CHAPTER 8. ROAD PAVEMENT REPAIRS - FLEXIBLE PAVEMENTS

8.1 SURFACING FAILURES

Description
Surfacing failure is the breaking up of the surfacing layer (seal or asphalt) exposing but not affecting the underlying layer. The resulting depression is usually of uniform thickness. To differentiate from structural failures check that the overall road shape has not changed from when it was built and that there are no signs of displacement and little or no rutting. Surfacing failure should not be confused with a pothole which extends through the surfacing and at least into the underlying base.

Causes
- Old, dry, brittle surfacing which has cracked in a diamond-like pattern and is debonding from the base in circular patches.
- Surface layer debonding from the base or the old surface (in the case of a reseal or overlay) because of poor preparation of that layer before surfacing for the following reasons:
  i) the tack coat was poorly applied resulting in an uneven application
  ii) the surfacing was applied to a wet surface or before the tack coat had broken, trapping water which with traffic loading stripped the binder or lifted the surfacing
  iii) the original surface was contaminated with clayey fines (often caused by construction traffic from haul roads).
- Mechanical damage caused during an accident or where vehicles have burnt out.
  Ingress of water always aggravates these conditions.

Extent
- Isolated: Localised failures occurring at one or two places. These can be treated as isolated repairs.
- Intermittent: Where there are a number of failures at close spacings these should be treated as a surface patch repair.
- Extensive: Particularly where the failure is as a result of brittle failure of old surfacing, the area is extensively cracked and showing widespread debonding. This cannot be treated as routine maintenance and must be referred to SANRAL for periodic maintenance measures such as milling.
Response time
Loss of surfacing is always serious as it exposes the underlying layers to traffic and weather. Where the base is a granular material repairs should be carried out as soon as possible. Where the underlying layer is a cemented material or an old surfacing which is visually sound the repair can be addressed as a routine operation but should be done before the onset of the rainy season.

Repair methods
Before starting repairs check the surrounding areas for debonding by tapping the surface with a hammer. A dull sound indicates lack of bond. Mark out the extent of debonding on the surface.

Isolated Repairs: Depending on the thickness of the layer localised failures can be made good either with a coarse slurry or a fine asphalt. Debonded material adjacent to the hole(s) should be lifted off with a flat spade. The hole should be well cleaned by washing if contaminated with fines and a light tack coat applied to the floor and sides (0,2l/m² net cold binder). Good penetration and distribution of the tack coat can be achieved by "scrubbing" the floor and sides with a bristle broom. It is usually not necessary to trim the hole to a rectangular shape but all the loose material should be removed and irregular sides should be trimmed to neat lines.

Intermittent Repairs: Groups of closely spaced failures should be marked out in rectangular shapes, the surface layer should be removed over the whole area, the underlying layer cleaned, tacked and depending on the layer thickness replaced either with a coarse slurry or a fine asphalt. Alternatively the condition could be treated by trimming off the poor surfacing (by hand or with a grader) and clearing out all loose material. The surface should then be fogged with a diluted emulsion, a skim coat of either coarse slurry or fine asphalt applied and rolled with a pneumatic roller.

Extensive: No routine maintenance should be carried out other than emergency holding measures in localised areas using coarse slurry or fine asphalt. Such holding measures should be carried out in localised areas only where the underlying layer is breaking up and causing a hazard to traffic.

Caution
If the road surface has widespread cracking and is left too long before periodic maintenance measures are carried out the underlying pavement layers may be damaged. This would result in much more expensive repair methods being required to restore the serviceability of the road. The Route Manager should thus ensure that SANRAL is made aware of this situation as soon as possible.
8.2 POTHOLES

Description
Potholes are surface failures which extend into the base layer forming a hole. Normally such failures would be less than 0.5m² in area, are isolated and are not associated with displacement. If left for any period of time particularly in wet conditions potholes could develop into major structural failures.

Causes
Potholes are caused by traffic which breaks up the surface and underlying base in areas of localised weakness or where the surfacing is damaged or structurally cracked. Water accelerates the formation and deterioration of potholes.

Extent
Isolated: Localised failures should be treated as isolated repairs.
Intermittent: Where there are a number of potholes closely spaced the failures should be treated as a patch repair (see Pavement Failures).
Extensive: Provided the pothole failures are not accompanied by sideways movements (displacement) their repair can still be carried out as routine maintenance. However where over a road length of say greater than 100m more than 5% of the area consists of potholes an estimate of the cost of such repairs must be compared with the cost of doing a periodic maintenance repair or other action on the whole area (e.g. rip, stabilise, recompact, seal).

Response time
Potholes generally increase in size and depth gradually as a result of traffic action. Periods of rain wet up the base and accelerate the rate of deterioration. As the pothole grows it becomes noticeable to traffic both visually and from the impact on the vehicle wheels. Traffic will attempt to avoid larger potholes. Early treatment of potholes is recommended while they are still small and not a significant disruption to traffic. During the wet seasons repairs should be carried out as a matter of urgency.
Repairs

All potholes should be cleared of loose material, trimmed to a rectangular shape and primed with a diluted emulsion. Shallow potholes (<25mm) can be filled with a coarse slurry. Deeper potholes should be excavated to a minimum depth of 40mm and the base of the hole should always be in sound material. The holes could be backfilled with either asphalt or slurry bound macadam. Where cold asphalt is used it may be necessary to seal the surface with Petroseal or similar. Larger potholes can be treated as for patch repairs (see Pavement Failures). All repairs should be referenced and a number and date painted on the adjacent road surface.

Caution

Referencing of repairs should be carried out on a daily basis and not left to the end of the month or later.

8.3 PAVEMENT FAILURES

Description

Pavement failure consists of a combination of rutting, cracking and displacement of the road surface and base layer usually accompanied by disintegration of the surfacing. The resulting surface distress can be a major hazard to traffic. Apart from crocodile cracking and pumping of fines lateral movement of the yellow line provides clear visual evidence of the problem except in the case of asphalt surfacing where this may be plastic flow in the asphalt layer only. The failures occur in the wheelpaths mainly in the outer wheel track and on surfaced shoulders used by heavy vehicles as a climbing lane.

Causes

The pavement distress is either structural failure of the pavement layers in fatigue as a result of repeated deflections under heavy vehicles, or a bearing capacity failure of poor quality material. All forms of pavement failure are related to the frequency and intensity of heavy vehicles and the rate of deterioration is strongly influenced by the presence of water. Where the pavement structure becomes wet even the best quality pavement materials may fail under heavy loads (see comments under Drainage) and over a short period of time. The possible presence of subsurface water must be checked to ensure that this is not a contributing factor to the failure.
Extent
Pavement failures can be isolated occurring in localised places. On older heavily trafficked roads coming to the end of their pavement life, failures tend to be intermittent to extensive often with the worst conditions occurring in cuttings.

Response time
Because of the danger to traffic failed areas should be repaired as a matter of urgency. Where these failures are widespread the volume of repair work will quickly exceed the capacity of the Contractor. SANRAL should be made aware of the problem and a suitable holding measure strategy agreed on until such time as rehabilitation can be carried out. Ideally widespread failures should be identified before the start of the maintenance contract and must be discussed with SANRAL.

Repairs
Patch repair methods are described in detail in Appendix D: Bituminous Pavement Repairs. The following summarises the recommended procedure.

- Mark out the extent of the area to be patched. Make sure that the repair extends into the sound adjacent surface.
- Excavate the patch to the underside of the base layer and check the quality of the underlying subbase by visual assessment and the use of a DCP. On most of the national roads the failures are largely confined to the base layer. However, where necessary continue excavation until a sound underlying layer is found.
- Check the excavation for subsurface water and where necessary install subsurface drains. Where the surface has cracked and deformed water may have entered from the top resulting in the failed material being wet. There is no point in installing subsurface drainage in this case.
Backfill the excavation using the better quality existing pavement material for reinstatement of any lower layers.

Reconstruct the base layer using either an ETB or a hot mix asphalt (see Materials in Chapter 7).

ETB: The layer should consist of an imported crushed stone treated with 3% anionic stablemix emulsion and 1% cement (mass/mass) compacted at optimum fluid content to at least 100% of modified AASHTO maximum density (check specified compaction requirements). Experience indicates that particularly under heavy traffic it is important to use a good quality crushed stone rather than existing pavement material. In finishing off the ETB surface enrich it with emulsion. This allows the opening of the patch to traffic without the final surfacing and permits the ETB to cure. In all base layers other than asphalt the use of ETB is preferred.

Asphalt Base: Hot mix asphalt base using an approved mix is recommended for use in existing asphalt base, for emergency repairs and for situations where traffic volumes are so high that fast repairs are necessary.

Final base levels: The use of screed rails placed longitudinally either side of the patch is essential to control the finished level, to provide an even ride and to ensure sufficient fluffed up material for adequate compaction (140 to 150mm loose compacts to 100mm). The maximum compacted thickness of any layer should not exceed 150mm. Where an asphalt wearing course is required the top of the base should be at least 25mm below the existing surfacing (see Appendix D). With an ETB, which should be allowed to cure before surfacing, this can create a hazard to traffic. For wearing course treatments other than asphalt the base can be constructed flush with the existing surfacing.

Apply a surface treatment either slightly overlapping the patched area or seal around the joint between the existing and new surface. Surface treatments can consist of asphalt, a prefabricated 13mm bitumen rubber patch, a "Cape Seal" or a double seal. The latter hand applied seals need to be applied with care and skill to avoid bleeding. When handspraying mask around the patch with reinforced paper to give a neat finish.

Where the base is surfaced with asphalt a hot mix from commercial sources or an on site "hot" mix (see Materials in Chapter 7) is preferred.

Reference the patch by painting a number and date on the adjacent existing surfacing.

Caution

Where the ETB is left open too long under traffic without surfacing or during wet weather, ravelling of the upper surface can occur. Where such conditions are expected the surface can be protected with a thin slurry.

Cold asphalt has been used with little success. If sufficient emulsion is added for compaction the cold asphalt is rich and in the summer months shoves under heavy traffic. Alternatively if less emulsion is used the cold asphalt is stable but due to poor compaction is porous and in the wet season becomes saturated and ravel.
8.4 CRACKS

Introduction
Before any crack treatment is applied, it is recommended that the crack mechanisms and factors affecting the crack behaviour are understood. Some cracks are superficial and affect only the surfacing while other cracks can originate from much lower depths in the pavement. It is not advisable to apply a specification based on superficial observations of the cracks.

Cracks can be broadly classified as active and passive cracks. The active cracks generally originate from levels below the surfacing while the passive cracks apply to the surfacing. Active cracks have significant movement across the joint horizontally and/or vertically. In this manual the cracks are grouped as follows:

Active cracks:
- Stabilisation cracks (primary cracks in a block pattern developing with time into secondary cracking with pumping of fines).
- Volcano cracks (often stabilisation cracks in low traffic areas like the shoulder).
- Expansive soil cracks (often parallel to road edge).
- Longitudinal cracks (settlement/slip).

