CHAPTER THREE

Introduction to Chipsealing Technology

Previous page: Chipsealing underway on the West Coast of the South Island, New Zealand. On the left is the bitumen sprayer (distributor) applying the binder, the yellow machine in the center is a self-propelled chip spreader being fed chip by the truck on the right. Photo courtesy of Les McKenzie, Opus

Chapter 3 Introduction to Chipsealing Technology

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This Chapter aims to introduce the practitioner to the basic principles and terminology used in chipsealing technology. These basic principles are expanded in Chapters 4, 5 and 6 in sufficient detail so that they can be applied to the design and selection of chipseals and other surfacing seals. Chapters 7 to 11 describe the practical details of preparing for and constructing the seals including Chapter 9 which describes the chipseal design process.

3.1 Terminology for Road Surfacings

Before learning the basics of sealing technology, it is important to learn some of the terms used in roading and some of them are shown in Figures 3-1 and 3-2 relating to rural and urban roads.

3.2 The Road

A road[1] is a route trafficable by motor vehicles. In law, it is the public right-of-way between the boundaries of adjoining properties and is owned or administered by a Road Controlling Authority (RCA). It is often shown as 'road' or 'legal road' on a plan. In customary use, road refers to all land between the legal road boundaries and typically includes the carriageway, footpaths and other accessways, berms and other unpaved areas constructed for public travel. Where roads have not been formed, the term also refers to so-called 'paper roads'.

The carriageway or roadway is that portion of a road or bridge devoted particularly to the use of vehicles, inclusive of shoulders and auxiliary lanes. A divided road is considered to have two carriageways.

3.3 The Pavement

The pavement is that portion of the road placed above the design subgrade level for the support of, and to form a running surface for, vehicular traffic.

Pavement Layers

The subgrade is the trimmed or prepared surface (or upper line) of the formation, i.e. the surface of the ground, soil, rock or other material. It is the width of the road-bed after earthworks have been completed, on which the pavement is constructed. It has been worked and compacted to sustain the traffic load to be imposed on the pavement.

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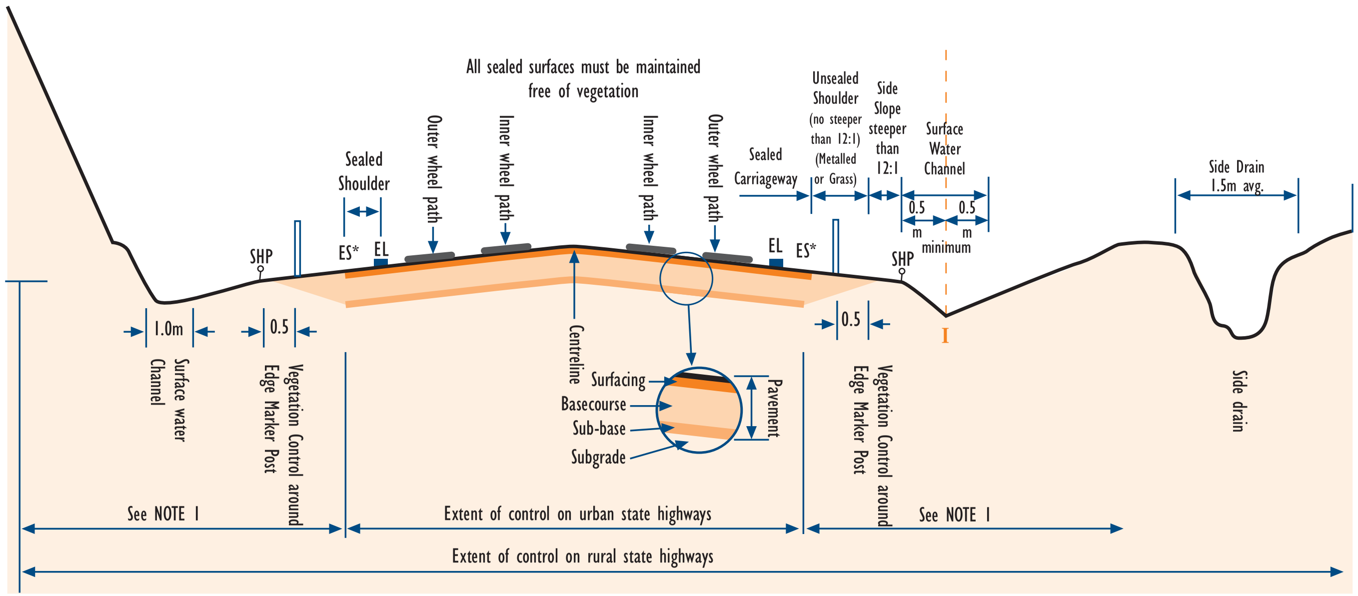
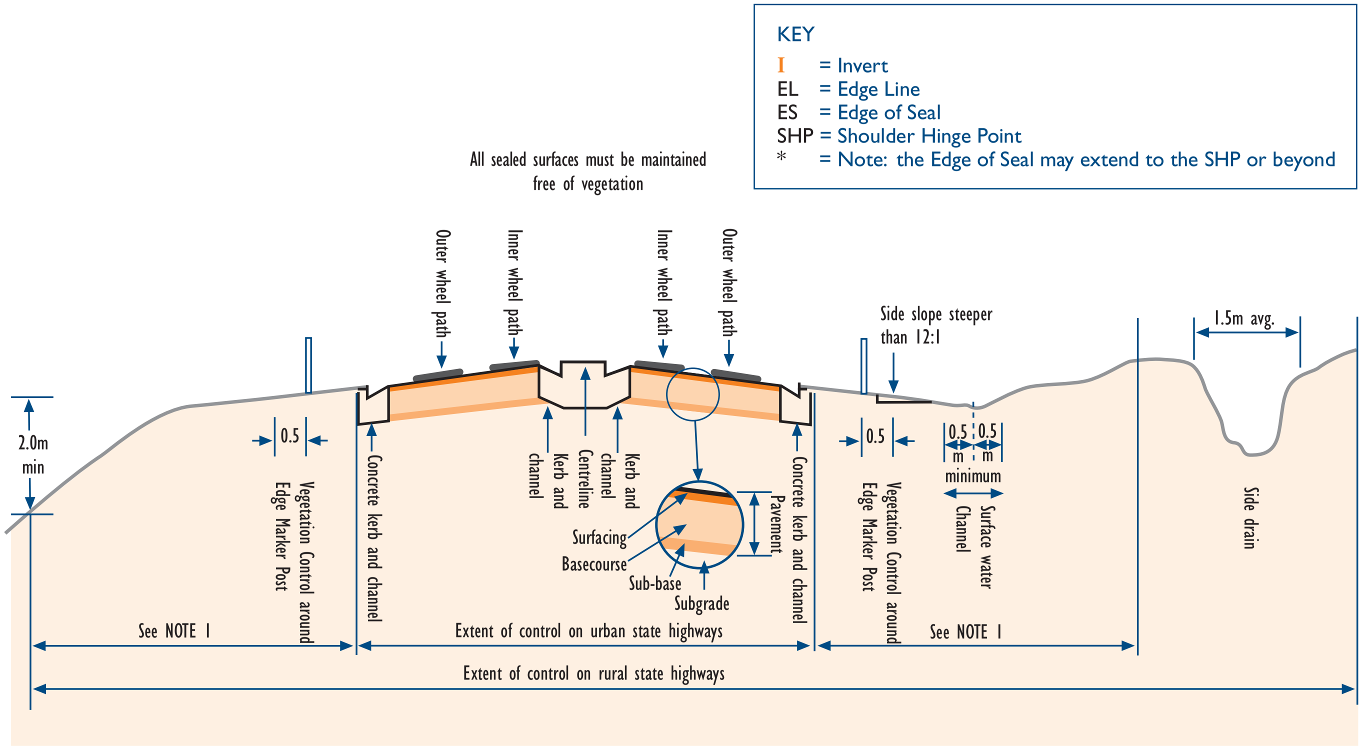
[1] Definitions of terms are listed in the Glossary.



NOTE 1 Limit of vegetation control required for safe site distances. This distance must be a minimum of 3.0 m on straights and on the outside of curves, and a minimum of 5.0 m on the inside of curves

Figure 3-1 Terminology applied to a typical rural road.
Adapted from TNZ C1 Addendum No. 1:1997 and Transit New Zealand State Highway Maintenance Contract Proforma Manual SMO32, Issue 2: March 2002



NOTE 1 Limit of vegetation control required for safe site distances. This distance must be a minimum of 2.0 m on straights and on the outside of curves, and a minimum of 5.0 m on the inside of curves

Figure 3-2 Terminology applied to a typical urban road.
Adapted from TNZ C1 Addendum No. 1:1997 and Transit New Zealand State Highway Maintenance Contract Proforma Manual SMO32, Issue 2: March 2002

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The sequence of layers of a pavement, working up from the subgrade, are:

- Sub-base – the material laid on the subgrade below the basecourse, either for the purpose of making up additional pavement thickness to prevent intrusion of the subgrade into the base or to provide a working platform. It is the bottom layer of a pavement, usually constructed from coarse material.
- Basecourse (base, road base) – one or more layers of material usually constituting the uppermost structural element of a pavement and on which the surfacing may be placed. It may be composed of fine crushed rock, natural gravel, broken stone, stabilised material, asphalt, or Portland cement concrete.
- Surfacing (also called top surface, wearing course, surface course) – the uppermost part of a pavement, specifically designed to resist wear, including abrasion, stress caused by turning traffic and similar damage from traffic, and to minimise the entry of water to the pavement. The purpose of the surfacing is to improve the service that a pavement gives to traffic by making it safer, more economical or more pleasant to use.

  Surfacings may be constructed of chipseal or asphaltic concrete, or other material. The materials may be bound, i.e. by a binder; or unbound granular material of particles consisting of gravel and sand that is compacted but not bound.

Types of Pavement

Flexible pavements – the thin granular flexible pavement is ideal for use in New Zealand and is typically low cost. In an unbound flexible pavement the basecourse is constructed of unbound granular material. Surfacings for flexible pavements are of the following types: running-course metal (not covered in this book); top surfaces of chipseals; several layers of chipseals; or thin asphaltic concrete. Thin surface flexible pavements are by definition less than 45 mm thick.

Rigid pavements – pavements in high stress situations may be of rigid construction, using high strength rigid concrete as a construction layer, or layers of dense asphaltic concrete. These pavements, while very strong and durable, have relatively high cost. Thick rigid pavements constructed of structural asphalt are generally 110 mm or greater in thickness.

(Asphaltic concrete layers of 50 to 110 mm thickness are avoided for road pavements for structural reasons, and are not considered in this book on chipseals. Austroads Pavement Design Guide (2004) covers the topic.)

Functions of the Pavement

One of the most important functions of a pavement is to withstand the loading imposed by traffic and the resulting stresses. The surfacing engineer's task is to design a pavement that performs well under those stresses.

- Compressive Stresses (Figure 3-3) – these are the vertical stresses generated by a vehicle that are dissipated down through the pavement layers.

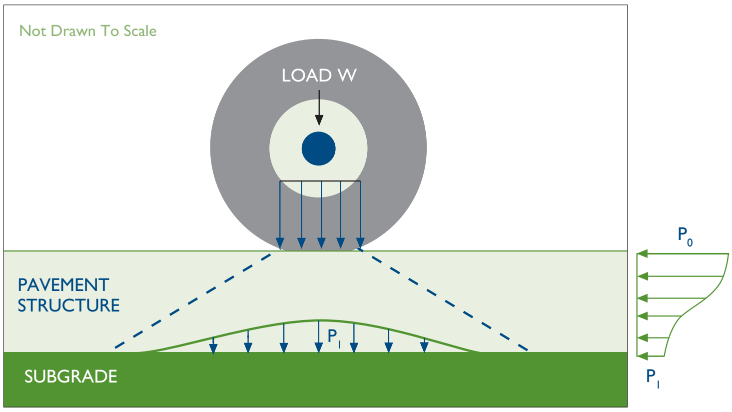

Figure 3-3 Compressive stress exerted under a wheel load.

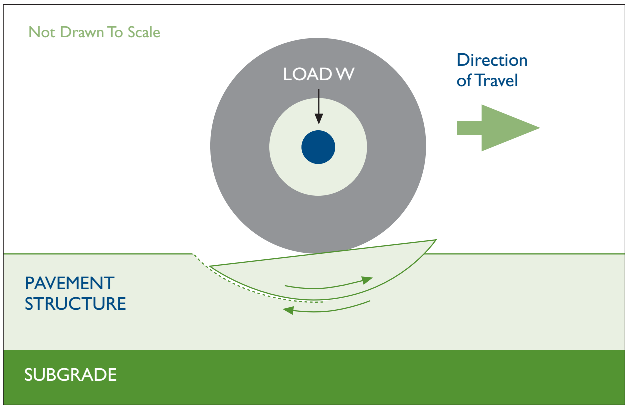

Figure 3-4 Shear stresses exerted by a braking wheel.

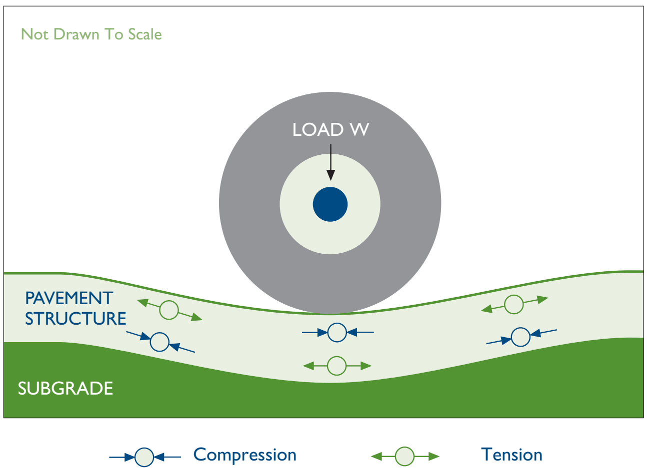

Figure 3-5 Tensile–compressive stresses exerted by a load in a bitumen-bound layer (from Transit NZ 1993).

- Shear Stresses (Figure 3-4) – these are generated by shear in the pavement during braking, acceleration, etc., by the loaded vehicle tyre.
- Tensile Stresses (Figure 3-5) – these are generated by deflection of the pavement surface by the loaded vehicle tyre. The tensile stresses can only be generated in bound materials such as cement and bitumen-bound materials, and are not present in granular basecourse.

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The basic philosophy of pavement structural design is to choose, for the different layers, materials that have sufficient shear strength to carry the traffic loading, and to use those materials to limit both compressive stress on the subgrade, and tensile strain at the bottom of any bound layer.

3.4 The Chipseal

The surfacing known in New Zealand as a chipseal, or seal, is called a 'surface dressing' in the United Kingdom and many other countries, or a 'sprayed seal' in Australia. It comprises a uniformly sized stone, aggregate or 'sealing chip' embedded in a 1 to 2 mm-thick film of bituminous (or synthetic) binder, to provide a thin waterproofing layer as the top surface of a pavement (Figures 3-6 and 3-7).

Each grade of chip is made up of very nearly single-sized chips of the same shape to provide a uniform depth of macrotexture.

Macrotexture is the texture of the chipseal that can easily be seen with the eye, i.e. 0.5 mm to 10 mm and is frequently referred to as 'texture'.

Microtexture is the microscopic surface of the chip, i.e. up to 1 mm.

Single or multiple layers of binder and chip may be used.

3.4.1 The Binder

The binder is a waterproof adhesive viscous material that binds to both the existing road surface and to the sealing chips of the chipseal to make a cohesive mass.

The binder needs to be liquid enough (i.e. have low viscosity) to be sprayed onto the pavement surface. To achieve this low viscosity, it may be heated, or diluted with a volatile solvent such as kerosene when it is called a cutback bitumen, or mixed with water to make a bituminous emulsion.

It hardens as it cools, or as the solvent evaporates, or the emulsion breaks (i.e. the emulsion breaks down to its constituents of water, and bitumen which forms a continuous film on the chips). It then hardens or cures sufficiently to be able to hold the chip firmly

Figure 3-6 Constructing a first coat chipseal near Gisborne in the 1920s was not highly mechanised, compared to the line of construction machines used in the 2000s shown in Figure 3-7.
Left: Hand spraying the basecourse, from the tractor-drawn bitumen distributor. Right: Spreading the chip by shovel as the tip truck was not yet in use. Photos courtesy of John Matthews, Technix Group Ltd

Figure 3-7 Constructing a chipseal.
Clockwise from top left: Spraying binder and spreading chips in one operation. Top right: Spraying the binder. Bottom right: Spreading the chips. Bottom left: Rolling the surface. Photos courtesy of Les McKenzie, Opus

in place when it can then withstand the action of traffic. This may be within a matter of minutes or hours, depending on the binder type. The binder must stay at a relatively low viscosity for long enough after it first lands on the road for the chips to re-orient to their final positions, under rolling and gentle trafficking (Figure 1-2). By the time the binder has hardened the chips must have re-oriented and locked into their final positions.

A seal is tender for the first 24 to 48 hours depending on traffic loading, seal type, binder type, and environmental conditions. It may be susceptible to damage from heavy rain or low temperatures for some weeks after construction. Traffic control measures are used to reduce vehicle speeds during this time.

In New Zealand, a binder is almost always based on bituminous material that is produced as one of the products of refining crude oil at an oil refinery. Bitumen may be called asphaltic bitumen or asphalt in the US or other countries, and it is the primary material in 99% of surfacings used in New Zealand. It occurs either as a natural deposit or produced by non-destructive distillation of natural deposits, generally crude oil. (For more information, see Chapter 8.) Some special purpose seals use synthetic binders or polymer modified binders (PMB).

3.4.2 The Aggregate or Sealing Chip

The aggregate or sealing chip is an essential part of the top surface as it adheres to and protects the binder and basecourse from traffic wear, supports all the wheel contact forces, and provides surface friction thus creating a skid-resistant surface.

Aggregates for chipsealing are manufactured to meet specified properties, which include strength, weathering resistance, size (and uniformity of size), shape and polished stone value (PSV).

Usually chip is manufactured from crushed rock (details are in Chapter 8) and, in the past, specifications have required that ‘naturally occurring aggregates’ were to be used. However in recent years, chip has also been manufactured from synthetic materials such as ‘calcined bauxite’ (see Section 8.5.2), for specialist or exceptional circumstances. New materials are likely to be developed for use as sealing chip in the future. There is a growing trend toward conservation and the re-use of materials and recycling.

Sealing chip should be required to meet the performance properties of a certain sealing specification, rather than be specified according to the origin of the parent material. The current specification in New Zealand for sealing chip is TNZ M/6 *Specification for sealing chip* (Transit NZ 2002).

Manufacture of chip involves producing chip with angular faces and of similar size and shape within each grade. Traditionally this process is achieved by crushing and screening into sizes or grades as required by the TNZ M/6 specification (more details in Section 8.5). Different sizes or grades of chip are used. The size and type of chip is decided during a detailed treatment selection and design process for a chipseal (Chapter 6). Grade sizes of sealing chips are Grades 2 (coarsest), 3, 4, 5, and 6 (finest). For chipseals constructed of two or more layers of different sized chips, a two figure convention is used. The first chip listed is the lower layer in the chipseal, therefore Grade 3/5 means that Grade 3 is used in the first layer or coat, and finer Grade 5 chip is used in the overlying second layer or coat.

3.5 Basic Requirements of a Surfacing

The purpose of a top surface is to:

- protect the pavement and subgrade from environmental damage related to weathering;
- waterproof the pavement;
- provide a wearing surface that is resistant to abrasion by vehicles using it, and resistant to crushing under traffic loading;
- provide a dust-free surface under any conditions, and thereby contribute to traffic safety, comfort, and convenience by providing a smooth surface;
- provide non-skid properties to an existing surface;
- provide pleasant travel at an economical cost.

3.6 Sealed Pavement Types

Pavements in New Zealand fall into one of two main classes:

- Unsealed (not discussed further in this book);
- Sealed.

Sealed pavements can be divided into a further four broad classes of surfacing:

- Chipseal surfacings (Section 3.7)
- Slurry Seal surfacings (Section 3.8)
- Asphaltic Concrete surfacings (Section 3.9)
- Specialist surfacings (Section 3.10).

3.7 Chipseal Surfacings

Many chipseal types exist. Some can be used for more than one purpose while others are very specialised in their use or require a specific set of circumstances in order to be successful.

Chipseal surfacings are considered as either:

- First coats (includes Prime coats);
- Reseals (includes Second coats and Pretreatment Seals).

3.7.1 First Coats

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A first coat is the initial seal on a prepared unsealed surface, which is usually a basecourse. They must be designed to adhere to and provide waterproofing for the unsealed prepared basecourse. They are the first treatment for a granular pavement or overlay, and serve principally to prepare the base for the main treatment.

A first coat seal (Figures 3-8 and 3-9) should be an integral part of the pavement construction design and the planned subsequent seals in years to come. Selection of a first coat treatment and of future seal coats must therefore be included during the initial pavement construction design. Generally, a first coat is only expected to last one year before being resealed, although they may last much longer on low traffic volume roads.

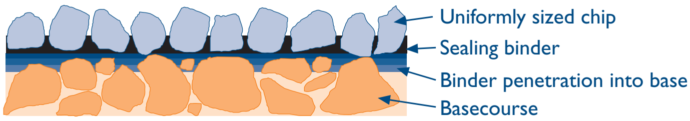

Figure 3-8 A first coat seal. Courtesy of Austroads Sprayed Sealing Guide (2004)

Figure 3-9 A first coat seal under construction on a road on the West Coast of the South Island.
Photo courtesy of Les McKenzie, Opus

First coat binders need to be fluid enough to wet through dust and adhere to the stone surfaces, yet not so fluid that they will neither hold the sealing chip nor run off into side drains. Past practice has been to include relatively large quantities (>6 parts per hundred (pph)) of cutter[2] in first coat binders to aid the wetting process.

Although very few occasions occur where the first coat seal itself does not perform its function, the success of the first coat seal is a direct reflection of the quality of pavement or basecourse construction at the time of sealing.

Construction of a surface to which a first coat will adhere must be a well-bound, relatively dry, smooth hard surface, with a surface of clean stones showing and with no unbound fine material (dust), see Chapter 7 for more details.

A first coat may be applied to an existing pavement as part of a repair patch or applied to the pavement shoulders as a seal widening.

3.7.2 Prime Coats

High cutback-content prime coats (also called prime seals) which have up to 50% cutter in the bitumen have been used and are often specified in other countries. In New Zealand however, the use of high cutback prime coats is not encouraged because of the hazardous nature of the cutback binder (known as the primer) and its effects on the environment.

If a prime coat is used, its main function is to ensure a good bond between the larger stones in the basecourse and the surfacing. To achieve this, a low viscosity, bitumen-based binder (the primer) is used, which penetrates or 'wets through' any surface dust layer then adheres firmly to the stone beneath (Figure 3-10).

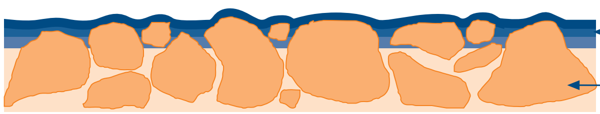

Figure 3-10 A prime coat seal. Courtesy of Austroads Sprayed Sealing Guide (2004)

To achieve this function of providing a good bond between basecourse and surfacing, the primer must have the following properties:

- It must be able to penetrate the fine surface dust layer that always coats the aggregate particles of a granular basecourse surface.

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2 Cutback bitumen is a bitumen which has its viscosity temporarily reduced by the addition of a volatile diluent or 'cutter', such as kerosene, to make it more fluid for ease of application.

- It must adhere easily and quickly to the surface of the coarser particles in the basecourse surface.
- It must be compatible with the subsequent surfacing to promote rapid adhesion to it.

These demands can be met by using a penetration grade bitumen binder which is cut back to a low viscosity with a rapid to medium curing volatile cutter, and contains an adhesion agent. Kerosene is the usual cutter although other solvents such as mineral turpentine can be used.

Because cutback prime binders are hazardous, alternatives to prime coats are available. These can include emulsified primes, and the mixing of slow-breaking emulsions into the basecourse layer during the construction process of watering and compacting the basecourse.

These techniques can allow the use of harder, more viscous chipsealing binders in the next seal coat to be applied. These can provide improved waterproofing, longer seal life, and allow the use of larger sized chip.

Prime seals can also be used on timber bridge decks to promote adhesion between the chipseal and the timber.

3.7.3 Reseals

A reseal is any chipseal applied to a surface which has previously been sealed. A reseal is applied because the existing surfacing is showing, or is about to show, signs of distress. Reasons for resealing a surface is to improve one or more of the following:

- Loss of waterproofing;
- Reduced skid resistance;
- Ageing and brittleness of binder;
- Chip loss;
- Old chipseal showing hairline cracks requiring repair;
- To reinstate or increase surface texture (macrotexture).

3.7.4 Second Coats

The term second coat refers to the reseal applied to a first coat seal. In the past, the term was used to differentiate between the reseal applied after a first coat and subsequent reseals. They were almost without exception applied within 12 months of the first coat being laid on state highways but other RCAs had different policies. Such policies had usually been made because the RCAs were confident of obtaining adequate waterproofing and long life of the seal using a delayed second coat.

However today, for all intents and purposes, a second coat is a reseal and will be referred to as a reseal from here on.

In more recent years pavement and surfacing designers have been resealing first coats on a 'need to' basis rather than following a blanket policy. If the timing of a reseal is based on engineering judgement, the reseal to a first coat can extend the overall life of the pavement surfacings, because it is then sealed at the most appropriate time which maximises the value gained. Some first coats may not need to be resealed for several years, depending on factors such as the quality of pavement construction, the first coat seal type, and traffic volume. However care needs to be taken because extending the life of a first coat beyond its appropriate life may result in premature pavement failures.

3.7.5 Pretreatment Seals

Treatments which may be applied to a surface as a pretreatment to resealing are many, and some are included in the category of seals. They are discussed in detail in Section 7.1.3.

3.7.6 Single Coat Chipseal

A single coat is a single sprayed application of sealing binder followed immediately with a single application of chip which is spread and rolled into place (Figure 3-11). It is always applied using a larger chip than the existing surface chip, with the exception being a voidfill (Section 3.7.9).

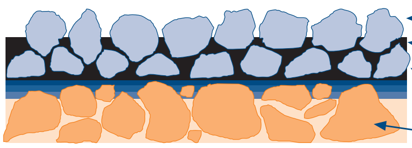

Figure 3-11 A single coat chipseal.

Category

- First coats.
- Reseals.

When to use

- Best in situations where traffic stresses are not great.
- Suitable for low to high traffic volumes.

Existing surface condition required

- When applied as a reseal, existing macrotexture variation must be within limits relative to the chip size nominated in the reseal.

- Existing surface texture must be consistent, not too coarse, with a sound surface and sound pavement condition to be successful.

Advantages

- Low cost.
- Can provide excellent waterproofing because the binder is concentrated in one layer.
- Will provide macrotexture.
- Simple to construct.
- Can perform well in most situations provided they are well constructed, including stressed sites such as steep grades provided the traffic volumes are of medium to low density.

Limitations

- Limited resistance to traffic stresses (e.g. cornering stresses).
- Should never be applied with a chip that is the same size as existing surface chip, unless it is an old worn surface.
- Not very tolerant of a wide variation in underlying texture.

Summary comments

- A straightforward standard seal.
- Single coat seals have been used extensively throughout New Zealand for as long as chipseal surfacings have been constructed.
- Their simplicity and ease of construction make them a cost-effective choice in all simple non-stressed environments.

3.7.7 Two Coat Chipseal

A two coat is a chipseal with two applications of binder and two applications of chip (Figure 3-12), applied in the following sequence:

- An application of sprayed binder is followed immediately with an application of large size chip.
- Then a second application of sprayed binder, and a second application of smaller chip.
- Both coats are applied one after the other with little or no time delay between coats.

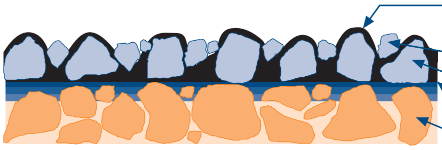

Figure 3-12 Two coat seal (two applications of chip and two applications of binder), shown here as a 'Two Coat as a First Coat seal'.

Two coat chipseals and other chipseals with more than one layer of chip are sometimes known as 'multicoat seals'.

Category

- First coats.
- Reseals.

When to use

- In areas with low or high traffic volumes.
- In difficult conditions, often where other seal types are not suitable because of site conditions, e.g. high stress areas.
- Can be used as a first coat, in which case they are called 'two coat as a first coat' seals.
- Often used when a non-conventional binder is specified, e.g. emulsions or PMBs, to aid chip retention.
- A two coat seal can be used without a pretreatment seal to seal off a porous underlying surface.
- Reasonably resistant to snow-plough damage as has less macrotexture than a single coat seal.

Existing surface condition required

- When applied as a reseal, macrotexture variation must be within limits relative to the chip size nominated in the reseal.
- Consistent underlying texture, although it is more tolerant of texture variation than a single coat.

Advantages

- Able to withstand more traffic stress than most other chipseal surfacings.
- More tolerant of texture variations in existing conditions than other chipseal surfacings.
- Can be constructed as a stress-resistant seal coat.
- Generally durable and long lasting due to chip interlock between the two layers.

Limitations

- More costly than single coat chipseals.
- During the construction of two coat seals and through their early life, loose chip can create considerable nuisance.
- Loose chip can be evident for many months after construction and regular sweeping is required.
- The appearance and performance of a two coat seal is subject to the construction techniques employed.

- Chip size compatibility and spread rates are critical, and directly affect the final outcome.
- Bitumen can be picked up by vehicle tyres (called 'tracking') because binder has been sprayed on the large chip.
- Depending on construction techniques, the seal can be rough and noisy, or smooth and quiet under the action of vehicle tyres.

Summary comments

- Two coat chipseals have been used in recent years as a cure to all problems and have been applied in many situations, but they are not a replacement for all seals.
- Their performance and appearance however is very dependent on construction and the selection of chip size and compatibility. (They can be rough and noisy or smooth and quiet, depending on the construction techniques that are used.)
- Construction techniques vary in rates of chip application and rolling, e.g. if the first coat is rolled (especially with a steel roller), a very different seal is constructed (because more chip realignment occurs) compared to one which is not rolled or not trafficked between coats.
- Although more complicated than a standard single coat chipseal, two coat seals have been used for some years now, and a skilled and experienced crew should have little trouble with construction of a two coat chipseal.

3.7.8 Racked-in Chipseal

A racked-in chipseal consists of one application of binder and two applications of chip (Figure 3-13), applied in the following sequence:

- A single application of binder is applied, followed by the application of a large chip which is widely spaced (with 'windows' between the chips).
- This is followed by a further application of smaller chip.
- The smaller chips fall into the windows between the large chips of the first application, and adhere to the layer of binder below.

