TRENDS AND CHANGES IN CHIPSEALING IN NEW ZEALAND

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ABSTRACT

An analysis of the age of chipseals when they are resealed on New Zealand state highways shows that, despite increasing traffic stress, there has been no significant reduction in chipseal life. This paper presents data on chipseal lives, compared with changes in traffic volumes, over a 15 year period. Trends, including the date of the introduction of the different initiatives are analysed. Different initiatives covered include the change from single coat to predominantly two coat chipseals, changes in contract types from traditional to predominantly performance based maintenance contracts, and the introduction of a skid resistance policy. An analysis is made of reasons for resealing and other concepts that may have contributed to chipsealing life remaining substantially the same despite long term continued growth in traffic stress on the state highway network.

INTRODUCTION

The increasing traffic volumes and traffic stress over the past 20 years have not lead to a significant reduction in mean chipseal life on the New Zealand state highway network, managed by the New Zealand Transport Agency[1] (NZTA). The reasons for this consistency of performance are explored here, and a variety of factors are identified for analysis.

The first significant point is that there has been an increase in traffic stress. This traffic stress is the kind that would naturally be expected to damage chipseals (an increase in heavy vehicles). However, chipseal lives have not reduced.

Secondly, longer chipseal lives are not simply a measure of reduced budget and doing less work. Budget has kept pace with network maintenance needs and this is shown by a number of performance measures which indicate an overall improvement in surface condition.

Changes in sealing practice have contributed to the result of a consistent mean chipseal life despite increasing traffic volumes and traffic stress.

Changes in sealing practice that are investigated in this paper include:

- Change from single coat to predominantly multicoat (e.g. two coat) chipseals
- Introduction of a skid resistance policy
- A change of contract type across the state highway network to predominantly performance based contracts
- Changes in binder types
- Changes in reasons for resealing.

[1] Formerly Transit New Zealand. On 1 August 2008 Transit New Zealand and Land Transport New Zealand were merged to form the New Zealand Transport Agency.

CHIPSEAL LIFETIMES AND PERFORMANCE

In order to show that changes in chipsealing practice have contributed to a fairly constant mean chipsealing life over the past 15 years, the following factors are investigated:

- Chipseal lifetime
- Achievement of expected life
- Traffic volumes
- Surface Condition Index
- Good Skid Exposure.

Several different chipseal lifetime and performance indicators are presented in this paper. In this section each indicator is explained, and the state highway network trends are presented.

Sealed Surface Lifetime Calculations 2009

Figure 1 shows the mean lifetimes for sealed surfaces laid on the state highway network. (Mean lifetime is the inverse of the annual rate of resurfacing on the state highway network).

The data presented in Figure 1 is based on statistics published annually by the New Zealand Transport Agency (NZTA) and its predecessors Transfund New Zealand (2002 – 2004) and Land Transport NZ (2005 – 2008).

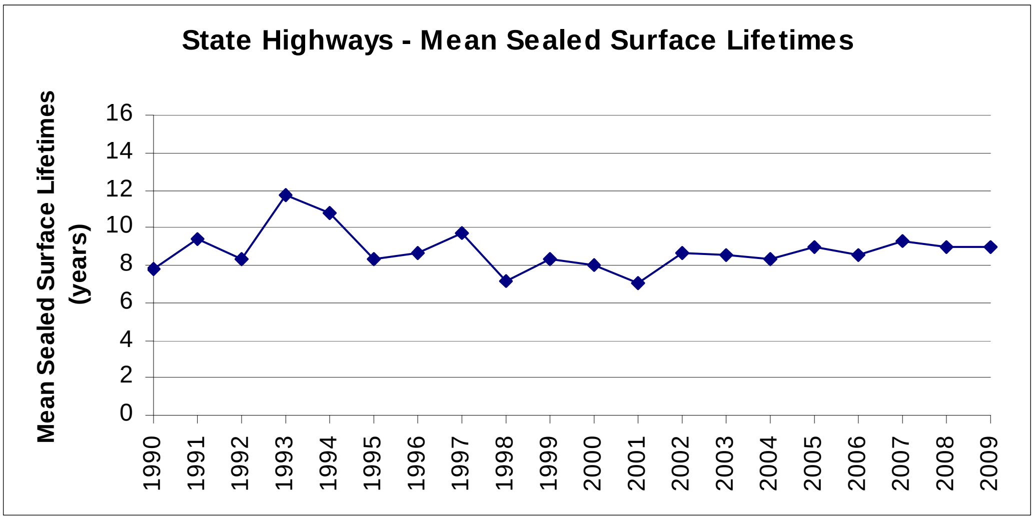

Figure 1: Mean Sealed Surface Lifetimes (includes chipseals and asphaltic concrete) on the New Zealand state highway network. Source: Transfund New Zealand (2002 – 2004), Land Transport NZ (2005 – 2008).

The data shown in Figure 1 is calculated from Equation 1:

$$A = \frac{N}{L - R} \qquad \textbf{Equation 1}$$

Where:

A = Mean Lifetime

L = Reported length sealed

R = Reported length of rehabilitation in the previous year (this is to remove second coat seals from the chipseal life equation)

N = Reported length of sealed network

The factor *N* in Equation 1 is the total sealed length of state highway and includes lengths sealed with asphaltic concrete as well as those with chipseal surfaces. Factor *L* is reported sealed road resurfacing which includes both asphaltic concrete and chipseal resurfacing. As asphaltic concrete makes up a small percentage of the state highway network length, the shape of the graph in Figure 1 is assumed to be identical to the shape of the mean chipseal lifetime graph, for the purposes of this paper.

Over the years from 1990 to 2008 the traffic volume on the state highway network has increased significantly (shown in Figure 6) but this has caused no obvious trend in the mean seal life.

A possible explanation for the apparent improvement in chipseal performance could be an increase in rehabilitation, resulting in an increase the *R* value in Equation 1 and resulting in an increase the mean seal lifetime *A*. However, the percentage of the network length that is rehabilitated each year has also remained relatively constant. For the years 2005 to 2008 the average percentage rehabilitated was 1.7% while in 1992-1995 period it was 1.8%.

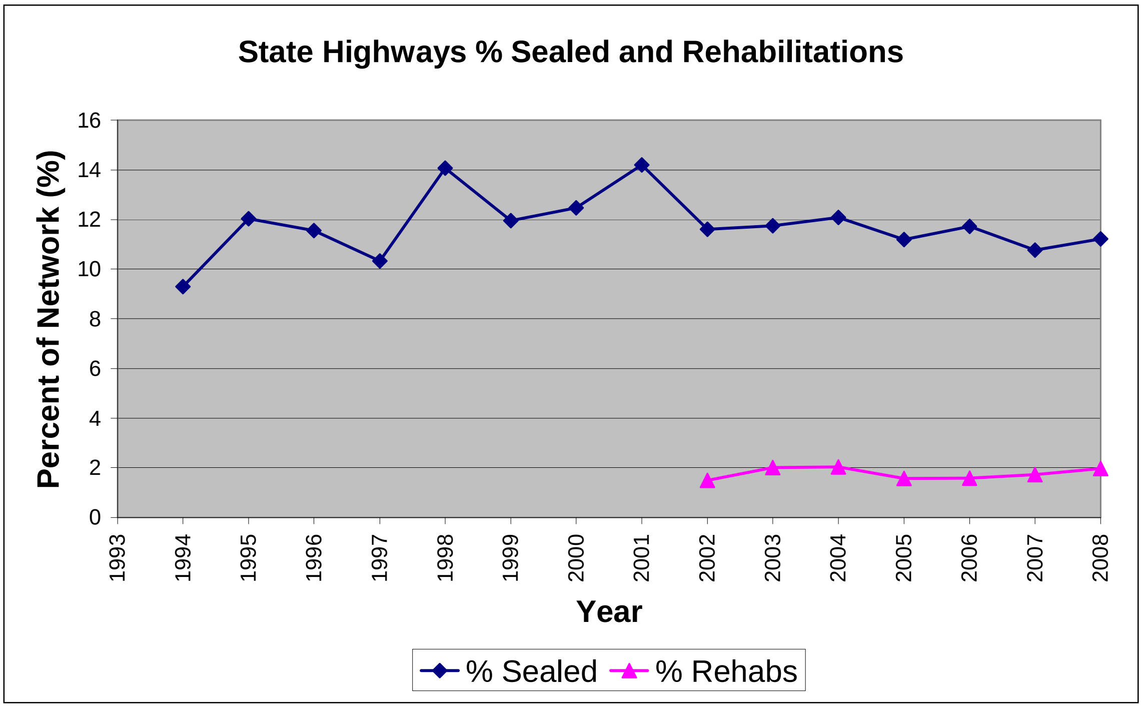

Figure 2*:* *Percent Sealed Surfaces and Rehabilitations (includes chipseals and asphaltic concrete) on the New Zealand state highway network. Source: Transfund New Zealand (2002 – 2004), Land Transport NZ (2005 – 2008), Annual Plan.*

Budget impact

A peak in the mean sealed surfacing lifetime graph (Figure 1), e.g. at 1997, relates to a drop in the percentage of the network sealed that year (Figure 2).

