

Disclaimer

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CHAPTER 4 - CRACK TREATMENTS

4.1 OVERVIEW

This Chapter provides background and supplemental information to Section 37-6 of the Caltrans Standard Specifications, 2025, "Crack Treatments".

Cracking in hot mix asphalt (HMA) pavements occurs when stress exceeds the tensile and/or shear strength of the pavement layer. Crack sealing and crack filling, as shown in Figure 4-1, are methods used to repair cracks in pavement surfaces. The cause of the crack and its activity play a dominant role in determining the success of crack sealing or filling operations. This chapter addresses crack treatments associated with HMA pavements (also referred to as flexible pavements).



Figure 4-1 Crack Treatments

Cracks provide paths for surface water to infiltrate the pavement structure leading to weakness of the base and subgrade, resulting in pavement damage. Crack types include alligator (fatigue), longitudinal, transverse, block, reflective, edge, and slippage cracks. Each crack type is discussed below.

Alligator Cracking: Alligator cracks (also referred to as fatigue cracks) present in a pattern similar to an alligator's skin, as illustrated in Figure 4-2. It may result from aging and oxidation or traffic loading. Fatigue cracks are first evident in the wheelpaths of a lane as a

result of repetitive loads and high deflections, and inadequate structure, often due to weak and/or wet bases or subgrades. This type of cracking is structural and, if not repaired, typically develops into potholes and pavement disintegration. Crack sealing will not treat this type of structural failure. But longitudinal cracking in the wheel paths is often the first visible sign that alligator cracking is starting to develop and may benefit from early crack sealing. Caltrans refers to longitudinal cracking in the wheel path as Alligator A, and multiple interconnected cracks in the wheel path as Alligator B cracking. Alligator C cracking is multiple interconnected cracking across the entire roadway.

When alligator cracking is more widespread than just in the wheelpaths, and shows pavement aging/oxidation, mass crack sealing strategies, such as a scrub seal or a geosynthetic reinforced chip seal (GRCS) can provide an effective sealer. When severity of alligator cracking is medium or high, digouts are recommended.



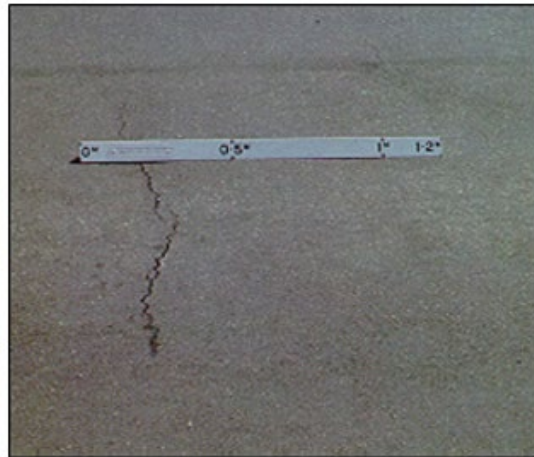
Figure 4-2 Alligator (Fatigue) Cracking

Longitudinal Cracks: These linear cracks run longitudinally along the pavement, as shown in Figure 4-3, and are caused by thermal stress and/or traffic loadings. They occur frequently at paving joints/seams that are usually between adjacent travel lanes or between a travel lane and the shoulder. At these joints the HMA density is lower, and air voids are higher. Longitudinal cracking may also be an early stage of wheelpath alligator cracking. It may also be associated with poor asphalt binder adhesion or stripping within the HMA mix. These cracks can usually be treated with crack sealants, but asphalt sealant lines may compete with lane lines and cause confusion to drivers if not sanded.



Figure 4-3 Longitudinal Cracking

Transverse Cracks: These linear cracks occur perpendicular to the centerline of the pavement, or laydown direction, as shown in Figure 4-4. Transverse cracks are generally caused by thermally induced pavement shrinkage at low temperatures and are often referred to as ‘thermal’ cracks. When the tensile stress due to thermal contraction/shrinkage exceeds the tensile strength of the HMA pavement, cracks occur. Thermal cracks often penetrate through the entire HMA layer and typically widen and deteriorate over time. These cracks can be treated with the proper crack sealing techniques and materials.



(Direction of Travel →)

Figure 4-4 Transverse Cracking

Block Cracking: These cracks form regular blocks (Figure 4-5) and are the result of age hardening of the asphalt coupled with shrinkage during cold weather. They can be treated with crack sealants.



Figure 4-5 Block Cracking

Reflection Cracking: Reflection cracks are caused by cracks, or other discontinuities, in an underlying pavement surface that propagate up through an overlay due to movement or differential stresses across the crack. They exhibit any of the crack patterns mentioned and must be treated according to the original distress mechanism. Figure 4-6 illustrates

reflection cracking in HMA over a jointed Portland cement concrete (PCC) pavement. With proper techniques and materials, these types of cracks can be sealed.



Figure 4-6 Transverse Reflection Cracking

Edge Cracking: These are crescent-shaped or fairly continuous cracks that intersect the unbound pavement edge and are located within 2 ft (0.6 m) of the pavement edge, adjacent to an unpaved shoulder, or due to lacking shoulder backing (SHRP, 1993). Edge cracks are caused by overloading at the unbound edge of the pavement, shear failure, or erosion (loss of support) in the shoulder. This structural type of cracking cannot always be treated with crack sealants. Figure 4-7 illustrates edge cracking.



Figure 4-7 Edge Cracking

Slippage Cracks: These cracks produce a characteristic crescent shape, as shown in Figure 4-8, and are caused when the top layer of the HMA slips (shears) and separates from the underlying material, often due to traffic deceleration, high deflections, and a poor bond between the layers (inadequate tack coat for an overlay).



Figure 4-8 Advanced Slippage Cracking

4.2 PROJECT SELECTION

Crack treatment may be used as a preparation for a full surface treatment (e.g., chip seal) or as a 'stand-alone' sealing of a cracked HMA pavement, with no cover. Projects are selected considering the following general guidelines:

- The pavement structure should otherwise be sound.
- Cracks are typically only treated when greater than ¼-inch (6 mm).
- Wider cracks (> 1.5-inch) will require specialty treatments such as 'mastic' products.
- Routing should be done on linear thermal 'working' cracks.
- Extensive crack sealing (e.g., of alligator cracking) is not cost effective.
- 'Stand-alone' crack sealing (not covered up) can be unsightly.
- The effects of crack sealing on smoothness and ride must be considered.
- Is sanding of sealant necessary (e.g., where longitudinal lines of crack seal compete with lane lines and cause confusion to drivers?).

4.2.1 Project Planning

Ideally, crack-sealing treatments should be applied during relatively cool weather when the crack opening (width) is at its midpoint, usually in the spring or fall. Weather conditions during installation need to be appropriate for the material used, not too cold or wet. Since non-working cracks do not change in width significantly with temperature, application of crack filling treatments can proceed at any time of the year when weather conditions are appropriate. Traffic control during the application of the treatment should be in force long enough to allow for adequate curing of the product and prevent tracking. Before opening to traffic, it is sometimes recommended to apply sand or the manufacturer's recommended de-tack agent to the tacky crack treatment material in the traveled way. Excess sand can be a safety hazard to traffic, especially motorcycles, so sweep to remove excess sand prior to opening the lane.

Where smoothness and ride quality are a concern, crack treatment materials should be smoothed flush with the pavement. For aesthetic reasons and to minimize material cost, the material should not be placed more than 2 inches wider than the width of the crack (on either side of the crack).

4.2.2 Seal vs. Fill

Crack sealing and filling prevent the intrusion of water and incompressible materials into cracks. The methods vary in the extent of crack preparation required and the types of sealant materials that are used. Caltrans typically only uses crack sealing strategies and materials, so crack filling is not discussed in detail.

Crack Sealing

Crack sealing is the placement of materials into working cracks. Crack sealing requires thorough crack preparation and often requires the use of specialized high-quality materials placed into working cracks to prevent the intrusion of water and incompressible materials. Crack sealing is generally considered to be a longer-term treatment than crack filling. As noted above, Caltrans typically only uses crack sealing (not filling) strategies and materials.

Due to the moving nature of working cracks, a suitable crack sealer must be capable of:

- Remaining adhered to the walls of the crack
- Elongating to the maximum opening of the crack and recovering to the original dimensions without rupture
- Expanding and contracting over a range of service temperatures without rupture or delamination from the crack walls; and
- Resisting abrasion, pick-up and other damage caused by traffic.

4.2.3 Treatment Performance

The performance life of a treatment is based on the amount of crack preparation and the type of material used. According to FHWA, “Crack Sealing is the single most cost-effective preventive maintenance tool available”. Advance crack sealing can also enhance the performance life of surface treatments such as chip seals.

Although overbanding can be effective in prolonging the life of the sealant, in California, excessive overband crack treatments have contributed to poor ride, ride noise and poor surface appearance, and are not recommended unless overbanding has been squeegeed flush to the surface of the road. It should not be placed more than 2 inches wider than the width of the crack (on either side of the crack).

According to FHWA, emulsions or asphalt materials placed in a flush configuration in unrouted cracks (see Section 4.3.4) can provide 2 to 4 years of service while hot applied rubber asphalt sealant placed in flush or overbanded configurations (Section 4.3.4) can provide 6 to 8 years of service.

Several methods exist for evaluating a treatment's performance. One method is based on determining a treatment's effectiveness. Treatment effectiveness is the success of the treatment - measured as the percentage of the total treatment that has not failed (See below) To determine the condition of a treatment, visual inspections of the treated areas are required. Per FHWA, inspections for treatment failure should be carried out once per year.

Treatment Failures

Treatment failures can be attributed to improper treatment selection, improper material selection, poor workmanship, and improper application or lack of post-treatments. Common treatment failures include:

- **Adhesion loss:** The sealant does not adhere to the sides or bottom of the crack.
- **Cohesion loss:** The sealant fails in tension by tearing or rupturing.
- **Potholes:** The crack is not completely sealed, allowing water into the pavement, and continued deterioration leads to pumping and pothole formation.
- **Spalls:** The edges of the crack break away as a result of poor routing or sawing.
- **Pull-out:** Sealant has poor adhesion and is pulled out of crack by traffic or snowplow action.

4.3 MATERIALS

Crack sealing material specifications for Caltrans flexible pavements fall under Standard Specifications Section 37-6 and Section 94. It's especially important to consult material suppliers for product grade recommendations for specific site conditions and climate. Section 37-6 discusses the Authorized Materials List (AML) for Crack Treatment Materials found at: <https://dot.ca.gov/programs/engineering-services/authorized-materials-lists>. The materials and methods discussed below apply only to HMA pavements, unless specified otherwise.

4.3.1 Materials and Specifications

Crack Sealing Materials

Asphalt Sealants

Crack sealing materials are designed to adhere to the walls of the crack, stretch with the movement of the crack over the range of conditions and loads associated with the crack location, and resist abrasion and damage caused by traffic. For sealing working cracks, the preferred sealant is usually elastomeric. This means the sealant has a low modulus of elasticity and will stretch easily and to high elongations (usually around 10 times its non-strained dimensions) without fracture. Such sealants also recover over time close to their original dimensions.

Historically, in California most sealants have been ‘hot pour’ rubber-modified asphalt materials. After being melted and applied at elevated temperatures, they set or ‘cure’ by cooling and reforming into complex structures. Because of the lighter diluents in these products, they require a cure period prior to placing a surface treatment (e.g., chip seal). This can be months, depending on local climate.

Table 4-1 shows Caltrans specifications for various crack treatment materials, based upon the climate zone in which it is to be used (Caltrans Standard Specifications Section 37-6). The map of the Caltrans Pavement Climate Regions may be found at: <https://dot.ca.gov/-/media/dot-media/programs/maintenance/documents/office-of-concrete-pavement/climate/pavement-climate-regions-100505-a11y.pdf>

Table 4-1 Crack Treatment Material

Material Properties	Test Method	Deserts, Slow Moving Traffic	Desert	South Coast, Central Coast, Inland Valleys	North Coast, Low Mountain, South Mountain	High Mountain, High Desert
Quality Characteristic ¹	ASTM Test Method ²	Type 1 Material	Type 2 Material	Type 3 Material	Type 4 Material	Type 5 Material
Softening point (min.)	D36	102°C	96°C	90°C	84°C	84°C
Cone penetration at 77°F (max.)	D5329	35	40	50	70	90
Resilience at 77°F, unaged, %	D5329	20-60	25-65	30-70	35-75	40-80
Flexibility ³	D3111	0°C	0°C	0°C	-11°C	-28°C
Tensile adhesion, %, (min.)	D5329	300	400	400	500	500
Specific gravity (max.)	D70	1.25	1.25	1.25	1.25	1.25
Asphalt compatibility	D5329	Pass	Pass	Pass	Pass	Pass
Sieve test (percent passing)	See note ⁴	100	100	100	100	100

Notes:

¹ Cold-applied crack treatment material residue collected under ASTM D 6943, Method B and sampled under ASTM D 140 must comply with the grade specifications.

² Except for viscosity, cure all specimens at a temperature of $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and relative humidity of 50 ± 10 percent for 24 ± 2 hours before testing.

³ For flexibility test, the specimen size must be 6.4 ± 0.2 mm thick \times 25 ± 0.2 mm wide \times 150 ± 0.5 mm long. Test mandrel diameter must be 6.4 ± 0.2 mm. Bend arc must be 180 degrees. Bend rate must be 2 ± 1 seconds. At least 4 of 5 test specimens must pass at the specified test temperature without fracture, crazing, or cracking.

⁴ For hot-applied crack treatment, dilute with toluene and sieve through a No. 8 sieve. For cold-applied crack treatment, sieve the product as-received through a No. 8 sieve. If the manufacturer provides a statement that added components passed the No. 16 sieve before blending, this requirement is void.

Non-Asphalt ‘Composite’ Sealants

Non-Asphalt Composite Sealants (NACS) are crack and joint sealants formulated from non-asphalt, non-rubber raw materials. These raw materials typically involve polymers (e.g., SBS) and resins derived from natural plant sources such as pine trees, and in some situations their use may provide important advantages.

Like asphalt sealants, these thermoplastic sealants can be formulated to tolerate crack openings and closings without cracking or debonding from crack surfaces. Natural resins can also have inherently high resistance to oxidative age-hardening and retain their flexibility.

Also important is that NACS can be pigmented to match the lighter color of aged asphalt pavement surfaces. This can help reduce the appearance and negative aesthetics of crack sealing – especially in urban streets and scenic areas as seen in Figure 4-9.

Due to the ‘rapid setting’ properties, NACS can be utilized in advance of other maintenance surface treatments (e.g., slurry / micro surfacing, TRMSS, chip seals) with little or no ‘cure’ time necessary prior to placing the surface treatment. Bleed-through of the sealant or bumps in the surfacing is also minimized. There is also no wait- -time (cure) required before placing a thin HMA overlay.

Any sealant with a rapid set, may reduce disruption to traffic, increase safety for road crews by reducing exposure to traffic, and offer the potential for overall time savings.

As with other materials, suppliers of NACS should be consulted for application details.



Figure 4-9 Non-asphalt Composite Sealant

Mastic Materials (All Types)

'Mastics' are used for cracks wider than 1.5-inch, deteriorated cracks, transverse thermal cracks, cupped cracks, lane joint separations, wider shoulder joint cracks, and even some utility cuts and patches (Figure 4-10). They are hot-pour proprietary products, which may combine finer engineered aggregate with either an asphalt-based or a non-asphalt 'composite' thermoplastic binder. The hot material flows well into cracks, is adhesive and moisture sealing, supports normal rolling traffic, snowplows, and resists weathering. Depending on the type of mastic, the color can vary, which can be an advantage where aesthetics of the crack sealing or patches is a concern.



Figure 4-10 Hot Mastic Crack Sealing of a Wide Crack

Because transverse thermal cracks are often quite wide (> 2 inches) they can affect ride quality (smoothness). So, the ability of mastic sealers to fill and level these major cracks can result in improved pavement smoothness and rideability, especially on wider or deteriorated thermal cracks.

4.3.2 Storage and Handling of Materials

Chapter 2 of this guide identifies procedures for material storage and handling. In all cases, the manufacturer's recommendations for storage and handling of their particular materials should be closely followed. Problems can result from the sealant material being too hot or too cold. Additional information can be found in Section 4.5.1 Troubleshooting.

4.3.3 Material Placement Methods

Once a suitable seal or fill material has been selected, as set forth in Caltrans Standard Specifications Section 37-6, the appropriate placement method must be determined. Placement methods vary according to the nature of the crack. When selecting the placement method, one should consider the method's applicability to 1) the type of crack, 2) the dimensions of the crack channel, 3) the type of crack channel (routed or unrouted), and 4) the finish requirements. Each method carries its own set of equipment and preparation requirements. Typical placement methods used on flexible pavements include the following:

- Flush Fill
- Overband
- Reservoir/Routing
- Combination

Flush Fill Method

In the flush fill method, material is forced into an existing uncut crack. Once filled, the crack sealant is struck off flush with the pavement, with minimal surface smearing. Figure 4-11 illustrates the flush fill method. When using thermoplastic materials, the crack should be filled to slightly below the surface to allow for expansion in hot weather.

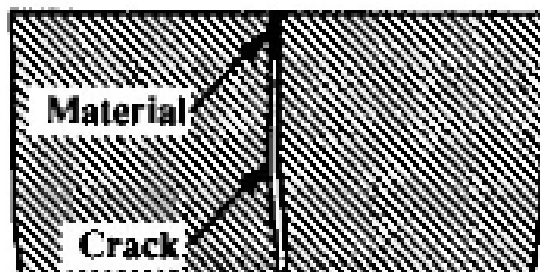


Figure 4-11 Flush Fill Method (FHWA, 1999)

Overband Method

In the overband method, material is forced into and placed over a crack. If the material is squeegeed flat, it is referred to as a 'band-aid'; if not, it is referred to as "capped". Figure 4-12 illustrates the overband method with both finishing options.

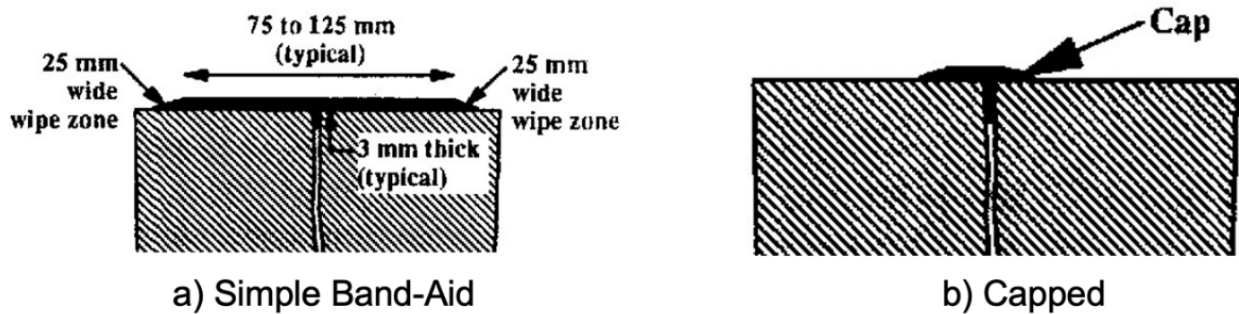


Figure 4-12 Overband Method (FHWA, 1999)

Caltrans does not recommend this overbanding practice and advises that all crack sealing on highways be squeegeed flush if material is left above the surface. Overbanding can create a rough ride (high IRI) and/or excess road noise.

Conventional hot asphalt sealants with overbanding can cause problems (bumps and bleed spots) when placing subsequent overlays. Therefore, overbanding should only be used on low-speed roads that will not be overlaid within six months, to allow sealant to 'cure' prior to placing the overlay.

Reservoir/Routing Method

The reservoir/routing method should be used for any project with highly 'working' linear cracks, such as thermal cracking in severe climate areas. In this method, the crack is routed by a special machine (Figure 4-13) to form a wider 'reservoir' that is then filled with a sealant. The wider dimension of the sealant allows for greater elastic response (strain) of the material. The depth and width of the reservoir vary according to job requirements. Reservoir dimensions will be greatest when working with very active working cracks. The sealant may be left flush or slightly below the surface of the reservoir. Crack routing will often depend on the number of cracks and whether the router can follow the crack. Linear cracks (e.g., thermal cracks) are the most commonly routed.



Figure 4-13 Routing Machine

Typical reservoir widths range from 0.5 to 1.0-inch (12 to 25 mm), and even up to 1.5-inch (38 mm) in very cold climates. Reservoir depth ranges from 0.5 to 1.0-inch (12 to 25 mm) (see Table 4-2). The dimensions used are only approximations because the equipment does not make exact cuts.

Routing use is appropriate for pavements in good condition, without extensive, non-linear cracking. Crack routing machines, when operated by trained, experienced personnel, can follow linear cracking, and even some meandering random cracks. Sweeping of the routing debris will be required.

Table 4-2 Recommended Crack Routing and Sawing Dimensions

Nominal Crack Width*	Rout or Saw Width	Rout or Saw Depth**	Width in Areas of Temperature Extremes	Depth in Areas of Temperature Extremes**
¼ inch	½ inch	½ inch	1 inch	½ inch
3/8 inch	½ inch	½ inch	1 inch	½ inch
½ inch	¾ inch	¾ inch	1 inch	½ inch
5/8 inch	¾ inch	¾ inch	1.5 inches	¾ inch
¾ inch	routing is optional***	¾ inch***	1.5 inches	¾ inch
7/8 inch	routing is optional***	¾ inch***	1.5 inches	¾ inch
1 inch	routing is optional***	¾ inch***	1.5 inches	¾ inch

* Nominal crack width is the approximate width for 80% of the length of the crack

** If using recessed fill method, add ¼ inch

*** Use routing if crack is deteriorated. Use backer rod to limit sealant material depth to 1 inch.

Combination Method: Backer Rod with Recessed Finish

Thermal cracking can develop over time and penetrate the full depth of the asphalt layers. As thermal cracks progress down through the asphalt layers, they typically continue to widen and can be 0.5 to 1-inch (12 to 25 mm) or wider and exceed 4-inch (102 mm) in depth. If these types of cracks are sealed or filled full depth, they require large volumes of sealer. The sealer can also soften and migrate under loads in hot weather and begin to pull out under traffic. If an overlay is applied, the heat of the new mat can draw the sealer materials up into the overlay. This can result in ‘fat spots’ or flushing and shoving in the overlay. These symptoms can only be remedied by changes in construction procedures or the removal and replacement of the affected overlay materials.

To avoid these problems, sealant application should not exceed about 1-inch (25 mm) in depth. To limit the sealant depth, for full depth, wide linear cracks, a compressible backer rod material can be used. Blow out any debris with air, fill the crack with backer rod to approximately 0.5 to 1-inch (12.5 to 25 mm) below the adjacent pavement surface. Then apply the crack sealer over the top of the backer rod and along the crack faces so that the surface of the sealant is cupped slightly below the adjacent pavement surface. This recessed finish allows some movement of the crack and sealer material without creating an undesirable hump on the surface. This process fills and seals the deep wide crack while reducing the quantity of sealant and limiting the impact on subsequent paving operations.

4.3.4 Selecting the Appropriate Placement Method

The appropriate placement method should be based on the governing considerations of the project. These include:

- Type and extent of the sealing or filling operation
- Traffic conditions & speed
- Crack characteristics
- Material requirements
- Desired performance (expectations)
- Aesthetics
- Cost

Table 4-3 outlines placement method issues in relation to project considerations.

Table 4-3 Placement Method Considerations

Project Consideration	Method Applicability
Type and Extent of Operation	Most filling operations, and some sealing operations, omit crack routing. However, in more severe temperature areas (mountains, desert) routing is desirable for cracks exhibiting significant movements.
Traffic*	Overband configurations affect pavement smoothness and ride, and experience high tensile stresses directly above the crack edges, leading to adhesive edge separations. Thus, overband configurations should be avoided for sealing cracks on high speed, heavily trafficked roads.
Crack Characteristics	In lower traffic speed areas, if no overlay is planned, overband configurations may be appropriate for cracks having a considerable edge deterioration (> 10 percent of crack length), because the overband simultaneously fills and covers the deteriorated segments in the same pass. However, if the pavement may be overlaid in the future, a scrub seal should be considered as an alternate method to address edge deterioration without overbanding.
Material Type	Highly modified asphalt or non-asphalt composite sealant are the materials of choice for crack sealing. Conventional 'PG' asphalt binder should only be used as crack sealer in areas not exposed to traffic, due to tracking or abrasion problems that may result.
Desired Performance	For long-term sealant performance, flush reservoir and routing configurations provide the longest life...especially in extreme climate (thermal) areas
Aesthetics	Overbanding and combination configurations detract from the general appearance of the pavement. Where aesthetics is a major concern, overbanding should be avoided and/or non-asphalt composite sealants should be considered. Sanding of fresh sealant can also reduce its visibility.
Cost	Excessive crack sealing can be costly. Be selective and minimize smearing! In severe climate areas, omission of crack routing reduces equipment and labor costs, but may decrease treatment longevity.

* Ride Quality is an important consideration

4.4 CONSTRUCTION

4.4.1 Safety and Control

The Resident Engineer (RE) can examine and approve the contractor's Traffic Control plan prepared in accordance with the Caltrans Safety Manual and the Caltrans Code of Safe Operating Practices. The signs and devices used must match the traffic control plan.

Equipment requirements and safety concerns vary according to the treatment method chosen. Special equipment may be required for:

- Routing or Sawing
- Crack Cleaning and Drying
- Application of Sealer or Filler
- Finishing Method
- Trafficking and Subsequent Treatments (e.g., sanding)

Equipment requirements are covered in more detail in Sections 4.4.4 through 4.4.6 of this chapter.

4.4.2 Climatic Conditions

Crack sealing treatments should be placed during relatively cool or moderate weather, when the cracks are at their midpoint of seasonal expansion. However, this may conflict with prevailing weather conditions, as adherence of most high viscosity and emulsified asphalt crack sealants is limited at low temperatures. Spring or Fall are generally good seasons for application in most parts of California, as air temperatures are typically moderate. Under these conditions, cracks are usually at or near their mid-point of movement, which helps to ensure that the crack sealant or filler will not be expanded or compressed too much when the crack closes & opens with ambient temperature increase or decrease following application of the sealant. Compression of sealant as the pavement expands in hot weather will usually cause sealant bumps that affect the ride.

4.4.3 Preparation

Site preparation requirements vary according to the sealing or filling method and materials chosen for the project.

Cleaning & Drying

At a minimum, cracks must be cleaned of rock, debris, vegetation, and dust. Compressed air is the go-to tool for this job (see Figure 4-14). A narrow, sharp pick or other tool can also be used to clean out the crack. In cooler, damp conditions, a 'hot lance' tool can be used to dry out and preheat the crack area.



Figure 4-14 Airblast Cleaning of Crack

Air blasting involves directing a concentrated stream of air into the crack or joint to blow it clean. Air blasting equipment is effective for cleaning cracks, but not for drying them. Should a crack require drying, hot air blasting (hot lance) should be used. Air pressure should be a minimum of 97 psi (670 kPa) with a flow of 2.5 ft³/s (0.07 m³/s). Air blasting equipment must be equipped with moisture and oil traps.

In cooler climates, in addition to cleaning and drying the crack, hot air blasting also warms the crack to promote enhanced bonding. Hot air blasting is done using a hot compressed air 'hot lance' tool (see Figure 4-15). Ensure that the pavement is not overheated or heated for excessive periods of time, as this will result in unnecessary hardening of the asphalt binder in the pavement adjacent to the crack.



Figure 4-15 Hot Lance

Wire brushing or brooming involves the use of a wire broom or stiff standard broom to brush out the crack or joint. Wire brushing can be an effective cleaning method and may be done manually or using power driven brushes.

Routing

When crack routing is used, cracks need to be cleaned and dried prior to application of the filler or sealant. If pavements are cracked extensively, or cracks are non-linear, routing of the cracks may not be appropriate. Crack routing becomes especially important in climates where crack movement is very high, since it allows more filler to be used and provides better control of the crack channel shape. Secondary cracks along the primary crack are not usually routed. Crack routing equipment includes vertical spindle routers and rotary impact routers. Damage to the surrounding pavement should be kept to a minimum. The use of carbide bits improves the quality of routing and typically produces clean reservoir cuts. Figure 4-16 illustrates a rotary impact router in use.

Debris and dust left in a crack, resulting from routing or pavement use will affect the adhesion of the sealant or filler. Debris also contaminates the sealing or filling material and reduces cohesion. Reduced adhesion or cohesion normally results in early failures. To avoid these contamination-related failures, routed cracks must be cleaned and swept prior to being treated.



Figure 4-16 Crack Routing Operation and Equipment

4.4.4 Application of Sealer

The material selected could determine the application method. Cold asphalt emulsions are water based and are poured directly into the cracks. Emulsions must be blotter coated with sand prior to being trafficked. Emulsions may be applied via gravity feed devices, such as pour pots, or via pressure hoses. Some emulsions may require heating to achieve appropriate application viscosity.

Hot applied rubber-modified sealants have excellent adhesion, and do not require the application of a thin sand coating (blotter coat) prior to trafficking. However, sanding may be used to reduce the visual impact for aesthetic reasons. Hot applied sealants need to be heated, agitated and maintained at the correct 'kettle' temperature throughout their application. Control of temperature is important in preventing degradation. For such materials indirect oil heating on the kettle is recommended. Material suppliers should be consulted for proper application procedures.

The application rate of material plays an important role in the quality of a crack sealing or filling project. Problems associated with over applied sealer or filler material include waste of material, unsightliness, bumps, fat spots, localized tenderness, and bleed-through or flushing when treated areas receive a surface treatment (e.g., chip seal) are later overlaid with HMA.

Figure 4-17 illustrates a hot pressure feed sealing operation and a gravity fed pour-pot for cold-pour sealers.

'Mastics' are special hot-pour products, which may combine finer engineered aggregate with an asphalt-based or synthetic, polymer modified, thermoplastic binder. The material is easy to apply, adhesive, seals against moisture penetration, handles pedestrian and rolling traffic and snowplows and resists weathering.

For wide cracks (>1.5 inches) the material is dispensed into a manual box screed or wheeled mastic applicator and slowly dragged across the surface of the cracked pavement to allow maximum penetration and coverage (see Figure 4-18). To prevent settling, fill the crack first with a tool just slightly wider than the crack. After the initial application settles, apply a second pass with a tool wide enough to form a flush surface or a very slight overband.

This product is designed for cracks wider than 1.5 inches. Routing the crack may allow the mastic to better adhere to the crack area.



a) Hot Pressure-fed process



b) Cold-pour pot

Figure 4-17 Hot Pressure Feed Sealing Operation



Figure 4-18 Hot Mastic Application

4.4.5 Finishing

Finishing techniques will vary depending on the application and type of material chosen. Flush finishes and overbanding methods require the use of a squeegee. In some cases, a preformed plate on the hand wand assists in making the required flush result. Figure 4-19 shows three typical flat finishing techniques. Sealants left on the surface must be squeegeed to prevent a rough ride. Wide smearing of excess material on the surface is wasteful, unsightly, and should be avoided.

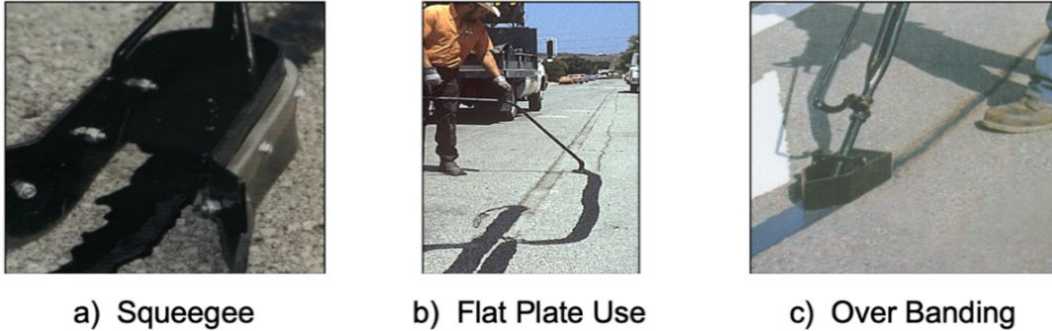


Figure 4-19 Typical Flat Finishing Techniques

Blotter coats of clean sand can be used with crack sealing to ