

Update on use of Glenbrook **Melter Aggregate** to improve skid resistance and seal lives in Hawke's Bay: A route case study

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1. This presentation is an opportunity to bring you a brief update on the use of melter aggregate in chip seals on New Zealand State Highways.
2. Melter chip has been shown to provide consistent skid performance on high demand sites resulting in a decrease in wet Loss of Control (LOC) vehicle accidents.
3. As a result chip seal lives can be extended until replacement is required for distress other than polishing.

Content

- What is Melter aggregate?
- Overview of SH5 within the Hawke's Bay Region
- Case study SH5 RP 190/4.9 to 5.1
- Case study SH2 RP 577/13.6 to 13.8
- Chipsealing in New Zealand Practice Note
- Brief update of Melter chip supply



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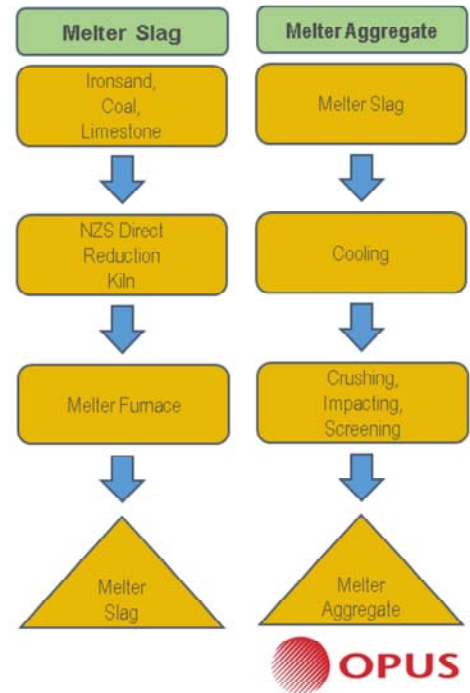
1. Briefly look at how melter chip is produced in New Zealand.
2. Look at the successful use of melter chip for reseals on SH5 (part of the National state highway roading network) within the Hawke's Bay region.
3. We will look at two specific accident sites where melter chip seals have been constructed to reduce wet LOC accidents.
4. Site 1, on SH5 between Napier and Taupo.
5. Site 2, on SH2 between Napier and Wairoa.
6. I will talk about Chipsealing in New Zealand and the melter aggregate practice note.
7. And will finish with a quick update on the availability of melter chip for use in chip seals throughout New Zealand.

What is Melter Aggregate?

- Slag is a generic term used for the (non metallic) co-product of iron and steel production
- EAF slag is produced from the electric arc furnace steel making process, and may contain free lime
- Melter slag is from the unique NZ Steel iron making process and does not contain free lime
- Glenbrook melter aggregate is produced from cooled, crushed and screened melter slag. It has important applications in roads and civil projects



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1. Excellent material on the New Zealand Steel website www.nzsteel.co.nz.
2. “The steelmaking operation at New Zealand Steel’s site at Glenbrook is a unique process that uses ironsand found on the local coast and turns it into iron and steel – no other steelmaking operation in the world makes steel in the same way.”
3. “The main by-product of steelmaking is slag (known as steel aggregate). Slag is non-metallic residue from the iron and steelmaking processes. It contains minerals such as silica, alumina and titania from the ironsand and other combinations of calcium and magnesium oxides, derived from other raw materials. It is produced in four different processes of the steelmaking operation. In the iron melters, iron slag is formed by fusion of limestone, ash and other fluxes added to the original ironsand (silica, aluminium, titanium). Iron slag is less dense than the molten iron in the large melters and so floats on top of the iron. This allows the slag to be tapped (poured) from the melter separately.”
4. Melter aggregate is crushed from melter slag and is used for constructing pavements, filter materials, asphalt (asphaltic concrete / hot mix) production and more recently as sealing chip.

Melter Chip?

