during which unchannelised traffic compaction can occur. The maximum time standard for absence of lines (up to 15 days, for local roads) is seldom exceeded.

Overchipping is a continuing niggle. Significant, systematic differences are observed between different contractors with, as an example, one set of checks showing contractor B using Grades 3, 4 and 5 chips by around 3-10, 15-20 and 25% respectively more than Contractor A.

Vapour bleeding was evident, particularly on older basecourses. More had occurred in the late summer of 1992/93 than in the previous three seasons.

Treatment selection and design appear to be done more by experience than formal procedure and formula, made possible by good staff continuity in both the regulatory and operational sections of the district, and relative stability in available contractors.

Problem lengths are relatively few.

Site selection was based on examination of the 1989/90 sections that were rated as showing unexplained loss - about 2km of Grade 3 and 3 km of Grade 4 - and finding reasonably matching good sections from the same season.

The choice is shown on p.47.

GOOD	POOR
350 vplpd 14/3/90 Site S/3 Grade 3 reseal on widening Raes Bush - Nightcaps	200 vplpd 90/91 Site S/2 Grade 3 reseal Otautau - Tuatapere
100 vplpd 22/1/90 Site S/1 Grade 4 reseal Centre Road	175-200 vplpd 5/3/90 Site S/5 Grade 3 reseal Raes Bush - Mossburn RP 22.4 - 25.6
	175-200 vplpd 5/3/90 Site S/4 Grade 4 reseal Raes Bush - Mossburn RP 21.1 - 22.4

The Raes Bush - Mossburn site was the lowest volume unexplained chip loss, poor condition site that could be found. Nearest matching events occurring in same season were sought.

Nearly all sealing time records had been archived and were not available during interview and inspection. But data from RAMM, available testing records, and the obviously clear memory of the site supervisor were used.

Conclusions:

- Overchipping occurred to a variable degree.

- Residual binder used was 180/200 plus 2 parts per hundred AGO. No reason was found to depart from this - it is also the general material for State Highways in Region 14.

- For traffic and chip types observed in Southland District, a target rate of 15% higher than RD286 would carry little risk of premature flushing, largely due to the tolerance of chipseals under low traffic volumes. The extra binder cost can be evaluated against the longer life that can be expected for better (i.e. 40% or more) embedment.

- The good quality here relies on personally held experience. More quantified records of design and performance are desirable so that problems following any staff promotion or change will be minimised.

PROCESSED DATA FOR STATE HIGHWAYS REGION 2 inspn 28 Jan 93

	Sectn no.	Type	Tfc (vplpd)	SS dia (mm)	ALD (mm)	Des (l/sm)	All 80/100 Other (pph) AGO	Ker	Adh	Application Hot	Temp	ResCold	Ratio act/des	Loss% W/B
SH1 RP264/ 9.24	2/8a	R3P	1600	185	9.95	1.708	0	6	1.0	1.99	167	1.71	1.00	.35 rise
	2/8a	R3P	1100	185	9.95	1.796	0	6	1.0	2.02	167	1.73	0.96	.28 rise
	2/8a	R3P	2700	205	9.95	1.531	0	6	1.0	2.02	167	1.73	1.13	.30 rise
SH1 RP308/ 2.04	2/5	R2	5000	205	10.19	1.438	0	5	1.0	1.91	170	1.65	1.15	
SH16 RP 47/ 2.10	2/3	R3L	700	280	9.59	1.626	0	5	1.0	1.90	170	1.64	1.01	.50 rise
SH1 RP303/ 5.29	2/1	R3	5000	200	9.95	1.422	0	6	1.0	1.93	170	1.65	1.16	4-2
SH1 RP274/11.35	2/6	S3	3000	180	10.15	1.615	0	6	1.0	2.02	160	1.74	1.08	3-8
SH16 RP 37/ 0.30	2/4a	R3	1400	280	9.66	1.492	0	5	1.0	2.05	166	1.78	1.19	5-10
	2/4b	R3	1400	245	9.66	1.541	0	5	1.0	1.98	166	1.72	1.11	10-15
SH16 RP 22/ 9.87	2/2a	R3	1500	170	9.65	1.747	0	6	1.0	1.94	172	1.67	0.95	20-40
	2/2b	R3	1500	190	9.65	1.662	0	6	1.0	2.06	172	1.76	1.06	20-20

These observations are listed in the order Good, Fair, Poor.

2/8 Limited binder rise, but great meniscus. Indiscernable chip loss from this precoated.

2/5 now buried. Rated as v good, for comparison at this volume.

2/3 sealed 1989 locked G5 later. Rate low for unlocked, ideal locked.

2/1 Some loss, a bit overchipped, but binder still low. Could go +10%

2/6 Nov seal obs at 14mths. 3% loss wheeltracks, 8% loss between. About 10% more binder reqd.

2/4 losses match applicaations, only 30% embedment.

2/2 Chipping exactly right. Loss matched low application at surveyed Xsection.

Note 2/7 Cowans Bay inspected without measurement.

As at 27Apr93
Filed as
CASE_RD2.ENC
& CASE_RD2.PRN

STATE HIGHWAYS REGION 2 (AUCKLAND)

Inspections: Friday 28 January 1993
Some vapour bleeding was evident, but less than in other areas.

Unexplained chip loss: was relatively rare. To obtain the preferred systematic coverage, most cases were taken from Oct, Nov 1991, and one each from the ends of 1988, 1989 and 1992.

Local comment included:

- No problems at traffic volumes below 1500 vplpd.
- Because there has to be enough binder to hold the chip in place to allow long term traffic to settle it down, both client and consultant are reluctant to use a traffic factor of less than unity. Even though high traffic volumes would dictate low binder application rates for long term performance, the seal has to survive the first winter for that long term performance to be achieved.
- There is some lack of discrimination between a texturising and a void filling treatment.
- Reluctance to use smaller than a Grade 4 for a reseal (i.e. G5 texturising chip not favoured).
- Significant unresolved concerns about binder quality.

The scheduled sites examined and analysed are undivided rural (generally two lane) highways, in two groups:

- Volumes 2500 to 5000 vplpd covering Very Good, Good, and Fair (4)
- Volumes 700 to 1400 vplpd covering Good, Fair, and Poor (3)

Conclusions:

- Overchipping occurred but generally only to a limited degree.

- Consistent use of 80/100 binder believed more satisfactory than 180/200.

- Effectiveness of traffic compaction in the first days after sealing depends on traffic operating speed. With pre-coated chips, traffic is slower.

- For traffic and chip types on observed State Highways in Region 2, a target application rate of 15% higher than algorithm RD286 would carry little risk of premature flushing, and up to 20% might be justified in places.

PROCESSED DATA FOR STATE HIGHWAYS REGION 5 insp 21 Jan 93

	Sectn	Type	Tfc	SS dia	ALD	Des		All 80/100			Application			Ratio	Loss%
	no.		(vplpd)	(mm)	(mm)	(l/sm)	e	Other (pph)			Hot	Temp	ResCold	act/des	W/B
								AGO	Ker	Adh					
SH35 RP225/ 8.84	5/5 *	R5	370	150	5.00	0.981	0.10	0	3	0.6	1.11	175	0.97	0.99	4-10
SH35 RP213/ 0.30	5/4a *	R5	540	150	5.00	0.932	0.10	0	3	0.6	1.06	175	0.93	1.00	4-10
SH35 RP213/ 0.30	5/4b	R5	540	250	5.00	0.932	0.10	0	3	0.6	1.06	175	0.93	1.00	4-10
SH2 RP390/ 13.69	5/1a *	R5	670	230	5.00	0.906	0.10	0	3	0.5	1.59	162	1.41	1.55	0-2
SH2 RP390/ 13.69	5/1b *	R5	670	310	5.00	0.906	0.10	0	3	0.5	1.70	162	1.51	1.66	10
SH35 RP159/ 8.10	5/2	R4	225	180	8.79	2.036	0.32	0	3	0.5	1.72	162	1.52	0.75	0-8
SH35 RP172/ 7.27	5/3 *	R4	320	230	7.06	1.458	0.18	0	12	0.6	1.64	152	1.34	0.92	0-5
SH35 RP308/ 1.41	5/6 *	R3	500	170	9.25	1.959	0.37	0	14	0.6	2.23	148	1.80	0.92	0-2

5/5 & 5/4 were designed by local nomograph. e values for 150 & 250 sand circles are normally 0.48 and 0.14 respectively. TNZ Manual G5 value of 0.10 is used here.

5/5 seal is good - nests in hungry previous sealcoat.

5/4 seal is variable - good where ss <170, strip where ss >200

5/1 was designed by local nomograph. e values for 230, 310 are 0.18, 0.08
So G5 doesnt nest in old G3. 5/1a OK in wheelpath, 5/1b insufficient between wheelpaths.

5/3, 5/6 both good, both way out of season, June 1992

5/2 Jan seal, WP OK up to 8% loss between WP. Conclude a bit low on appn.

As at 26Apr93
Filed as
CASE_RD5.ENC
& CASE_RD5.PRN

STATE HIGHWAYS REGION 5 (GISBORNE)

Inspections: Thursday, Friday 20, 21 January 1993

Vapour bleeding was clearly evident, and associated with older pavements, with poor side drainage.

Unexplained chip loss: candidates and comparison sites were all from sites sealed between January to March 1992.

Grade 5 reseals where they nest into the underlying chip, would probably work better at an application rate 10% higher than Bituminous Sealing Manual value.

Conclusions:

- Bleeding caused by wet underlying pavements should not be confused with over-application of binder.

- Grade 5 chip really only works well when it can nest into a rather coarse texture, or be uniformly applied to a very smooth surface.

- While kerosine contents produce a soft binder for a considerable time, they **do** allow traffic compaction to continue through the cold winter period. In this district they had over four months before being really exposed to warm temperatures.

- Bulking with a high kerosine content allowed cases 5/3 and 5/6 to develop a satisfactorily compact mat, with relatively low residual binder rate.

PROCESSED DATA FOR STATE HIGHWAYS REGION 6 inspns 19, 20 Jan 93

	Sectn no.	Type	Tfc (vplpd)	SS dia (mm)	ALD (mm)	Des (l/sm)	All 80/100 Other (pph) AGO	Ker	Adh	Application Hot	Temp	ResCold	Ratio act/des	Loss% W/B
SH2 RP721/ 0.20	6/1	R3	3150	230	9.35	1.367	0	3	0.5	1.79	175	1.57	1.15	2-6
SH2 RP650/ 5.62	6/3a	R3	3500	220	8.32	1.237	0	5	0.7	1.55	170	1.34	1.08	1-5
SH2 RP650/ 5.72	6/3b	R3	3500	220	8.32	1.237	0	5	0.7	1.62	170	1.40	1.13	1-5
SH2 RP675/ 9.00	6/2	R3	675	290	8.49	1.448	0	5	0.6	1.75	170	1.51	1.04	0-0
SH5 RP204/ 1.60	6/4	R3	730	270	9.08	1.550	0	5	1.0	1.91	170	1.65	1.06	0-2
SH5 RP204/11.30	6/6a	R3	615	242	8.95	1.612	0	5	1.0	1.73	170	1.50	0.93	0
SH5 RP204/11.30	6/6b	R3	200	190	8.95	2.047	0	5	1.0	2.28	170	1.97	0.96	0
SH5 RP204/11.30	6/6c	R3	615	300	8.95	1.529	0	5	1.0	1.60	170	1.38	0.90	0
SH5 RP204/ 8.54	6/5	R3	725	235	8.95	1.591	0	5	1.0	1.92	170	1.66	1.04	2-40
SH2 RP608/19.80	6/7a	R3	620	260	8.50	1.507	0	6	0.5	1.75	167	1.50	1.00	See note
SH2 RP516/ 1.92	6/8a	R3	550	270	8.70	1.549	0	6	0.5	1.64	170	1.40	0.91	Just hold
	6/8b	R3	550	300	8.70	1.512	0	6	0.5	1.78	170	1.52	1.01	Flushing

6/1 includes SBS. CBD Waipukurau. Obs thru lanes overchip just holding.
6/3 both appear high appn rate, but cubical chip, and 6/3a held by drylock.
6/2 good in wheelpaths (at rate shown). Low between. Moisture induced flushing.
6/4 good
6/6 has 3 yrs old flushed G5 underneath. Excellent at 1 yr old, may flush later.
So G5 doesnt nest in old G3. 5/1a OK in wheelpath, 5/1b insufficient between wheelpaths.
6/5 tortuous, and high speed. Drylocking was recomm at 1 week.
6/7 tortuous, traction scab uphill, BWP loss 7% downhill.
6/8 included for wetbase induced flushing. Complicated by doubts on true ALD.

As at 27Apr93
Filed as
CASE_RD6.ENC
& CASE_RD6.PRN

STATE HIGHWAYS REGION 6 (HAWKE'S BAY)

Inspections: Wednesday, Thursday 19, 20 January 1993
Initial inspections were with both Transit New Zealand and Works Consultancy Services staff.

Vapour bleeding was clearly evident; associated with older pavements, and with poor side drainage.

Unexplained chip loss: candidates and comparison sites were all from sites sealed between January to March 1992.

Site selection was based on Grade 3 only, with examples of good and bad at high volume (3000 to 3500 vplpd) and low volume (715 to 925 vplpd).

