ASPHALT PAVEMENT MAINTENANCE

A guide for evaluating pavement surface conditions to preserve, extend and maintain pavement service life through timely efficient maintenance practices.

BRITISH COLUMBIA
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ASPHALT PAVEMENT MAINTENANCE, FOURTH EDITION

A GUIDE TO OPTIMIZING THE PAVEMENT LIFE CYCLE THROUGH QUALITY/TIMELY PAVEMENT MAINTENANCE PRACTICES

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INTRODUCTION

Pavement failures come in three major types: cracks, surface deformations, and surface defects. Cracks are the cracking of the pavement surface and range from hairlines to broad gouges. Alligator cracking, where cracks form a grid or blocks is especially serious. Surface deformations are ruts, washboarding (shoving) and other distortions of the pavement surface. Improperly repaired utility cuts which have sunk are also in this category. Surface defects are asphalt oil on the surface (bleeding), loose aggregate spalling off (raveling), and potholes. It is not uncommon to have multiple failures overlapping, especially alligator cracking and surface deformations.

There are several causes of pavement failure: failure from water seeping into the pavement structure; a failure due to poor quality materials used in the road base; a failure of construction (improper compaction); an increase in loading on the pavement due to change of use; or a failure of the asphalt mix. Water seeping into the road structure weakens the mix or under layers, and should be fixed by first fixing the drainage then by removing weakened portions and replacing them. Water seeping into the road structure can often be prevented by prompt sealing of cracks and the regular maintenance of storm drains and ditches. A failure of construction is generally due to two things: improper compaction, or failure to properly tack coat. Both change of use and a failure of the asphalt mix indicate that the asphalt mix in the area is not strong enough and must be addressed by changing the mix used. Before any repairs are done, the cause should be determined or the failure will re-occur.

For all failures the repair process has four steps: identifying the failure, identifying the cause of failure (usually drainage), correcting the cause of failure, and repairing the failure. Temporary repairs are often performed while waiting for expert help to identify cause of failure or because conditions do not allow a permanent repair. (Generally, the weather needs to be warm and dry for permanent repairs.) Temporary repairs are done to keep water from seeping into the pavement through a crack or depression or for driver safety (e.g. pothole spray patching.) Temporary repairs should be replaced as soon as possible with a permanent repair. All repairs should be done with appropriate safety and traffic control measures in place.

Obviously, it is desirable to stop pavement deterioration before the road fails; this is the purpose of surface treatments. Performed on a regular schedule, these are preventative maintenances. Surface treatments consist of a thin layer applied over the top of an existing asphalt pavement, to seal microcracking and provide a new, smoother wearing surface. (They will also treat ravelling.)

At a pavement's end-of-life, rehabilitation becomes necessary. If the pavement has been well-maintained and there are not significant base failures, it may be possible to do an asphalt overlay or hot-in-place recycle; if the pavement is very worn and requires total replacement, a mill and fill may be a better option.

All products used on Ministry of Transportation and Infrastructure (the Ministry) roads should come from the Ministry's Recognized Products List, which can be found at http://www.th.gov.bc.ca/publications/eng_publications/eng_pubs.htm. These are products which meet the Ministry's standards; however, no endorsement is intended or given.

Additionally, the Ministry's standards for highway construction, The Standard Specifications for Highway Construction can be found at http://www.th.gov.bc.ca/publications/const_maint/contract_serv/standardspecs.htm

The standard specifications are the official Ministry requirements for all road work and should always be followed when performing repairs. Standard specification (SS) 502, Asphalt Pavement Construction, covers the general requirements; additional sections are mentioned where relevant.

Other Ministry publications may be of use and can be found at: http://www.th.gov.bc.ca/publications/repopubs.htm.

For any concerns you may have or advice about pavement repairs, contact your regional office. Photographs of the defect(s) should be sent, as they can save the regional staff a field visit. You should consult your regional office when a new or unfamiliar technique is being proposed, or the same stretch of road requires repeated repairs (this indicates that that stretch of road may require rehabilitation.)

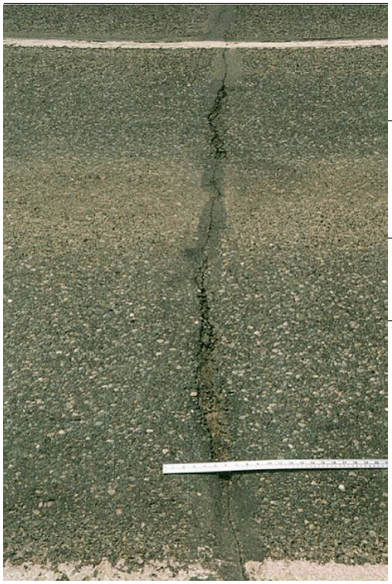
For concerns about bridges or large culverts (greater than 3m wide) contact the Bridge Group at headquarters (250)-387-6931.)

Lastly, this guide contains the best practices used at the time of its publication and is intended for the information and understanding of Ministry staff to aid them in the field; a contractor may use any technique which meets the requirements of the Standard Specifications and/or the tender documents and is not prohibited by the Standard Specifications and/or tender documents.

IDENTIFICATION, CAUSES AND REPAIRS CHART

For detailed information on pavement inspections a copy of the 2012 Pavement Surface Condition Rating Manual should be obtained from: http://www.th.gov.bc.ca/publications/const_maint/cmb_publications.htm. All photos in this section are taken from that manual.

DESCRIPTION: Cracking across the road lanes



Possible Types*

Transverse Cracking (TC), also known as Thermal Cracking

Most Likely Cause

Shrinking due to low temperatures, frost heave, and reflection cracks.