In 1997, the skid resistance policy was introduced on the state highway network (TNZ T/10 Specification for skid resistance investigation and treatment selection). In 1998 extra funding was made available for regions to improve the overall skid resistance of their networks by completing extra resurfacing with a higher skid resistance aggregate. A slight dip in mean sealed surfacing lifetimes in 1998 is therefore due to the extra funding made available and the extra surfacing completed in 1998.

The mean sealed surfacing life in Figure 1 gives no indication of the standard deviation of chipsealing lives on the state highway network.

A more detailed analysis of chipsealing life is by analysis of surfacing data, which is stored in the Roading Assessment and Maintenance Management System (RAMM) database. This is provided in the calculation of achievement of expected life below.

Achievement of Expected Life

A careful analysis of RAMM surfacing data has revealed the age of each chipseal on the state highway network at the time it was resurfaced in the 2008/09 year. This age (attained life) has been compared to the default expected life for that particular seal (the age in years expected from the chipseal, from Table A1, Appendix 1) and expressed as a ratio E (Equation 2). If a chipseal was resealed when it was aged at exactly its expected default life (i.e. Attained Life = Default Seal Life), it would have a ratio of $E = 1$. The cumulative portion of the network chipsealed in the 2008/09 year and the 2002/03 year for increasing values of E is shown in Figure 3.

$$E = \frac{C}{S}$$ **Equation 2**

Where:

E = Achievement of Expected life

C = Attained life (the age in years of the old chipseal which was resealed)

S = Default seal life (age in years expected from the chipseal from Table A1, Appendix 1)

From Figure 3, it can be seen that 63% of the old chipseals resealed on the state highway network in 2008/09 did not reach their expected default life, i.e. for 63% of the state highway network, $E < 1.0$. This is very close to the results from data in the 2002/03 year where Ball and Patrick (2005) found that $E < 1.0$ for 66% of the state highway network. This confirms that the national state highway mean sealing lives have not just remained the same, but the shape of the graph in Figure 3 shows that the distribution of the chipseal lives has remained very similar.

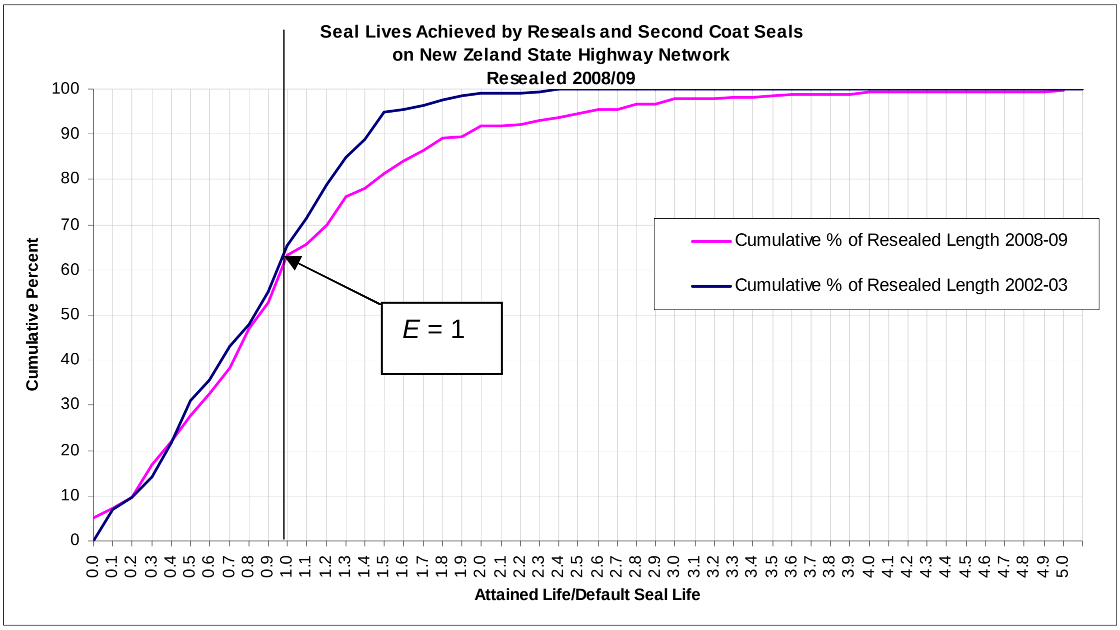

***Figure 3*: Seal Lives Achieved by Reseals and Second Coat Seals on New Zealand State Highway Network Resealed 2008/09, and in the 2002/03 year. Source: RAMM data, Ball and Patrick (2005).**

Analysing the % of reseals that did reach their expected life for each state highway region shows a range from 15% to 79%.

This is a surprisingly wide variation. It is reasonable to expect the *E* = 1 line to cross at 50% or lower for each region. Further investigation is required of those regions with the greatest variances from default seal life.

Traffic Volumes

Traffic volumes on the state highway network are shown in Figures 4 to 7. Heavy vehicles (Figure 5) are vehicles greater than 3.5 tonnes.

Figure 4 shows the significant increase in Vehicle Kilometres Travelled (VKT) on the state highway network 1998 – 2005. (Growth in VKT appears to be flattening off in recent times, and this might be a reflection of increased fuel prices and the downturn of economic activity in New Zealand). Overall VKT has continued to increase, although no corresponding drop in chipseal life can be seen in Figure 1.

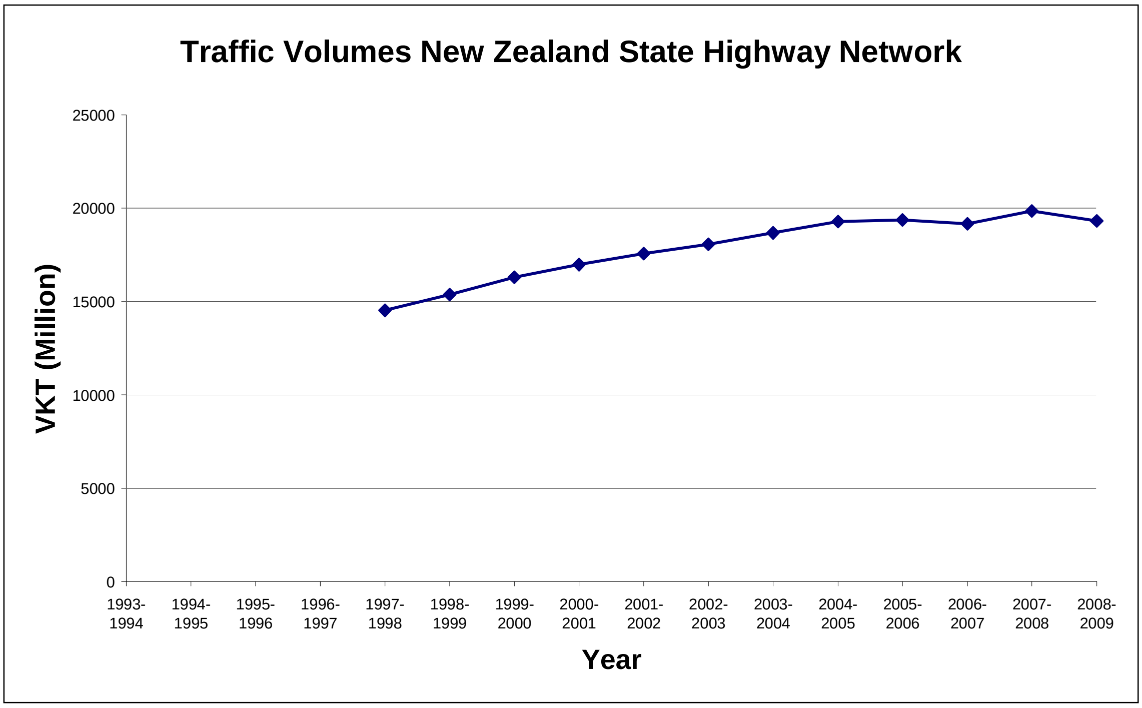

Figure 4: Traffic Volumes in Million Vehicle Kilometres Travelled (VKT). Source: State Highway Traffic Data.

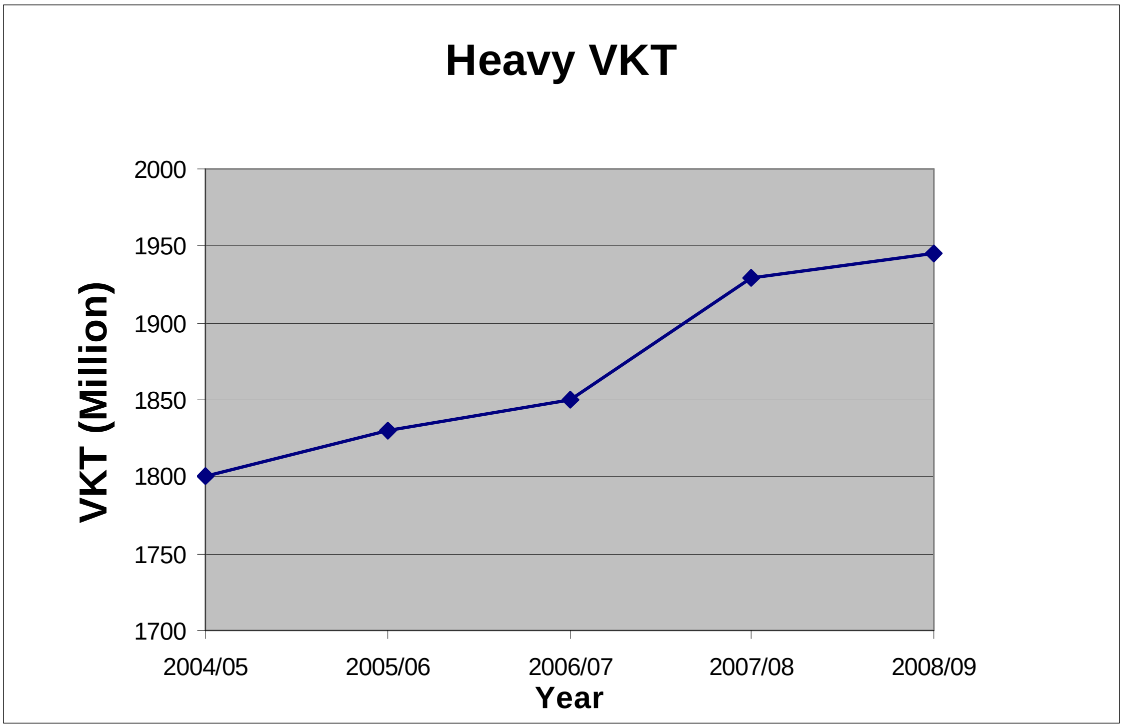

Figure 5 Heavy Traffic Volumes in Million Vehicle Kilometres Travelled (VKT). Source: State Highway Traffic Data.

Figure 5 shows the steady increase in Heavy VKT (vehicles greater than 3.5 tonnes), on the state highway network from 2004 to 2008.

Figure 6 shows data collected from continuously counted telemetry sites where the base (1.00) is indexed at 1989.

Despite the continued growth in traffic volumes and heavy traffic volumes shown in Figure 6, no corresponding drop in chipseal life can be seen in Figure 1 over this period.

(Traffic data provided in this section is intended to be used as an approximate indication of traffic flows on state highways throughout New Zealand).

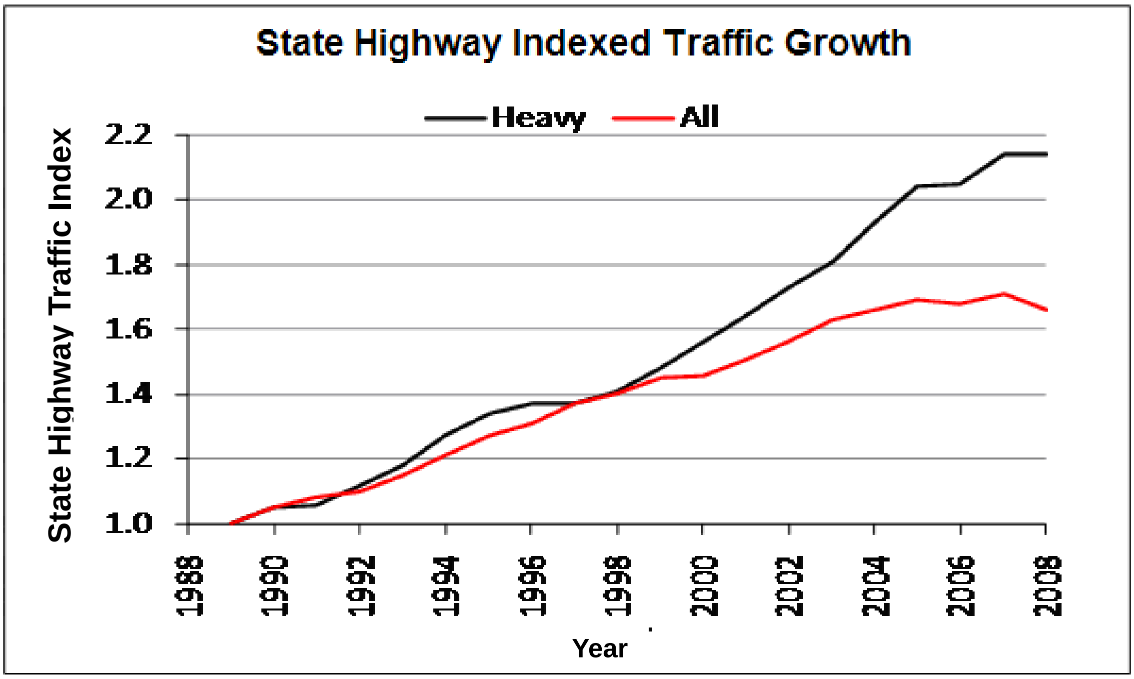

Figure 6 State Highway Indexed Traffic Growth. Source: State Highway Traffic Data.

Surface Condition Index

To supplement the use of seal life as a performance indicator, the Surface Condition Index (SCI) from the *State Highway National Pavement Condition Report 2008* is used in this paper.

The national SCI is plotted in figure 7. An explanation of how the SCI is calculated is shown in Appendix 6.

The difficulty with SCI is that it is a composite index made up of a combination of surface condition data (cracking, ravelling, potholes, flushing) and surface age and expected surface life. The inclusion of the expected surface life as a factor may mask or enhance the effects of innovations and improvements to sealing practice in any region being studied. Therefore it is important that further research be undertaken to look more closely at the trends in the surface condition data making up the SCI before strong conclusions be made on the effects of improvements to sealing practice.

The following table of categorisations of SCI (Table 1) will assist in interpreting the graph.

Table 1: SCI Categorisation. *Source: State Highway National Pavement Condition Report 2008*.