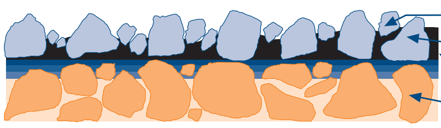

Figure 3-13 A racked-in seal (one application of binder, two of chip).

Category

- First coats.
- Reseals.

When to use

- In areas with low or high traffic volumes.
- In difficult conditions where other seal types are not suitable, and where loose chip from two coats cannot be tolerated.
- On just the high-stress intersections in a long run of single coat chipseal.
- In town centres where loose chip needs to be kept to a minimum.
- Often used where a non-conventional binder is specified, e.g. a PMB, to aid chip retention.
- Reasonably resistant to snow-plough damage as has less macrotexture than a single coat seal.

Existing surface condition required

- When applied as a reseal, macrotexture variation must be within limits relative to the chip size nominated in the reseal.
- Consistent surface texture and pavement condition are required to provide a good surface.
- Surface conditions required are similar to those for single coat seals.
- The most important objective during racked-in seal construction is to produce a first layer that ensures a surface condition with adequate windows left between the chips of the first layer when they are being spread onto the binder. This allows the smaller chip to fit between them.

Advantages

- Cost effective.
- Able to withstand more traffic stress than single coat chipseals.
- Can withstand more texture variation in existing conditions than a single coat seal.
- Less loose chip than single coat seals.
- Can be constructed quickly.
- Can use less binder than a two coat or single coat seal.
- Racked-in seals generally do not generate tracking of bitumen.

Limitations

- As with two coat seals, the construction techniques used will significantly influence the final outcome.

Summary comments

- Racked-in seals were first constructed many years ago, and in more recent times have come back into use.
- Racked-in seals are being used in moderately stressed situations where two coat seals which generate loose chips are less favoured.
- Although more complicated than a standard single coat chipseal, they have been in use for some years, so a well-trained crew should have little trouble with seal construction of a racked-in seal.

3.7.9 Voidfill Seal

A voidfill seal is a single very light application of binder, followed by a single application of small chip designed to fit into the macrotexture of an existing chipseal surface (Figure 3-14). Also known as a void seal.

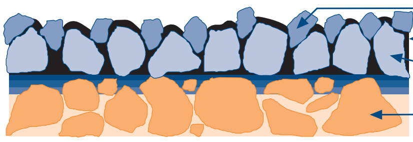

Figure 3-14 A voidfill seal (a single application of binder and small chip over existing seal).

Category

- Reseal.

When to use

- On a surface requiring resealing that has coarse texture which creates excessive binder demand (usually when sand circles, used to determine macrotexture of the surface, are 170 mm or less).
- On a surface showing early signs of chip loss. However, if the chip loss is advanced a voidfill will not fix the problem and a texturising seal should be used (Section 7.3.4.3).

Existing surface condition required

- Coarse texture.
- Not to be applied to a smoother textured surface.

Advantages

- Provides a cost-effective, smooth, consistent surface for subsequent reseals.
- Uses minimal binder.
- The chip application rate is lower than that for a single coat seal.
- When used appropriately, they can prevent cumulative development of uneven texture.

- They can prevent long-term problems caused by excess binder in the chipseal layers because proportionally more chip is present and less bitumen is required.

Limitations

- Can only be applied to coarse textured surfaces.
- As they reduce texture, the resulting smooth surfaces can influence skid resistance at high speeds in wet weather. Therefore a new voidfill should not have less than 0.9 mm macrotexture depth.
- Generally they need to be resealed in 2 to 3 years, except in areas with low traffic volumes where they can achieve a very long life.
- Incorrect chip size selection (e.g. too large) can re-create coarse texture and so defeat the purpose of the voidfill seal.
- They should not be applied where excess binder has already accumulated at the road surface (called flushing), because the binder will be displaced and rise up around the voidfill making the problem worse.

Summary comments

- A voidfill seal fills the existing coarse texture with chip and requires very little binder.
- The resulting seal is a smooth even-textured surface on which subsequent reseals can be applied, using minimal binder application rates.
- Normally a new voidfill should not have less than 0.9 mm texture depth.
- While they can last a long time in areas of low traffic volumes, generally they have a short life.
- A relatively simple seal type and comparatively easy to obtain a good job.
- Voidfills play a very important role in the life cycle of the pavement surfacing because the voids are filled with chip rather than binder. This alters the overall ratio of binder to chip (called the binder:stone ratio).
- Because more chip is present and less bitumen is required, the binder:stone ratio is lowered in the successive seal layers, and this reduces the chance of layer instability developing (more detail is in Section 4.7.4.2).
- Care is required to select the correct chip size because the aim is to fill the void as close to level with the existing chip as possible, and to avoid using a large chip that can sit higher than the existing chip.
- Design of voidfill bitumen application rates is by experience. Usually an experienced seal designer selects a relatively low binder application rate, rather than apply the design algorithm which would result in application rates that are too high.
- Voidfill seals must not be applied to flushed or bleeding wheelpaths (i.e. bitumen at the surface) as they will tend to make these problems worse. Other treatments for such distressed areas can be sandwich seals, water cutting, etc. (see Chapter 7 for treatments for flushed and bleeding wheelpaths.)

3.7.10 Sandwich Seal

A sandwich seal (Figure 3-15) is applied in the following sequence:

- A layer of large chip is spread directly on the existing surface.
- This is followed by a relatively light application of binder.
- A smaller chip is then spread directly onto the sprayed binder.
- The surface is rolled to compact the seal.

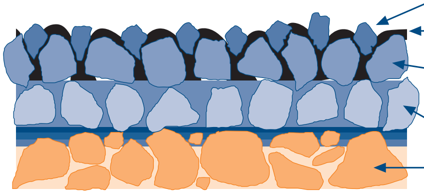

Figure 3-15 A sandwich seal.

Category

- Reseal.

When to use

- On existing sealed surfaces which are unsuitable for conventional resealing as they are rich in binder (e.g. flushed surfaces with little to no texture).
- To help correct binder:stone ratios in unstable or potentially unstable seal layers.

Existing surface condition required

- Little to no texture, and rich in binder.

Advantages

- Sandwich seals can be a cost-effective seal to restore texture to smooth binder-rich surfaces.
- They can prolong the life of a pavement surface which is nearing the unstable phase, usually related to successive build-up of seal layers.

Limitations

- Because the surface to which a sandwich seal is applied is generally nearing the unstable phase, their performance can be unpredictable.
- If the existing surface is very rich in binder, the sandwich seal may only temporarily restore texture.
- Their success is dependent on the accurate assessment of the amount of free binder in the existing surface, which is used in calculating the appropriate binder application rate.
- Success and appearance are also subject to chip size compatibility and construction techniques.

- Although good results have been achieved, sandwich seals are not suitable in all high stress situations.

Summary comments

- On flushed surfaces sandwich seals are used to absorb existing surface binder by using larger chip sizes of Grades 2 and 4. In urban environments a finer Grade 3/5 sandwich seal may be more appropriate.
- Sandwich seals have been developed in recent times as a valuable cost-effective method of sealing over unstable multiple chipseal layers.
- By nature they are considered by some as a repair, but they are becoming a valid reseal, albeit with some unpredictable results.
- It is a relatively new chipseal type on the New Zealand market that is more complicated to achieve than two coat seals.
- Sandwich seals have been used (Figure 3-16) for some years now in some parts of the country, while in other parts of the country they are little used. Therefore seal construction crews who are employed to lay sandwich seals range from skilled and experienced crews to those who are learning. This may add to the variability of the results.

Figure 3-16 A sandwich seal under construction in Hawke's Bay.
Clockwise from top left: Applying the first layer of large chip to the flushed surface without binder. Top right: Applying the binder over the large chip. Bottom right: Applying the binder over the large chip. Bottom left: Small chip being spread over binder over large chip.

Photos courtesy of Laurence Harrow, Opus

3.7.11 Wet Lock Seal

A wet lock maybe applied to a new seal to improve its durability under unexpected traffic stress. Wet locks create an interlocking seal layer using smaller chip which fits into the texture between the large chips. A light application of binder is used to make sure the smaller chip adheres to the underlying seal (Figure 3-17).

3

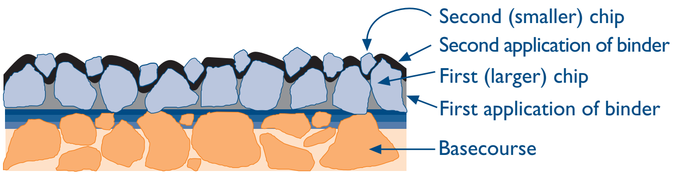

Figure 3-17 A wet lock seal.

They differ from two coat seals in that they are not necessarily constructed immediately one coat after the other, and the two coats can use different binders. Often the wet lock seal is applied after a period of time (e.g. the next day). A wet lock is not used as a first coat seal but could be applied to a first coat seal. The first coat is designed as a single coat seal and the second coat as a voidfill.

The binder:stone ratio in a wet lock is higher than that for a racked-in seal or two coat seal. This means a wet lock may increase the risk of future flushing.

A bitumen emulsion is often used as a binder as the emulsion binder application rate is typically low, reducing the risk of binder run-off.

Category

- Reseal.

When to use

- To enhance surfacing strength.
- Where a single coat is failing or about to fail (usually due to under-application of binder). Applying a wet lock avoids a seal failure.
- Can be used on just the high stressed intersections in a long run of single coat chipseal.

Existing surface condition required

- Coarse texture, to enable the small chip to fit between the large chip.
- The selection of chip size is important for the seal to be successful.

Advantages

- Wet locks can greatly enhance the strength of a seal without generating as much loose chip as does a two coat seal, because chips on the bottom layer are rolled and swept before the wet lock coat is applied.

- When designed and constructed appropriately, they can produce less traffic noise, have more consistent texture, and are more resistant to traffic stress than a two coat seal.

Limitations

- When used as a repair, care is required with binder application rates to avoid over-application which results in flushing.
- Overall macrotexture will be reduced but should still meet minimum texture requirements.
- When designed and constructed with a delay between the applications of the two layers, the risk of traffic damage and chip loss to the bottom layer is very high.

3

Summary comments

- Wet locks are not used often and are usually employed as a repair of a single coat which shows early signs of failure.
- Very strong, well-constructed seals can be achieved but the risk of flushing that may be caused by excess binder needs to be assessed in the design.
- When designed specifically and not used as a repair a strong seal can be achieved, but the risk of traffic damage to the bottom layer may be high if the delay between coats is too long.
- Wet locks are no more complicated to apply than a standard single coat chipseal or voidfill, and a chipsealing crew should have little trouble with its construction.
- Can be designed and used for the construction of a strong well-bound seal coat on a new pavement construction where the bottom chipseal layer is not trafficked before the wet lock is applied.