An additional two Grade 3 bleeding sites at low volume were examined.

Grade 3 Second coat or reseal, both high volume:

6/3 Fair, offered adjacent sections, showing effect of 5% change in application rate. The lower was drylocked to hold in place. Both now have similar low chip loss, but low embedment at about 35%. Order of 5-8% overchip. Indicates target of algorithm RD286 +15% would be about right.

6/1 Fair in through-lanes, but poor on parking lanes illustrated need for control of rolling (whether traffic or construction rolling) when using polymer. Edges of through-lanes do not get trafficked, position of joint between runs deserves design. Effect of recent increase in power-steer cars evident on parking lanes.

Grade 3 Second coat and reseal, 1200 to 1500 vpd all lanes

6/2 Good in wheelpaths, low between. Moisture-induced flushing.

6/4 Good. Good chip application rate. Had help from being on a compatible 5 year old worn Grade 5.

6/6 Good condition and fair embedment now. Had 3 years old smooth G5 underneath. Long 8% grade results in low speeds for outer up and some outer down traffic.

Grade 3 Reseals, "Bleeding"

6/7 Sticky. Marginally low application rate on tortuous alignment leads to substantial chip loss and binder pickup.

6/8 At inspection cross section, moisture-induced flushing had occurred.

Conclusions:

- Traffic factor is critical for lightly laden lanes (particularly passing lanes) and the designer could well define the longitudinal joint positions.

- High HCV counts and speed reduction related to grades can be equivalent to substantial added traffic. Note apparently grossly (30%) higher application in passing lane giving same texture as outer lanes.

- Tortuous 8% grades with current B-train line haul are too difficult for simple G3 reseal.

- Overchipping is general.

PROCESSED DATA FOR STATE HIGHWAYS REGION 7   inspns 8,10 Jan 93

	Sectn no.	Type	Tfc (vplpd)	SS dia (mm)	ALD (mm)	Des (l/sm)	All 180/200 AGO	Ker	Adh	Application Hot	Temp	ResCold	Ratio act/des	Loss% W/B
SH3 RP240/ 7.29	7/1	R2	2600	270	11.23	1.591	0	3	0.5	1.80	162	1.59	1.00	4-10
SH3 RP240/ 7.29	7/2	R2	2600	290	11.23	1.570	0	3	0.5	1.83	162	1.62	1.03	4-10
SH3 RP240/ 7.61	7/3 *	R3	2000	180	8.79	1.519	0	3	0.5	1.59	162	1.41	0.93	0-2
SH3 RP240/ 7.61	7/4	R3	2600	180	8.79	1.467	0	3	0.5	1.70	162	1.51	1.03	10
SH3 RP240/ 7.61	7/5	R3	600	180	8.79	1.785	0	3	0.5	1.72	162	1.52	0.85	10-40
SH3 RP240/ 7.61	7/6a *	S3	2600	180	8.43	1.419	1	3	0.5	1.58	162	1.40	0.99	0-2
SH3 RP240/ 7.61	7/6b *	S3	2600	175	8.43	1.440	0	3	0.5	1.67	162	1.48	1.03	0-2
SH3 RP240/ 7.61	7/6c *	S3	2600	185	8.43	1.400	0	3	0.5	1.63	162	1.44	1.03	0-2
SH3 RP240/ 7.61	7/6d *	S3	2600	185	8.43	1.400	0	3	0.5	1.73	162	1.53	1.09	0-2
SH3 RP321/13.30	7/7 *	S3	1525	200	7.97	1.387	0	3	0.5	1.64	162	1.45	1.05	2-4
SH45 RP 0/ 5.12	7/11	R3	2500	200	7.88	1.286	0	3	0.5	1.40	162	1.24	0.96	5-20
SH3 RP338/10.00	7/8	R2	1225	190	10.59	1.845	0	6	0.5	2.20	156	1.90	1.03	10-20
SH3 RP338/11.04	7/9a *	S2	1225	175	10.59	1.908	0	6.5	0.5	2.32	150	2.00	1.05	0-2
SH3 RP338/11.20	7/9b *	S2	1225	165	10.59	1.960	0	6.5	0.5	2.35	150	2.03	1.04	nil
SH45 RP32/ 12.96	7/10	S2	625	165	11.2	2.242	0	3	0.5	2.56	162	2.27	1.01	10-20