Categorisation of SCI	
≤ 0	Excellent
0 < to ≤ 5	Very Good
5 < to ≤ 10	Fair
10 < to ≤ 20	Poor
20 < to ≤ 100 (the maximum)	Very Poor

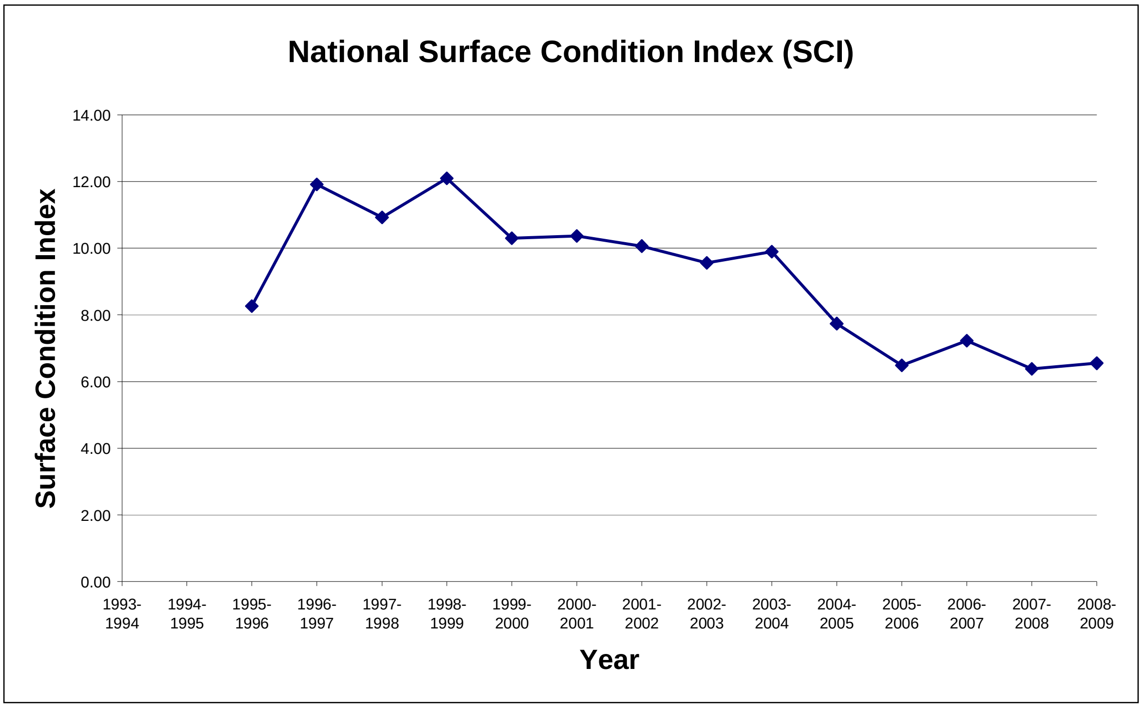

Figure 7: Surface Condition Index (SCI) on the New Zealand state highway network. Source: State Highway National Pavement Condition Report 2008

Figure 7 shows that SCI has been steadily improving on the state highway network, moving from “Poor” (SCI of 10 to 20) in the period 1996 – 2001 to “Fair” (SCI of 5 to 10) from 2002 onwards. SCI stayed level in the period 1999 – 2003 and also in 2005 – 2008. It is perhaps instructive to identify the initiatives that were undertaken in the periods 1997 to 1999 and 2003 to 2005, which caused each improvement in SCI.

One area to be investigated to explain the trends in Figure 7 is a change in contract types. From the mid 1990’s to the year 2000, P/17 Performance Based Specification for Reseals was introduced progressively around the state highway network. After that, performance based maintenance specifications, the 5-year Hybrid and 10-year Performance Specified Maintenance Contracts (PSMCs) were introduced in the period 1999 – 2002 over about two thirds of the state highway network. These have not affected the overall mean life (figure 1) but further research is needed to understand whether these contract types have influenced seal performance.

Good Skid Exposure

Another performance indicator is Good Skid Exposure (GSE) (Figure 8). This data was not found to be a good indicator of success of the initiatives tried in different regions. Usually GSE is in the range 95 to 98% and gives some movement in response to initiatives.

An explanation of how GSE is calculated is shown in Appendix 7.

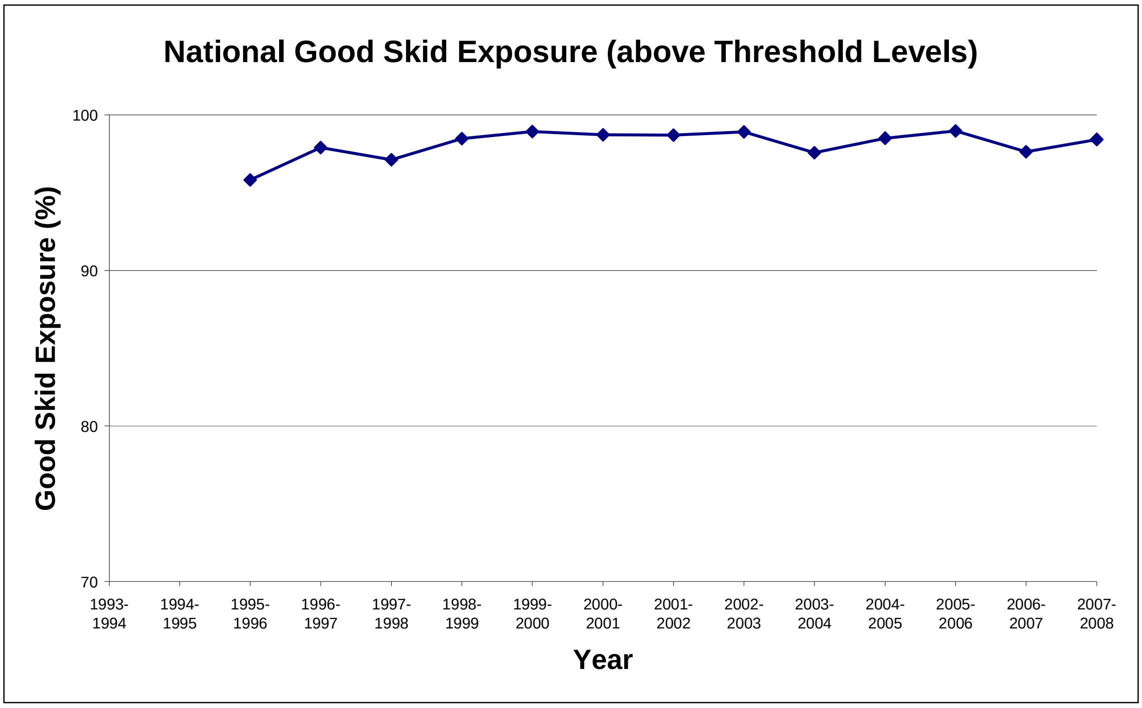

Figure 8: Good Skid Exposure on the New Zealand state highway network. Source: State Highway National Pavement Condition Report 2008.

The good skid resistance shown on the state highway network, particularly the increase from 1995 onwards can be explained by better selection of high PSV aggregates after the introduction of a skid resistance policy in 1997.

CHANGES TO SEALING PRACTICE

Treatment selection, the selection of the seal type and chip, is one of the most important aspects of chipsealing. In the past the choice was associated only with the size of chip to use in a single coat seal. Now a large number of seal types are available and the choice of treatment is based not solely on engineering decisions but also on cost, safety, environmental and user preferences (from *Chipsealing in New Zealand*).

Chipsealing in New Zealand gives a flow chart of the basic engineering decisions that need to be made for treatment selection and a recommended sealing sequence. The sealing sequence and the flow chart are designed to guard against using a succession of seals having the same or similar chip size which would increase the chance of layer instability.

