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CHAPTER 5 PATCHING

5.1 OVERVIEW

Patching corrects severe localized defects in Hot Mix Asphalt (HMA) pavements. Because of the intensive concentration of personnel and equipment and lane closures, it's one of the most expensive maintenance procedures for pavements, (per unit of measure such as cost/ton, cost/in^2, or cost/yd^2). It can be done as a permanent 'stand-alone' repair, or in preparation for a full surface preservation treatment or prior to an HMA overlay. Patching restores the pavement surface to a state where other preservation treatments can be used with improved success.

The primary methods of patching include: 1) the replacement of materials that have been lost due to localized pavement distress or disintegration (e.g., potholes), 2) the complete removal (dig out) and replacement of larger or continuous segments of failed pavement, or 3) the localized application of a thin layer of asphalt mix or chip seal over segments of pavement that exhibit only surface-related distress/distortion. Once patched, the distressed area is stronger and can, at least temporarily, carry traffic with a lower rate of deterioration.

Patching may be a temporary, semi-permanent, or permanent treatment. The appropriate method to be used depends on the traffic level, the time of the year the repair is carried out, the time until scheduled rehabilitation, and the availability of equipment and personnel. Patching is best carried out during clear, moderate weather conditions. However, emergency repairs may require patching during poor (e.g., winter) weather conditions. In these instances, the durability of the patch is likely to be poor and the patch should be considered 'temporary'. Accordingly, it is a good strategy to plan for a more permanent repair of these areas when better weather conditions prevail.

This chapter addresses four types of common patching applications:

- Pothole patching,
- Digout patches
- Edge repairs
- Surface "skin" patching.

Each patching method is discussed below. Unless noted, there is no Caltrans Standard Specification for these maintenance treatments. In some cases, specialty materials are addressed in the Caltrans Authorized Materials List (AML).

5.1.1 Pothole Patches

Potholes are a safety hazard – especially to motorcycles and bicycles. Patching them should be a very high priority. A pothole forms when the material in a small but highly distressed area is removed by the action of water and traffic. Since pothole formation is accelerated in wet weather, potholes must often be filled in a wet condition. This usually requires specialty 'quick patch' materials. Of course, merely filling a pothole will usually not prevent the development of distress adjacent to or within the patch. For this reason, these patches are usually considered temporary. Maximum performance is achieved when the entire distressed area is dug out and repaved with HMA. This method is described later under Digout Patches section.

The primary methods recommended for performing pothole patching are:

- Temporary 'quick patch' cold mixes, or possibly HMA
- Spray injection patching (not widely used in California)
- Hot molten products (e.g., mastics, composites)

5.1.2 Digout Patches

Larger permanent patches (aka "digouts") are used when the pavement has failed in localized areas (usually wheelpaths) to an extent that the underlying support materials have degraded due to the presence of water, become infiltrated with fine-grained materials, or otherwise lost their load-carrying capacity. Unlike typical pothole patching, digout may require the removal and replacement of some of the underlying base material. Ideally, the digout area is "repaved" with a thickened section of new HMA. Due to the structural improvement offered by this method, it is sometimes referred to as "spot reconstruction".

Larger digout patching may also take the form of continuous removal of deteriorated wheelpath areas using a narrow head milling machine, followed by placement of the new, continuous HMA 'inlay' patch.

5.1.3 Edge Repairs

Edge repairs are used when the pavement exhibits longitudinal cracking, depression and/or disintegration near the shoulder edges. This type of failure is due to the action of traffic and the loss of edge support that occurs from the presence of water, the loss of shoulder backing material, or aggressive growth of vegetation near the pavement edge. The main materials and methods used in edge repairs are the same as those associated with digout patching and skin patching.

5.1.4 Surface "Skin" Patches

Skin patching - sometimes referred to as "surface reinstatement" patching, is performed to: 1) level a depressed area (e.g., rutting), 2) seal a permeable area or 3) arrest a surface deterioration problem (e.g., raveling). Skin patching does not usually involve a digout.

Typically, one of four methods is used:

- A thin layer of HMA or certain cold mixes can be applied to the existing surface, and rolled with truck tires or a light roller.
- Infrared heater patching/leveling uses specialized equipment to heat smaller areas and re-level them, often with some additional HMA used.
- Some hot mastics and composites can also be used for skin patching.
- A small area sealcoat (chip seal) is applied wherein a coat of asphalt binder (emulsion) is spray-applied and covered with a layer of aggregate "chips"- usually a washed sand or fine aggregate (about 3/8-inch). This type of patching is usually rolled using just the maintenance truck wheels.

5.2 MATERIALS, SPECIFICATIONS AND COSTS

5.2.1 Materials & Specifications

The following materials and specifications are suggested for use with the various patching applications:

- Pothole Patches

'Quick patch' cold mix proprietary products are specially designed for pothole repair and can quickly address the pothole hazard (see Figure 5-1). These products are a blend of aggregate and specialty asphalt binders. Various commercial proprietary brands of quick-patch products are available in most areas of California. Specialty quick-patch products provide a simple, fast and effective means of filling potholes. Because these quick-patch products only address the immediate pothole hazard, they are usually not considered permanent repair and should be followed eventually by a more permanent HMA repair of the larger defective area. But, as a rule, these products work well when used for quickly removing the pothole hazard.

These proprietary brand name products are similar in the sense that they are 'cold' products made expressly for pothole patching and can even be placed in a wet pothole with good survivability. They contain special binder additives and are usually available in plastic bags or 5-gallon pails. This portability allows them to be carried in any pickup truck and used as needed when a pothole is encountered. They can also be made in bulk by local plants and made available to road agencies by the truckload. Where these specialty quick-patch products are not available, certain local cold (cutback) mixes can be used, but will usually require a cure (hardening) period and may not have as good a survival rate as the specialty quick patch products.

There are many good quick-patch products commercially available in California for this type of simple pothole repair. No generic Caltrans specification is available.

Figure 5-1 Quick Patch Material in Pothole

Conventional cold (cutback) mixes can also be used, but they will often ravel under traffic because they require a cure (hardening) period. They also require bulk mixing and outdoor stockpiling and have a limited shelf life. They are considered temporary patches (Dailey et. al., 2017). The old “throw and go” approach of applying conventional cold mix products is not the most effective way of addressing potholes.

Conventional HMA can be used if it can be kept hot in the field – possibly in a special patching truck or trailer with a heated box.

Mastic patching involves hot-applied proprietary materials – including non-asphalt materials usually containing fine aggregate, which are melted in a hot kettle and are either pumped or flow by gravity into the pothole. The material is self-leveling and just lightly groomed using hand tools. No compaction is required. For some mastics, the use of a bulking aggregate may be recommended.

‘Composites’ are hot-applied proprietary (non-asphalt) materials, that may also be appropriate for pothole patching. These ‘engineered’ products contain special polymer blends and function over a wide range of temperatures - and may or may not contain any aggregate.

Spray injection patching is quite different in that it involves specialty equipment, asphalt emulsion and clean, dry aggregate.

The more unconventional pothole patching materials and processes should be demonstrated on a test area for approval.

- Digout Patches - For these patches, use HMA meeting the Caltrans Section 39 Specifications. Choose a mix appropriate for the climate and the anticipated traffic loading (e.g. Caltrans Type A). Pave according to Caltrans Standard Specs, Section 39 – “Method” Process. Hot mastic and composite material may also be used for smaller digout patches. But the use of large volumes of these specialty materials may affect the recyclability of the HMA pavement.
- Edge Repairs - For these types of repairs, use the digout process and materials (above) or skin patching process (below).
- Surface “Skin” Patches – Several types of procedures/materials can be used, as follows:

- Use HMA with smaller maximum size aggregate (e.g., Type A, 3/8-inch-max). Where available, cold mixes made with certain harder grades of MC or SC liquid asphalt (cutback) binders, can also be used. An asphalt tack coat on the old pavement surface should be used.
- For infrared heater patching, small amounts of supplemental HMA may be necessary, as well as a liquid rejuvenating agent and sprayer.
- Hot mastics and composites are proprietary products.
- Small area chip seal patches should be done according to good chip seal practices (e.g., Caltrans Std Specs Section 37, “Sealcoats”), but these involve mostly handwork, without the use of mechanical chip spreaders and emulsion distributor trucks.

5.2.2 Cost and Performance: General Concepts

The main costs associated with patching include:

- Labor
- Materials
- Equipment
- Traffic Delays

Cost effectiveness is determined by the patch survival rate. To determine the patch survival rate, repairs should be monitored for at least one year. Monitoring consists of checking for the presence of repairs and noting the survival or failure of each pavement section. Figure 5-2 shows typical survival rate curves, where A, B and C might represent three separate patch processes or locations. The area under the curve represents the patch survival rate.

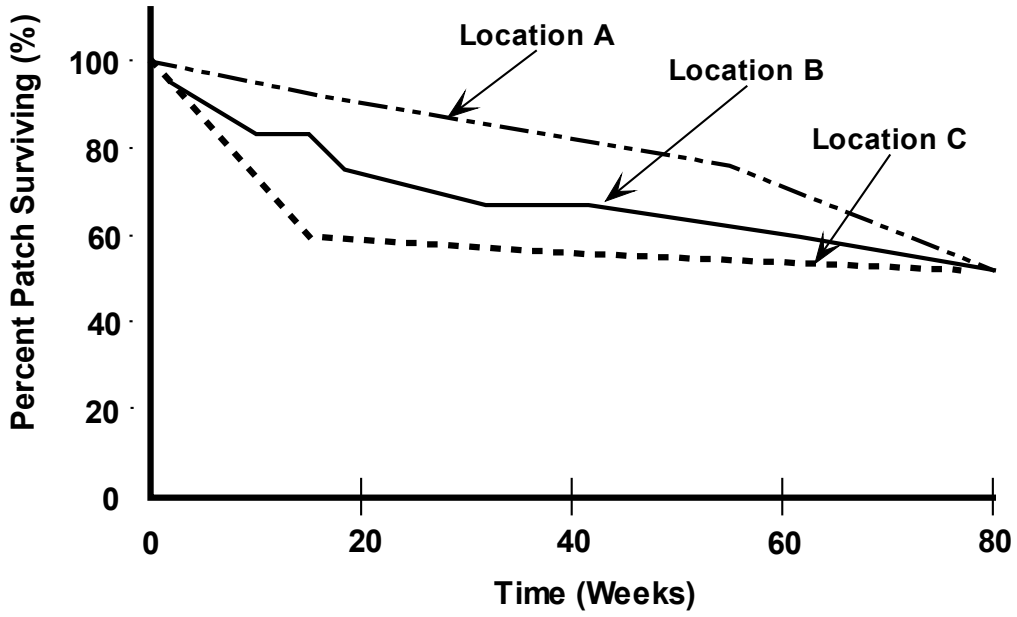


Figure 5-2 Typical Survival Rate Curves (FHWA, 1999)

Using the patch survival rates and the initial costs, cost comparisons of different patching methods can be made, perhaps on an annual cost basis. For example, digouts patching is generally carried out using larger equipment with lane closures and is therefore usually the most expensive method of patching. But since their survival rates should be greater, their cost effectiveness may be higher than other simpler patching methods.

The relative costs of patching methods, along with other pavement maintenance practices are discussed in Chapter 3.

5.3 PROJECT SELECTION & PAVEMENT DEFECTS

5.3.1 Pothole Patches

Potholes are a form of very localized disintegration of the pavement that may be associated with poorly compacted HMA, cracking, base failure or aging of the pavement. Potholes often appear after rain or during thaw periods when pavements are weaker. They should be considered a high priority, emergency repair, since they pose a safety hazard – especially to motorcycles and bicycles. The preferred procedure for addressing potholes is to quickly fill them with specialty ‘quick patch’ cold mixes. In heavier traffic areas, only smaller (< 2 feet width), deeper (> 2 inches) potholes should be patched with these special proprietary mixes, which can be placed even in wet weather when the pothole contains water. Quick patching, without a lane closure, can pose a danger to maintenance workers, so traffic levels and worker safety should be a consideration when using this strategy.

HMA and hot mastic can also be used but require special heating equipment and lane closures. The spray injection process involves specialty equipment, either truck-mounted or trailer-mounted. Since lane closures and follow-up sweeping may be required for this process, it may not be appropriate for urban, heavy traffic roadways.

In addition to response time, lane closures, and their associated costs and traffic delays, should be a consideration in choosing the appropriate method for patching potholes.

5.3.2 Digout Patches

Larger, more permanent “digout” patches are primarily used to repair localized areas of structural failure in the wheelpath area of the lane. These areas usually exhibit “alligator” cracking or more extensive deterioration, possibly a series of potholes with patches, which must be dug out, and a full pavement structure restored. Digout patches can involve either full or partial depth removal of the HMA layer, depending on the nature of the pavement distress. Distresses limited to the surface of the pavement (e.g., raveling, bleeding) will need only a partial depth digout, but these digouts will usually require a milling machine. Digout patches can be done as ‘stand-alone’ repairs or as preparation for a full surface treatment or an HMA overlay. This will affect the type of digout repair used. Since the material used is usually HMA, proximity to a hot mix plant should also be a consideration, and heating equipment for keeping the HMA hot for smaller patches should be used.

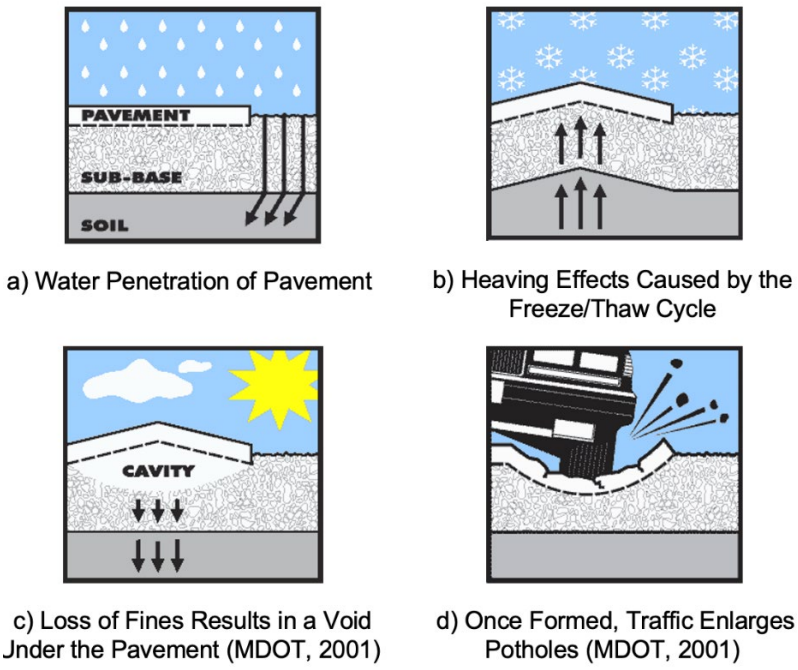
Hot mastics and composites will require proprietary materials and special equipment. These specialty products should be limited to smaller digout patches (say 3' × 3' max) so as not to affect the overall recyclability of the HMA pavement.

Lane closures will also be required for digout patching.

The generally accepted "mechanisms" that lead to larger wheelpath failures are:

- A localized, weak, depressed area exists in a wheelpath, which leads to cracking, water intrusion and further weakening of the pavement structure.
- Raveling, or moisture induced "stripping", may also lead to cracking and weakening of the HMA pavement layer.
- Water penetrates the pavement, softening the underlying base layers, which increases deflections. Figure 5-3a illustrates how water can penetrate a pavement.
- Ice formation and heaving in the pavement occurs in some climatic areas. Figure 5-3b illustrates heaving due to a freeze-thaw cycle in a cold climate.
- Fines from the underlying pavement layers are lost due to migration or "pumping" with water to the surface, reducing overall structural strength and support for the pavement surface. Figure 5-3c illustrates the resulting cavity when the fines are lost.
- Once a pothole is formed, it will continue to grow until a larger digout patch is necessary.
- Figure 5-3d illustrates the role traffic plays in enlarging a pothole.

In California, other causes of localized wheelpath failures include loss of subgrade support due to increase in moisture or due to deterioration of the asphalt pavement because of localized moisture sensitivity problems.



a) Water Penetration of Pavement

b) Heaving Effects Caused by the Freeze/Thaw Cycle

c) Loss of Fines Results in a Void Jnder the Pavement (MDOT, 2001)

d) Once Formed, Traffic Enlarges Potholes (MDOT, 2001)

Figure 5-3 The Cause of Potholes (MDOT, 2001)

5.3.3 Edge Repairs

Edge failures occur when the edge of a pavement breaks up, as a result of traffic loading at the edge of the pavement and the infiltration of water at the edges of the pavement or through an unpaved shoulder. Although edge failures are usually out of the primary wheel paths, their presence can accelerate the deterioration of the pavement in the traveled way. Edge failure repair will usually require a full-depth digout repair and often involve correction of drainage problems (e.g. restoring cross-slope, removing shoulder vegetation 'dams') and restoration of shoulder backing material for lateral support.

Hot mastics and composites will require special equipment and materials.

Edge repairs will usually require a lane closure.

5.3.4 Surface "Skin" Patches

Surface "skin" patches are appropriate for areas that do not have an extensive structural problem. They can be used to level depressions, arrest raveling or seal coarse 'rock pocket' areas. They are often viewed as temporary fixes or possibly as a preliminary leveling treatment for a full surface treatment or overlay. They may involve applying supplemental asphalt mixes (hot or cold) or a localized chip seal application. Heater (infrared) patching/leveling will require special equipment.

Hot mastics and composites will require special equipment and materials and should not be so extensive that they affect the recyclability of the pavement.

Skin patches will always require lane closure.

5.4 CONSTRUCTION

5.4.1 Pothole Patches

Construction procedures for pothole patching vary according to the nature of the pothole and materials selected. The primary patching techniques are described below.

a. Quick Patch Method

The quick-patch method is often used for temporary, emergency quick patches of small potholes. This is the method most appropriate when weather conditions are too poor for an HMA patch to be placed, or the road is due to be rehabilitated soon. It is usually the fastest, least expensive and least labor-intensive method for patching a pothole. Since this type of patching is often done without lane closures, traffic levels and worker safety should always be considered.

For increased survivability of the patch, specialty 'quick-patch' cold mixes (Figure 5-4) should be used, where available.

Figure 5-4 Completed Patch Using a Quick-Patch Product

These specialty quick-patch cold mixes can simply be deposited in the pothole (even a wet one), given minimum compaction by hand or wheel rolling, and then opened to traffic. For deeper potholes, where practical, the material should be placed and compacted in 2 to 3-inch lifts. Maintenance crews can carry bags or buckets of this material and do rapid filling of potholes as they find them. Equipment for these quick patches is normally limited to shovels and hand tampers. Compaction is often simply done by tamping or wheel rolling the patch. Manufacturer's guidelines should be followed.

Conventional HMA can also be used if it can be kept hot enough - for example, in a heated, closed 'oven' truck or trailer (Figure 5-5).

a) Obtaining Hot Patching Materials from Heated Trailer by Hand

b) Unload Patching Material from Patching Truck

Figure 5-5 Hot Patch Trailer or Truck

(Safety Note: To avoid fires or explosions, cold mix products involving volatile binders with lower flash points should not be held in closed, heated patching vehicles.)

Pothole patching by the quick patch method involves the following steps:

- Patching material is placed into the hole, with or without cleaning and/or drying of the hole.
- The material is shaped with a rake or shovel.
- The material in the pothole is compacted using a hand tamper or the maintenance truck tires.
- The finished patch should have 1/8 to ¼-inch (3 to 6 mm) of crown to help avoid ponding water.
- Clean-up any loose debris.

b. Spray Injection Patching

Spray injection patching is a rapid and effective method of patching potholes that requires specialized equipment. These patches are usually considered temporary. The operation may require lane closures to be done safely in heavier traffic areas. The steps for injection patching are described below:

- Prepare the site for patching by blowing debris and water from the hole with the application nozzle. Figure 5-6a illustrates site preparation.
- Spray a tack coat of emulsion onto the sides and bottom of the hole at a rate of approximately 0.2 gal/yd^2 (1 liter/m^2). Figure 5-6b illustrates the application of a tack coat.
- Blow an asphalt/aggregate mixture into the hole, filling the hole to the top. Figure 5-6c illustrates filling the prepared hole.
- Finish with a layer of dry aggregate to minimize pick up by traffic. Figure 5-6d illustrates the application of a finish coat. Figure 5-7 shows a spray injection patching truck. Note: It is not necessary to roll a pothole patched using this method. This is one advantage of the injection method.
- If necessary, sweep any loose aggregate that might be hazardous to motorists.

a) Site Preparation

b) Application of Tack Coat

c) Filling the Prepared Hole

d) Application of Finish Coat

Figure 5-6 Spray Injection Patching (Manual)

Figure 5-7 Spray Injection Patch Truck

c. Hot Mastic and Composites Patching

Proprietary materials containing fine aggregate are melted in a hot kettle and are either pumped or flow by gravity into the pothole. The material is self-leveling and just lightly groomed using hand tools. No compaction is required (Figure 5-8). For installations of hot-applied mastic patching, product should be installed in layers not exceeding 2.5-inch thick (6.3 cm) with cooling to 200°F (93°C) maximum before applying the next layer. The final layer to the pavement surface level should be ½ to 1-inch (1.2 to 2.5 cm) thick. This layering process reduces material shrinkage during product cooling.

Figure 5-8 Hot Mastic Placement (Courtesy of Maxwell Products)

For installations over 2-inch (5 cm) deep some materials can benefit by adding up to 25% by volume of a ‘bulking aggregate’ to the patch, in layers for improved stability and quicker cooling. (Figure 5-9). Roofing felt or other similar strips can be used along the work area boundaries to create neat, well-defined edges. The strips should be removed immediately after application before material cools.

Figure 5-9 Application of Hot Mastic With ‘Bulking Aggregate’ (Courtesy Crafco)

Some hot-applied proprietary 'composite' (including non-asphalt) materials may also be appropriate for pothole patching. These 'engineered' mastic-type products contain special polymer blends and function over a wide range of temperatures and may not contain any aggregate. They may also be lighter colored to blend in and improve the aesthetics of patches.

5.4.2 Digout Patches

Larger permanent patches involve the cutting and removal of the entire distressed area and usually replacing it with a thickened HMA layer. This type of patch - also referred to as a "digout", "plugging", "mill-and-fill", or "R&R" is usually made where localized alligator cracking or other distress has occurred - usually in the wheelpath of the lane.

To digout and replace an area of HMA, the following process is used:

- Mark the boundaries (cut line) of the distressed area (Figure 5-10a), taking care to encompass a slightly larger area than the actual distress. A good rule of thumb is to go 1-foot beyond any visible cracking. Cut straight edges and square corners. The repair boundaries should be as rectangular as possible and should take into consideration the dimensions of the equipment that will be used for removal of the old material and compaction of the new material (e.g., where practical, make the cut width at least as wide as the roller).

- Where practical, keep the longitudinal cutline out of the wheel path area. Cut along the boundaries of the patch using either a diamond saw or air hammer with a spade bit (see Figure 5-11a. and 5-11b.). If using an air hammer, care should be taken not to damage the adjacent good HMA by not rocking the hammer. Just allow it to make the vertical cut.

- Make additional cross-cuts within the patch area, if necessary, to further break up the failed material for removal, and remove the old pavement pieces, debris and any water from the hole. Depending on the size of the digout, this may be accomplished manually, with a pick and shovel or with various combinations of power equipment, i.e., a pneumatic hammer and shovel, backhoe, or front-end loader.

- As an alternative for wheelpath digout (Figure 5.12), cold milling equipment (Figures 5-13a and 5-13b) can also be very used especially where the digouts are lengthy or numerous, or perhaps for full-lane width (Figure 5-15). The milling should be straight and parallel to centerline. Avoid meandering patches.

- It is also recommended that, where appropriate, additional material (e.g. aggregate base) be removed to allow the new HMA patch area to be at least 50% thicker than the old HMA layer. The goal being to provide a thickened HMA layer over this localized weak area, hopefully eliminating the need to do repeat patches in this same area in the future. If the digout area is

extremely wet, limit the depth of material to, say 12 inches (and try to eliminate the source of the water).

- In areas of very thick HMA, partial depth milling of the old HMA is often an alternative to full-depth removal. In these situations, hot mastic or composite materials may be effective 'inlay' patching materials.

- Re-compact any exposed Aggregate Base (AB) material with a roller or vibratory plate compactor.

- Apply a "tack coat" of asphalt emulsion to the vertical cut faces of the old HMA pavement at a rate of approximately 0.2 gal/yd^2 (1 liter/m^2) using an asphalt emulsion. The tack coat should either be sprayed or brushed onto the cut faces, not poured (No tack coat is applied to the aggregate base surface). Figure 5-10c and 5-14 illustrates the tack coat application.

- Select an HMA patching mix appropriate for the traffic it will carry. In areas with heavy truck traffic and city buses, a Caltrans Type A mix, or possibly Type C (high stability) mix, should be used with a harder binder grade (e.g., PG 70-10).

- The thickness of any lift of HMA should be at least 3 times the maximum aggregate size. For thicker patches, say more than 4 inches, the HMA should be placed in more than one lift. In very thick patches, the thickness of any lower lift of HMA should not exceed 5 inches, with the final (surface) lift not exceeding 3 inches. (With thicker lifts it's often difficult to attain the required smoothness.)

- Place the HMA patching material into the hole. If the patch is placed manually, use a shovel (not a lute) to place (not throw) and distribute the HMA material, taking care to avoid segregation of the larger aggregate. For a single-lift patch, the hole should be overfilled by 20 to 25 percent of its depth to provide adequate material for compaction. Enough excess material should be placed so it will end up flush with the surrounding pavement after 3 - 4 passes of the roller. Repeating roller passes are always necessary for proper compaction.

- An asphalt lute ("rake") should be used to 'bump' and groom the patch edges. Care should be taken to not over-rake the edges and remove too much of the new material from the perimeter joint area. This can result in poor density and a potential for raveling in the perimeter area of the new patch.

- Compact the patch material with a vibratory device, preferably a small vibratory roller. For thicker multi-lift patches, it is preferable to use rollers whose width is less than the width of the digout, so that the aggregate base and each lift of HMA can be thoroughly compacted. It is very difficult to achieve satisfactory compaction with equipment that bridges the repair area.

Figure 5-10d illustrates the compaction of the patch material. Make at least 3 roller passes. Repeating roller passes are always necessary for proper compaction of HMA.

- Whenever any part of the roller drum is contacting the surrounding old (cold) pavement, the vibratory action should be turned off to avoid cracking the old pavement. Use static rolling mode only.

- Ideally, full compaction should be completed at the time of construction so that future traffic will not further compact the patch. But the finished patch should have a slight (0.1 to 0.2 inch) crown, as illustrated in Figure 5-10e, to allow for some slight additional compaction by traffic and to help prevent standing water from accumulating in the patch area.

- A straight edge should be used - in both the transverse and longitudinal directions - to make sure that the patch surface will not create a bump for traffic.

- For areas with higher rainfall, or where the patched area will be covered by a surface treatment (e.g., chip seal, slurry seal), the entire patch surface should be fog sealed with asphalt emulsion, possibly followed by a sand application to avoid pickup by tires.

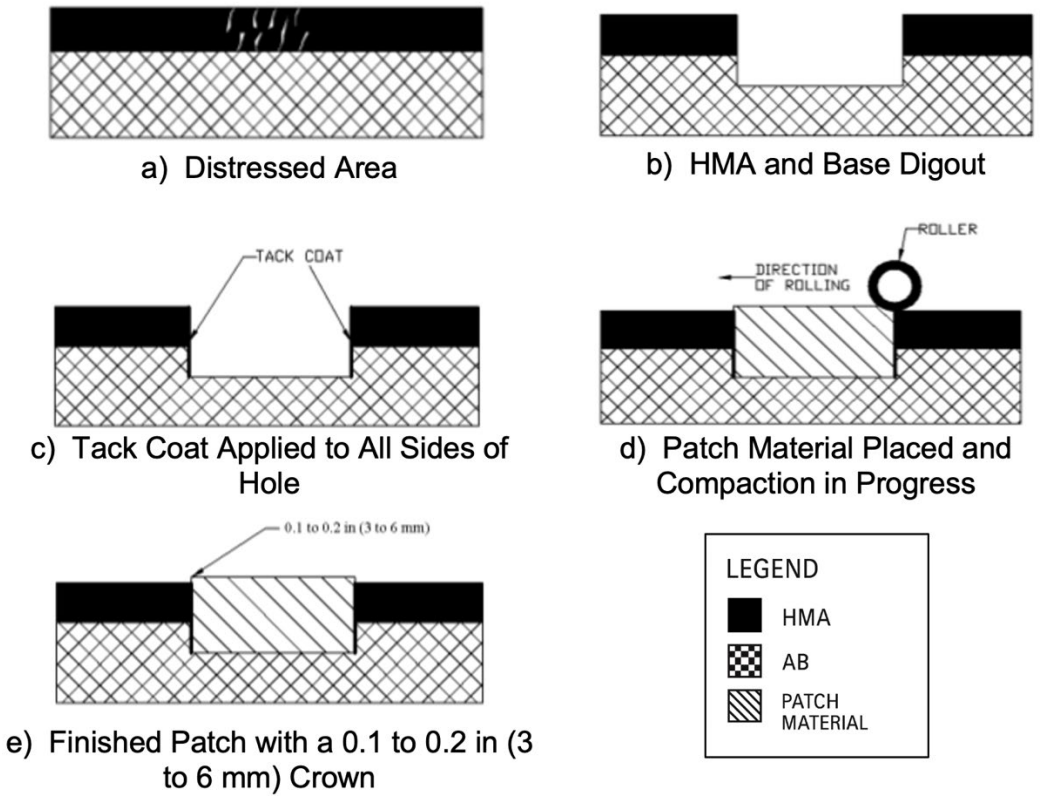


Figure 5-10 Dig-Out Patch Construction Steps

Primary equipment includes a pavement saw, a jackhammer with spade bit, a small backhoe or front-end loader, a dump truck, a small steel drum roller, and a straightedge. Figure 5-11 shows the sawcut boundary and jackhammered cut lines. If using a jackhammer, care should be taken not to damage or weaken the perimeter area of good pavement.

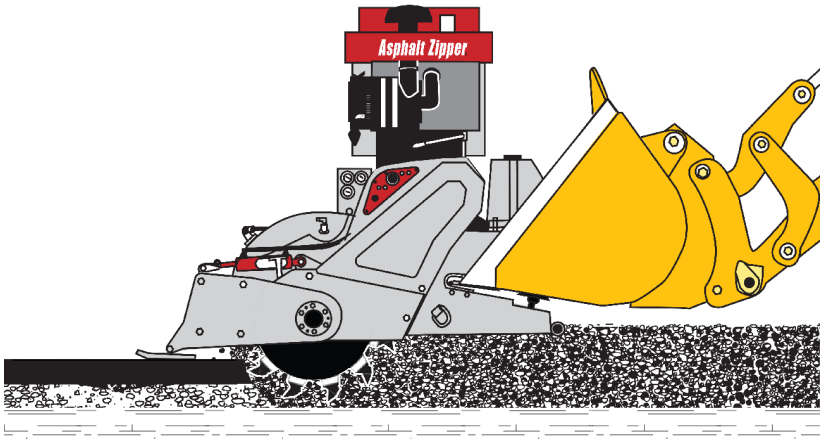
Figure 5-11a Sawcut Lines for a Digout Patch

Figure 5-11b Jackhammered Cut Lines

Alternatively, as mentioned earlier, for more extensive dig out work as for continuous wheelpath patches, small (narrow head) milling machines could be used (Figure 5-12). These smaller milling machines (Figure 5-13), usually from 2 to 4 feet wide, are often an accessory for front loaders.

Figure 5-12 Continuous Patch in Wheelpaths

a) Milling Unit Mounted on Front Loader



b) Milling Unit

Figure 5-13 Small Milling Unit Mounted on Front Loader (Courtesy of Asphalt Zipper, Inc.)

As with all digout patches, a tack coat of asphalt emulsion should be applied to the vertical 'cut' face of the milled area (Figure 5-14).

Figure 5-14 Existing HMA Removed at the Cut Lines of the Patch, and Tack Coat Applied on Vertical Faces of the Cuts

For milling out larger digouts (half-lane, full-lane widths), dedicated larger milling machines should be used. Where partial depth HMA milling is done, and the surface is swept, a tack coat should be applied to the milled, exposed surface of the old HMA, which will be the floor for the new HMA patch. (Figure 5-15).

Figure 5-15 Full Lane Width Partial-Depth Milling with Tack Coat

Larger milled areas may also take the form of long, continuous digout of a deteriorated wheelpath area using a narrow-head milling machine. (Figure 5-16). This may be full-depth or partial-depth removal of the HMA layer.

Figure 5-16 Milling Out the Distressed Area

To improve the durability of a larger patch, the perimeter ‘surface edge’ of the patch may be finally sealed to prevent the intrusion of water, and a fog seal applied to the entire patch. Edge sealing involves the application of asphalt crack sealing material on the surface along the perimeter edges of a patch. Sealing materials should be polymer-modified or rubberized crack sealant to allow for differential movement between the existing pavement material and the new patch material. Figure 5-17 illustrates a finished “edge seal” application. It should be noted that this is often considered aesthetically unpleasing and is sometimes referred to as “picture framing” the patch. So, where the patch is not going to be covered

by a surface treatment or an overlay, this practice is frequently eliminated. Another option for improving aesthetics would be to apply light sand to the fresh sealant to help it blend in the surrounding surface.

Also, if a chip seal will be placed over pavement containing the new HMA patch, a fog seal should first be applied to the patch surface to promote better performance of the chip seal.

Figure 5-17 Digout Patch with Surface Edge Seal Treatment

5.4.2 Edge Repairs

The basic construction steps associated with a repair along the edge of the pavement depend upon the severity and depth of the deterioration (Figure 5-18). If the distress is confined mainly to the HMA surface, then the steps associated with surface skin patching (section 5.4.3) should be employed. If, on the other hand, the deterioration extends well below the surface, then the steps associated with a larger dig-out patches (above) are more appropriate. In both cases, the intent is to provide leveling and improved structure, lateral support and drainage along the pavement's edge.

Accordingly, extra precautions should be taken for achieving adequate compaction and maintaining good surface drainage at that interface with the shoulder. Work on the shoulder area to promote good surface drainage is often necessary, such as removal of vegetation 'dams'. The reinstatement of shoulder backing material may also be required.

Figure 5-18 Example of Edge Cracking of a Pavement

5.4.3 Surface "Skin" Patches

a. Large 'Skin' Patches

Surface "skin" patches may be done for the leveling of depressions or wheel ruts, for correcting and arresting a surface deterioration (e.g. raveling) or for sealing a localized porous or highly cracked areas. For leveling work, special asphalt mixes are used – either a small ("fine") aggregate HMA or high-quality cold mix made with a heavy grade of cutback asphalt binder. When leveling ruts, the new patches should be rolled with a rubber-tired roller, since steel drum rollers will bridge any depressions.

Skin patching may involve asphalt mixes (hot or cold) or a localized chip seal application. Hot mastics and composites should be used for minor leveling only, so as not to have enough volume to affect the recyclability of the pavement. These products will require special equipment and materials.

For large skin patches, typically, one of two methods is used, as follows:

- A thin layer of HMA (or certain cold mixes) can be applied to the existing surface, the process can involve several steps:
    - Possibly milling the upper ½ to 1-inch to remove the distressed material or provide leveling.
    - Scraping off raised markers and thermoplastic markings.
    - Cleaning the pavement surface of debris and dirt using a broom machine.
    - Distributing an asphalt emulsion tack coat over the existing surface using an asphalt distributor truck.
    - Transporting the patching mix (keeping HMA hot)
    - Mix placement using either a paving machine or 'blade-spreading' (or by hand for smaller areas)

- Roller compaction using rubber-tired (pneumatic) for depressed / rutted areas
- Set temporary asphalt markings and open for traffic.

Figure 5-19 shows the hand leveling of a skin patched area and Figure 5-20 illustrates the final rolling of the skin-patched area. (Use pneumatic rollers for rutted areas.)

Figure 5-19 Hand Leveling of a Skin Patched Area

Figure 5-20 Rolling of a Skin Patched Area

- For sealing and minor leveling of porous areas (e.g. rock pockets) or to arrest raveling, a localized thin layer of hot mastic or composite material, or a localized sealcoat (e.g., chip seal, spray patching or parking area sealcoat) can also be used.

Choosing the appropriate skin patching method will depend on traffic levels and on what materials and equipment are available.

b. Small ‘Skin’ Patches

Smaller ‘skin’ patches involve improving small areas of pavement that have deteriorated due raveling, deformations or localized wear. Three common methods are used.

- Leveling asphalt mix - Application of additional hot mix asphalt (or an appropriate cold mix made with cutback asphalt) containing smaller aggregate - say 3/8” or smaller. This involves first cleaning the surface with a push-broom. Then an emulsion tack coat is applied to the old pavement surface. The leveling mix material is deposited by hand and feathered by the skilled use of a lute and push broom. The material is then rolled (before cooling if a hot mix is being used). Rolling is best done with pneumatic / rubber-tired roller. The final surface should be checked with a straight edge. This is especially important on higher speed roads and highways where bumps cannot be tolerated.

- Hot mastics or composites - These hot, proprietary materials are poured and spread by hand and become stable upon cooling. (Figure 5-21).

Figure 5-21 Skin Patch with Hot Mastic Material (Maxwell Products)

- Heater (Infrared) Patching Infrared heater patching involves heating a small (up to 4 feet by 8 feet) distressed area with a propane or diesel fueled indirect heater device. No flames should directly touch the asphalt surface. The heating device can be truck mounted or a towed trailer. (Figures 22a-c). This type of patching involves the following steps:

    - Heating / softening the distressed pavement to a depth of 1 to 3 inches
    - Scarifying and raking the surface to break up the crack pattern and re-level it
    - Spray-applying a rejuvenator
    - Possibly adding new HMA for leveling
    - re-compacting the patched area with a plate compactor or small roller

a) Truck-Mounted Heater (Rose Paving, 2013)

b) Heater Latent Raised

c) Trailer-Mounted Heater

Figure 5-22 Equipment Mounted Heaters for Patching

5.5 TROUBLESHOOTING AND FIELD CONSIDERATIONS

5.5.1 Troubleshooting Guide

This section provides information to assist maintenance personnel with troubleshooting problems with patching and edge repair projects. Table 5-1 outlines common problems and related solutions.

Table 5-1 Troubleshooting Common Patching Problems

Problem	Solution
Patching Material Picks Out (Ravels)	• Ensure the hole is cleaned properly and not too wet. • Ensure sufficient tack coat is applied. • For potholes, use specialty 'quick patch' products when holes cannot be dried properly. • Ensure the patch is compacted and solid before trafficking. • Dust patch surface with sand or small aggregate. • For larger HMA patches, place material while it's hot (>250F), and allow it to cool before traffic is allowed over the patch. • Ensure required compaction is achieved. • Apply a fog seal (and sand) as a routine part of the HMA patching. • Wait for warmer weather to do the HMA patch.
Flushed, rich Surface	• Reduce asphalt binder content in the patching mix. • Reduce the surface fog seal application rate or use sanding. • Allow longer time before trafficking. • Ensure the gradation of the aggregate is appropriate.
Uneven Surface	• Spread the mix more evenly • Ensure HMA is at the right temperature for placement and compaction. • Reduce the thickness of surface lift to < 3-inch. • Ensure adequate compaction is achieved in each lift. • Check the surface with a straightedge
Loss of Cover Rock in Seal Coat Patches	• Ensure the old pavement surface is clean & dust free. • Ensure the aggregate is clean (dust free) and not too wet. • Ensure enough emulsion binder is sprayed. • Ensure aggregate is spread while the emulsion is still brown. • Ensure emulsion fully cures before sweeping and allowing traffic.

Table 5-1 Troubleshooting Common Patching Problems (Continued)

Problem	Solution
Traffic Compacts Mix to Below Edge of Hole	• Add enough loose mix so that the hole / digout is overfilled enough to remain 0.1 to 0.2 in (3 to 6 mm) high after compaction. • Ensure adequate compaction at the time of placing the patch. (Use minimum 4 roller passes.) • Allow longer cooling or curing time before opening to traffic. • Use a more stable patching mix (e.g. Type A)
Surface of Patch Ends Up Too High	• Don't place so much loose mix • Use more compaction effort (minimum 4 roller passes).

5.5.2 Field Considerations

The following field considerations are a guide to the important aspects of performing a patching project. Table 5-2 contains items that should be considered to promote a successful job outcome. Thorough answers to these questions should be determined, as required, before, during, and after construction. The intent of the tables is not to form a specification or report, but to bring attention to important aspects and components of the project process. Some information is product specific and contained in the relevant Caltrans Standard Specifications, Standard Special Provisions, or Special Provisions for the project.

Table 5-2 Field Considerations

	Preliminary Responsibilities (General)
Project Review	• Extent of base / structural failure? • Use just pothole patches, or are larger digouts required? • Will patches be temporary or permanent? • Will patches be covered up by a surface treatment? • Traffic make-up (buses? trucks?); lane closure required? • Depth of digout required? • Will surface drainage / cross slope need corrections? • Quantities and type of material & equipment required? Availability? • Time of year patching will be done? (Emulsions may not be an option.)
Document Review	• Specifications for materials (e.g. Caltrans Standard Specifications) • Methods & procedures • Available Special Provisions • Traffic Control Plan • Materials approvals (mix designs, certificates of compliance, AML, etc.)

Table 5-2 Field Considerations (Continued)

	Material Checks
Pothole Patching (Quick Patch Mixes)	• Availability of specialty “quick patch” material? • Bagged vs. bulk • Availability of hot mastic or composite materials? • Patching by ‘in-house’ crews or contractors?
Pothole Patching (Spray Injection & Mastics)	• Emulsion: grade, specifications & certification by supplier • Aggregate: size, cleanness value (CV) test, moisture content • Hot mastics or composites available? • Lane closure OK?
Large Permanent Patches (Digouts)	• Use HMA mix Type (A,) appropriate for the traffic (e.g. cars vs. tucks & buses) • Use HMA PG binder grade appropriate for the climate (hot vs. cool) • Mix design documentation • Binder and aggregate specifications • Recompact old base material • Emulsion tack coat for vertical cut faces • Fog seal surface?
Heater Patching	• Availability of equipment / contractor • Size of area to be treated • Rejuvenator grade & certification by supplier • Depth of patch or leveling required
Edge Repairs	• Same as for digouts above • Is drainage correction needed? • Shoulder backing material (AB) required? • Remove shoulder vegetation ‘dams’ requires
Surface Skin Patches (Using HMA or Cold Mix)	• Material source? Source location? • HMA – Use finer mix (1/4 - 3/8” max) at proper temperature? • Cold Mix – Is correct grade of cutback binder in in mix?
Surface Skin Patches (Using Chip Seal, Spray Patcher or Hot Mastic)	• Emulsion: grade, specification & certification by supplier, application rate? • Aggregate: size, cleanness, moisture content (damp OK), application rate? • Hot Mastic manufacturer’s recommendations being followed?

Table 5-2 Field Considerations (Continued)

	Equipment Inspection
Pothole Patching (Quick Patch Mixes)	• No special equipment is needed. • A hand tamper is recommended. • Hot kettle for mastics & composites
Pothole Patching (Spray Injection & Mastics)	• Specialty equipment is required and should be demonstrated on a test area. Is equipment free of hydraulic leaks? • Verify that safety warning lights and signals are working. • In heavy traffic areas a shadow car or truck may be necessary. • A power broom or street sweeper may be necessary to remove debris. • Mastic heater adequate? • Do a test area.
Large Permanent Patches (Digouts)	• Digout equipment may include jackhammers, saws, small milling machines, backhoes, and small front loaders. • All equipment should be free of hydraulic leaks. • Tack coat application devices should be adequate for coating vertical edges. • Steel drum rollers must be capable of use in the “static” mode. • Rollers or plate compactors should be narrow enough to fit into the digout area. • Lutes and push-brooms must be the proper size. • Density measuring devices (e.g. nuclear gages), if used, should be properly calibrated.
Heater Patching	• Specialty equipment is required and should be demonstrated in a test area. • Rejuvenator spray application must be carefully controlled / metered.
Edge Repairs	• Same as for Digouts
Surface Skin Patches (Using HMA or Cold Mix)	• Tack coat application equipment should be inspected for operation. • Larger patches should be “blade laid” and rolled with a rubber-tired roller. • A lute should be used for feathering the edges • A straightedge should be used to check the final surface. • A rubber-tired roller should be used, if available.
Surface Skin Patches (Using Chip Seal)	• Can spray applicator for asphalt emulsion binder be easily controlled to yield uniform application of the emulsion? • Can aggregate applicator produce a uniform coverage of aggregate? • Brooms for pre- and post- sweeping should be adequate. • Is a power broom needed?

Table 5-2 Field Considerations (Continued)

	Project Inspection Responsibilities
Pothole Patching (Quick Patch Mixes)	• Is the operation safe to traffic and the workers? • Is the prepared hole no more than 2' wide and at least 2" deep? • Multiple lifts should be required if hole is very deep. • Has all the loose material & debris been removed from the hole. • All water need not be removed. • Has enough compaction effort (tire rolling, tamping) been applied to the new patch • Is the final surface crowned only slightly higher than the surrounding pavement? • Is sanding necessary to prevent tire pick-up?
Pothole Patching (Spray Injection & Mastics)	• Is the operation safe to traffic and to the operator? • Is traffic heavy enough that a lane closure or shadow vehicle is needed? • Is the weather dry and warm enough for the emulsion to cure? • Are the emulsion and aggregate the correct type and within specification? • Is there an adequate supply? • Is the machine effective in blowing the hole free of loose debris and spraying the tack coat? • Is the rate of emulsion being mixed adequate to coat the aggregate? • Is the sprayed mix filling the hole without excess? • Is a waiting time necessary before opening to traffic? • Is mastic temperature correct (per manufacturer)? • Is mastic flush with pavement? • Is sanding (and sweeping) needed?
Large Permanent Patches (Digouts)	• Has the digout area and cutline been laid out properly? • Is the digout wide enough for a small roller? • Is digout to the specified depth? • Is there a tack coat on the cut edges? • Has the AB been raked and recompacted? • Has enough extra loose mix been placed to allow for compaction? • Is the HMA temperature hot enough (250°F at rolling)? • Have at least 3 roller passes been made in all areas? • Has surface been checked with a straight edge and a level for cross slope? • If required, is a fog seal specified for the surface? • Is there a waiting (cooling) time before opening the HMA to truck / bus traffic?
Heater Patching	• Can the equipment heat the pavement to the required depth without excessive smoke? • Is supplemental new HMA required for leveling? Source? • Is the rejuvenator (if used) being applied uniformly at the proper rate?

Table 5-2 Field Considerations (Continued)

	Project Inspection Responsibilities

Edge Repairs	• Same as for "Digouts" above, plus the following:
	  o Are shoulder repairs and restoration of shoulder backing needed?
	  o Will the repair and shoulder area drain properly?
	  o Does the HMA patch have a sloped "safety edge"?
	  o Has fog line striping been restored?

Surface 'Skin' Patches (Using HMA or Cold Mix)	• Is the old pavement surface swept clean? • Is a tack coat (emulsion) applied? • On larger patches is a blade or strike-off screed used? • If using HMA, is the mix hot enough during the rolling? • Have the patch edges been raked and feathered properly to avoid a bump. • Has the mix been rolled at least 3 passes with rubber tires? • Has the patch been checked with a straight edge and cross-slope for drainage? • Has the fog seal been applied? (if required) • Has a sanding been applied? (if required)
Surface Skin Patches (Using Chip Seal)	• Is the weather dry and warm enough (> 70F) for an emulsion chip seal? • Is the surface of the old pavement swept clean? • Is the application rate of emulsion (gal /sy) adequate for the aggregate being used? Is it applied uniformly? • Is the aggregate the proper size and clean (i.e., meeting the Cleanness Value specification)? • Is the aggregate spread immediately and raked to provide a uniform coverage with only slight excess chips? • Is the aggregate rolled with rubber tires? • Is excess aggregate swept up and removed from the pavement? • Does the surface meet straight edge requirements for smoothness? • Will a second application (double chip seal) be necessary? • Is an emulsion fog seal (flush coat) applied over the aggregate? Is it the proper grade? • Is sanding necessary to prevent pick-up by traffic?

5.6 REFERENCES

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Note: Caltrans manuals referenced above may have later editions than those cited. Refer to the latest editions of these references for the most current information.