* after sectn no. indicates good.
7/1 and 7/2 both Feb, slight hi chipspread, reqd repair at 12 months.
7/3 Feb slight climb lane good, contrast 7/4 in matching downhill lane fair/poor
7/5 overtake lane very poor - held to RD286 on 1 way traffic
All 7/6 good tho a little lean, range -1 to +9% of nomograph
7/7 fair to good, no repairs required
7/8 Dec, held till Aug losses in patches to 100mm (o'chip indicated)
7/9a,b Dec Good as possible with low (40%) binder rise.
7/10 all marginal for lock coat at 1 year   Note coarse pretexture
7/11 Feb Urban Pitting on CL and wheelpath loss Inc RP

As at 23,26Apr93
Filed as
CASE_RD7.ENC
& CASE_RD7.PRN

STATE HIGHWAYS REGION 7 (TARANAKI)

Inspections: Friday, Sunday 8,10 January 1993

Unexplained chip loss: occurred at relatively few sites.

Impression is that less vapour bleeding occurs in Region 7 than elsewhere.

Sites for examination were chosen mainly from all contract sections for 1991/92 season. It was possible to select sites that compared Grade 2 and Grade 3 under the same traffic on adjoining sections, with varying quality.

Chip loss correlates with low application rates and overchipping.

Losses of upstanding, low embedment chips, tended to occur in cold weather (August).

Conclusions:

- Traffic factor is critical for lightly laden lanes (particularly passing lanes) and the designer could well define the longitudinal joint positions.
- Chip application rate is a key element in first winter performance.
- Target of +5% on algorithm RD286 would look right for the observed sections.
- "Cubical" stone (ratio AGD/ALD = 1.85) needs a little more binder.

PROCESSED DATA FOR STATE HIGHWAYS REGION 10 inspn 26 Feb 93

	Sectn no.	Type	Tfc (vplpd)	SS dia (mm)	ALD (mm)	Des (l/sm)	All 180/200 Other (pph) AGO	Ker	Adh	Application Hot	Temp	ResCold	Ratio act/des	Loss% W/B
SH60 RP 89/ 5.23	10/1	S4	650	170	7.96	1.686	1	4	0.7	1.92	156	1.69	1.00	W0-2/B1-3
SH60 RP 89/12.62	10/2B	R3+	650	235	10.54	1.867	1	4	0.7	2.28	162	2.00	1.07	Nil loss
SH60 RP 89/11.56	10/2A	R4	650	210	7.96	1.521	1	4	0.7	1.82	156	1.60	1.05	See note
SH60 RP103/ 5.00	10/3a	R3+	650	160	10.86	2.208	1	4	0.7	2.48	160	2.18	0.99	W15-50/B12
	10/3b	R3+	650	160	10.86	2.208	1	4	0.7	2.38	160	2.09	0.95	W3-5/B9-10
SH6 RP131/17.40	10/5	S3D	1950	160	9.07	1.661	2	3	0.7	2.18	152	1.94	1.17	
SH60 RP 17/ 5.38	10/4a	S3D	1400	155	8.40	1.672	1	4	0.7	1.92	158	1.69	1.01	W1B1
	10/4b	S3D	1400	155	8.40	1.672	1	4	0.7	1.99	158	1.75	1.05	W1B1

These observations are listed in the order Good, Fair, Poor.

10/1 All looks good, with <5% chiploss due to overchipping and crowding.

10/2B Some moisture forced bleed, otherwisw embed 40-45%, Good.

10/2A Both sides same subtexture. LHS 10% loss BWP, variable 0-10 in WP.
RHS 1-2% loss BWP, 0-1in WP Chip spread 8% high.

10/3 Poor condition. Insuff binder and crowded chips.

10/5 Drylocked same day. Appn rate about ideal for the rather crowded chip, but less chip (and binder) would have been better.

10/4 Drylocked with G5 sameday. OK on drylocked curve, just. But 4-6% strip on CL so unless main chips are put on sparse, drylock needs just as much binder, perhaps more.

As at 27Apr93
Filed as
CAS_RD10.ENC
& CAS_RD10.PRN

STATE HIGHWAYS REGION 10 (NELSON)

Inspections: Friday 26 February 1993

Unexplained chip loss: occurred at relatively few sites.

Bleeding was quite extensive in 1992/93. In nearly all cases observed it was related to wet basecourse, rather than binder over-application. Sites for examination were chosen mainly from the 12 separate second coat or reseal sections that had stripped or bled badly between 1990/91 and 1992/93.

The observed sections had chip of Grade 3 or small Grade 2 size.