3.7.12 Dry Lock Seal

A dry lock is the application of small chip to a new chipseal (Figure 3-18), usually after some traffic has used the new seal. No binder is applied before spreading the dry lock chip. The small chip fits into the texture of the new larger seal chip (and is chosen so it only just makes contact with the binder) where it forms shoulder-to-shoulder contact to add strength and prevent damage to the new seal.

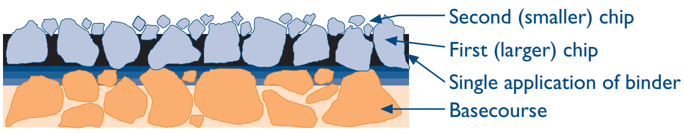

Figure 3-18 A dry lock seal.

It is used to provide a temporary running coat to protect a new seal from traffic stresses because it provides a protective layer of chip over the new seal.

Category

- A dry lock is not a reseal but can be applied to a reseal.
- A dry lock is not a first coat but can be applied to a first coat.

When to use

- In any circumstance where some added protection from damage caused by traffic stresses is required.
- Can be used on just the high stressed intersections in a long run of single coat chipseal.
- Usually applied to a larger size single coat chipseal where the small chip of a dry lock will help prevent the large chip from being plucked out of place.

Existing surface condition required

- Fresh seals, usually a few hours after sealing and rolling is complete.
- Coarse-textured seals with large size chips to enable the locking chip to fit into the texture.

Advantages

- Inexpensive and easily applied.
- Can resist moderate traffic stresses without the need for a two coat or a racked-in seal.

Limitations

- Applying the locking chip too early, i.e. before the large chip has been rolled and is embedded, can cause the small chip to settle beneath the large chip and prise it loose.
- A dry lock seal will reduce overall macrotexture.

Summary comments

- Dry locks are often referred to as inexpensive insurance against traffic damage for single coat seals in moderately stressed situations.
- A dry lock seal is very simple to achieve, and no binder is required.
- A dry lock seal is quite different to a racked-in seal. The small chip fits tightly between the large chip which has been rolled and bedded in. Individual single small chips fit between large chips and only just make contact with the binder.

  In a racked-in seal, more than one small chip will fit between the large chips and the small chip makes contact and embeds into the binder. The large chip will not necessarily be rolled and fully embedded before application of the small chip. This achieves a seal that is very different in both appearance and performance.

3.7.13 SAM Seal

A SAM is a Stress Absorbing Membrane. SAM seals can be single coat, two coat or racked-in seals which use a PMB (Figure 3-19).

The use of a PMB introduces properties to the seal coat which make it more resistant to reflective cracking from an underlying cracked surface. (PMBs are discussed in detail in Section 8.4.)

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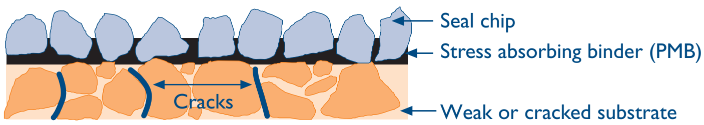

Figure 3-19 A SAM seal. Courtesy of Austroads Sprayed Sealing Guide (2004)

Category

- Reseal.

When to use

- To seal cracked pavements.

Existing surface condition required

- Pavement defects, e.g. cracking, that can be improved by the special properties of PMB.
- The same conditions as required for single coat, two coat or racked-in seals.

Advantages

- SAM seals can provide enhanced performance in cracked pavement situations (see Section 8.4.7 for uses of PMBs).
- A SAM seal will not repair a flushed surface but can prevent binder pick-up on vehicle tyres (tracking) in hot weather.

Limitations

- SAM seals are more costly than conventional binder seals.
- Construction techniques must carefully comply with best practice and the binder manufacturer's recommended procedures.
- Limitations are similar to those of PMBs (Section 8.4.10).

Summary comments

- Although SAM seals are in fact PMB seals, SAMs are specifically designed to minimise reflective cracking in a pavement, whereas a PMB seal can be used for a variety of other purposes.

- They are essentially a single coat, a two coat, or a racked-in seal with a binder that is specifically modified for a particular situation.
- As a PMB is involved, a relatively high pavement temperature (e.g. 20°C) is required at the time of chipsealing.
- The same comments for conventional single coats, two-coats and racked-in seals apply also to their PMB equivalents.
- For resisting or delaying reflective cracking, high binder application rates (>2 ℓ/m²) are used.

3.8 Slurry Seal Surfacings

As a slurry seal has properties of both chipseal and asphalt, it is included in this book. An in-service slurry behaves and fails like a chipseal but the technology to produce it is more like that used for an asphalt.

Slurry seals are specifically designed mixes of aggregates, an emulsified binder and additives, applied to a surface and spread to a specific depth.

Depths of slurry seals vary, depending on the aggregate sizes used, and typically they range from 5 mm to 8 mm in depth.

Where the emulsion binder is modified by adding polymer (usually up to 3% of the binder), the technically correct term for a slurry seal is microsurfacing. The term microsurfacing is well recognised overseas but has not found favour in New Zealand. Most slurry sealing in New Zealand contains polymer modified emulsion (PME) and thus meets the specified criteria for microsurfacing.

3.8.1 Slurry Seal

A slurry seal (Figure 3-20) is a surfacing comprising a specially graded aggregate (ISSA 2004a, b, Austroads 2003) mixed with an emulsion binder, a small percentage of filler (commonly cement), and water.

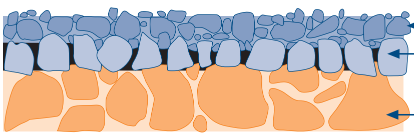

Figure 3-20 A slurry seal. Courtesy of Austroads Sprayed Sealing Guide (2004)

These components are mixed in the correct proportions, usually in a truck-mounted mixing plant (slurry truck), and the resulting slurry is spread onto the road surface by a special spreader box dragged behind the truck.

The four recognised aggregate gradings that are available for slurry seals range from Type 1 (nominal 3 mm maximum size) through to Type 4 (nominal 10 mm maximum size).

Type 1 is used where a very fine texture is required. Nominal aggregate size is 3 mm resulting in a surface texture of typically 0.3 mm. It is seldom used in New Zealand and is most suited for use on footpaths or voidfilling on airport runways.

Type 2 is most commonly used as a reseal, wearing course and/or voidfill on urban residential streets, low to medium volume roads, carparks and footpaths where fine texture, low traffic noise and lack of loose chips are desirable. It has a nominal maximum particle size of 5 mm, resulting in a surface texture of around 0.5 mm.

Type 3 offers a coarser texture for use on roads with higher traffic volumes (e.g. on state highways). It has a nominal maximum particle size of 7 mm.

Type 4 has the coarsest texture and can be successfully applied as a wearing course on high traffic volume sites. It is however most suited for rut filling and minor shape correction of the surface as a stand-alone repair or pre-reseal treatment.

Category

- Reseal (technically deemed to be a thin asphaltic surfacing).

When to use

- As a cost-effective alternative to chipseals where an asphalt-like surface is desirable.
- As a thin wearing course to restore skid resistance and to prevent chip loss (also called fretting).
- To reduce road noise.
- Slurry seal has been reported to have been used over ageing porous asphalts or similar surfaces that are beginning to fret and wear away. The slurry effectively fills the worn areas, prevents further wear and restores a smooth even surface that can extend the seal life by many years.
- Can be used to repair ruts in the pavement by applying a layer of slurry just in the rut itself.

Existing surface condition required

- The surface should be clean as mud and oil deposits will be detrimental to a good bond.
- Thick build-ups of pavement markings, e.g. thermoplastic, should be removed in advance.

3

Advantages

- Once cured, a properly designed slurry will withstand a high level of traffic stress. Thus slurry seals are well suited to urban and other high stress situations.
- Once cured, has low risk of binder pick-up on vehicle tyres (i.e. tracking).
- In all cases, slurry seals offer very good skid resistance properties, low traffic noise compared with chipseals, and excellent chip retention in areas where loose stones are undesirable.
- Less tyre–road noise.
- More texture than that of a dense asphaltic concrete.
- Safer for sealing crew to apply than conventional chipseals and asphalt because emulsion binder is used and so slurry is applied at less than 100°C.
- More environmentally friendly because emulsion binder is used, and so lower quantities of volatile chemicals such as kerosene are added.

Limitations

- Slurry seals generally provide good skid resistance in all situations but, because of their relatively fine textures, they may not always be suitable for high speed situations where coarse-textured surfaces are desirable to reduce braking distances in the wet.
- Slurry seals should never be applied over young (<1 to 2 years old) chipseals that contain cutbacks or diluents, as this will lead to early flushing or bleeding of the surface. The causes of flushing are explained in Chapters 4 and 6.
- Ideally, slurry seals should only be laid when average air temperatures can be expected to exceed 10°C for a few days following construction. Below this temperature the risk is that the mix will not cure properly and may result in early failure.
- Because a slurry seal is a non-structural surfacing, avoid using it on flexible pavements having deflections greater than 1.5 mm, or where cracking or other pavement failures are structural or extensive. Otherwise the cracks will soon reflect through the slurry causing early failure by cracking or delamination.
- A small degree of flushing or minor cracking can be repaired with slurry, but in moderate or extreme cases the flushing or cracking will reflect through to the surface.
- Longitudinal joints may be visible.
- Specialist slurry plant is required.
- Testing is required, e.g. compatibility of the slurry aggregate with the emulsion binder, durability and wear tests.

Summary comments

- The typical thickness of a slurry is about 5 to 8 mm so only minor levelling of the underlying surface is possible with a single coat of slurry. Some shape improvement is achievable if an initial levelling course is applied immediately before a second top coat. This is called a two-coat slurry.

- The mix hardens as the emulsion breaks and the surface is generally trafficable with care after 10 to 20 minutes. Final curing and hardening of the surface takes place over the following few days.
- The durability of a slurry is sometimes considered to be less than that of a chipseal. However its durability is highly dependent on the aggregate and binder properties, specifically how they react with each other. Many aggregate sources are unsuitable and thorough laboratory testing during the mix design process is an essential prerequisite to ensure an adequate seal life will be achieved. Accurate metering of mix components during construction is essential to ensure that mix design targets are achieved.
- Design criteria and specifications are detailed in either ISSA (2004a, b) or Austroads (2003).

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3.8.2 Cape Seal

A cape seal (Figure 3-21) can best be described as a two coat seal where the first coat is a chipseal and the second coat is a slurry seal. The chipseal is constructed, and is followed soon after by the application of a slurry seal which fills the texture of the chipseal.

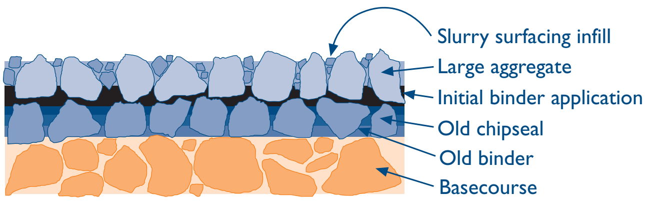

Figure 3-21 A cape seal.

The seal coat provides an effective waterproof membrane, and the slurry fills the interstices between the chips to provide a smooth surface and to lock the chips in place. This effectively combines the best properties of both these types of surfacings where either one on its own would fail to provide the desired outcome.

The chipseal typically uses a Grade 2, 3 or 4 chip and usually incorporates a PMB, with polymer levels of between 3% and 6%. The purpose of the polymer is to provide a high level of chip retention, high surface texture, and a more effective membrane to ensure the cracked surface remains waterproof through its life.

For a cape seal, the slurry is constructed in the normal manner (see Section 3.8.1). The aggregate grading for the slurry seal coat should be targeted to match the voids in the chipseal component. Typical combinations include:

- Grade 2 chip/Type 3 slurry;
- Grade 3 chip/Type 2 slurry;
- Grade 4 chip/Type 2 slurry.

3

Some flexibility to these combinations is possible depending on factors such as the size of chip and type of end-result texture desired.

Category

- Reseal.

When to use

- In situations where high resistance to traffic stress, reduced traffic noise and a smooth texture are required, and where chipseals or asphaltic concrete are not acceptable options.
- On moderately cracked or flexible pavements in urban and/or residential areas with moderate to high traffic stress.
- Where slurry seals cannot be used on their own as they would not fix cracking in the underlying old chipseal or provide adequate waterproofing.
- When a high level of waterproofing as well as a smooth, tough, durable surface is required.

Existing surface condition required

- Significant texture variations can be accommodated. However badly flushed or bleeding pavements may ultimately reflect through.

Advantages

- Cape seals combine the best features of both a chipseal and a slurry seal surface.
- They produce a smooth, quiet, waterproof, stress-resistant surface.

Limitations

- In very high stress areas (such as roundabouts and sharp corners), cape seals can sometimes slide on the underlying pavement.

Summary comments

- Success has been achieved when precoated chips are used, as these chips adhere well to the binder, and enable the seal to withstand traffic stress before and during the construction of the slurry layer.

- All loose chip must be swept up from the first chipseal coat immediately before slurry sealing.
- Cutback binders containing any volatile diluents, such as AGO or kerosene, must not be used in cape seals. The diluents trapped in the lower layer will cause the slurry seal to flush or bleed. (This is the key reason why precoated chips and PMBs are used in most instances.)
- Binder application rates can be reduced by up to 10%, although this requires judgement based on traffic volumes and the level of cracking in existing surfaces.
- Chip application rates should be sufficient to provide normal shoulder-to-shoulder contact. Over-chipping must be avoided at all costs.
- The slurry seal is normally constructed within one to two weeks of the chipseal being completed. This allows time for proper chip embedment.
- Some practitioners suggest that the slurry should be laid thick enough so that the tips of the underlying chips protrude from the finished surface (Figure 3-22), while others consider the slurry should completely hide the chips. The latter approach is the most common and provides a smoother and quieter running surface, although it is not a true cape seal.

Figure 3-22 Detail of a cape seal surface. (The coin is about 3 cm diameter.)

Photo courtesy of Les McKenzie, Opus

3.9 Asphaltic Concrete Surfacings

Asphaltic concrete is not discussed in depth in this book. However it is a surfacing treatment which is often applied over existing chipseals, and in many cases constructed directly over a new chipseal. In the latter case the chipseal is often referred to as a 'membrane seal' and is applied as waterproofing beneath the asphalt layer. Examples of this latter seal type are OGPA and OGEM, Membrane and SAMI seals.

3.9.1 OGPA and OGEM

Open-Graded Porous Asphalt (OGPA) and Open-Graded Emulsion Mix (OGEM) are special seals that allow water to drain off the surface but not let it penetrate through to the basecourse. They are used to reduce spray on motorways and other roads with high traffic volumes (Figure 3-23).

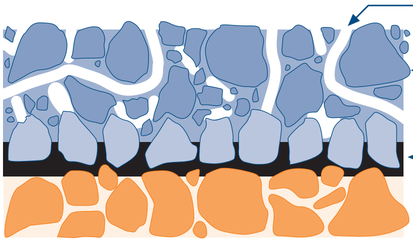

Figure 3-23 An OGPA with waterproof chipseal membrane beneath.

3.9.2 Membrane Seal and SAMI

Membrane seals are constructed to aid waterproofing beneath the asphalt layer. This seal is usually constructed with a binder having little to no cutback and a light covering of chip. They are usually covered soon after with asphalt and are only expected to carry asphalt construction equipment but not normal road traffic. A minimum application rate of 1 ℓ/m^2 is normally applied.

SAMI is a Stress Absorbing Membrane Interlayer (Figure 3-24), usually constructed with a PMB and a light covering of chip (and not to be confused with a SAM, Section 3.7.13).

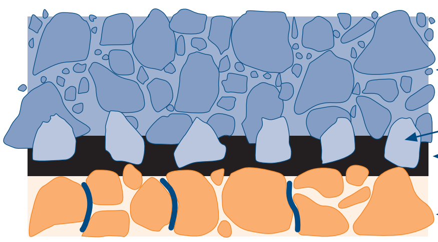

Figure 3-24 SAMI, a polymer modified chipseal membrane underlying an asphalt surfacing.

These membranes are an integral part of the asphalt pavement design and construction sequence, and therefore should not be considered a chipseal as defined in this book.

3.10 Specialist Surfacings

Many specialist surfacings exist in various forms and, as technology develops, new and innovative products are developed to meet specific needs.

Most specialist surfacings at present are associated with providing skid resistance, or with delineating uses of a pavement (e.g. coloured bus lanes). They can be types of chipseal but they can also include asphalt mixes and coloured surfacings.

Examples currently in use include high skid-resistant surfacings using Calcined Bauxite chips and synthetic binders, and coloured treatments used for cycleways or bus lanes. See Section 8.5.2 for information on synthetic aggregates, e.g. slag.

3.10.1 Fog Coat, Rejuvenating Seal or Enrichment Seal

The seals referred to as Fog Coat, Rejuvenating Seal, or Enrichment Seal are essentially all the same kind.

They are a light application of binder, with no chip applied, and usually sprayed over an ageing coarse-textured chipseal. The binders used are usually emulsions with low bitumen contents.

Category

- Reseal.

When to use

- To rejuvenate or enrich an existing seal coat.
- Usually applied to old very coarse seals, often in low traffic environments where the texture is still coarse, the chip is still in good condition, but the binder is becoming brittle and chip loss is beginning to occur.
- To prevent chip loss in new seals where binder has been significantly under-applied.

Existing surface condition required

- Coarse textured seals with low or brittle binder, where chip loss has occurred or is about to occur.

Advantages

- These seals are inexpensive and easy to apply.
- They prolong the life of the existing surfacing without significantly reducing texture.

Limitations

- These seals reduce skid resistance for a short period after spraying.
- Care is required to prevent run-off of the binder, especially when using low bitumen-content emulsions.
- Traffic speed restrictions must remain in place until the binder wears off the tops of the chips and the skid resistance increases to acceptable levels.

3

Summary comments

- These rejuvenating seals are a cost-effective solution to maintaining coarse-textured surfacings when they need waterproofing or more binder.
- Use where surfacings are showing signs of failure related to brittle binder.
- In the past they have been applied to chipsealed airport runways or lightly trafficked roads.
- They are not often used in New Zealand because they create low skid resistant surfaces.
- Where appropriate, the application of a rejuvenating seal (i.e. no chip is applied) can extend the life of the surfacing by rejuvenating the binder and hence maintaining the original coarse texture.
- A voidfill seal can achieve the same outcome without the loss of skid resistance.

3.10.2 Geotextile Seal

A geotextile seal (Figure 3-25) incorporates a geotextile, which is a synthetic fabric composed of flexible polymeric materials used in geotechnical or general engineering earthworks, for strengthening, and retaining or restricting movement of water or sediment.

A geotextile seal is constructed usually by a light application of binder, over which a geotextile fabric is laid. The fabric is sprayed with binder at a rate to both saturate it and leave enough binder to hold the chips. Chip is then spread, followed by rolling. The chipseal that is laid over the fabric can be a single coat, two coat, or racked-in seal.

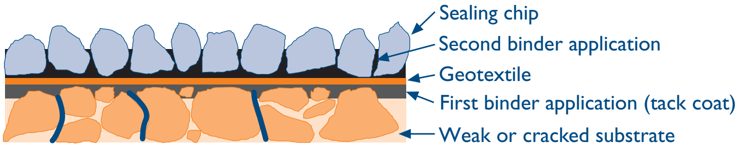

Figure 3-25 A geotextile seal. Courtesy of Austroads Sprayed Sealing Guide (2004)

Category

- First coat.
- Reseal.

When to use

- On soft, flushed or severely cracked pavements (Figure 3-26).
- To extend the life of a pavement by delaying the need for reconstruction.
- Used over a wet soft subgrade, such as a peat or sand.
- Also can be used to waterproof a bridge deck and restrict water from entering bridge joints.

Figure 3-26 Laying a geotextile on a cracked surface.
Clockwise from top left: The cracked pavement to be treated. Top right: Laying the fabric over a bitumen tack coat on the cracked pavement. Bottom right: the fabric in place. Bottom left: Saturating the fabric with bitumen. The next step is to lay chip on top as for a conventional chipseal.

Photos courtesy of Julien van Dyk, The Isaac Construction Co. Ltd

Existing surface condition required

- Used on a range of surface conditions.
- Designers use experience to determine the most appropriate chipseal type to use and the construction method required.

3

Advantages

- A strong, waterproof mat can be achieved which will cover cracked and stressed surfaces.
- A geotextile seal has been shown in research by Towler & Ball (2001) to prevent future flushing.
- Can be an economic alternative to reconstruction of a severely cracked pavement.

Limitations

- Geotextile seals can be costly in comparison to conventional seals.
- Success is very dependent on design and construction techniques. It is advisable to follow the manufacturer's recommendations.
- The seal can slide and move as a mat if not adhered to the underlying surface, especially in situations of stresses caused by stopping and turning traffic.
- Geotextiles that incorporate a grid give limited strength benefit in surfacing applications.
- Geotextile seals of fabric-only type do not provide strength but do provide a medium that allows increased binder thickness, suitable for repairing cracks and preventing future flushing.
- When used on a flushed binder-rich surface, the fabric has the ability to absorb binder. However, estimating the correct binder application rate so that the binder is enough to hold the chipseal as well as saturate the fabric is very difficult.

Summary comments

- Geotextile seals incorporate the use of fabrics in the seal coat to enhance performance.
- They are used in specific circumstances and care is required in the surfacing design and construction to ensure success.
- The fabric manufacturer's instructions and industry best practice must be consulted and followed in the construction of this type of seal.
- Applying the fabric evenly is difficult, with problems in areas that have many service covers or corners. A specially built jig to hold and apply the fabric helps to alleviate some of these problems, but these jigs are not common in New Zealand.
- Although some RCAs are reporting success with this technique, further research and experience is required before it should be considered low risk.

3.11 Defects in Chipseals

To continue the theme of defining the terminology related to chipseals, the following section defines the defects that are found in chipseals (which lead to resealing and repairs), and causes of the defects are touched on. Causes are covered in greater detail in Chapter 4, while the repair of defects are covered in Chapters 7 and 12.

Some of the defects listed below are pavement faults as distinct from chipsealing faults. Definitions of these are included as well so that the reader can understand the terminology when it is used in later chapters.

In New Zealand, the definitive reference relating to defects of the road surface, footpath surface, and kerb and channel is contained in the *RAMM Road Assessment and Maintenance Management System Road Condition Rating Manual, National Roads Board New Zealand, June 1988* (prepared by the Local Government Training Board, for NRB 1988). Commonly referred to as the *RAMM Rating Manual*, this book is currently out of print, so key portions of it relating to road surface defects are reproduced below. The word 'rating' refers to the activity of collecting road surface condition data for input to the RAMM system, or other pavement management system (see Chapter 5). Rating is also a name given to road surface condition data (e.g. the Rating Table in the RAMM database (CJN Technologies 2004)).

3.11.1 Deformation

3.11.1.1 Rutting

Rutting is deformation (Figure 3-27) of the pavement surface. A rut has a regular shape (saucer shaped in cross-section) and looks as though the pavement surface has sunk downwards, or depressed, with no other apparent signs of pavement distress. Rutting may be caused by any of the following:

- Water in or beneath the pavement layers, or the collapse of an underground pipe or other service.

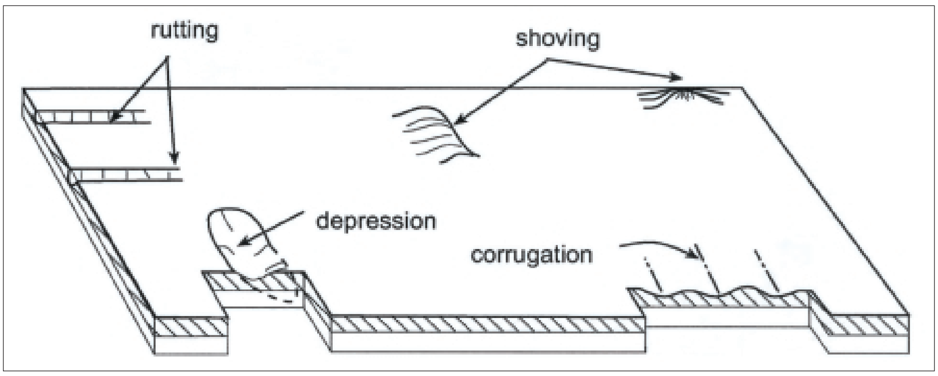

Figure 3-27 Types of pavement deformation. Courtesy of Austroads Sprayed Sealing Guide (2004)

- Within-pavement densification, e.g. it can often be seen where excessive heavy vehicles have caused depressions in the wheelpaths. This would indicate pavement deterioration and may be the normal end-of-design-life failure mode.
- As a result of construction faults, when it occurs in a relatively short time from construction.
- Contamination or deterioration of the structural layer.
- As a result of subgrade deformation which is a structural weakness of the pavement layer.
- When a deep layer of bitumen-rich surfacing has accumulated during the life of the pavement (although this usually results in shoving and shallow shear, see below).

To record the extent of rutting, the RAMM Rating Manual (NRB 1988) states:

> *the length of wheelpath which has rutted to a depth of 30 mm or greater as measured from a 2 m straight edge placed across the wheelpath. If the whole carriageway area or a large part of it is shaped so it holds water then it is rated as if all the wheeltracks in that area are rutted, e.g. for a two lane carriageway holding water over 20 m of the inspection length the rating for rutting would be 4 x 20 = 80 m.*

Note that some RCAs require rating of ruts of as little as 20 mm depth.

The RAMM Rating Manual also states "Rutting has occurred when traffic has caused wheeltracks in the carriageway to be depressed with no bulging in the adjacent pavement."

3.11.1.2 Shoving

Shoving, also called shallow shear, is deformation of the pavement surface where the pavement itself or just the surfacing layers have been deformed and misshapen, with accompanying pavement distress such as alligator cracking, pumping or potholes. Figure 3-28 shows shoving, which may be caused by:

- water in or beneath the pavement layers;
- excessive shear stresses in the surfacing layers by heavy vehicles on corners;
- the disintegration of the granular basecourse layers of the pavement after excessive and repetitive loading.

To record the extent of shoving, the RAMM Rating Manual states:

> *This rating records the length of wheelpath showing shoving in the inspection length. Where there are other defects in the length of shoving being rated, they are to be ignored for rating purposes; e.g. if both alligator cracking and potholes are present in a length of shoving, they would not be rated.*
>
> *Shoving occurs when material is displaced to form a bulge or heave alongside the depressed area… Shoving frequently occurs in the outside wheeltrack often as a result of poor drainage. It can also occur as the result of a poorly designed asphaltic concrete or as a result of moisture entering the pavement through cracking.*

3.11.2 Cracking

Cracks in a bituminous surfacing allow surface water to infiltrate the underlying pavement layers and, with time, to filter through to the foundation (subgrade). This can cause a significant reduction in pavement strength and can very quickly lead to pavement deformation and shear failure unless the cracks are sealed.

There are many types of cracking (Figure 3-29), but the three types of crack recorded in the RAMM system are Alligator, Longitudinal and Transverse, and Block cracking.

Figure 3-28 Shoving in a pavement. Photo courtesy of Les McKenzie, Opus

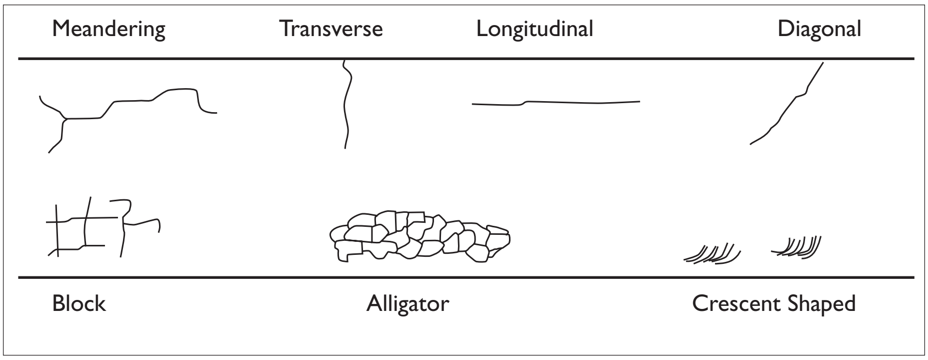

Figure 3-29 Types of cracking in a pavement. Courtesy of Austroads Sprayed Sealing Guide (2004)

The crescent-shaped cracks in Figure 3-29 are caused by shear of the surfacing layers, and the pavement would normally be rated as 'shoved' in New Zealand. The front of the crack points in the direction of the traffic stream.

Alligator Cracking – so named for its semi-regular polyhedral shapes, reminiscent of the pattern on an alligator's skin (Figure 3-30). It is also know as chicken wire cracking as it has the appearance of chicken wire mesh.

Figure 3-30 Alligator cracking has a cracking pattern like an alligator skin.

Photo courtesy of Les McKenzie, Opus

To record the extent of alligator cracking, the RAMM Rating Manual states:

> *This rating records the length of alligator (fatigue) cracking showing in the wheelpaths of the carriageway…. Fine cracking often found at the edge of the seal is not to be rated as alligator cracking. Alligator cracking is to include all polygon-shaped cracking irrespective of the size of the polygons formed by the network of cracks.*

Alligator cracks are easiest to observe in the coldest months of the year as the surface contracts and the cracks open up. After light rain the cracks are more obvious as the surface dries leaving moisture in the cracks. If the rating survey is done over the summer months then fine alligator cracks are much harder to see due to expansion of the carriageway surface and glare off the surface. But looking into your shadow, cracks can usually be observed.

Longitudinal and Transverse Cracks – long cracks that run along or across the road (also includes diagonal and meandering cracks). This type of cracking (Figure 3-31) can occur in overlays over cement-stabilised bases, and also in overlays over bituminous bases wherever cracks in the old pavement have not been properly repaired, and this is known as reflective cracking.

Figure 3-31 Longitudinal and transverse cracks run along or across the road.

Photo courtesy of Les McKenzie, Opus

To record the extent of longitudinal and transverse cracking, the RAMM Rating Manual states:

The rating for longitudinal and transverse cracks records the length of cracking in the carriageway…. Large rectangular cracks are to be included as these are generally a more severe form of longitudinal and transverse cracks which have extended sufficiently to form a network.

Block Cracking – cracks found, for example, around service covers (service holes, etc.) where the rigid concrete mounting ends and the chipseal begins. Block cracking in thin surfacing mixes may lead to alligator cracking. Block cracks are often caused by the reflection of cracks in an underlying layer, e.g. from a cement-bound basecourse.