Use of Two Coat Chipseals

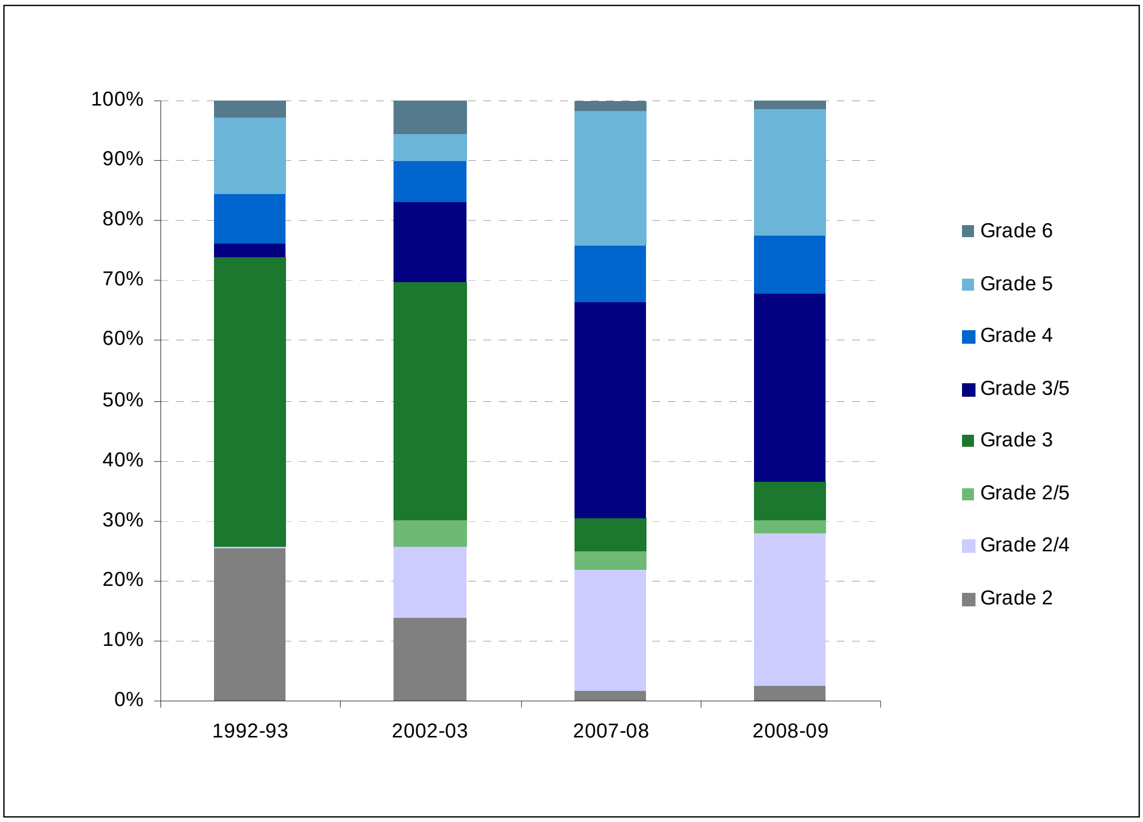

Figure 9: National Sealing Practice (by portion of SH Network Length) 1992 to 2009. Source: RAMM data[2].

As can be seen from Figure 9, the proportion of single coat chipseals completed in 1992-1993 (particularly the larger grade 2 and grade 3 sized chipseals[3]) has been replaced in the 2007 – 2009 period by many more multicoat chipseals, i.e. two coats or racked-in seals, of chip grades 2/4, 2/5 and 3/5.

The move to sealing under P/17 Performance Based Specification for Reseals has shifted the risk (imagined or real) to the contractors. Some clients are of the opinion that contractors have adopted the "short-term" measure of more expensive multicoat seal types to manage their risk associated with traffic stress and texture variation in the surface to be sealed.

[2] The data for Figure 9 is presented in Appendix 3.

[3] See Appendix 2, Chip Sizes, to convert from chip grade to size in mm.

Use of Harder Binders

In an effort to reduce bleeding there has been a move towards using harder binders. The binders 80/100 (similar to a Class 170 binder) and 130/150 (similar to a Class 80 binder, if such a class existed) are now more widely used.

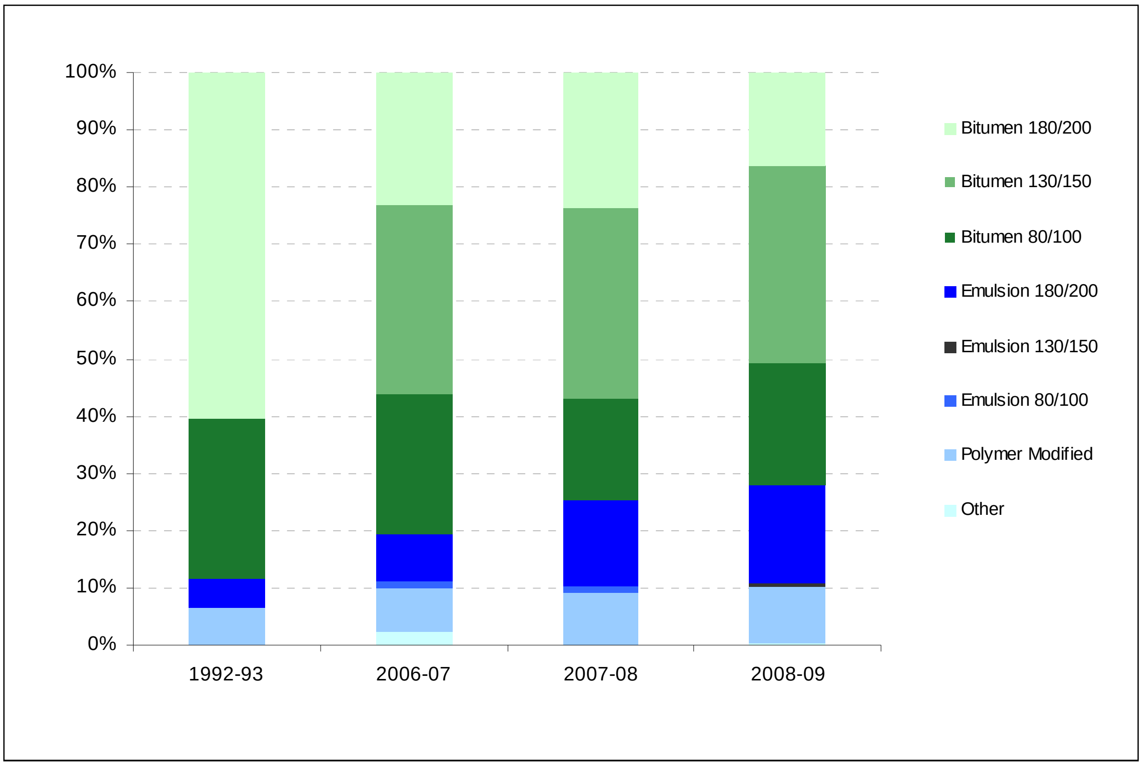

Figure 10: State Highway Binder Use (by % of resealed Network Length) 2006 to 2009. Source: RAMM data[4].

Figure 10 shows that the use of the softer 180/200 cutback binders has gone from 60% in 1992-93, to 23% in 2006-07, to 16% in 2008-09. The use of 180/200 emulsified binders has risen from 5% in 1992-93 to 20% in 2008-09.

There was no 130/150 in use in 1992-93. Since its introduction, use of 130/150 has remained about the same at about 33%.

The use of the harder 80/100 binders has remained about the same at about 20%.

In 1992-93 the polymer modified binders, 6%, were applied using hot cutback binder and were predominantly natural rubber, although a small amount of SBS polymer was in use. From 2006 to 2009 the emulsions are predominantly SBS and were all applied as polymer modified emulsions.

The use of emulsion binders has risen from 6% in 1992-93 to almost 30% in 2008-09.

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[4] The data for Figure 10 is presented in Appendix 4.