- Is crushed from melter slag to meet the NZ Transport Agency specification for sealing chip
- Generally has a rough, porous (vesicular) appearance
- Is hard and durable with good crushing resistance
- Provides good on-road skid performance

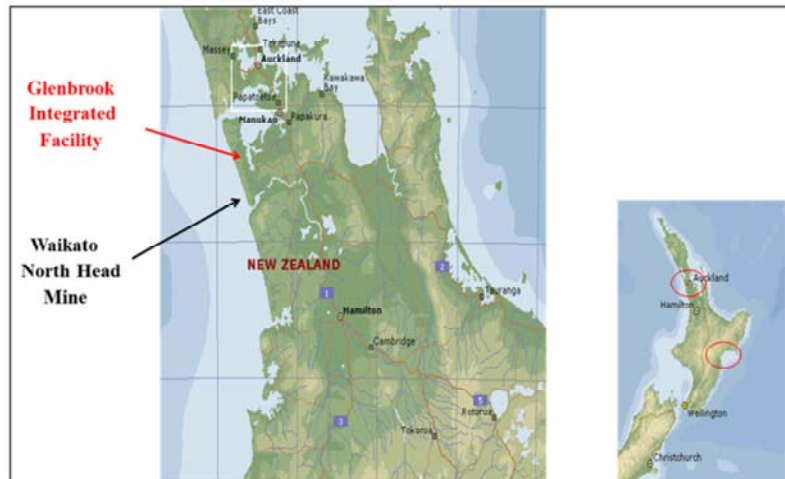


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1. All sealing chip used on New Zealand's state highways and most local authority roads must be crushed to meet the NZTA M6 specification for sealing chip.
2. This specification sets out the material requirements including strength, durability, polishing value, cleanness, size and shape for sealing chip.
3. While melter chip is hard and durable the vesicular nature of the stone means that additional fines can be generated in the crushing test as material is broken from the thin walls of the vesicles. This was a possible stumbling block early in the use of melter chip so an amendment to NZTA M6 allowed for an additional 3% of fines to be generated above the 9% limit specified for natural aggregates.
4. Annual SCRIM testing has shown melter chip maintains acceptable on-road skid performance where chip from natural aggregates have traditionally polished. So the evidence to date is that melter chip will extend chip seal lives by maintaining acceptable skid resistance on high demand sites.

Melter Chip Production



Glenbrook to Hawke's Bay
Regional Boundary 320km



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1. The New Zealand Steel mill is located at Glenbrook approximately 50km south of Auckland city and just west of Pukekohe.
2. The Iron sand is mined at a number of sites from Port Waikato to as far south as Taharoa on the west coast of the North Island.
3. The cart distance from Glenbrook to the regional state highway boundary on SH5 is approximately 320km.
4. All of the local Hawke's Bay sealing chip is crushed from hard river worn greywacke stone extracted from local rivers. While this aggregate is very hard and extremely durable it polishes quite quickly to low SCRIM values on sites with high traffic stresses.
5. Since the introduction of the NZTA T10 skid resistance management specification all high polish stone value (PSV) sealing chip calculated to meet the traffic stresses of high demand sites in Hawke's Bay has needed to be imported from outside of the region.
6. This and the poor performance of some imported high PSV chip reinforced the need to look at other possible aggregates and so the trials using melter chip on SH5

began.

Hawke's Bay History using Slag Aggregate

- 1999 EAF slag trials in NZ – three sites were constructed in the Hawke's Bay region
- 2006 saw the introduction of melter chip reseals
- Originally limited to low risk sites on SH5
- 2010 Specified for use on **ALL** SH5 reseals
- Prioritised for use on high demand sites throughout the Hawke's Bay region



1. Hawke's Bay (HB) history applies to the State Highway network under the control of the NZ Transport Agency and not the various other local authority roading networks.
2. In 1999 trials using sealing chip crushed from electric arc furnace (EAF) slag were constructed around the country. Three trial sites were constructed on the Hawke's Bay SH network. SCRIM measurements recorded following the construction of these trial sites showed an unacceptably low skid performance so further use of EAF chip was banned.
3. So when we looked to trial melter slag chip seals we initially choose relatively low demand sites just in case it did not perform as well as we were hoping.
4. Initial SCRIM testing showed very good skid performance so melter chip seals were constructed on high demand sites. SCRIM testing of these sites also showed good skid resistance.
5. As the melter chip continued to provide good skid resistance on high demand sites and there were high numbers of wet loss of control (LOC) accidents on SH5 the 2010 maintenance contract specified all chip seals on SH5 were to be constructed using melter chip. However this requirement changed in subsequent years so that melter chip could be used on other high demand sites throughout the HB region

particularly where there were wet LOC accidents.

6. Note the road marker is yet to paint the edge lines in the photograph on the right where the site has been resealed using melter chip.

Hawke's Bay Crash Record – Particularly SH5

- Lower annual daily traffic counts but high percentage of HCV's (>18%)
- No detours - important freight route including HPMV's
- Low skid values due to aggregate polishing
- Wide temperature variation –
(winter icing to summer bleeding bitumen)
- Frequent wet loss of control injury and
fatal accidents

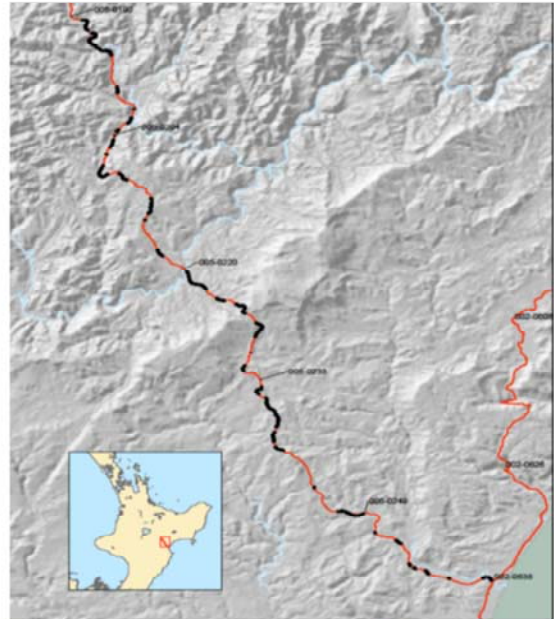
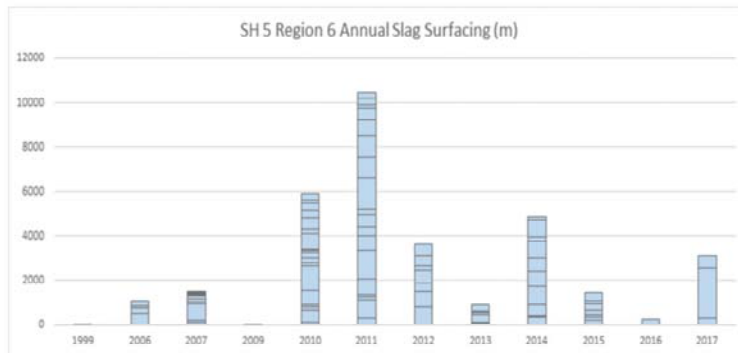


1. SH5 is the main route between Napier and Taupo in the centre of the North Island. In fact it is the only route between these two centres unless you take a significant detour on local roads not designed for the weight and volume of traffic that SH5 carries.
2. While the annual average daily traffic is relatively low with approximately 2,600 vehicles travelling between Napier and Taupo there is a significant percentage of heavy commercial vehicles.
3. There is no direct rail link to Hawke's Bay from the north so significant freight is moved across this road by heavy vehicles including high productivity motor vehicles (HPMV's) permitted to carry longer and heavier loads than normal heavy commercial vehicles. There are also large pine plantations between Napier and Taupo so there can be significant changes in logging truck counts depending on log prices and harvesting programmes.
4. The alignment of SH5 is curvilinear and has some significant changes in elevation from sea level at the coast to three summits at around 720m. The weather variation between summer and winter is significant with a range in pavement surface temperatures between +55 to -3 degrees Celsius. So there are sections of the road that will be treated for bleeding bitumen in summer and treated for ice in the

winter. There can also be long periods of dry weather in the summer and very heavy rainfall in the winter.