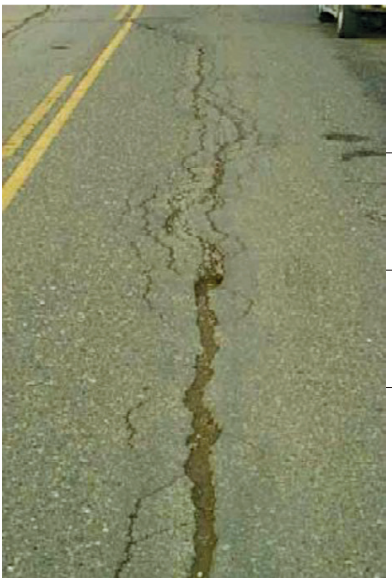
Possible Repairs

Crack Treatment

Notes:

Reflection cracks are where the cracks in the surface beneath are mirrored by the surface above. Thermal cracking is most often the result of the use of too hard of an asphalt binder

DESCRIPTION: Cracking parallel to road lanes



Possible Types*

Longitudinal Wheel Path Cracking (LWP), Longitudinal Joint Cracking (LJC), Meandering Longitudinal Cracking (MLC),

Most Likely Cause

Frost heave, poor joint construction (LJC), heavy traffic (LWP), and construction problems (MLC)

Possible Repairs

Crack Treatment or Spray Patching (if cracks are > 35 mm in width)

Notes:

The difference between these cracks is location. All can be caused by frost heave, plus each has its own likely cause.

DESCRIPTION: Cracking at the edge of the pavement

Possible Types*

Pavement Edge Cracking (PEC)

Most Likely Cause

Inadequate granular or asphalt structure on the shoulder (too little support for the paved shoulder in its base), vehicles running close to the pavement edge, poor edge drainage, and frost heave.

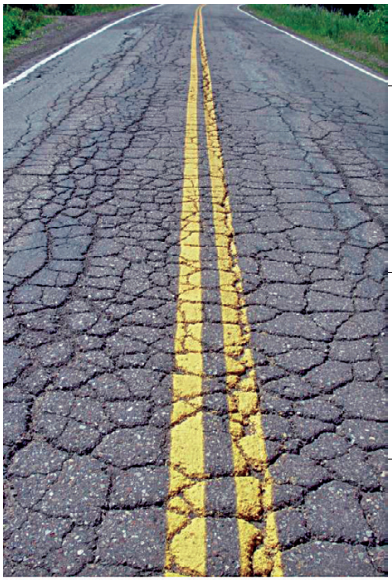
Possible Repairs

Crack treatment and/or rebuilding the shoulder wider, with good fill.

Notes:

Check for adequate ditching to ensure there is no standing water. Vegetation should be cleared away from ditches, as plants retain moisture and cause poor drainage.

DESCRIPTION: A grid or network of cracks, like a wire mesh



Possible Types*

Alligator Cracking (AC)

Most Likely Cause

A failure of the road base material at some level, due to poor quality materials, inadequate structure, lack of base strength, or lack of drainage. May be deep or shallow.

Possible Repairs

Repair of drainage if necessary, possibly replacement of base materials, then a full depth patch. For temporary repair spray patching may be utilized.

Notes:

As alligator cracking indicates a failure of the basic structure of the road, its presence as part of any failure indicates that failure is severe and requires full depth patching. Removal of the failed asphalt must take place prior to any patching.

DESCRIPTION: Depressions in the wheel path (ruts)

Possible Types*

Rutting (RUT)

Most Likely Cause

Excessively soft asphalt due to poor mix design or improper compaction during construction. Alternatively, base materials collapsing or poor support of pavement by road shoulder.

Possible Repairs

Temporarily, grinding pavement level. Severe rutting should be replaced with a full depth patch as soon as possible.

Notes:

Should never be solely paved over; without grinding or levelling the ruts will mirror through and re-appear.

DESCRIPTION: Waves in pavement along direction of travel, 'washboarding'

Possible Types*

Shoving (SHV)

Most Likely Cause

Heavy loaded vehicles slowing down or speeding up – i.e. at intersections or on hills. Also, poor stability of the asphalt mix or unstable base. Asphalt may be destabilized by fuel spills, inadequate tack coating or dirty surface prior to paving.

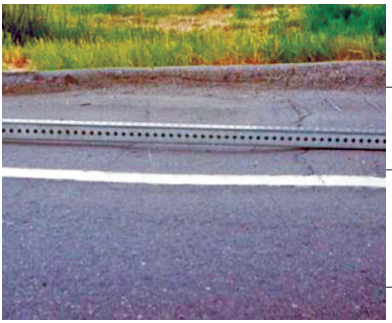
Possible Repairs

Temporarily, grinding pavement level. Should be replaced with a full depth patch as soon as possible.

Notes:

Should never be solely paved over; without grinding the waves will mirror through and re-appear.

DESCRIPTION: Pavement bulged or sunk



Possible Types*

Distortion (DST)

Most Likely Cause

Frost heave or settling of the base materials.

Possible Repairs

Temporarily, leveling. Should be replaced with a full depth patch as soon as possible.

Notes:

Distortions may be caused by failures of any portion of the road structure. Check for collapsing embankments, failed culverts and other failures of road structure if severe distortion is found.

DESCRIPTION: Sunken utility trench

Possible Types*

N/A

Most Likely Cause

Improper compaction of the backfill used.

Possible Repairs

Levelling or full depth patching. If full depth patching is done, the backfill from the hole should be used to re-fill the hole.

Notes:

Whenever trench construction is performed it is a good practise to utilize the excavated material or materials similar to the existing material to help ensure new area does not promote frost heaving or uneven settlement.

DESCRIPTION: Sticky, shiny and slick black substance on road

Possible Types*

Bleeding (BLD)

Most Likely Cause

Tack coating tracking onto existing paved surface, mix design with excessive asphalt content or low air voids, and poor application of a surface seal coat.

Possible Repairs

To low severity bleeding, sand may be applied to absorb the oil and create a gritty surface. If it is a safety concern milling and/or an overlay patch.

Notes:

More common on hot days, which reduce the viscosity of the asphalt oil.

DESCRIPTION: Hole in the pavement

Possible Types*

Pothole (POT)

Most Likely Cause

Localized issues with the asphalt mix or drainage.

Possible Repairs

For temporary repair, filling with cold mix. Otherwise, a pothole patch.

Notes:

DESCRIPTION: Loose material coming off of road surface, leaving pits and gouges

Possible Types*

Ravelling (RAV)

Most Likely Cause

Poor adhesion of aggregates due to wet aggregate or lack of asphalt, aggregate fracturing due to heavy loads, poor compaction allowing water to strip aggregate, poor construction causing segregation of asphalt and aggregate and old pavement that has been weathered.

Possible Repairs

A surface treatment. Sealcoat or microsurface if ravelling is extensive, spray patching if localized areas.

Notes:

ASPHALT REPAIR METHODS

Repair methods range from quick emergency fixes for potholes and simple crack sealing techniques, to completely ripping up a stretch of road and rebuilding it. A repair should be selected on the basis of severity of pavement failure. If the failure is severe, complete rebuilding may be an option.

Before any repair is done, the cause of failure should be identified and addressed. For many types of failures, water penetrating either the asphalt or the base courses may be the culprit—drainage should always be checked. If the cause of the pavement failure is not addressed, the same repair will need to be made repeatedly, wasting time and money.

REPAIR PROCEDURE

The general repair procedure for pavements is:

1. Determine the type (see the Identification, Causes, and Repairs Chart on pg. 3) and frequency of failures: How many failures are there in the pavement and how close together are they? The more failures are present, the more severe the pavement failure.
    a. Alligator cracking combined with other failures indicates a severe failure of the underlying materials. That stretch of road will need complete re-building. Except for safety reasons (e.g. a deep pothole), patching should be avoided.
    b. If there are many areas requiring skin patching and/or leveling in one section, consider rebuilding the road section. Applying an overlay-style 'patch' will not fix the problem.
2. Determine cause(s):
    a. Check drainage
        i. Check ditches for standing water, plants and vegetation or blockages. Vegetation can retain water and blocks ditches, causing swampy conditions. The vegetation may need removal if this occurs, the same as a blockage.
        ii. Check any storm water lines for blockages.
        iii. Check the road slope—will water drain off the road or pool on the road?
        iv. Check any culverts—are they plugged or collapsed? Report collapsed culverts to the Bridges section at the Ministry (see Ministry Phone Numbers on pg. E-1.) Culverts under 3 m are not the responsibility of the Bridges section and should be reported to the maintenance contractor for repair. (See Bridge handbook for details.)
    b. Check for construction issues

c. Check for changes of use—how much traffic is using the route? Are there more semi-trailers? Heavy trucks and busses are often a cause of pavement damage.
d. Does the road have a strength deficiency?
e. Have load restrictions been put in place during spring break up?

If none of the above are found, the issue may be with the mix design of the asphalt or the base materials. Contact the regional office for geotechnical advice and assistance (see Ministry Phone Numbers on pg. E-1); a temporary repair should be performed if safety or water penetration into the pavement is an issue.

3. Fix the causes, if possible. If the causes are not correctable by the contractor, contact the regional office; see Appendix E, Ministry Phone Numbers. A temporary repair should be performed if safety or water penetration into the pavement is an issue.
4. Once the underlying causes are fixed, check the weather. Permanent repairs require warm, dry conditions, often for several days. If the weather is unsuitable, schedule a permanent repair for a more suitable time when the weather forecast is conducive to the work. Perform a temporary repair if safety or water penetration into the pavement is an issue. Note: crack sealing with an asphalt emulsion may not be as weather limited; check the product specifications for temperature range and if the product can be used on wet pavement. Often it is best to conduct crack sealing early in the year, before the heat of the summer. The cracks will close up in the summer making them difficult to treat properly.
5. If the weather is good, perform an appropriate permanent repair:
   a. Cracks (pg. 13):
      i. Under 25mm, a crack should be sealed.
      ii. Over 25mm, a crack should be filled.
   b. Depressions, shoving, and potholes should be full depth patched (pg. 14.)
   c. Ravelling can be repaired by an overlay (pg. 17), graded aggregate seal (pg. 15.), microsurface, or spray patch (if localized).

TEMPORARY REPAIRS

Temporary repairs are done when time, resources, or weather do not allow a more permanent solution. Locations that have been temporarily repaired should be noted, and given a permanent repair as soon as possible.

Temporary patches are placed to seal a pavement against water (for example spray patching alligator cracking), or for user safety (for example a quick fill of a pothole with cold mix.)

Common temporary repairs include:

- Skin patches;
- Pavement leveling;
- Grinding ruts level;
- Pothole filling with cold mix;
- Spray patching.

SKIN PATCHES

Properly constructed skin patches seal pavement surface defects so that moisture cannot enter the pavement and cause further deterioration. Skin patches are temporary repairs and should not be done over large areas in an application similar to laying down a pavement overlay; it should only be used on small 'tabletop' sized areas that have failed.

Procedure

1. Begin by marking the outline of the patch area with a lumber crayon or spray paint.
2. Clean the area to be patched of all debris, especially dust and dirt, using a broom or compressed air. Dust and dirt on the surface to be patched will prevent a bond from being formed between the old and new pavement.
3. Apply an asphalt tack coat to the area. The tack coat is the patch's only adhesive bond with the underlying layer, so apply it conscientiously. Since the asphalt used to prime the patch area is usually emulsified asphalt, it must be allowed to set or cure prior to placing the patch mix (you will see the emulsified product turn from a brown to a black colour.)
4. When the tack coat has cured, the asphalt mix is applied to construct the patch to the desired level. Make sure that drainage is not impaired by the raised surface of the patch. Careful raking and trimming of the patch surface and edges is necessary to provide a smooth surface. The edges are carefully "feathered" to provide a smooth transition. Repeated layers may be necessary—see steps 4, 5, and 6 in Pavement Leveling below.

5. Compact the patch thoroughly. Start compacting from the outside edges working towards the centre. Poor compaction leaves a weak patch that fails quickly.

Make Sure:

- The size of the patch is only slightly larger than the failure – several failures in an area should be patched individually, not given a large overlay. If the frequency of the failures is very high, thought should be given to grinding the pavement completely off and repaving.

PAVEMENT LEVELING

Pavement levelling is the repeated application of asphalt layers to a depression or hole until the compacted repair is flush with the road surface. Like skin patches, pavement levelling should not be done over large areas in an application similar to laying down a pavement overlay.

1. Begin by marking the outline of the depression with a lumber crayon or spray paint.
2. Clean the area to be patched of all debris, especially dust and dirt, using a broom or compressed air. Dust and dirt on the surface to be patched will prevent a bond from being formed between the old and new pavement.
3. Apply a light but thorough tack coat to the pavement surface, to bond the repair to the existing asphalt.
4. Apply a layer of hot mix asphalt not thicker than 75mm for proper compaction.
5. Compact the layer thoroughly. Poor compaction leaves a weak patch that fails quickly.
6. Repeat steps 3, 4, and 5 until the patch is level with the surface. (Use a straight edge on the road to check.) Feather the edges where they meet with the existing surface. Ensure the feathered edge does not extend past the tack coating as the material will not bond.

TEMPORARY POTHOLE REPAIR

To temporarily repair a pothole clean out the loose material and standing water in the hole, and fill it with a premixed patch material (cold mix asphalt). See Pavement Leveling, pg. 11, for a description of the process, replacing the hot mix with the patch material. Cold mix can be used in colder temperatures than other types of asphalt; it may be possible to place a temporary patch in the middle of winter. Check the product specifications for details. A semi-permanent patch can be made by leveling the pothole with hot mix or by spray patching (see pg. 11.)

Make Sure:

- Spray patching is not utilized on large or deep potholes as the material will push and be displaced.
- The cold mix is compacted, even if the wheels of a truck are all that is available.
- The final grade of the filled and compacted pothole repair is slightly above the final grade of the surrounding roadway.

SPRAY PATCHING

Spray patching involves a truck with a boom arm that can spray high pressure air, asphalt emulsion, or aggregate. The truck uses the air to clean the surface, then sprays a tack coat of asphalt, dumps aggregate into the defect, and follows it up with another blast of asphalt. Typically, the spray patching operation can be controlled from the cab of the truck, and requires only one operator. This makes it very economical; however it is not suited for all pavement repairs. Transverse or thermal cracking should always be treated early on with a crack seal. Only in cases of bad neglect, where the transverse cracks have been allowed to open beyond 35 mm should spray patching be considered as a viable option. Spray patching should only be used on very wide cracks (greater than 25mm wide) and on smaller potholes—large, deep potholes are not suitable for spray patching.

An example of spray patching used to treat transverse cracks. This is an example of poor spray patching, as the ride was not improved because the patching created bumps.

Make Sure:

- Surfaces to be treated are clean, free from dust and debris, and dry.
- Spray patching is not utilized on large or deep potholes as the material will push and be displaced.
- Spray patching is not conducted on cracks less than (25 mm or 35 mm), otherwise the spray patching only forms a bridge over the crack, and does not penetrate into the crack to permanently seal it like a proper crack seal process will.

Permanent Repairs

The objective of a permanent repair is to fix the failure so the patch will not need to be re-done. This requires that the cause of the failure be addressed and that care be taken in how the repair is constructed. Improper compaction, for example, will cause a full depth patch to fail rapidly.

CRACK TREATMENTS

The objective of crack treatments is to prevent the entry of water into the road base. Water causes loss of strength, transports fine materials (contaminating the base course), and results in the subsequent failure of the base and pavement layers. Where water is present in the base, moving traffic causes fine materials to pump out of the base and undermine the pavement. This action causes minor cracks and failures to spread, creating major problems. Cracks under 25mm are sealed; over 25mm are filled. Note: spray patching is only suitable for crack filling, i.e. cracks wider than 25mm. Crack treatments are covered by SS 536.

CRACK SEALING

Crack sealing products can be generally divided into two categories:

- Hot rubberized seals, comprising of a mixture of asphalt and rubber.
- Hot or cold non-rubberized seals, normally an emulsified high float consisting of treated asphalt products.

Cold seals are designed for application at ambient temperature; hot seals must be heated to high temperatures to turn liquid for use.

Only those products designated as crack sealers listed in the Ministry's Recognized Product List should be used. In areas with more temperature variations, non-rubberized seals, usually asphalt emulsions, are preferred as rubberized seals will flex out of the crack as the pavement shrinks and expands with temperature changes. In areas with fewer temperature changes, rubber seals are preferred, as they are stronger. Refer to the latest version of the recognized Products List for a list of products available.

Pavements over ten years old should not be sealed with rubber seals as the seal will be stronger than the pavement. As the pavement naturally expands and contracts, the rubber seal will not move, pulling the pavement apart. Rubberized seals can cause issues with future rehabilitation, notify the Regional Program Manager prior to use.

Procedure:

1. The crack must be cleaned using compressed air to permit the sealant to penetrate down into the crack. Additionally, the cracks must be dry. Usually hot compressed air is used for cleaning as it both cleans and dries. Dust on the pavement edges will prevent the sealer from bonding with the crack sides, and leads to early failure of crack seals.
2. The sealing compound is applied, at the temperature recommended by the manufacturer in order to properly penetrate the cracked area.
3. The crack sealer is squeegeed to spread the sealer evenly in and onto the failed area to form a bond with the surrounding asphalt pavement surface. An overlap of sealant is needed to bond the seal with the surrounding pavement. The width of the overlap at the crack should be a minimum of 25mm and a maximum of 40mm on each side of the crack.
4. For emulsified asphalt seals, blinding sand should be applied after the sealer has had time to flow into the crack and setup and prior to traffic being allowed. Note: this sand makes roads dirty, leads to sand on road edges, and causes difficulties for cyclists. On high volume or urban roads, rubber seals, which do not require sand, are preferred.

Make Sure

- Rubber crack seal is heated to the correct temperature, as specified by the manufacturer
- Cracks are properly cleaned (blown out), and dry.
- The overlap is smooth and does not create bumps

CRACK FILLING

Crack filling is similar to crack sealing, except an asphalt mix is placed in the crack instead of a liquid product being poured into it. Cracks over 25mm wide should be filled. A spray patching machine (pg. 11), can be used. Warm mix asphalt, with a longer handling time than hot mix, is an excellent choice for crack filler.

MILL AND FILL PATCHES

Mill and fill patches should be used to permanently repair pavement failures where the cause is determined to be in the asphalt and not the base. A mill and fill patch is the same as the rehabilitation option, simply done on a smaller scale.

Note: Larger sections of mill and fill (greater than tabletop size) become a rehabilitation option, and should not be pursued. If the failure is generalized, notify the regional paving manager.

See pg. 18, Mill and Fill, for the procedure.

FULL DEPTH PATCHES

Full depth patches remove damaged pavement and base materials, and then reconstruct the base and pavement removed. They should be used to permanently repair pavement failures where the cause is determined to be in the base below the asphalt i.e. distortions: shoving, rutting, and potholes. Perform a full depth patch after the causes of base and pavement damage have been determined and fixed.

Procedure:

1. Begin by marking the outline of the damaged area with a lumber crayon or spray paint. Then mark a cutline on pavement 30 cm (one foot) out from damage area ensuring a smooth transition between the existing asphalt surface and the new patch material
2. Using a pavement saw cut the pavement out on the cutline. Edges should be smooth and vertical; ragged edges will result in pavement failures around the new patch.
3. Remove the cut pavement and all underlying base material as deep as necessary to reach firm support. If water in the structure is the cause of the failure, adequate drainage should be installed or existing drainage repaired so that the failure does not reoccur.
4. Level and compact the base material. If the depth of excavation warrants, additional good granular material may be added and compacted in 15 cm or 6 inch layers to raise the base level. Compaction of the underlying base material (with the use of water to aid compaction) is necessary to ensure that it provides proper support for the pavement layers.
5. A tack coat of emulsified asphalt is then applied to the vertical faces of the cut. The purpose of the tack coat is to provide an adhesive and waterproof asphalt bond between the patch and the surrounding pavement.
6. Patch the area with hot mix asphalt. The asphalt patch should be placed in several layers of not more than 75mm because single deep layers cannot be compacted properly.
7. Careful raking and trimming of the asphalt surface, especially in the top layer of the patch, should be done to provide a smooth and even surface finish. The uncompacted mix is left high enough to leave a compacted patch that is flush with the surrounding surface. Quick and thorough compaction of the joint area helps make a strong, watertight bond between old and new pavement. If the mix is allowed to cool prior to placing, proper compaction cannot be achieved. . Start compacting from the outside edges working towards the centre.

SURFACE TREATMENTS

Surface treatments are done to extend pavement life by applying a fresh surface to the pavement. These treatments will seal hairline cracks, but not large ones, and are commonly used to address widespread ravelling. Depressions, shoving and potholes should be fixed, cracks treated, and the underlying cause of these failures addressed before any of these seals are applied. Otherwise, the previous problems will re-occur.

Surface treatments are usually scheduled by the Regional Resurfacing Manager. The regional office will know what roads are scheduled for surface treatments in your area in the next few years.

Surface treatments are covered by SS 531, with the exception of graded aggregate seals which are covered by SS 508.

GRADED AGGREGATE SEALING

Applying a graded aggregate seal (GAS) on an existing pavement improves the road surface in the following ways:

- It fills and seals fine cracks in the pavement and protects ravelling surfaces, preventing further deterioration of the road and subsequent damage to the base by re-establishing an impervious surface;
- It provides an abrasion resistance surface coat of aggregate which resists the wearing action of traffic;
- It provides a skid resistant surface, especially in wet weather; reducing hydroplaning
- It provides a light coloured, more reflective road surface for better night visibility.

A GAS should not be applied over pavement failures except ravelling: cracks should be filled, depressions levelled and areas of base failure (indicated by alligator cracking or other severe pavement distresses) excavated and replaced. A GAS, however, makes an excellent cover for these types of repairs, restoring a smooth, level surface and protecting the underlying pavement from further damage. SS 508 covers GAS.

Procedure:

1. Prepare road surface to be sealed—sweep for dust and loose debris, fill major holes and cracks, level any depressions or bumps by the application of levelling course, grinding or with pavement patches.
2. Spray emulsified asphalt evenly onto the road surface using a distributor truck, which glues the aggregate to the existing surface. The quantity of emulsion is calculated in a mix design which will vary depending on the properties of the aggregate to be used. Generally the application rate of emulsion is 1.7 to 2.2

litres per square metre. It is important to provide a perfectly even film of asphalt on the road surface, proper adjustment and operation of the distributor unit is critical:

- The operator must ensure that all the nozzles are clean and spraying properly. Plugged nozzles should be immediately removed and cleaned.
- All the nozzles should be set at a 30 degree angle to the spray bar, so that the spray from each nozzle does not interfere with the adjacent ones. Special wrenches are available to set the nozzles properly. An incorrect setting of the nozzles results in very uneven spray patterns.
- After the nozzles have been set to the correct angle, the height of the spray bar is adjusted so the surface receives an even coverage of asphalt. A "triple overlap" is recommended. That is to say that each area receives coverage from three adjacent nozzles. Double overlap is also acceptable. It is important that the overlap produces a consistent application over the entire width of the spray.
- To determine the spraying temperature of the asphalt consult a viscosity chart, follow the manufacturer's instructions or contact the local Field Services Paving Manager.

Where excess asphalt occurs, more aggregate will adhere, resulting in ridges. Where insufficient asphalt occurs, aggregate will not stay in place, resulting in streaking. It is vital that the asphalt is applied smoothly and evenly to the whole surface.

3. Spread aggregate on top of sprayed emulsified asphalt with the use of a mechanical spreader. This should be done within about one minute of the asphalt lay down for optimum binding. If this does not occur, then ravelling may result. The objective is a one layer thick coat of aggregate, so care should be taken to not over or under spread. Under spread, and the surface is not durable; overspread and much of what has been spread will need to be broomed off.

Some spreaders are equipped with comb screens on the front. This screen ensures that the coarser aggregate is deposited on the surface ahead of the finer material. The coarse aggregate creates the strength, and the fines fill the voids. This helps reduce the amount of "whip-off", or aggregate dislodged by traffic, giving a more durable surface.

4. Compact the aggregate, embedding it in the asphalt layer. This should be done with rubber-tired rollers. Steel drum rollers risk crushing the aggregate, and do not embed aggregate as thoroughly, as they only contact the high points of the surface.
5. Broom off excess aggregate. This is usually done once after compaction ensuring the asphalt emulsion is cured, and then again several days later.
6. Traffic control. After the seal coat has been completed, it is important to keep traffic at low speeds on the road – high speed vehicles will dislodge aggregate, ruining the job. Only several days after the seal coat has been applied is it safe to use the road at higher speeds.
7. A fog seal will sometimes be applied after final brooming. A last coat of emulsified asphalt over the aggregate, to increase waterproofing and resistance to aggregate breaking loose.

FOG SEALING

A fog seal is a coat of slow setting asphalt emulsion applied over top of an existing asphalt pavement to rejuvenate that pavement. It increases the waterproofing of the existing pavement by filling voids that have resulted from normal wear and tear. Some fog seals include rejuvenating agents for the existing asphalt binder. A fog seal may also stop ravelling, depending on the severity of the failure.

Application is the same as the first steps (1 and 2) of a GAS, except the rate of application will vary depending on the product used.

SLURRY SEALING

A slurry seal is similar to a fog coat, but contains aggregate as well. It is used to treat moderate to severe ravelling, and to rejuvenate a pavement surface.

MICROSURFACING

Microsurfacing is a further development of the slurry seal, containing an asphalt emulsion, aggregate, and a polymer additive which increases strength. It is used to fix rutting, ravelling, and as a rejuvenating treatment to improve the quality of the road surface. It is an engineered product that should only be applied by qualified professionals with specialized equipment.

PAVEMENT REHABILITATION

HOT IN PLACE RECYCLING

Hot in Place recycling(HIP) involves heating and milling of usually the top 50 mm of asphalt pavement, blending in rejuvenating solvents and 20% to 25% virgin aggregate and asphalt binder, then placing and compacting the product similar to a typical paving process. It is done by a 'train' of machines, typically a heater, then two heater/grinders, followed by a heater/grinder with the ability to homogenously mix in the virgin mix, then a regular paver and rollers. SS 515 covers HIP.

Advantages

- Provides an economical and environmentally favourable pavement life extension product.
- Will typically result in extending the service life of the pavement by 7 to 10 years.

Disadvantages

- Is only generally only able to treat the travel lanes. If the shoulders require treatment, or multiple turning, deceleration, acceleration, or parking lanes are present, this is not usually the best option.
- Can only treat one lane at a time.
- Recycles the existing material, so if the desire is to change the properties to address a specific deficiency, this can be limiting.
- Is limited to treating only the top 50 mm of asphalt surface. If deep mill repairs are required other treatment options should be considered.

ASPHALT OVERLAY

An overlay is the placing of one or more lifts of asphalt pavement on top of an existing asphalt pavement.

Procedure:

1. Prepare road surface to be rehabilitated – sweep for dust and loose debris, fill major holes and cracks, Level any depressions.
2. Apply a tack coat of emulsified asphalt evenly onto the road surface using a distributor truck.
3. Pave the road with a thin overlay (40mm to 75mm).
4. Compact the asphalt mix with an appropriately sized roller at the right speed. Too small or fast and improper compaction results; too large or slow and aggregate is crushed. 5 km/h is a good top speed for rolling. Notes:
    - If the mix cools off, compaction cannot occur, and the road needs to be milled and re-paved.
    - Passes should overlap by 50%.
    - Do not end passes at the same point; depressions will result.
    - Joints should be compacted first.
    - A combination of rubber and steel rollers is recommended, the steel roller will provide most of the required compaction and the rubber will seal the surface.
    - As with all repairs, proper compaction is key – improper compaction causes the pavement to rapidly deteriorate.
5. Apply a second overlay, if needed.

Advantages

- Adds strength to the roadway
- Can be a cost effective treatment
- Can treat any width of roadway, including shoulders, ramps, etc.

Disadvantages

- Does not mitigate cracking (generally any thermal cracking present with reflect through the new overlay quickly)
- Raises the final grade of the road which prevents its use in curb and gutter areas, and can add to costs when the following are present:
- Traffic islands
- Guardrail
- Catch basins and/or spillways
- Asphalt curbing

MILL AND FILL

Mill and fill is done when there are no significant issues with the base, but the pavement is worn out or failing. Localized base failures are fine, and can be fixed by full depth patching (pg. 14.) By milling to a specified depth, deficient or failing asphalt pavement is removed, and is replaced with new asphalt pavement.

Hot-in-Place Recycling can be used as an environmentally sensitive alternative to a mill and fill, but requires specific conditions (see Hot In Place Recycling, pg. 17.) The 'mill and fill' approach described here is more versatile, but does not provide the environmental and cost benefits of a well-planned and properly executed hot in place recycle.
SS 511 covers cold milling; paving (fill) is covered by SS 502.

Procedure:

1. Mill the surface to remove the damage pavement. After milling, the surface needs to be swept to remove dust and any loose particles.
2. Apply a tack coat of emulsified asphalt evenly onto the road surface using a distributor truck ensuring all vertical surfaces receive a tack coat as well.
3. Pave the road with a thin lift of asphalt mix (40mm to 75mm). This may be done with full scale equipment for large repairs, or a spreader box towed behind a dump truck for smaller ones.
4. Compact the asphalt mix with an appropriately sized roller at the right speed. See asphalt overlay above for compaction notes.

Advantages

- Provides the greatest range of customization to allow for varying milling, depths dependant on the surface needs to nature of the deficiency.
- Generates Recycled Asphalt Pavement (RAP) millings, a valuable product, which can be partially re-incorporated into the hot-mix or used for shoulder construction or RAP paving.
- Dependant on the existing pavement depths and the depth of the milling, will mitigate or help to mitigate reflection cracking

Disadvantages

- Often more costly than other treatments, as it requires additional equipment and processes.

RAP PAVING

RAP (pavement millings), can be placed on existing gravel, seal coated, or asphalt surface to smooth surface defects and extend pavement life. On gravel, RAP creates a harder, dust-free surface economically. Much RAP paving in the past was constructed simply by spreading the material (sometimes in quite a thin lift) with a grader, and compacting it with rollers. Properly constructed RAP paving involves screening the RAP, adding a rejuvenating agent, and placing a thick layer.

Procedure

1. Screen or crush the RAP so that no particles are greater than 37.5 mm.
2. Blend a rejuvenating solvent with the RAP in a pug mill, softening the RAP.
3. Place the softened RAP product on the roadway with a paver in a single lift no less than 75 mm.
4. Compact the final product. See asphalt overlay above for compaction notes.

Advantages

- Provides a very cost efficient hard surface for low volume roads
- Increases the strength capacity of roads
- Can provide a very good running surface on badly deteriorated roads, since it is applied in a thick lift.
- Can later be sealcoated or overlayed when surface defects arise.

Disadvantages

- Does not provide enough strength to be used on higher volume roads, or roads where industrial traffic is commonplace.
- Does not have the life expectancy of hot mixed asphalt
- Often in the past RAP has been used to treat gravel roads and then simply neglected. Without proper maintenance, and/or a surface treatment applied at the appropriate time, a RAP road can be costly to repair if left to deteriorate too long.

APPENDICES

APPENDIX A:

HIGHSPEED NETWORK LEVEL PAVEMENT SURFACE CONDITION SURVEY

The Ministry collects data on BC major highway routes using laser and surface profiles to calculate a Pavement Distress Index (PDI). This index gives an indication of the roadway's surface deterioration over time. The data collector collects photos at the same time as the PDI. The digital photos can help in identifying areas needing maintenance or rehabilitation.

For detailed information on pavement inspections and the distress ratings a copy of the 2012 Pavement Surface Condition Rating Manual should be obtained from: http://www.th.gov.bc.ca/publications/const_maint/cmb_publications.htm

FLEXIBLE PAVEMENT DISTRESS RATING

This rating system applies to both the high speed network level survey and surveys done on foot. There are 12 distress types:

Cracking

- LWP (Longitudinal Wheel Path)
- LJC (Longitudinal Joint Cracking)
- PEC (Pavement edge Cracking)
- TC (Transverse Cracking)
- MLC (Meandering Longitudinal Cracking)
- AC (Alligator Cracking)

Surface Deformation

- RUT (Rutting)
- SHV (Shoving)
- DST (Distorting)

Surface Defects

- POT (Potholes)
- RAV (Ravelling)
- BLD (Bleeding)

Note that Shoving, Distortion and Ravelling are not included in a high speed machine detection inspection.

The distress types selected for the rating system represent the most predominant distress manifestations observed in British Columbia, focusing on those that progressively affect the pavement's ability to support traffic loads. Each distress type is classified and rated

according to its severity and density. In most cases, there are three levels of severity that describes the condition of the distress with definitions for each level—low, moderate and high. There are five ranges of density that indicates the portion of the road surface affected by a specific distress type. Photographs and drawings of distress types are provided as a reference for assessing severity and general mechanisms of failure listed.

The Ministry collects data on BC major highway routes using laser and surface profiles to calculate a PDI. This index gives an indication of the roadway's surface deterioration over time. The data collector collects photos at the same time as the PDI. The digital photos can help in identifying areas needing maintenance or rehabilitation.

For detailed information on pavement inspections and the distress ratings a copy of the 2012 Pavement Surface Condition Rating Manual should be obtained from: http://www.th.gov.bc.ca/publications/const_maint/cmb_publications.htm

APPENDIX B:

ROAD STRUCTURE

The road structure is more than a layer of pavement; it contains several layers of aggregates topped by the pavement layer, designed to spread the traffic loading from a concentrated load under the vehicles' wheels to a broader area which will not over stress the underlying soil. Traffic loading is usually measured in Equivalent Single Axle Loads (ESAL's), equal to 80 kN (18,000 lb).

ROAD LAYERS

A road is comprised of several layers. The top part is the actual asphalt surface and is the part the traffic travels on. It is made up of an asphalt and aggregate mixture. In some roads, the asphalt pavement is made up of 2 or more pavement types, to give the road greater strength. The base course is a well graded crushed aggregate road base, compacted down, which transmits the load from the binder course to the sub base course. The sub base course is either a crushed or pit run granular base that transmits the load from the base course to the ground The subgrade is the actual, in-place ground surface; it is often compacted with a roller before applying the courses.

The only course which is required to be present is the surface course. However, this would make for a very weak, easily destroyed road. On good, solid ground, however, it is not uncommon to lay only a surface, binder and base course, and skip the sub-base as the existing soil can take the loading directly from the base course. Older roads may have skipped the base and sub-base courses entirely and simply are a layer of asphalt on top of the subgrade. Such roads are likely to be very prone to failures and should be replaced as soon as practical.

A gravel road has a similar structure, but with extra layers of crushed rock on top of the base course in place of the asphalt pavement. The top surface of a gravel road may be sprayed with several layers of sealcoat, in lieu of paving to provide a more durable, dust-free surface. (This is not, however, an equivalent to paving.)

APPENDIX C:

FROST HEAVE AND THAW WEAKENING

Frost heave is a common cause of pavement distortions and failures. Simply put, water enters the base materials and freezes. When this water freezes, it expands and takes more volume. The easiest direction to displace soil is up, to the surface, creating a bulge of soil. However, if the soil has pavement on top, the pavement bulges and cracks.

Frost heaves can be prevented by either preventing water from entering the road structure by improving drainage, or by changing the road structure material. The most cost effective solution is usually drainage improvements. Check all ditches and ensure water is flowing easily in them; if water is not flowing, often vegetation removal will fix the problem.

APPENDIX D:

ASPHALT PAVEMENT TYPES

Asphalt has two components: an aggregate and a bituminous binder, sometimes called the oil. The aggregate is gravel or crushed rock, plus sand (fines.)

The bituminous binder is an engineered product produced in the distilling process of crude oil and is a thick, tarry substance which glues the aggregates to each other. In order to mix it with the aggregate, traditionally the binder is heated to very high temperatures (approximately 150°C.) This turns the binder liquid, making it easy to mix in with the aggregate and then place on the road and compact. Additionally, additives may be added to the asphalt binder, usually anti-strip, but sometimes polymers as well. Anti-strip assists the bond between the asphalt binder and the aggregate reducing ravelling; polymers increase strength and ability to perform within a greater temperature range. Bituminous binders are graded by various means, including penetrtion, viscosity, and expected performance.

For tack and seal coats, various asphalt binders have been made that have better flow. Note: this resistance to flow is known as viscosity—the regular binders have high viscosity until they are heated, whereas those used for cold mix or tack coating have a lower viscosity at more normal temperatures. Emulsified asphalt is the most common of these low viscosity asphalts, though cutback asphalt—where the binder is diluted with a lighter oil, such as kerosene—is also used.

Additionally a variety of asphalt pavements are being made from recycled asphalt. Called RAP, recycled asphalt pavements, they are a more environmentally friendly option which is often cheaper than new HMA. (See pg. 19.)

Complementing RAP is recycled in place asphalt pavement, where the old road surface is heated, milled off and fed directly into an onsite, moving, recycling unit, which mixes the milled material with admix and a rejuvenating agent, and lays the combined asphalt product back down on the same road. In BC, this is called Hot-In-Place Recycling (HIPR.) (See pg.17.)

ASPHALT TYPES

HOT MIX ASPHALT

Hot mix asphalt is the standard paving asphalt. It is made at temperatures close to 150°C, carried hot in covered dump trucks to the paving location, and applied with an asphalt paver and compacted with rollers. Care must be taken that it does not cool below the specified compaction temperature (approximately 135°C) before it is compacted, or the pavement will quickly fail in use, commonly by rutting, shoving, or ravelling.

WARM MIX ASPHALT

Warm mix is similar to hot mix, but has a longer working time – warm mix can be compacted at mix temperatures that, for hot mix, would lead to pavement failure. This makes warm mix easier to carry long distances and use—it does not have to be kept as hot as hot mix. Because of the long use time, warm mix is good choice for crack filling and patching.

COLD MIX ASPHALT

Cold mix asphalt can be used straight out of the bucket or stockpile, making it a very popular patching material. It requires no heating. However, cold mixes are usually weaker than warm or hot mix asphalts, making it suitable only for temporary repairs. Cold mix can be stockpiled.

SPECIALTY BINDER TYPES

EMULSIFIED ASPHALT

Emulsified asphalt is a form of binder used to create cold mix asphalt. It is also used as a tack and seal coat. It resembles a thick, brown liquid when it is poured out, and dries to black, pure asphalt binder. Emulsified asphalt which has turned black is said to have 'broken', and once emulsified asphalt is completely dry it is said to have 'set' or 'cured'.

Emulsified asphalt is made by suspending bituminous asphalt binder in water by using an emulsifying agent. Emulsions are made by either an anionic (negatively charged asphalt droplets) or cationic (positively charged asphalt droplets) process. Care must be taken not to mix the two in machines; if they are mixed, the asphalt immediately hardens and is difficult to remove.

CUTBACK ASPHALT

Like emulsified asphalt, cutback asphalt is a form of binder used to create cold mix asphalt or as a tack and seal coat. However, rather than being emulsified with water, it is diluted using another petroleum product. This makes it less environmentally friendly – the diluting agent evaporates off, releasing a volatile substance into the atmosphere. It is also more expensive; kerosene or another suitable diluting agent costs more than water and an emulsifying agent.

Due to environmental VOC regulations, many cutback asphalts are not permissible for use. The difficulty in obtaining regulatory approval for cutback asphalts, combined with their higher cost, means they are now rarely used.

APPENDIX E:

MINISTRY PHONE NUMBERS

Complete contact information for the Ministry's regions can be found at: http://www.th.gov.bc.ca/contacts-regions.htm.

HEADQUARTERS (VICTORIA BC)

- Engineering Branch: (250) 387-6931
- Construction and Maintenance Branch: (250) 387-7627
- Bridge Engineering Section: (250)-387-6931
- Engineering Materials & Pavement Engineering: 250-387-6931

REGIONAL AND DISTRICT OFFICES

SOUTH COAST REGION

- Regional Headquarters: (604) 527-2221
- Lower Mainland District: (604) 527-2221
- Vancouver Island District: (250) 751-3246

SOUTHERN INTERIOR REGION

- Regional Headquarters: (250) 828-4220
- West Kootenay District: (250) 354-6400
- Rocky Mountain District: (250) 426-1500
- Okanagan Shuswap District: (250) 712-3660
- Thompson Nicola District: (250) 828-4002
- Cariboo District: (250) 398-4510

NORTHERN REGION

- Regional Headquarters: (250) 565-6185
- Peace District: (250)787-3237
- Fort George District: (250) 565-4410
- Bulkley-Sitkine District: (250) 847-7403
- Skeena District: (250) 615-3970