The active cracks are easily identified and there should be little difficulty in selecting the most suitable treatment which should be able to accommodate movement.

Passive cracks
- Surfacing cracks (old and brittle surface or overstressing of the surfacing layer) - not limited to wheel tracks.
- Single cracks (long, transverse and random).
- Crocodile cracking (overstressing of base/subbase) usually with rutting - limited to wheel tracks.

Passive cracks are less easy to identify and care needs to be taken in dealing with them. Incorrect identification of the causes of such cracks can lead to expensive and unnecessary repairs.

In the repair of open cracks (say greater than 3mm) hot applied proprietary sealants are frequently used. There is considerable merit in using a "cold" rubber crumb slurry to form a "wet" seal as an alternative. The cold sealant is likely to be easier to handle and control particularly on rural projects.
ACTIVE CRACKS
STABILISATION CRACKS

Description
Stabilisation ("Block") cracking is active cracking with a very distinctive block form which with time deteriorates to secondary cracking at closer spacings. If untreated large open closely-spaced cracks develop. In the latter stages of cracking the resulting small blocks become loose and move with a rocking action under traffic. These cracks are associated with cemented pavement layers particularly the base and to a lesser extent the subbase. The secondary cracking is related to heavy traffic volumes and is accompanied by typical pumping of fines. (See Figure 2 of the crack deterioration mechanism).

Causes
The cracks are initially caused by shrinkage of the stabilised layer material reflecting through the surfacing and then by daily movement (expansion and contraction) due to thermal variation between day and night temperatures. Further vertical movements occur as a result of wheel loads (especially heavy vehicles) causing deflection of the stabilized blocks or slabs. During wet conditions water penetrates untreated cracks and under traffic pumping and transportation of fines occurs (Figure 2). Due to the loss of fines deflections increase with time and secondary cracking occurs.

Extent
The spacing (extent) of block cracking depends on the type of material, the type and quantity of stabilising agent and whether secondary cracking is taking place. Normally the initial crack spacing would be Large
(TMH9 >2,5m). If these cracks are left untreated over two to three wet seasons this would deteriorate to Narrow spacing (<0,5m).

Response Time
If stabilisation cracking is left untreated under heavy traffic for any length of time, extensive secondary cracking is likely to occur. This will make it very difficult to treat as a routine maintenance measure. Thus stabilisation cracks should be treated as early as possible, preferably before the next wet season.

Repair
The primary objective of the repair is to remove all loose particles and to prevent water ingress. The cracks vary in width from about 1mm to 3mm depending on the temperature and time of the day. Blow out all loose material and grit from the cracks. Prime cracks with an inverted emulsion prime (MSP1 or similar). Fill the cracks with a stable grade anionic emulsion modified with an anionic latex (8% nett rubber on nett bitumen), or a cationic spray grade emulsion modified with a cationic latex. These materials are to be injected with special equipment under pressure (see Equipment in Chapter 7), care being taken not to apply prime or emulsion on the surface outside the cracks - excess to be removed.

Where the block cracking degenerates to secondary cracking (see Figure 2) initially these are hairline cracks with pumping of fines. These can be treated with a geotextile bandage which can reduce or stop the pumping of fines. Where the secondary cracks are open and the “blocks” of pavement are not rocking they should be treated as for open block cracks as described above.

At the stage where isolated areas of blocks are rocking under traffic these should be removed and the areas repaired as described under repairs for Pavement Failures. Where such areas are occurring more frequently it may be necessary as a holding measure (to provide a safe ride) to treat the blocks by cleaning out the loose material in the cracks, sealing them with slurry or fine asphalt and possibly applying a geofabric bandage.

VOLCANO CRACKS

Description
Volcano cracks are active cracks that usually occur along with stabilisation cracks in the base in areas where there is little or no traffic such as on the shoulders. They can also be seen on some old bridge joints close to the balustrades. The cracks are open up to 10mm wide with a raised edge like the rim of a volcano.

Causes
Fine material and dust fill the active crack and during expansion conditions (the heat of the day) inhibit movement forcing the edges of the crack upwards. During cooler periods the crack opens,
the fines fall deeper into the crack (assisted by traffic vibration) and additional fines are collected. This cycle continues progressively forcing up the edges (see Figure 3).

**Extent**

The extent of volcano cracks is associated with traffic usage and will be more widespread where traffic does not use certain areas of the road.

**Response Time**

Treat cracks at the same time as the stabilisation cracks.

**Repairs**

The crack should be prepared by blowing out all loose material. The surface for a width of 300mm on either side of the crack should be treated with a rejuvenator or a solution of 1 part RC250 and 2 parts dieselene. The crack should be primed with an inverted emulsion prime (MSP1 or similar), tacked with a modified emulsion and filled with a rubber crumb slurry consisting of: 0.2 parts cement to 10 parts rubber crumb and dry mix before adding about 5 parts water. Then mix 0.3 parts latex with 4.5 parts emulsion, combine with the rubber crumb and mix thoroughly. Compact the raised areas around the crack with a pedestrian vibratory roller until the area is level with the surrounding surface. Note: the crack is now in compression and can accommodate minor movements.