5. From a safety perspective the major concern was the high number of wet LOC injury and fatal accidents.

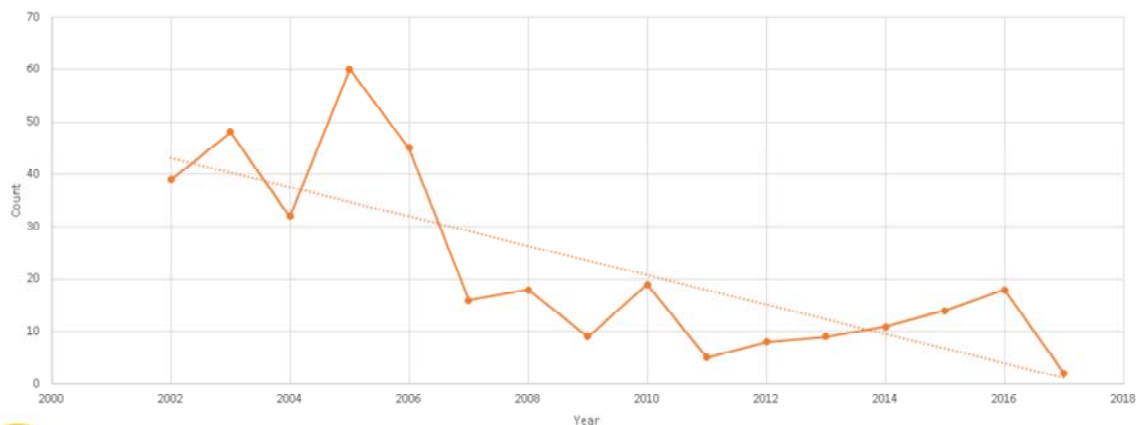
Melter Chip Reseals – SH5



1. The chart on the left shows the number and length of chip seals using slag based chip since the trials of EAF chip in 1999.
2. From 2006 the melter chip seals were being trialled and you can see the large increase from 2010 when melter chip seals were specified in the maintenance contract. From 2012 the number and length of melter chip seals reduced as other high demand skid sites throughout the remainder of the network were resurfaced using melter chip.
3. The map to the right shows the curvilinear alignment of SH5 and where melter chip seals have been completed, particularly on the higher demand curves.

Melter Chip Reseals – SH5

SH 5 (RS 190 to RS 264) Wet LOC accidents CAS



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1. This graphs shows that there has been a significant drop in wet road LOC accidents on SH5.
2. We believe that this significant reduction is in part due to the progressive sealing of high demand skid sites with melter chip.
3. The introduction of the T10 skid resistance specification, completion of safety improvements, education, Policing and ABS will also have contributed to the reduction in wet road LOC accidents.

Case study 1: Tarawera Hill SH5 (RP 190/ 4.9 to 5.1)

- AADT 2600 with 23% medium and HCV's
- Curve 50m radius, -8% grade, +4.2% cross-fall – generating a design speed of 40km/hr (curve speed advisory sign of 35km/hr)
- Using the curve context model from NZTA Research Report 477 to calculate approach speeds – inc 78km/hr, dec 99km/hr (Curve context table RAMM)
- Numerous loss of control accidents for northbound (decreasing direction) traffic. Sliding across the southbound lane and hitting the guardrail barrier on the opposite side of the road. 89% of accidents wet LOC.



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Case study 1

1. Site 1, is located on SH5 close to the Hawke's Bay regional boundary. This section of the highway is in hilly (some would call mountainous) terrain and is a particularly curvilinear alignment.
2. The curve context data in the RAMM data base has been calculated using the curve context model published in NZ Transport Agency Report 477. This calculates the design speed of the curve to be 40km/hr and the down hill approach speed to the curve to be 99km/hr.
3. The general nature of the accidents was north bound vehicles coming over the crest of the hill would increase speed on the 220m down hill gradient and then realise they were travelling too quickly to negotiate the tight 50m radius curve. This would cause them to brake heavily which caused a number of vehicles to lose control and slide across the southbound lane hitting the guardrail on the opposite side of the road particularly when the road surface was wet.

Case study 1: Tarawera Hill SH5 (RP 190/ 4.9 to 5.1)