Failure Mechanisms

Reasons for Resealing

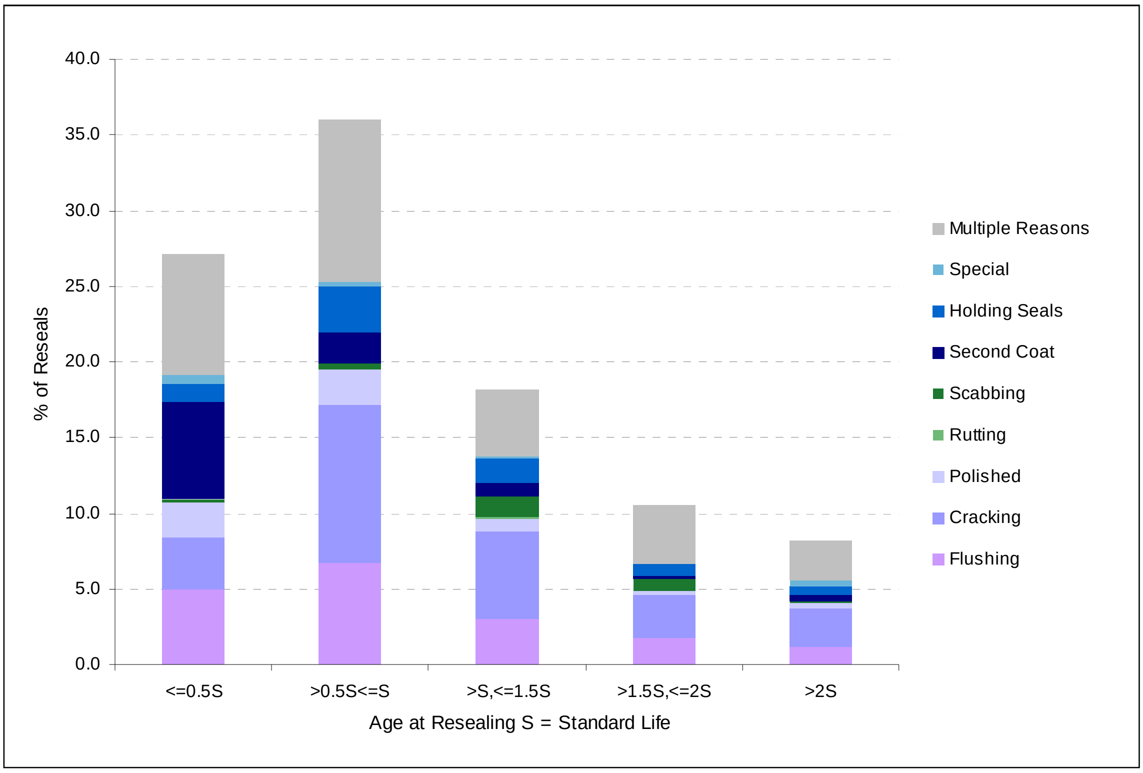

Figure 11: National Reasons for Resealing[5] 2008-9 Season (Length). Source: RAMM Data[6].

As shown on Figure 3, about 63% of the old chipseals resealed on the state highway network in 2008/09 did not reach their expected default life (*S*). Figure 11 shows the Reasons for Resealing[5] for chipseals completed in the 2008-09 season, calculated from length sealed (not from area sealed). The reasons for resealing have changed over the years as shown in Figure 12.

[5] See Appendix 8, Table A8 for expanded Reasons for Resealing.

[6] The data for Figure 11 is presented in Appendix 5.

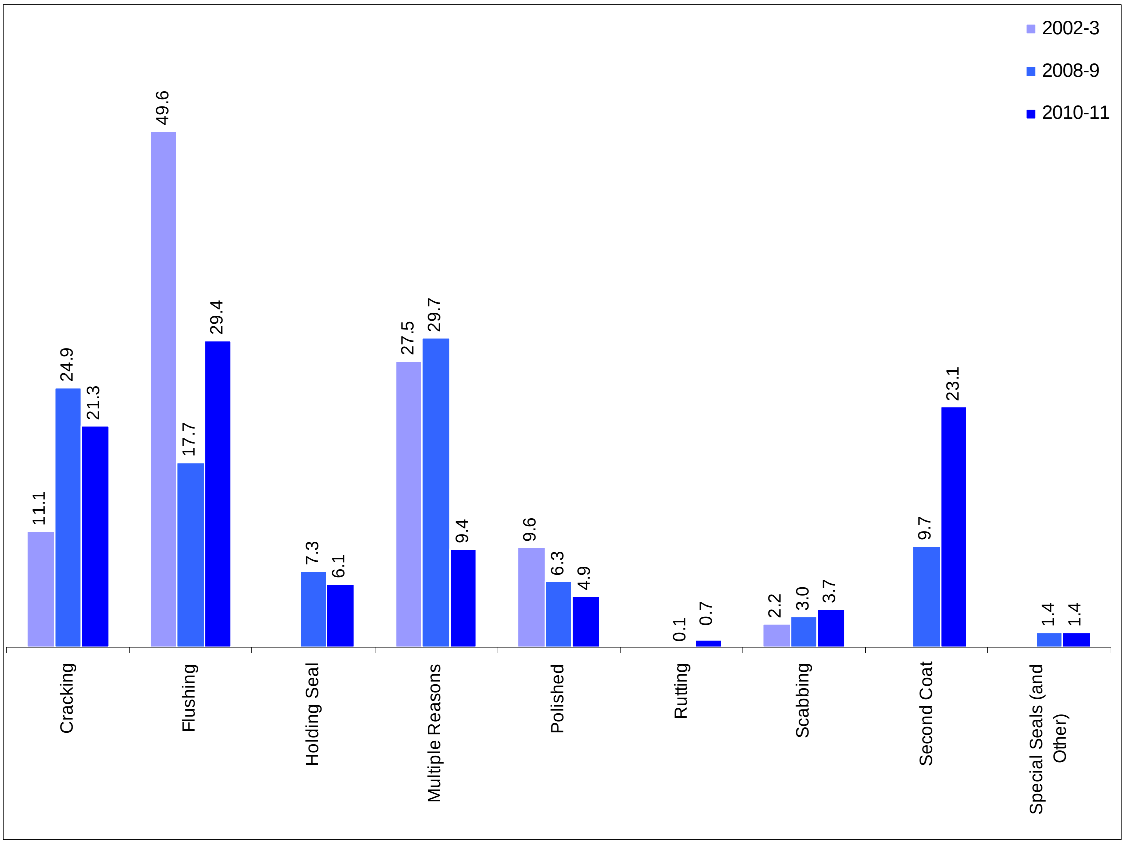

Figure 12: National Reasons for Resealing 2002, 2008 (actual) and 2010/11 (predicted). Source: RAMM Data, Ball et al (2004), Annual Plan Request 2010/11

Information for 'North Canterbury' and 'Northland' were unavailable to be included in the 10/11 figure above. See Appendix 8, Table A8 for expanded Reasons for Resealing.

The network Engineer is required to give a reason for resealing in the RAMM database. Figure 12 compares the distribution of reasons for the 2002-03, 2008-09 and 20010-11 resealing seasons.

Flushing has historically dominated the reasons for resealing on the New Zealand state highway network. When the 2008-09 data was released, it was surprising to see that cracking was more prevalent than flushing. These results were checked against the predicted reasons for resealing for the 2010/11 year. Predictions for 2010/11 were found to be consistent with historical performance, predicting more flushing than cracking.

A possible explanation for the increase in cracking on the network is the increased use of harder binders, as discussed in the section above on the use of binders, although this could be challenged.

Figure 11 indicates cracking is a reason for resealing early in the life of a seal. Reasons for this are unclear. It could be suggested that this is caused by the use of use of cement stabilisation, however cement stabilisation as a rehabilitation treatment of a basecourse uses less than 2% cement and thus shrinkage cracking is not an issue. When higher levels of cement are used it is as a subbase and then an unbound granular layer is used as the basecourse.

The increase in second coat sealing in Figure 12 is associated with the variation in the yearly rehabilitation performed. As was stated earlier the average rehabilitation performed is relatively constant but there can be a variation of over 1% of the length of the network between years. This is equivalent to an approximate change in second coat seals of 10%.

The data in Figure 12 is not considered as reliable as would normally be desirable for robust research by the authors of this paper. The authors were challenged by practitioners (NZTA Area Engineers) over the increase in cracking and the massive decrease in flushing between the

2002 and 2008 data. This is why the data from the 2010/11 Annual Plan Request was added to Figure 12, to ascertain if these trends were real. The trends shown in the 2010/11 data are more in keeping with what practitioners were expecting to see (i.e. New Zealand state highways still have a flushing problem).

A memo has been issued to all the network engineers to clarify the use of the "Reasons for Resealing" and to encourage consistency into the future. There are huge differences in regional reporting, which are influencing the proportions seen. It is hoped through the tightening up of the definitions and the introduction of restrictions regarding what can be reported, that more consistent data will be seen in the future which will enable a more robust examination to be performed.

DISCUSSION

Regarding contract type, the introduction of P/17 Performance Based Specification for Reseals, Hybrid and 10-year Performance Specified Maintenance Contracts (PSMCs) have not affected the overall mean life. Further research is to be performed on whether the contract type has influenced seal performance. Also research is needed into Key Performance Indicators (KPIs) which are strong influencers of decisions made regarding seal type and binder selection in Hybrids and PSMCs. It is desirable to better understand the influence of KPIs on chipseal life and performance.

Change in seal types and change in technologies associated with seal type and binder selection may be associated with different forms of contract delivery. More research is needed in this area.

SCI is a composite measure and more research is necessary on its component inputs to understand their impact on overall seal performance.

Another area for future investigation is the relationship between funding, resurfacing rates, chipseal lives and measures of pavement surface condition.

CONCLUSION

The New Zealand state highways' mean chipseal lives have been relatively constant since 1991 even though there has been an:

- Increase in traffic
- Introduction of a skid resistance policy
- Change in contract type

Change in seal types and changes in technologies associated with seal type and binder selection may be associated with different forms of contract delivery. More research is needed in this area, to relate these changes to the effects on chipseal life.

New Zealand is fortunate to enjoy very good relationships between NZTA, contractors and clients and this has fostered good communications and it is believed has also contributed to the ability of New Zealand chipseals to withstand the stress of the 21st century vehicle loadings.

New Zealand has a very comprehensive inventory, surfacing data and condition database which has allowed these investigations to be made. Future areas of research needed include getting more robust data on "reasons for resealing" and getting a better understanding of the drivers that affect seal performance through:

- Identifying what components of the SCI have changed to indicate improvement.
- Investigation into the increase in cracking (is it real?)
- Changes to chipsealing binders and their effect

- Influence of contract type on seal performance

- Analysis by region to understand the factors and initiatives in each region that have contributed to seal lives staying consistent

- Investigation of those regions with the greatest variances from default seal life

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AUTHOR BIOGRAPHIES

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Joanna Towler has had 15 years experience in the roading industry. Joanna holds the position of Roading Engineer at the New Zealand Transport Agency's National Office in Wellington, in the Operations Section. Joanna is responsible for specifications relating to road surfacings and delineation for New Zealand state highways and has been involved in a wide variety of projects, ranging from performance based chipseal specifications, to skid resistance, to road markings.

Joanna has also had local authority experience, working at Wellington City Council prior to joining Transit New Zealand, now the NZ Transport Agency, in the year 2000.

Joanna holds the degree of Bachelor of Environmental Engineering and has a Masters of Pavement Technology.

John Patrick

John Patrick is the Pavements Research Manager at Opus International Consultants Central Laboratories Lower Hutt New Zealand. John has over 40 years experience in roading investigations and research. He has been associated with a wide range of research into pavement materials including hotmix asphalt, granular basecourse, aggregates, and chipsealing and bitumen properties. He has also performed research into pavement performance and methods of measurement including roughness and skid resistance. John has been responsible for technical input into revisions to NZTA specifications and developing performance-based specifications for chipseals and hot mix asphalt. Practical experience has been gained during three years' employment with a roading contractor.

Peter Howe

Peter holds the position of statistical/data analyst for Traffic & Safety and the Asset Management team at NZTA.

Peter also holds a Bachelors and honours degree in both Physics and Mathematics, a post graduate certificate in statistics and currently studying for a post graduate diploma in econometrics.

APPENDIX 1

Table A1: Default Target Life (years) for each Pavement Use code. Source: Table C3 Reproduced from *State Highway National Pavement Condition Report 2008*

Surfacing Type[7]	Use 1 (<100vpd)	Use 2 (100-500vpd)	Use 3 (500-2,000 vpd)	Use 4 (2,000-4,000 vpd)	Use 5 (4,000-10,000 vpd)	Use 6 (10,000-20,000 vpd)	Use 7 (>20,000 vpd)
	years	**years**	**years**	**years**	**years**	**years**	**years**
Texturising Seals							
Grade 6	6	5	4	3	2	1	1
Grade 5	8	7	6	5	4	3	2
Grade 4	12	10	8	7	6	5	4
Void Fill Seals							
Grade 6	6	5	4	3	2	1	1
Grade 5	8	7	6	5	4	3	2
Grade 4	12	10	8	7	6	5	4
Grade 3	14	12	10	9	8	7	6
Locking Coat Seals							
Grade 6	6	5	4	3	2	1	1
Grade 5	8	7	6	5	4	3	2
First Coat Seals							
Grade 6	1	1	1	1	1	1	1
Grade 5	1	1	1	1	1	1	1
Grade 4	3	2	1	1	1	1	1
Grade 3	4	3	2	1	1	1	1
Grade 4/6	6	4	3	2	2	1	1
Grade 3/5	8	6	5	4	3	2	1
Grade 2/4	10	8	6	5	4	3	2

[7] See Appendix 2, Chip Sizes, to convert from chip grade to mm.

Surfacing Type[7]	**Use 1 (<100vpd)**	**Use 2 (100-500vpd)**	**Use 3 (500-2,000 vpd)**	**Use 4 (2,000-4,000 vpd)**	**Use 5 (4,000-10,000 vpd)**	**Use 6 (10,000-20,000 vpd)**	**Use 7 (>20,000 vpd)**
	years	**years**	**years**	**years**	**years**	**years**	**years**
Second Coat Seals							
Grade 6	6	5	4	3	2	1	1
Grade 5	8	7	6	5	4	3	2
Grade 4	12	10	8	7	6	5	4
Grade 3	14	12	10	9	8	7	6
Grade 2	16	14	12	11	10	9	8
Grade 4/6	14	12	10	9	8	6	4
Grade 3/5	16	14	12	11	10	8	6
Grade 2/4	18	16	14	13	12	10	9
Reseals							
Grade 6	6	5	4	3	2	1	1
Grade 5	8	7	6	5	4	3	2
Grade 4	12	10	8	7	6	5	4
Grade 3	14	12	10	9	8	7	6
Grade 2	16	14	12	11	10	9	8
Grade 4/6	14	12	10	9	8	6	4
Grade 3/5	16	14	12	11	10	8	6
Grade 2/4	18	16	14	13	12	10	9
Prime & Seal	7	6	5	4	3	2	1
Slurry Seal	8	7	6	5	4	3	2
Thin AC	12	11	10	9	8	7	6
Open Graded Porous Asphalt	12	11	10	9	8	7	6
Open Grade Emulsion	12	11	10	9	8	7	6
Premium	10	9	8	7	6	5	4

Surfacing Type[7]	Use 1 (<100vpd)	Use 2 (100-500vpd)	Use 3 (500-2,000 vpd)	Use 4 (2,000-4,000 vpd)	Use 5 (4,000-10,000 vpd)	Use 6 (10,000-20,000 vpd)	Use 7 (>20,000 vpd)
	years	**years**	**years**	**years**	**years**	**years**	**years**
Skid							
Structural AC	20	20	19	19	18	17	16
Concrete	60	60	50	50	40	40	40
Stone Mastic Asphalt	15	14	12	11	10	8	7
BOLIDT polyurethane	18	16	14	12	11	10	8
Bicouche/ Sandwich	14	12	10	9	8	6	4
Interlocking concrete blocks	50	50	50	50	50	50	50

APPENDIX 2

Chip Sizes

Extracts from *TNZ M/6* Specification for Sealing Chip.

Table A2: Chip Sizes, Grades 2, 3 and 4

Grade of Chip	Average Least Dimension ALD (mm)	Equivalent Australian Grade
2	9.5 – 12.0	14 mm
3	7.5 – 10.0	10 mm
4	5.5 – 8.0	7 mm

Table A3: Chip Sizes, Grades 5 and 6

Test Sieve Aperture	% Passing	
	Grade 5	Grade 6
13.2 mm	100	-
9.5 mm	95 – 100	100
6.7 mm	-	95 – 100
4.75 mm	8 max	-
2.36 mm	2 max	15 max
300 µm	0	8 max

APPENDIX 3

National Sealing Practice (by percentage of sealed length)

Chip Size - National Percentage By Length Sealed				
	1992-93	2002-03	2007-08	2008-09
Grade 2	25.5	13.8	1.5	2.5
Grade 2/4	0.4	12.1	20.2	25.5
Grade 2/5	0.0	4.2	3.2	2.2
Grade 3	48.1	39.7	5.6	6.4
Grade 3/5	2.1	13.3	36.0	31.4
Grade 4	8.5	6.8	9.2	9.7
Grade 5	12.5	4.5	22.5	21.0
Grade 6	2.9	5.6	1.7	1.4

APPENDIX 4

National State Highway Binder Use (by % of sealed length)

State Highway Binder Use by % of Resealed Network Length				
	1992-93	2006-07	2007-08	2008-09
Bitumen 130/150	0	33	33	34
Bitumen 180/200	60	23	24	16
Bitumen 80/100	28	24	17	21
Emulsion 130/150	0	0	0	0
Emulsion 180/200	5	8	15	17
Emulsion 80/100	0	1	1	0
Polymer Modified	6	8	9	10
Other	0	2	0	0

APPENDIX 5

National Reasons for Resealing 2008-09 (Percentage by length sealed).

Reasons for Resealing - National Percentage By Length Sealed									
	Cracking	Flushing	Holding Seals	Multiple Reasons	Polished	Rutting	Scabbing	Second Coat	Special
<=0.5S	3.4	5.0	1.2	8.0	2.3	0.0	0.2	6.4	0.6
>0.5S<=S	10.4	6.8	3.0	10.7	2.3	0.0	0.4	2.0	0.3
>S,<=1.5S	5.8	3.0	1.7	4.5	0.9	0.1	1.4	0.8	0.1
>1.5S,<=2S	2.8	1.8	0.8	3.8	0.3	0.0	0.8	0.2	0.0
>2S	2.5	1.2	0.6	2.6	0.4	0.0	0.1	0.3	0.4
	25.0	17.7	7.3	29.6	6.3	0.1	3.0	9.7	1.4

APPENDIX 6

Surface Condition Index

from *State Highway National Pavement Condition Report 2008*

Surface Integrity Index (SII)

During 1999 the Surface Integrity Index (SII) was developed as an overall indicator of surface condition in the NZ dTIMS System. The intent of this index was to allow maintenance intervention based on the compound effect of surface defects. The index has changed slightly (weighting factors etc.) since the original development but in essence has stayed the same. Apart from effectively assisting in the triggering of surface treatments the SII has also become very useful for reporting the predicted surface condition.

Surface Condition Index (SCI)

During late 1999, the then LTNZ (and previously known as Transfund) developed a RAMM Audit and Reporting procedure that considered a composite index for reporting the overall surface health. From this study a Resurface Demand Index (RDI) was developed which was used directly in RAMM for historical reporting on surface condition.

During 2002, a review was requested by the then LTNZ (and now part of the NZTA), of the RDI in order to be able to compare the historical surface condition to the predicted SII from dTIMS. As an outcome of this review the Surface Condition Index (SCI) was developed.

Expressions

*SII = MIN (100,(4 * ACA +0.5* ARV + 80 * APT + 1.2 * AFL + 3 * MAX(0,(AGE2 - SLIF) / SLIF * 12)))*

Where SII = Surface Integrity Index

ACA = area of all cracking (derived from alligator in RAMM) in %;

ARV = area of ravelling (derived from scabbing in RAMM) in %;

APT = area of potholes in %;

AFL = area of flushing in %;

AGE2 = surface age in years; and,

SLIF = expected surface (design) life in years.

*SCI =Min (100, [Min (100, (4 * ACA + 0.5 * ARV + 80 * APT + 20 * APH + 1.2 * AFL))] + [3 * Min (100, Max (0, ((AGE2 – SLIF) / SLIF * 12)))])*

Where SCI = Surface Condition Index

ACA = area of all cracking (derived from alligator in RAMM) in %;

ARV = area of ravelling (derived from scabbing in RAMM) in %;

APT = area of potholes in %;

APH = area of pothole patches in %

AFL = area of flushing in % (from high speed texture with MPD < 0.5mm);

AGE2 = surface age in years; and,

SLIF = expected surface (design) life in years.

Summary of Differences

The SII and SCI are comparable indices with similar defects, weighting factors and both indices use the HDM description of defects. They both are an aggregate of measured conditions and surfacing ages and for this reason the index is sometimes reported as these two separate components:

SII or SCI = Condition Index (CI) + Age Index (AI)

The only differences between the SII and SCI are:

- The SCI is based on historical values (transformed RAMM data) while the SII is a predicted condition (from dTIMS). We have decided to keep these two indices separate in order to indicate the data source difference;
- Because of the historical contents for the SCI, it includes pothole patches while the SII only contains potholes; and,

Both the indices contain an age index. However, it is difficult and too complex to build a reporting expression in RAMM which reports on earlier actual age indices, since this would require rebuilding of previous years inventory (surfacing) data. Therefore, standard RAMM reports for years before the current year use the age index of the current year, and only recalculate the condition indices for the earlier years. Hence if a RAMM report is run for previous years, any variation in the SCI is solely due to variation in the condition component (CI) of the expression.

Adoption within Highways & Network Operations Division

In 2004, we reported the current and earlier year's values of SCI. The age index for 2003 and before is constant (based on the 2004 value) and the only variation in previous years is due to the condition index.

As we report each year from now, the current age index will be calculated and so from 2004 onwards, our reporting of the SCI will show variation due to both condition and age indices.

Given the approximations surrounding pavement modelling and the rating of defects, interpretation for us of SCI (as reported in the pavement condition reporting) and SII (as output from NZ dTIMS) should be considered analogous.

For both the SCI and SII the following categorisation applies:

		Excellent	<=	0
0	<	Very Good	<=	5
5	<	Fair	<=	10
10	<	Poor	<=	20
20	<	Very Poor	<=	100 (the maximum)

APPENDIX 7

Good Skid Exposure

from *State Highway National Pavement Condition Report 2008*

Skid resistance is measured in each wheel-path and has been surveyed by SCRIM in 1995, 1998 – 2008. In 1999 only one direction of the network was surveyed except on divided highways where both directions were surveyed. Reporting is by skid site categories and the analysis levels which are described in section 2. Two analysis levels are applied in skid reporting; the threshold level (Skid Resistance graphs) is where we require remedial treatment to be initiated and the investigation level (Good Skid Exposure graphs) is where sites are closely monitored and prioritised for future treatment.

Good Skid Exposure reflects the volume of traffic exposed to highway lengths that are currently above the investigation or threshold levels for providing good skid resistance road surfaces. A significant investment has been made in this area over a number of years and we are now realising the benefits with a significant decrease in wet road skidding related crashes.

Skid Resistance Thresholds

Reports the percentage of SCRIM readings < analysis levels by skid site categories.

The 2001 Skid Investigation (IL) and Threshold Levels (TL) for the different site categories are shown below:

Table A4 Skid Resistance Investigatory and Threshold Levels from TNZ T/10

Site Category	Site Definition	Investigatory Level (NZMSSC)	Threshold Level (NZMSSC)
1	Approaches to: • railway level crossings • traffic lights • pedestrian crossings • roundabouts • Stop and Give way controlled intersections • One Lane Bridges (inc. bridge deck	0.55	0.45
2	• Curve < 250m radius • Down gradients > 10%	0.50	0.40
3	• Approaches to road junctions • Down gradients 5 – 10% • Motorway junction area including on/off ramps	0.45	0.35
4	Undivided carriageway (event – free)*	0.40	0.30

5	Divided carriageway (event – free)*	0.35	0.25

*event-free = where no other geometrical constraint, or situations where vehicles may be required to brake suddenly, may influence the skid resistance requirements.

Threshold Level Analysis

SCRIM readings are checked against the threshold level by the following method:

$$SCRIM_{thres} = \frac{SCRIM\ (LWP + RWP)}{2} - TL$$

The $SCRIM_{thres}$ readings < 0 is then reported as a percentage value.

$$\frac{\text{Number of } SCRIM_{thres} < 0}{\text{Total number of SCRIM readings}} \times 100$$

Units = %

Good Skid Exposure (GSE)

Reports the percentage of $SCRIM_{Invest}$ readings >= 0 for each network compared with the national value, and also by NSHS hierarchy.

This is expressed as a percentage of vehicle kilometres travelled (VKT) annually.

The method of calculation of Good Skid Exposure =

$$\frac{\text{VKT with } SCRIM_{Invest} >= 0}{\text{Total VKT}} \times 100$$

Where VKT = AADT x length (km) x 365

Units = %

APPENDIX 8

RAMM Reasons for Resealing

NZTA is in the process of standardising "Reasons for Resealing". Table A8 shows old reasons for resealing from RAMM, and also new categories which are shown on Figures 11 and 12.

Table A8 Reason for Reseal Categories

New	**Old**
Cracking	Cracking
Flushing	Flushing (unstable surface)
	Loss of Texture (not Flushing)
Rutting	Rutting
Scabbing	Scabbing
Second Coat	Second Coat
Polished	Polished Stone (from SCRIM)
	Skid Resistance
Special	Traffic Threshold
	Urban Issues (noise etc)
	Other
	Ravelling (AC Surfaces)
Holding Seals	Pavement Repairs and patches (subgrade)
	Potholes and Patches (surface issue)
	Roughness
	Shoving and its patches (road base)
Multiple Reasons	Condition
	Aged
	Birthday Seal
	Shape Correction
	(blank) - Unexplained