To record the extent of block cracking, the RAMM Rating Manual states:

> *This rating records the length of cracks present at joints in the surface of the pavement. These cracks would typically be found at construction joints in asphaltic concrete or at joints in the pavement surface where underground services have been laid.*

Shrinkage Cracks – are not recorded in RAMM but can occur in very old bituminous surfaces (especially in thin surfacing mixes) as a result of shrinkage. These shrinkage cracks are not usually associated with pavement deterioration but, if left unsealed for too long, moisture may filter through to the pavement foundation. This causes loss of strength which may result in surface deformation. Shrinkage cracking can also occur because tree roots have contracted, pulling the pavement during a drought, especially alongside windbreaks.

3.11.3 Chip Loss

3.11.3.1 Scabbing

Scabbing is chip loss from a chipseal. Chip loss may occur if there is not enough binder or if the binder does not adhere to the chip (Figure 3-32) because the chip was wet, dirty, or wetting and adhesion agents were not applied correctly. Chip loss can also occur on older surfacing when the binder oxidises or becomes hard and looses its grip on the chips. See Chapter 4 for discussion on causes of chip loss.

To record the extent of scabbing, the RAMM Rating Manual states:

> *This rating records the area of carriageway where the seal has lost more than 10% of the sealing chip. In the case of asphaltic concrete surfaces, this is the area of pavement showing signs of ravelling (surface attrition).*
>
> *Scabbing occurs when sealing chips become separated from the bitumen in a chipseal. In an asphaltic concrete pavement the aggregate loss from the mix is called ravelling and is rated as scabbing.*

3.11.3.2 Ravelling

Ravelling is the loss of chip from an asphaltic concrete or a slurry surface. It occurs where the binder has oxidised and is loosing its grip on the large- and small-sized aggregate of the surfacing. In a way, the asphalt or slurry is unravelling. If it is not halted, ravelling may cause deterioration to the extent that the surfacing mix no longer performs competently, resulting in a lack of waterproofing, and it can cause an uncomfortable ride.

Figure 3-32 Chip loss caused by dirty chip. Photo courtesy of Les McKenzie, Opus

3.11.4 Potholes

Potholes are formed when the pavement surfacing is lost so that the underlying basecourse is exposed (Figure 3-33). Often potholes become filled with water or even grass.

Figure 3-33 Potholes and cracks form where water gets under the pavement.
Photo courtesy of Les McKenzie, Opus

To record the extent of potholes, the RAMM Rating Manual states:

> *This rating records the number of potholes in the inspection length of carriageway. A pothole is an area where the carriageway surface has deteriorated, resulting in the cracking and eventual breaking up of the surface to form a cavity.*

Pothole Repairs

These are small (usually asphaltic) patches over potholes that have been filled in (i.e. repaired) and are considered just as important an indication of pavement failure as the potholes themselves. As repairs mean that the pavement surface has been compromised, the number of pothole repairs is counted along with potholes by the pavement management system when determining the need for resurfacing.

To record the extent of pothole patches, the RAMM Rating Manual states:

> *The same criteria and ratings apply here as for potholes except that the holes have been patched. A patch is to be rated as a pothole patch if it is less than 0.5 m² in area. If a patch is greater than 0.5 m² it is to be considered part of the pavement.*

3.11.5 Edge Break

Edge break is where the edge of the road has started to crack and fall away (especially on rural roads with unsealed shoulders). Edge break is defined when at least 100 mm of road edge has disappeared. It can leave a dangerous drop at the edge of the seal, and wheels of any vehicles that leave the road could become trapped over the side of the edge break, making it hard for the vehicle to easily make it back onto the carriageway.

To record the extent of edge break, the RAMM Rating Manual states:

> *This rating records the length of carriageway edge showing signs of edge break where there is no surfaced channel. Edge break is the reduction of the seal coat by more than 100 mm from the original line of the seal edge. If a channel is present then any break in the carriageway/channel boundary should be rated as ineffective surface water channel.* (Note: the topic of 'ineffective surface water channel' is not discussed in this book.)

Edge Break Repairs

To record the extent of edge break repair patches, the RAMM Rating Manual states:

> *… the same criteria and ratings apply here as for edge break except that the edge break has been patched.*

3.11.6 Flushing

Flushing creates a solid, smooth, black, slick surface caused by an excess of binder. Flushing may occur as the natural end-of-life condition of a well-designed chipseal, or as a seal design or construction fault. In hot weather a flushed surface may soften and bleed (Figure 3-34).

To record the extent of flushing, the RAMM Rating Manual states:

This rating records the length of wheelpath where the carriageway surface has flushed. A flushed surface is where the binder is level with or above the surfacing aggregate.

Current definitions of flushing in use by various RCAs include:

- When the chipseal's texture depth is less than 0.5 mm.
- When the chipseal's texture depth is
  - less than 0.7 mm (for areas where the posted speed limit is <70 km/h) or
  - less than 0.9 mm (where the posted speed limit is >70 km/h).
- When the binder is half way up the chip.

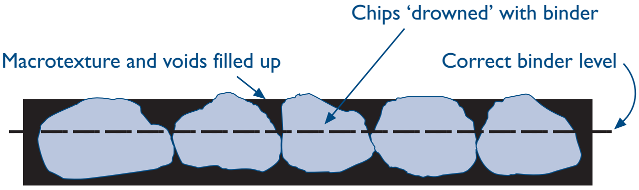

Figure 3-34 A flushed chipseal, in which excess binder rises over the chip and reduces macrotexture.

Figure 3-35 This road shows a slick, bleeding or flushed surface that has low friction and therefore low skid resistance.
Photo courtesy of Mark Owen, Transit NZ

Figure 3-35 shows a slick bleeding or flushed surface that has low friction and therefore low skid resistance. It is unacceptably slippery and unsafe as the tyres cannot grip the sealing chip. Also the surface does not have any texture.

Insufficient binder causing areas of chip loss leads to exposed binder and thus to a slick surface which is also classed as flushing.

3.11.7 Bleeding

In hot weather when the binder is soft, it will adhere to the vehicle tyres and be spread (tracked) over the surrounding road. This soft state is called bleeding and is undesirable because the binder coats the microscopic surfaces of the chips (the microtexture), creating a slick surface with a lowered skid resistance.

At a critical texture (which depends on chip size), the tyres can reach down into the spaces between the chips and touch the surface of the binder. There is also a critical viscosity (related to temperature and additives in the binder) at which the tyres are able to adhere to the bitumen. Although tracked bleeding binder may eventually wear off chips, it presents a hazard while it is present.

> To remember the difference between flushing and bleeding, a flushed road surface is solid in cold weather but may still bleed in hot weather.

3.11.8 Roughness

Roughness is a measure of the comfort of the ride (i.e. bumpiness of the road). Originally it was measured with a 'roughometer' or NAASRA roughness response meter, which literally counted the number of bumps recorded by a standard vehicle when it was driven over a certain length of road. Today, roughness is more usually measured by a set of lasers mounted on a vehicle, the data being analysed at the correct wavelength to correspond to road bumps. (A different wavelength is analysed from the same data to measure chip texture depth, and hence flushing.)

3.11.9 Loss of Texture

Loss of texture through flushing or other causes is measured by either sand circle measurements (TNZ T/3:1981) or by High Speed Data (HSD) collection. The texture output of HSD is the Mean Profile Depth (MPD). The principles of MPD measurement are shown in Figure 3-36.

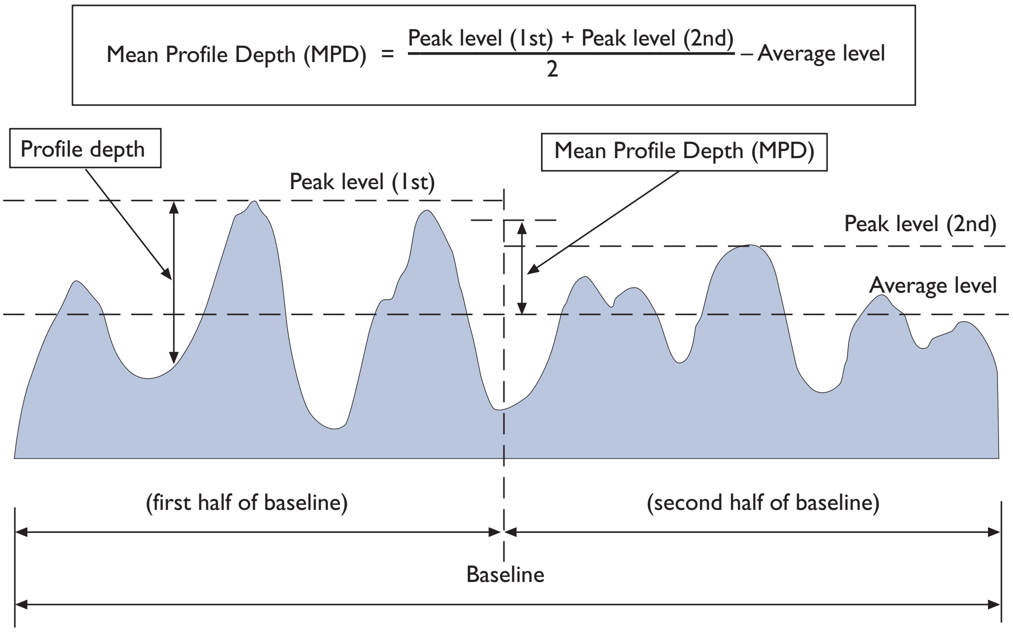

Figure 3-36 How the MPD (mean profile depth) is calculated from HSD (high speed data).

3.11.10 Loss of Skid Resistance

Skid resistance is measured as the wet-road skid resistance by the Sideway Coefficient Routine Investigatory Machine (SCRIM). (SCRIM and skid resistance are explained in Section 4.9.) Low skid resistance recorded by SCRIM may have been caused by polishing of the chip or related to bleeding and flushing masking the microscopic surface of the chip (the microtexture).

3.11.11 Conclusion

Shear failures (which cause shoving), depressions (rutting), and potholes form as a result of pavement ageing and loss of waterproofing. As the pavement gets older, and weaker or softer because water is leaking into the underlying layers or is not draining away, it deforms and the seal cracks, letting in more water which accelerates the damage.

Also the action of traffic causes pumping, which is the movement and ejection of fine particles in suspension through joints or cracks. This removes fine particles from the basecourse, which weakens it further, and the hydraulic pumping effect itself will eventually lift the seal.

To counter this natural deterioration, a well managed network will have a Pavement Management System in place for which the road condition rating data is collected and fed in, as described in Chapter 5. This means that the available budget is targeted to achieve the maximum return.

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