**Caution**

Do not use anionic and cationic binders in the same operation. If unavoidable ensure that all spray equipment is thoroughly cleaned, otherwise the emulsion will break prematurely in the equipment.
EXPANSIVE SOIL CRACKS

Description
Expansive soil cracks are active cracks with cyclical movements related to the wet and dry seasons of the year. These cracks are generally wide open and deep, extending down through the pavement to the subgrade. The cracks are often parallel to the centreline and occur mainly towards the edge of the road along shallow fills, fields and marshy areas.

Causes
The cracks occur where the road is constructed over expansive clay soils (high PI values and smectite) which are sensitive to seasonal moisture changes. These changes are most marked towards the edges of the pavement structure where most wetting and drying occurs.

Extent
The cracks generally vary from intermittent to extensive in expansive clay areas where pre-treatment of the roadbed and fills was not carried out during construction.

Response Time
The cracks are not a hazard to traffic but because of their size and depth allow moisture into the pavement system and the subgrade. Because they permit water ingress the cracks should be sealed on a routine basis before the next wet season.

Repairs
Clean out loose material from the crack and fill with a fine slurry of clean fine sand and lime (in equal parts) to the underside of the base. Alternatively wider cracks could be filled with a fine dry sand. It may be necessary to carry out two or three fillings of the crack. Prime the crack with an inverted emulsion prime (MSP1), then tack the crack with a modified emulsion and fill the crack with a rubber crumb slurry as described under Volcano Crack repairs. Allow the emulsion to break and then apply a geofabric bandage or a prefabricated bitumen rubber seal patch. Where cracks occur in the fill slope fill the crack with a bentonite (2%) and sand slurry to prevent ingress of water. Treat the top 100mm of fill material for a spade width either side of the crack with 2% bentonite and water and compact lightly to the shape of the slope.
LONGITUDINAL CRACKS

Description
Longitudinal cracks associated with settlement are close to the edge of the road and often occur on newly-constructed high fills or widened sections, parallel to the road centreline. Usually the cracks are open, wide and deep with little vertical displacement across the cracks. Slip failures occur in fill in the road pavement, with noticeable vertical steps across the crack (lower towards the outside of the pavement). The cracks form an arc towards the shoulder edge rather than a straight crack.

Causes
Longitudinal settlement cracks can be caused by differential consolidation between old and new fills, wetting up of newly constructed fill slopes (increasing the settlement load and reducing inter particle friction) or overbuild on the upper fill slopes. Slip failure is normally a combination of poor materials (in the fill subgrade), steep side slopes, poor compaction and water, resulting in a circular or wedge movement outwards and downwards.

Extent
Settlement cracks can be widespread on high fills. Slip cracks are usually isolated.

Response Time
Settlement cracks although often wide can be successfully handled by sealing at routine intervals. Slip cracks are an indication of a potential major localised failure of the road which could create a major hazard to traffic. The latter requires urgent reaction particularly during or after wet weather and SANRAL should be informed as soon as possible. As a temporary measure especially during ongoing wet weather slip cracks should be sealed as quickly as possible. Extra water entering open slip cracks will accelerate failure. See comments in paragraph 11.4: Soil/Rock Problems.

Repairs
Settlement cracks can be handled as for Expansive Soil Cracks. Where settlement is ongoing the cracks will need repeated treatment on an annual basis. While expansive crack sealing can be used to treat slip
cracks, in the interest of speed it may be necessary as a temporary measure to use any suitable readily available material such as clay to quickly close the cracks to prevent water ingress in the next rain storm. Emergency repairs should be carried out as soon as possible thereafter.

**Caution**
Failure to react quickly to signs of slip cracks could result in a hazardous situation on the road. For safety purposes it may be necessary to either close the shoulder or lane and in extreme cases the whole road.

### PASSIVE CRACKS
#### SURFACING CRACKS

**Description**
Surfacing cracks occur randomly over the road surface in a map format (diamond shape). These cracks are often referred to as map cracks. In extreme cases the surface deteriorates to a pattern which resembles and can be mistaken for crocodile cracks. This distress mode is not accompanied by any marked deformation or pumping of fines.

**Causes**
Where the cracks are randomly distributed this is as a result of drying out (oxidising) of the asphalt or binder which results in the surfacing becoming brittle. There is no deformation of the road surface.

**Extent**
Surfacing cracks are usually widely distributed varying from intermittent to extensive over a uniformly constructed piece of road. This can be a problem for routine maintenance if large lengths of road are involved.

**Response Time**
Because the cracks permit ingress of water to the underlying base or old seal the road should be sealed under periodic maintenance as soon as possible to protect the underlying pavement layers. Note: surface cracking can occur where the underlying pavement structure is still in a sound condition and is thus worth saving. Where periodic maintenance in the form of a reseal is
planned within the next 2 years, a fog spray and slurry treatment can be carried out to localised more severely distressed areas as a holding measure prior to this action. This should be done before the next wet season.

**Repairs**

Blow out the cracks to remove all loose material. Apply MSP3 inverted bitumen emulsion to the surface and squeegee the emulsion into the cracks. Apply a fine slurry and squeegee into the cracks.

**Caution**

Hot sealing of passive surfacing cracks is an expensive and unnecessary operation. Milling out of surfacing cracks where there is little sign of deterioration or structural distress of the pavement is not warranted and is not a routine maintenance operation.

Care must be taken not to create a smooth or fatty surface with the fine slurry. Restrict the emulsion content to a maximum of 170 to 180l/m³.

**CROCODILE CRACKS**

**Description**

Crocodile cracking consists of a series of small interlinked near circular cracks often associated with pumping of fines in or after wet weather. It is often accompanied by rutting of the pavement in the wheeltracks and precedes pavement failure.

**Causes**

Crocodile cracking is caused by repeated deflections of the upper pavement structure (base and subbase) under wheel loading, particularly heavy vehicles, causing fatigue and ultimately failure of these layers. The failure of the pavement layers is accelerated by the ingress of water and hydraulic pressures induced by heavy vehicle wheel loads.

**Extent**

On most national routes crocodile cracking occurs on older pavements which are reaching the end of their service lives as a result of fatigue brought on by high deflections often accompanied by poor drainage.
conditions. The cracks are thus usually extensive. At the start of the fatigue failure process crocodile cracks can be isolated or occur where localised poor pavement materials occur.

**Response Time**
Where widespread crocodile cracking is occurring accompanied by pumping and rutting the pavement is rapidly approaching the end of its service life. SANRAL should be alerted to the road condition and actions required under the maintenance contract agreed on. Where the overall pavement condition is still fair and only isolated cracking is taking place limited bandage cracksealing may be justified to extend the pavement life.

**Repairs**
Limited areas of crocodile cracking can be treated by applying a geofabric "bandage" or a prefabricated road patch as a holding measure. The bandage should be protected by treating it with a further application of latex modified emulsion and a nominal 4,75mm grit (the use of crusher sand is not recommended) as per the supplier's specification.

**Caution**
- Widespread treatment of crocodile cracking is not a routine maintenance task.
- Because of the deflections which accompany crocodile crack distress, applications of light sealants such as Petroseal or slurries will reflect cracking in a short period of time (less than 6 months) and are not recommended other than as a very short term holding measure.
- Pavement failure patch repairs of crocodile cracking are not recommended as routine maintenance except in exceptional circumstances such as a localised problem in a relatively new pavement.
A careful check should be made of the following drainage conditions which could be causing the cracking:
- poor shoulder drainage
- water standing in mitre drains
- blocked, shallow or flat side drains
- blocked culverts
- water standing on wet road
- subsurface water

LONG CRACKS

Description
Fairly straight single cracks which often occur along construction joints in the surfacing or base. Also quite common where the surfacing meets concrete channels and kerbs. The cracks are generally open but not wide (say less than 5mm). However, they tend to catch and hold water. Other random single passive cracks can be grouped under this description.

Causes
At construction joints the crack occurs at a point of weakness which will be affected by thermal differences. It is often difficult to determine the reason for some of the other random long cracks.

Extent
The occurrence of passive long cracks can vary from isolated to extensive.

Response Time
These cracks can be handled as routine on an annual basis before the start of the wet season.

Repairs
Depending on the width of the cracks use the same repair method as described for Stabilization Cracks (smaller cracks) or Expansive Soil Cracks (wider cracks). Where the surfacing abuts concrete elements clean out all loose material and prime the concrete with creosote to improve adhesion and allow to cure before treating.
8.5 PUMPING

Description
Pumping is evidenced by the distinctive staining of the road surface from soils fines from underlying pavement layers. The stains are usually in the pattern of associated cracks and can be "reprinted" away from the cracks by the action of vehicle tyres.

Causes
The two major factors in pumping are water and traffic. Pumping mainly occurs when the rate of flow of water into the system (through open or cracked surfacing) is more rapid than that leaving/draining the system. The rate of flow is often inhibited by dense plastic shoulders or channels and kerbs. This results in a build up of moisture in the low areas. When the system becomes saturated all the voids in the base/subbase/surfacing are filled with water. Under heavy vehicle wheel loads large hydraulic (pore) pressures are generated which:
- force water out of the system
- generate sufficient hydraulic force to loosen and transport fines and grit
- weaken the structure of the pavement resulting in secondary cracks and potholes
- lift asphalt surfacing in low-lying areas where the asphalt is preventing free flow of the trapped water.

Repairs
No specific repair methods are recommended for pumping alone as the pumping occurs with other forms of pavement distress such as cracks and pavement failure. The quick answer would be to get rid of either water or heavy wheel loads. Wheel loads are in fact increasing steadily on our national routes every year in both volume and intensity. It is thus clear that due attention must be given to protection of the pavement layers against water ingress by efficient drainage and elimination of ponding.

The prevention of water ingress is achieved mainly by regularly resealing the road surface (periodic maintenance). Between such reseals any cracks which allow water into the pavement structure should be treated. Apart from normal maintenance of side drains and drainage structures (see Drainage) the prevention of ponding on the surfacing or on the shoulders must be given top priority and shoulder crossfalls should be checked especially on flat grades.
8.6 DEFORMATION

Introduction
Deformation is the change in road surface profile with the profile either above or below the original constructed level. The three common forms of deformation are rutting, undulations and settlement (commonly referred to as "slacks").

RUTTING

Description
Ruts are longitudinal depressions in the surfacing in the wheel paths. These can be clearly observed in periods of wet weather especially on flat grades where the water runs in the depressions. Ruts can also be identified with a straight edge or stringline.

Causes
Ruts are caused by the action of heavy vehicles (made worse by loading) on the pavement structure which results in compaction and/or shear deformation in the pavement. Narrow ruts tend to indicate that the problem lies in the upper pavement layers whereas wide, even-shaped depressions are caused by problems in the lower layers. The degree of rutting can vary from 3mm to 20mm or more depending on the following factors:

- the type of surfacing and base (thickness of asphalt, cement treated, emulsion treated or crusher run base)
- the age of the road
- the volume of heavy vehicles using the road and the amount of loading (E80s/day)
- type of subgrade and drainage conditions
- construction built in depressions or level irregularities not caused by traffic. Check these with a 2m straight edge which will only span a rut and not "bridge" an irregularity.