Two groups were examined, simple Grade 3 (all 650 vplpd), and Grade 3 with drylock (1400 to 1950 vplpd)

Grade 3 Second coat or reseal, all low rural traffic:
March 1992 seals. Some overcrowding (over-application of chip) in all cases. With right chip application rate, desirable adjustment to algorithm RD286 assessed at +10% (for chip with ratio AGD/ALD = 2).

Grade 3 Second coat seals with drylock, all rural 2 lane:
March 1992 seals. Some overchip again, and better condition where trafficking gives positive rolling after application of locking chip. Again, adjustment assessed at +10% for enough embedment (AGD/ALD =2.13). But locking probably required for such an open (sand circles 155mm) subtexture.

Conclusions:

- Manual recommendation of special treatment if sand circle diameter is less than 170mm, is well founded.

- The option of a Grade 6 genuine void filling seal coat warrants consideration when the timing of construction requires a second coat before the first coat has densified.

PROCESSED DATA FOR STATE HIGHWAYS REGION 14 inspn 4 Mar 93

	Code	Type	ALD (mm)	SS dia (mm)	Tfc (vplpd)	Des (l/sm)	Ker, AGO	H2O	Adh	Application Hot	Temp	ResCold	Ratio act/des	Loss% W/B	
SH1 RP933/ 6.400	14/1	S3	9.58	196	1200	1.681	2	3	0.8	2.10	158	1.865	1.11	1/2	Great, CL emuls&grit
SH1 RP872/ 7.500	14/2	R3	7.85	200	1381	1.388	2	4	1.0	2.40	156	2.115	1.52	0/4	40%embed OK to drop .3 l/sm
SH96 RP0/ 14.600	14/3G5	S5	5.10	280	285	1.038	2	42	0.0	1.36	85	0.932	0.90	0/2	
SH96 RP15/ 3.200	14/4G5	R5	5.10	280	300	1.031	2	42	0.0	1.37	85	0.885	0.86	0/0	Flush in WP
SH96 RP50/ 3.400	14/5AG5	M5	4.73	280	370	0.939	2	61	0.0	1.39	82	0.792	0.84	30/0	Right between WP Loss in WP
SH96 RP50/ 4.800	14/5BG5	M5	4.73	280	370	0.939	2	61	0.0	1.42	82	0.810	0.86	50/30	Near total loss inferred from gritting
SH6 RP1157/6.500	14/6	S3	9.45	175	2000	1.631	2	3	0.8	2.25	158	1.999	1.23	1/2	10% xs chip. Embedment 15,25,20,20%

S is secondcoat, R reseal, M mixed (S on widening, R on rest)

Sand circle of 280 (e value of 0.10) used for G5 chip

Amnd wtr cont of emuls, 4 May 93	ALD for G5 was 75% of D50 14/5A the Grade 5 was a bit big for the grade 3 under with SS of 160 to 200
As at 25Mar93 Filed as CAS_RD14.ENC & CAS_RD14.PRN	14/5B probably the same Both were cold weather. 14/6 acceptable in lanes, but 10% XS. Gentle curves and width helped Basis for design of Grade 5 is very vague No conclusion for G5, use about +20% for G3

STATE HIGHWAYS REGION 14 (SOUTHLAND)

Inspections: Thursday 4 March 1993
The 1991/92 sealing season was the first with significant chip loss concerns. By the end of the 1992 winter, worrying bleeding was also occurring in places.

Unexplained chip loss: occurred at relatively few sites.

Sites for examination were chosen from 31 separate second coat or reseal sections in the 1991/92 season.

Grade 3 Second coat or reseal, at high rural traffic:

14/6 Makarewa 1500 to 2000 vplpd	Desk rate Good. Site-rate Good but low embedment. Low chip embedment, but estimated 10% excess chip.
14/2 Brydon 1380 vplpd	Desk rate Fair. Site rate Good but joint flushing at widening overlap. Little chip loss, 5-8% excess chip, generally 40% binder rise.
14/1 Awarua 1200 vplvd	Desk rate Poor. Site rate Fair but fragile, with emulsion void fill along CL. Looks great, but chip embedment v low, 15-30%. Chip excess 8-12%.

Sand circles all 200 or less. Conclude for here that plus 15% to 20% on algorithm RD286 would be good target, if chip application held down.

Grade 5 Second coat or reseal, at moderate to low rural traffic:
All cationic emulsion

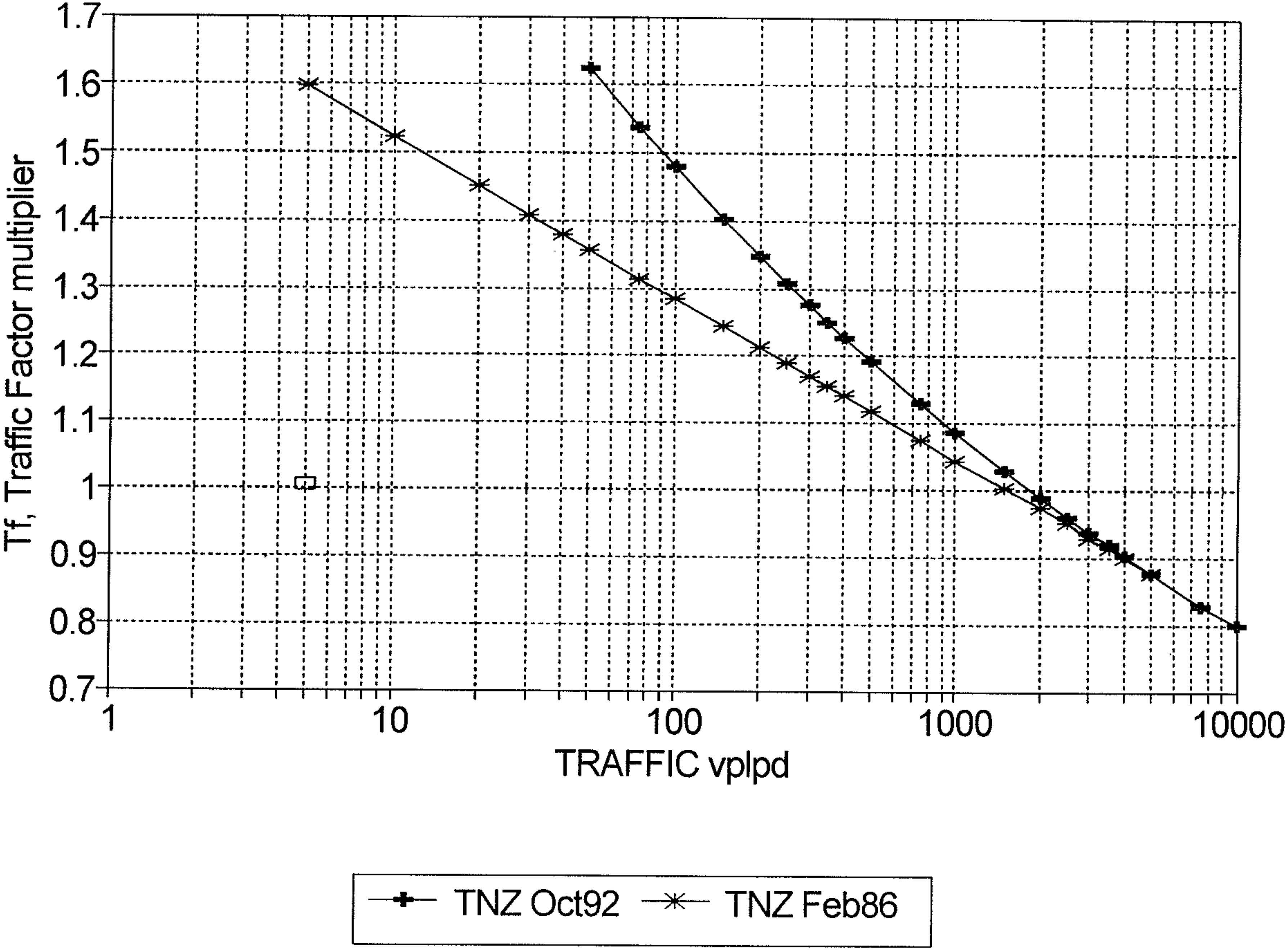
14/3 Rances Creek 285 vplpd	Desk rate Good. Site rate Very Good, with uniform 160mm circle result. Was on uniform 2yr old G4 first coat. Helped by low tfc and done in January.
14/4 Glencoe 285 vplpd	Desk rate Good. Site rate good. Previous smooth spots showing through as flush. Binder application rate could have been reduced. January job.
14/5a Bogburn 370 vplpd	Desk rate Fair. Field rate Fair. Loss in wheelpaths, and vapour bleed. April job.
14/5b Bogburn 370 vplpd	Desk rate Poor. Field rate Poor. Near total loss followed by Grade 5 gritting. April job.

Relative binder applications were about the same, when water contents of emulsions were taken into account. Both had same residual binder. Both tried to be reseals with chip held on top of existing surface. The April seals would have become quite hard binders after breaking, and resisted chip embedment into the binder.

APPENDIX 4 SENSITIVITY OF DESIGN SPRAY RATES CALCULATED BY SEAL DESIGN ALGORITHM RD286 (1993)*

CHIP	ALD mm	SAND dia mm	TRAFFIC v/l/d	RESID BINDER l/sm	%ge CHANGE APPLICATION	RESULTS FROM
Grade 3 on fine	9.75	360	1500	1.429	11.04	
	8.75	360	1500	1.287		ALD change of 11%
	7.75	360	1500	1.145	-11.04	
	8.75	400	1500	1.268	-1.41	
	8.75	360	1500	1.287		Sand Circ change of 11%
	8.75	320	1500	1.312	1.97	
	8.75	360	3000	1.172	-8.87	
	8.75	360	1500	1.287		Traffic double or half
	8.75	360	750	1.412	9.73	
Grade 3 on coarse	9.75	180	1500	1.715	9.03	
	8.75	180	1500	1.573		ALD change of 11%
	7.75	180	1500	1.431	-9.03	
	8.75	200	1500	1.501	-4.62	
	8.75	180	1500	1.573		Sand Circ change of 11%
	8.75	160	1500	1.675	6.45	
	8.75	180	3000	1.434	-8.87	
	8.75	180	1500	1.573		Traffic double or half
	8.75	180	750	1.726	9.73	
Grade 4 on coarse	7.50	180	1500	1.396	8.26	
	6.75	180	1500	1.289		ALD change of 11%
	6.00	180	1500	1.183	-8.26	
	6.75	200	1500	1.217	-5.63	
	6.75	180	1500	1.289		Sand Circ change of 11%
	6.75	160	1500	1.391	7.87	
	6.75	180	3000	1.175	-8.87	
	6.75	180	1500	1.289		Traffic double or half
	6.75	180	750	1.415	9.73	

APPENDIX 5 COMPARISON OF TRAFFIC FACTORS USED IN ALGORITHMS RD286 (1986) AND RD286 (1993)



APPENDIX 6 CONCLUSIONS OUTSIDE THE PROJECT

A6.1 Consequences of "overchipping" for "end result" specifications

Current proposals (and methods being trialed) for end result specifications use texture depth at 12 months as an indicator of residual life before the onset of flushing. The use of texture depth pre-supposes that the chips have become substantially bedded down "on their flats" at 12 months. Use of a simple minimum texture depth does not discriminate between good texture depth related to appropriate binder application rate, and high texture depth related to chip crowding, with an associated proneness to chip loss.

A6.2 Effects of AGD/ALD ratio

When specification of sealing chip by direct measurement of ALD and AGD (rather than by sieve sizing) was introduced in the mid 1960s, a number of producers found the shape ratio of 2.25 difficult to meet. Changes in production, and in the profession generally, have resulted in few people now querying this 2.25 limit. The range of shape ratios encountered during this project was from 1.77 to 2.23 with the majority falling in the range of 1.90 to 2.10 for AGD/ALD ratio.

During the site inspections it became evident that the more "cubical" chip (i.e. with lower shape ratio) did not suffer as much from overchipping. (There would be no question of an extreme cubical chip "bedding down on its flat".) But it was clear that the higher ratio chips, if **not** over applied, were more resistant to dislodgement under low speed scuffing (tight radius curves). It would appear that an optimum shape may exist, somewhere about an AGD/ALD ratio of 2.10.

A6.3 Effects of surface contamination

Surface contamination continues to cause some difficulties and it tends to be localised. One case apparently caused by systematic discharge from stock trucks was identified. Crossing places regularly used by livestock have shorter lives than the surrounding seal unless specially treated.

SH4 **11 Jan 1993**

Upper: General view of site.
Lower: Concern to keep binder application rates low to minimise "bleeding" just does not work where the binder is driven to the surface by dense, wet basecourse.
Note fresh bitumen bubble (arrowed) at bottom left corner of the ruler's shadow.

SH3 Wanganui City **11 Jan 93**

Upper: Seal generally appears to have good texture and only minor loss (when viewed from car at drive-over inspection).

Lower: Crowded chips have no opportunity to bed on their flat. Chip layer depth rises to about 1.5 x ALD.

Manukau City **26 Jan 1993**

Upper: General view of site.
Lower: Crowding and overlapping of chips is general, even in wheelpaths.
The effective voids in a layer of chip can change markedly as particles derived from chip breakdown fill the voids.