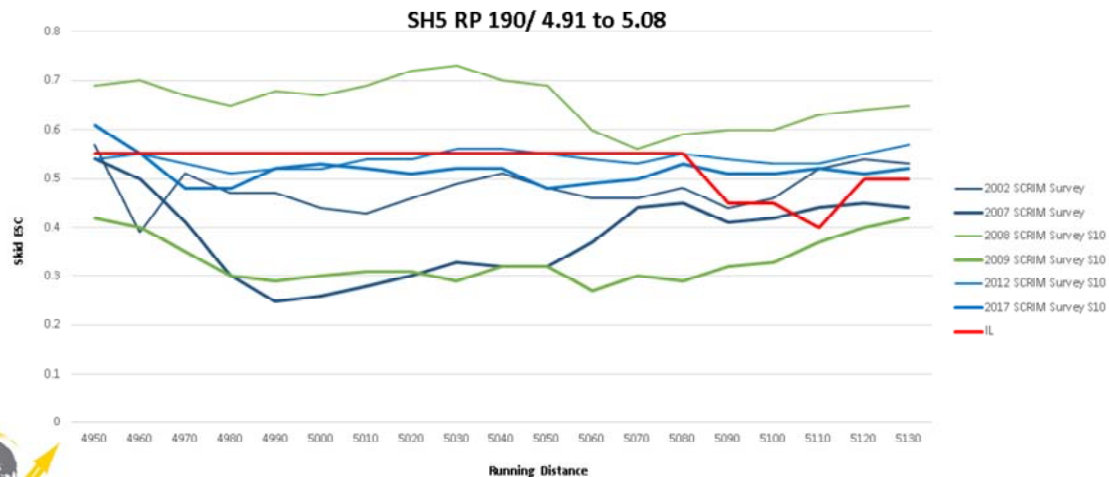


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1. This photograph taken from the November 2016 high speed data collection video gives some idea of the terrain and road alignment. There is a reasonable back drop of foliage beyond the curve and signage highlighting the curve and advisory sign of a slippery road surface when wet.
2. However none of that helps when you are travelling too quickly and need to brake heavily to negotiate the very tight curve ahead and the surface is providing very little in the way of skid resistance.
3. The melter chip seal was almost 7years old when this photograph was taken. Visually it appears to be performing well for northbound traffic.

Case study 1: Tarawera Hill SH5 (RP 190/ 4.9 to 5.1)



1. This curve is a site category 2 high which has a Investigatory Level (IL,ESC) of 0.55 shown by the red line.
2. In 2001 a Poplar Lane (~58 PSV) 3/5 two coat seal was constructed. The 2002 SCRIM survey was the first following construction and shows that the skid values had already polished to near the Threshold level (TL) which is 0.10 below the IL. Over a period of five years the skid values dropped significantly to below 0.30 ESC over a 40m length.
3. In 2007 a Linton Quarry (~58-60 PSV) 3/5 two coat seal was constructed. The 2008 survey show excellent skid values but the skid values dropped quickly and significantly as shown in the 2009 survey. The results of the 2009 survey are likely to have been affected by chip embedment as the pavement was recycled in late 2009.
4. In 2011 a Glenbrook melter chip 3/5 two coat seal was constructed. The 2012 SCRIM survey shows the skid values provided by the melter chip to sit just below the investigatory level at an average of 0.54 ESC. The 2017 survey shows that the melter chip although it has polished slightly is maintaining good skid values at an average of 0.52 ESC. The life of the melter chip seal already exceeds the lives of the previous two chip seals.

5. The crash data shows no wet LOC accidents recorded on this curve since the construction of the melter chip seal and is supported by the absence of accident debris and damage to the guard rail.
6. Note:- ESC is Equilibrium SCRIM Coefficient which is skid values that have been adjusted for within year and between year variations.

Case study 2: Waikare Gorge SH2 (RP 577/ 13.6 to 13.8)

- AADT 1755 with 30% medium and HCV's (fluctuates with logging demand)
- Curve 96m radius, -8.5% grade, +10.0% cross-fall – generating a design speed of 60km/hr (curve speed advisory sign of 55km/hr)
- Using the curve context model from NZTA Research Report 477 to calculate approach speeds – inc 96km/hr, dec 98km/hr (Curve context table RAMM)
- Numerous loss of control accidents for southbound (increasing direction) traffic. Hitting the bank on the LHS, and or losing control and sliding across the northbound lane and entering the deep drain on the RHS of the road (before the guardrail was installed). 100% of accidents wet LOC with 33% being night time crashes. Accident debris showed the number of crashes to be much higher than reported.



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Case study 2

1. Site 2, is located on SH2 between Napier and Wairoa. This site is on the northern side of the Waikare gorge and is in hilly terrain with curvilinear alignment.
2. The rail link between Napier and Wairoa has been closed for some years. There are large pine forests north of Napier so while the annual daily traffic count is low there is a high percentage of heavy freight and logging trucks.
3. The site has three back to back curves that start the decent into the Waikare river valley. The curve context data in the RAMM data base states the design speed of the curve to be 60km/hr and the down hill approach speed to be 96km/hr.
4. The general nature of the crashes was vehicles entering the down hill curves at speed (particularly if they were passing vehicles using the slow vehicle passing bay) losing control and either hitting the bank on the left side of the road or sliding across the road into the deep drain on the RHS of the road.
5. All LOC accidents recorded happened when the road surface was wet.

Case study 2: Waikare Gorge SH2 (RP 577/ 13.6 to 13.8)

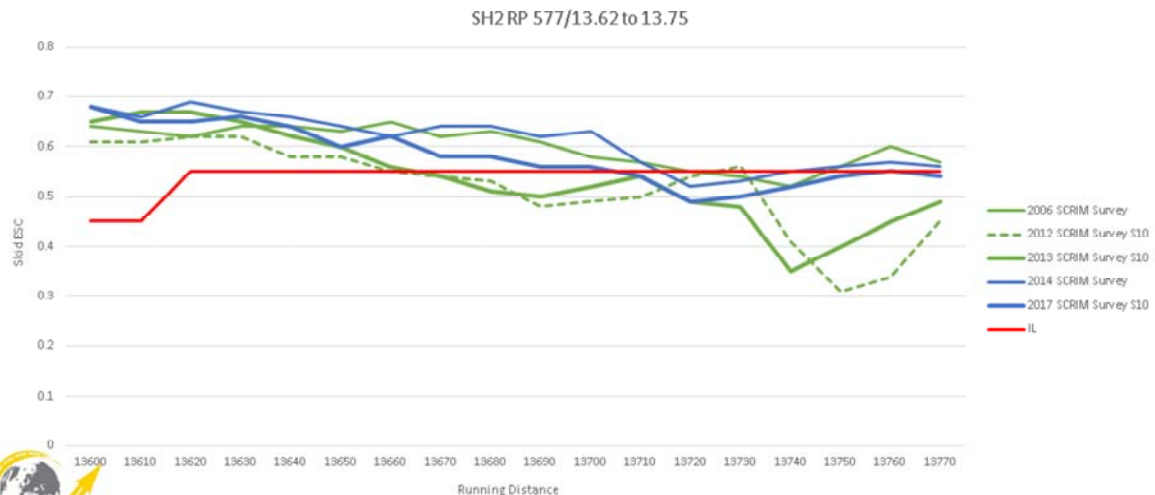


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1. This short video shows the gradient and curvilinear alignment of the site.
2. It also shows the slow vehicle bays for both the increasing and decreasing directions. It is possible that the south bound slow vehicle bay has increased the approach speed to the curve as motorists attempt to pass slow vehicles close to the end of the slow vehicle bay.
3. You can also see that the guard rail at the south end of the site on the RHS was extended to stop vehicles from ending up in the deep side drain.

Case study 2: Waikare Gorge SH2 (RP 577/ 13.6 to 13.8)



1. This is a category 2 high curve with an IL of 0.55 ESC.
2. A Poplar Lane chip seal was constructed in 2005 (15/02/2005). The 2006 survey (17/11/2005) shows good skid performance with most skid readings above IL. The 2012 and 2013 surveys show that polishing has occurred in the high demand section of the curve and for 20m is well below TL (which is 0.1 ESC below IL).
3. A Glenbrook melter chip seal was constructed in 2012 (25/01/2012). The 2014 survey shows initial skid values generally above IL for most of the site and while the 2017 skid values have dropped slightly below IL they remain reasonably consistent particularly through the area of high demand.
4. Although the initial skid values of the melter chip are not any higher on average than the initial skid values of the natural aggregate the melter chip appears more resistant to polishing particularly in areas of high traffic stress.
5. Along with the minor safety improvements completed at this site the use of melter chip has almost completely eliminated all of the wet LOC accidents with only one accident recorded since the 2012 resurfacing using melter chip. The lack of accident debris and damage to the guard rail would support this accident reporting.

6. The melter chip seal is currently just over 5yrs old and is showing good skid performance compared to the previous natural aggregate at a similar life.

Chipsealing in New Zealand - Practice Note

melter aggregate chip seals

CHIPSEALING IN NEW ZEALAND
Chapter 8: Practice Note 1
January 2017

Introduction
Melter chip is a premium synthetic chip produced by New Zealand Steel for surfacing high demand skid environments. Melter chip seals constructed at high demand and accident black spot sites have shown a reduction in wet road crashes. However there are some material properties of melter chip that impact on treatment selection, chip seal design and chip seal construction that need to be considered for the successful completion of melter chip seals.

melter aggregate chip seals

CHIPSEALING IN NEW ZEALAND
Chapter 8: Practice Note 4
January 2017

Introduction

Melter chip is a premium synthetic chip produced by New Zealand Steel for surfacing high demand skid environments. Melter chip seals constructed at high demand and accident black spot sites have shown a reduction in wet road crashes. However there are some material properties of melter chip that impact on treatment selection, chip seal design and chip seal construction that need to be considered for the successful completion of melter chip seals.

Description

The crushing test, melter chip does not breakdown like some other softer high demand chips, which (PFC) chip is high in value if done prior to a similar rate to some natural aggregates. A general note is also included about other natural aggregates under the same traffic stresses.



Photograph 1 - Melter chip in storage

Properties

Melter chip has the following properties:

1. It is generally hard and tough
2. It is a relatively homogeneous structure
3. Can have very flat smooth faces
4. Is relatively dense
5. Is quite dense as to heavier than natural aggregates

Hardness / Toughness

Melter chip is generally hard and tough although it does not absorb much of the NZTA 100 crushing resistance standard test. Additional force can be produced during the crushing test as fine edges are broken from the vesicles in the chip or fines produced during the crushing process and retained within the vesicles are shaken out during the crushing test. NZTA 100A, "Standard Specification for Road Chip Seal" has been developed to allow for this anomaly. Although there is often a higher percentage of fines produced in

the crushing test, melter chip does not breakdown like some other softer high demand chips, which (PFC) chip is high in value if done prior to a similar rate to some natural aggregates. A general note is also included about other natural aggregates under the same traffic stresses.

Texture (homogeneous) structure

Case vesicles are formed in the chip during the smelting and cooling process of the iron production. These vesicles give the chip a homogeneous look similar to some of the iron ore pellets and to the industrial properties of the rock the vesicles themselves make the chip more dense and can contribute to the chip's strength in the chip seal.

Flat / smooth surfaces

Case vesicles can have some very smooth, glassy flat faces that make up 5 to 10% of any sample. If the result will be potentially much lower than expected at below 10 PFC. Care needs to be taken to ensure that the PFC specimen is made up of a representative sample of the melter chip. On road performance in the field measures of the seal performance of melter chip.

Clearance

While melter chip is generally free from organic dust it can have a coating of fine slag dust probably generated during the smelting process. This can be seen on your skin if you hold a handful of wet melter chip. Additional dust may be caused during long term storage. This may require rescreening or pre-cleaning of the melter chip at the final destination prior to use to ensure good adhesion of the chip.

Density

Melter chip is denser than natural aggregates. Care needs to be taken in ordering and transporting melter chip to ensure sufficient chip is delivered to site to complete the required area of chip seals.

Treatment Selection

Melter chip seals would generally be reserved for high demand and accident black spot sites. Melter chip seals to be designed around the chip sizes available at the time. Melter chip seals can be achieved by further processing of PFC material.

Selection of appropriate surfacing types would generally be based on:

- Very high demand sites - Asphalt roads
- High demand sites - Two coat seals
- Moderate to high demand sites - Flashed chip seals
- Low to moderate demand sites - Single coat seals
- Visit the where the texture requires

Prepared effectiveness by mixing melter chip with natural chip used for the project with caution. If full resistance is required at the site melter chip should be used in some layers of the chip seal.

Small (2 to 3mm) melter chip "hotspot" seals have been used to increase skid resistance particularly on wet road surfaces where the aggregate has polished. These "hotspot" seals can be very successful but only on good chip material. The lower layer binder quantity and the timing of sweeping these seals is very important for their success.

Chip seal Design

Acceptance testing has shown that melter chip absorbs approximately 42% more moisture than natural aggregates. This is due to the vesicular (homogeneous) structure of the melter chip. For this reason consideration should be given to increasing binder application rates for melter chip seals. Binder application rates for two coat seals should be increased by 10 to 15% and by 10 to 20% for wet seal and single coat seals where there is no free binder on the surface of the chip. Melter chip should be stored in a dry area before the start of winter temperatures.



Photograph 2 - Melter chip in storage

Two coats on melter chip will be higher than for most natural chip seals due to the increased grit that melter chip provides. Polymer modification to toughen the binder should be considered for higher demand sites.

NZ Steel produces a limited range of chip sizes generally grades 1.5 and 3. Chip seals need to be designed around the chip sizes available at the time. Melter chip seals can be achieved by further processing of PFC material.

Chip seal Construction

Melter chip seals appear more prone to chip loss during the curing process than natural aggregates. This can be a problem with chip seals particularly where polymer emulsions are being used. Use of water to reduce adhesion of the chip to the surface may be needed with caution as it can increase the time for the emulsion to cure.

Experience has shown that when using emulsion binder emulsions can tend to happen when using melter chip than natural aggregates. This can be a problem with chip seals particularly where polymer emulsions are being used. Use of water to reduce adhesion of the chip to the surface may be needed with caution as it can increase the time for the emulsion to cure.

Chip seals appear to be a greater problem with melter chip than with natural aggregates particularly when using polymer binders. On Two Coat seals the higher binder application rate should be placed first to ensure a better bond of the large chip to the substrate to reduce the risk of the large chip being pushed from the seal.

There may also be a need for additional sweeping resource to sweep loose chip that has been kicked off each end of the sealing site.

Although melter chip is generally hard and tough, avoid over chipping particularly of the second chip in multi-layer seals. It appears that the melter chip seals may be sensitive to hardness and possible crushing of the small chip sizes from excessive chipping.

The true application of most material can appear better held or dirt in contact with stone but apply. Allowance should be made for a second application of material 1 to 4 months of the initial application of material.



Photograph 3 - Melter chip in storage

Note:
Density of melter chip is approximately 1.84 tonnes per cubic metre.
Density of natural chip is approximately 1.47 tonnes per cubic metre.

1. Chipsealing in New Zealand is a textbook compiled and printed in 2005 that covers all aspects of chip sealing in New Zealand.
2. In order to keep this textbook as current as possible changes and additions are added through practice notes. Each practice note is captioned with the topic to be covered and the chapter in the textbook to which it applies.
3. Constructing melter chip seals in Hawke's Bay has taught us that there are a number of differences from sealing with natural aggregates that need to be considered when designing and constructing melter chip seals.
4. A Chipsealing in New Zealand Practice Note has been written to assist seal practitioners to design and construct successful melter chip seals. This information is now available on the NZ Transport Agency web site as both a Technical Note and a Chipsealing in New Zealand Practice Note.

Melter Chip – Demand and Supply!

- There is demand for sealing chip that will provide improved skid performance on high demand curves than has been achieved using local natural aggregates
- There is limited melter chip available – 35,000 tonnes /annum
- Generally only to be used on high risk Site Category 1 (0.55 IL) sites
- NZ Transport Agency will manage the regional distribution of melter chip based on need. Physical works suppliers are not to place orders as this has created confusion



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- However suppliers will collect the agreed allocation of melter chip from NZ Steel

1. Demand for melter chip to improve skid performance on high demand skid sides has increased significantly as the on road performance of melter chip has been proven over time.
2. It has been shown to extend chip seals lives by maintaining good skid resistance for more years than can be achieved by most natural aggregates we have available to us in New Zealand.
3. As there is a limited supply of melter chip available, to ensure it is distributed to the networks of greatest need, Dave Whitehead of NZ Transport Agency who is responsible for the SCRIM budget, has provided these guidelines.

Acknowledgements

- **NZ Transport Agency** – Gordon Hart, Ken Holst, Dave Whitehead, David Cook (now retired)
- **New Zealand Steel** – Colin Morgan
- **Downer Hawke's Bay** – Brandon Walker, Teatua Samuel's
- **Opus Consultants** – Rowan Kyle, Peter Cenek



1. The introduction of melter aggregate for chip sealing on SH5 was influenced by a number of people shown in the acknowledgements.
2. I would like to specifically acknowledge Gordon Hart, NZ Transport Agency, who was the Hawke's Bay regional network manager and provided the initial impetus and allowance for the melter chip seal trials to go ahead.
3. Brandon Walker and Teatua Samuel's of Downer Hawke's Bay were particularly helpful in working through the contractual planning and construction challenges and learnings that happened along the way.
4. In particular I would like to give credit to the late Bill Bourke who was so passionate about seeing what he believed to be a great product used on the State Highway and worked through the issues with us to ensure its success. Bill has been proven right. It is a great product.

**Reduce wet LOC accidents!
Increase seal lives!**

**Thanks!
Any Questions?**

1. All round – Better lives!
2. Thanks!
3. Questions?