Extent
Rutting is generally intermittent to extensive but can vary considerably in degree (depth).

Response Time
On a relatively new pavement (up to 6 years) ruts deeper than 9mm suggest that something is wrong with the pavement structure and this should be brought to the attention of SANRAL. Any action required would not be routine maintenance. Where the pavement is middle aged (say 10 to 15 years) and ruts are in excess of 8mm it is recommended that nothing be done on rut filling under routine maintenance except where ponding occurs (typically on flat grades). Any significant ponding should be rectified as soon as possible especially before the wet season.
Where ruts are greater than 15mm to 20mm these are usually associated with cracking, pumping and displacement. Where these are isolated urgent repairs should be carried out as described under Pavement Failure.

**Repairs**

Fogspray the rutted areas with diluted emulsion. Apply a screed of coarse slurry or hot fine graded asphalt (the latter is preferred if readily available). Where coarse slurry is to be used a higher than normal cement content (1.5% to 2.5%) will stiffen up the slurry on curing. Both methods should be pneumatic rolled (the rear wheel of a laden truck can be used) and should be open to general traffic for several months before any sealing is carried out.

**Caution**

Rutfilling of long lengths is not a routine maintenance operation. Rutfilling should be trafficked for a significant time before reseals are placed to prevent punch in of chips. Normally on periodic maintenance reseal projects there are contractual time restraints. Where rutting is present on a routine maintenance project, and the budget permits, discussions should be held with SANRAL regarding a special rutfilling operation to be carried out by a specialist contractor well in advance of any anticipated periodic maintenance reseal contract (preferably several months before but never less than 12 weeks).

**SETTLEMENT**

**Description**

Settlement is evidenced by depressions (slacks) in the road surface. Slacks affect the riding quality and can be seen in wet weather when the surface water cannot drain away.

**Causes**

Settlement slacks are common on the approaches to structures and are usually as a result of poor backfilling close to the structure. Slacks can also occur over short lengths of road at intervals of approximately 2 to 4m or over fairly long lengths of road i.e. much greater than 4m. Short slacks could be caused by pocket failures of the foundation layers due to seepage from ponding or poor drainage in the mitre and table drains or build-up of water in the subgrade at the entrance and exits from cuttings. These slacks usually occur in the outer wheelpath adjacent to the shoulder, or sometimes in the shoulder.

Long slacks are caused mainly by settlement in fills and settlement of subgrade (e.g. collapsing sands or uncompacted subgrade) or by poor construction practice in end tipping fills or just poor compaction and poor control in placing fill to the correct widths at the toe of fill.
Extent
Normally slacks are randomly distributed at isolated places (often at structures). Each one should be treated on an individual basis.

Response Time
Where water ponds at settlement slacks or the ride over the slack is very bad a repair should be urgently effected. Other slacks contribute to a poor ride and can result in premature failure of the road pavement on the departure side of the slack or where standing water seeps into the pavement layers. The evaluation of the effect on the riding quality as a result of the slack is quite subjective but a marked "bump" in the ride should be taken out as a routine operation.

Repairs
Before work is started it is recommended that the cause of the slack be determined. Side drains and mitre drains should be checked for standing water and/or wet areas (vegetation such as reeds are clear indicators). Check the start and end of cuts for water concentrations (see Drainage for suitable measures). Providing the surface has not failed short slacks can be removed by string lining to beyond the slack, tacking with a diluted emulsion spray and placing hot asphalt by hand. Where the depth of the slack is greater than 50mm the asphalt should be placed in more than one layer (no layer > than 50mm). Long slacks where there are no surfacing or base failures can be repaired but hand work is not recommended as it is difficult to control the levels.

The following method has worked in practice:
Measure up the slack, arrange for a grader and a pneumatic roller and order hot medium graded asphalt. Clear off any dirt, silt and loose material from the surface of the road. Tack the surface with diluted emulsion. Dump the asphalt (delivery temperature not less than 150°C), spread and cut to level with the grader using the pneumatic roller in tandem with the grader. Where the maximum depth of the slack is greater than 150mm the asphalt should be placed in more than one layer possibly even leaving the first layer for a week or two under traffic. This work should be carried out on hot days during the middle of the day.

UNDULATIONS

Description
A non-localised wavy form of deformation often associated with heaving clay. Where significant
undulations occur they can be readily identified from the yellow line. The crests of the "waves" can be anything from a few metres to a hundred metres apart.

**Causes**
Main cause would be expansive clay subgrade movements. In certain cases poor compaction of fills and subgrade collapsing soils can also cause undulations through differential settlement (unusual on the national routes).

**Extent**
Can be extensive in areas of active clays or collapsing soils.

**Response Time**
While the rolling ride experienced over these sections is noticeable in most cases it is not necessary to do anything. Suitable signage can alert the travelling public and explain the uneven ride.

**Repairs**
Normally it is not possible or practical to carry out repair work under routine maintenance. However, occasionally at a drainage structure or in a low-lying ponding area treatment of one undulation may be necessary to deal either with standing water or a very bad bump. Repairs can be effected as described for Settlement.

### 8.7 TEXTURE

**BLEEDING**

**Description**
Bleeding is the movement of binder (bitumen) upwards relative to the aggregate or asphalt until there is a layer of free binder on the road surface. The road has a smooth slick appearance. In extreme circumstances small areas of "pluck out" occur where in hot conditions the free binder "sticks" to the surface of heavy vehicle tyres and pieces of the surfacing are lifted out on the tyres. This "pluck out" often occurs where a modified binder has been used for resealing over a gap-graded asphalt surface and punch in of chips has occurred.
Causes
- Over-application of binder either due to inappropriate design or construction actions.
- Punching of surface chips into the base or slurry levelling layer.
- Unstable asphalt.
- Problems with the quality of binder.
- Concentrations of traffic loadings on steep grades, at sharp corners, breaking on downgrades, approaching stops/intersections or sharp turning movements (intersections).
- Diesel or oil spillage.
- Volatiles "locked into" the seal from uncured prime or the use of cut back binders.

Extent
Bleeding can be isolated occurring at intersections, spray joints, patches and at random points. Where problems are due to a specific reason such as a construction overspray or steep grade, bleeding will occur over a discrete length. Alternatively bleeding can be extensive over long lengths of road.

Response Time
Where bleeding occurs over any significant length, actions to rectify this such as a reseal, an open graded asphalt overlay or mill out and replace do not form part of routine maintenance. Localised problems can be treated where they occur in potentially dangerous situations such as at an intersection or at a sharp curve. Warning signs should be erected indicating slippery conditions.

Repairs
Before attempting localised repairs the surface should be assessed for texture depth (sand patch test), presence and thickness of free binder on the surface and in the case of asphalt, stability (check line markings for movement). Enquire from SANRAL whether surface friction information is available.

Where free binder is present on the surface a rolled in stone could be considered. The size of stone, varying from 6.7mm to 9.5mm, would depend on the thickness of free binder. Work should be done in the middle of the day during periods of hot weather. Pre-treat the surface by spraying lightly with power paraffin and then heavy brooming the surface to break the oxidised surface and soften the binder. Apply a
light application of pre-coated chips, roll well with a pneumatic roller and broom off loose chips. Preheating of the aggregate to 150°C either in a local asphalt plant or for small quantities in a 200l half drum assists adhesion. Particularly where large stone is used or the binder film is thin, a tack coat of diluted emulsion at 0.6 per square metre may be necessary. A very light application of grit after chipping helps to lock up the chips under heavy traffic.

Prefabricated 13mm road patches or grit armoured geofabric bandages are ideal for repairing small bleeding areas (similar to treating of Crocodile Cracks).

As a holding action for a limited period (say 18 months), a lean application of coarse slurry can be applied. This would apply to the more severe potentially dangerous areas in widespread bleeding before a periodic maintenance contract is carried out.

An alternative treatment which has been used successfully in the past is to sandblast the excess binder off the road surface.

**Caution**
- Milling out is not appropriate on routine maintenance. This action, a reseal or an overlay, falls into the category of periodic maintenance.
- Crusher dust containing fines should not be used on bleeding areas. It forms a slick bitumen-rich unstable skin on the surface.

**RAVELLING**

**Description**
Ravelling is the loss of surfacing stone normally from seals but can also occur in lean asphalts or where rolled in chips come loose. Usually the tack layer of binder remains on the road.

**Causes**
- Underspray in seal.
- Dirty aggregate.
- Abrasion of traffic.
- Surfacing in cold weather.
- Opening the seal too soon to traffic before the bitumen has set up or because of under rolling.
- Ageing of the binder or asphalt.
- Underlying old seal or asphalt too porous and not pre-treated.
- Certain types of aggregate (from acidic rocks) used without pre-coating.

**Extent**
Generally ravelling is isolated and found commonly at surfacing joints. In certain cases it can be extensive. Often occurs along the centreline and on surfaced shoulders.
Response Time

Where ravelling is a construction defect and the exposed binder is undamaged and has aged (no likelihood of pick-up on vehicles tyres), narrow widths or localised areas can be left as a low priority. On an older seal or asphalt where ravelling is progressively increasing holding action may be necessary until the road is up for periodic maintenance.

Repairs

Localised areas of ravelling (construction related) can be treated in the same way as described for Bleeding. Apply a light spray of power paraffin to soften the surface. Apply a tack coat of emulsion, chip with a pre-coated aggregate (same size as the adjacent seal aggregate) and roll well with a pneumatic roller. Preheating of the aggregate to 150°C assists with adhesion. Fog spray lightly with a diluted emulsion and apply a very light application of grit or crusher sand.

Where progressive stone loss is occurring on an aged surface as a short-term holding measure (2 years) in limited areas, the surface could be treated with a diluted emulsion fog spray to retain the chips and where loss is severe followed by a fine slurry. A fogspray could be carried out as part of routine maintenance. Ravelling in bellmouths can be treated by the application of a slurry.

8.8 SHOULDERS - SURFACED

EDGEBREAK

Description

Edgebreak is the failure of the edge of the surfacing usually accompanied by a loss of gravel on the shoulder. If allowed to progress edgebreak can also result in loss of the underlying base layer.

Causes

- Loss of gravel on the shoulder leaving the edge of surfacing proud without support.
- Traffic riding close to or on the edge of the surfacing.
- Traffic turning on and off the surfacing e.g. at accesses, laybys and parking areas.
- Narrow width of surfaced road (unsurfaced shoulders) associated with significant volumes of heavy traffic.
Extent
The distress can be isolated (access) or extensive (narrow surface or shoulder gravel loss).

Response Time
Where edgebreak is left untreated for any period of time, the failure can result in progressive failure towards the centre of the road and also loss of base. This can become a hazard to road users. Such increase can be quite rapid at well-used turn-offs and these should be attended to as soon as they are identified. Widespread edgebreak which is occurring gradually should be repaired on a routine basis.

Repairs
The preferred repair method is to cut out all breaks neatly parallel to the centreline, remove all loose material, prime tack and replace with hot asphalt. The outside edge should be supported with some form of shutter to give good support during the repair. Cold asphalt may be used but is likely to be porous and should be sealed with Viaseal, Petroseal or similar. On thin surfacings where the base is still sound a coarse slurry repair can be successful. Once the outer edge has been repaired the shoulder gravel must be made up to level and compacted. At heavily used intersections where erosion of the gravel will quickly reoccur construct a concrete edgebeam. The use of precast blocks for the edgebeam is not recommended.

Loose gravel carried from intersections onto the surfacing can cause damage to the seal and also be a hazard to the travelling public. Loose gravel should be regularly broomed off the road. Where this occurs on an ongoing basis consider surfacing the bellmouth.

Caution
Where gravel loss occurs rapidly over widespread lengths (e.g. narrow surfaced width) the road edge must be frequently regravelled to prevent ongoing edgebreak. This situation should be brought to SANRAL’s attention so that during upgrading or rehabilitation this problem can be addressed by widening the bitumen surfacing.
8.9 SHOULders-GraVel

GraVel LosS / Steep ShOulder (DROP-OFFS)

Description
The gravel on the shoulder is lower than the adjacent surfacing causing a step from surfacing to gravel or falls away too steeply from the surfacing. This is often accompanied by surfacing edgebreak either localised at surfaced intersections, laybes and informal stopping places or over longer lengths particularly where the surfaced width is narrow.

Causes
- Water and erosion particularly on steep grades.
- Traffic, particularly heavy vehicles turning on and off surfaced pavements (localised).
- Narrow surfaced width - heavy vehicles are forced to ride close to the edge causing wind and wheel erosion.
- Poor quality gravel (not good wearing course material).
- Lack of regular maintenance/re-gravelling.

Extent
Isolated: Loss of gravel where vehicles turn on and off
Extensive: Long lengths on steep grades or where road surfacing is narrow.

Response Time
Gravel loss can give rise to edgebreak and on long sections can be a hazard to traffic which rides on the shoulder. At intersections/accesses gravel loss should be repaired before edgebreak starts, say when "step" is greater than 50mm.

Repair Methods
Isolated: At intersections/accesses/laybes construct a concrete edgebeam in accordance with the standard drawings. Check the approach grade from the side. If the transition from the surfacing to the shoulder crossfall is not gradual the gravel quickly erodes. Where necessary place extra gravel, rip up and re-compact to reform the shoulder.

Extensive: Import suitable wearing course gravel (refer to TRH2 for gravel specification) to make up shortfall, rework together with the in situ gravel in layer thicknesses of at least 75mm adding water and
compacting to 93% of Mod AASHTO density. If the shoulder is too narrow to accommodate a grid roller oversize must be either broken down in the borrow pit or finer material located. The shoulder crossfall should be at least 1% and preferably 2% steeper than the surfaced road crossfall. Make sure that the shoulder breakpoint is rounded off (no windrow) so that water drains off. Provided a reasonable crossfall and shape can be achieved the shoulder can be restored by constructing a wedge rather than reworking the shoulder for the full width and depth. Where available reclaimed asphalt material can be used to restore the shoulder.

**Caution**
If the gravel loss is widespread and is due to heavy vehicle action on a narrow pavement significant loss will rapidly occur again especially during a wet season, no matter how good the gravel quality is. Repeated gravelling of the shoulder at frequent intervals is costly and time consuming. Consideration should be given by SANRAL to either widening the road or treating the gravel in the worst areas with a diluted emulsion mixed and compacted into the top 25 to 30mm. Do not stabilise the shoulder material to the depth of the base layer with cementitious materials if the base is not stabilized. This will trap moisture in the base preventing drainage and base failure is likely to occur.

**FLAT/HIGH (EDGE BUILD-UP)**

**Description**
Locations where the gravel shoulders are either flat or higher than the surfacing, have a windrow of material at or near the break point or are overgrown usually are associated with either standing water or ponding during heavy rain.

**Causes**
- Lack of corrective maintenance.
- Incorrect re-gravelling work.
- Soil fines blown onto shoulder or washed on from surrounding lands during heavy rain.
- Spillage from quarry or coal trucks.

**Extent**
Generally these defects occur in a particular area and are intermittent to extensive.

**Response Time**
Where water ponds on the road and causes a traffic hazard the situation needs urgent attention.
Repair Methods

Flat or high shoulders need to be reshaped to the crossfall at least 1% and preferably 2% steeper than the road crossfall. Vegetation can also be removed during the reshaping operation. Care should be taken to ensure rounding off at shoulder break point (no windrows). Where vegetation is a significant problem herbicides can be sprayed by a suitably certified person. This can be an environmentally sensitive issue - (see paragraph 12.6 on control of vegetation). Where fines are carried onto the road by water suitable catch drains, mitre drains or side drainage need to be in place (see Chapter 10 on Drainage). It may be necessary to liaise with the landowner if the problem lies beyond the road reserve.

At low points in flat grades, concrete lined mitre drains can be constructed to remove water from the shoulders more efficiently.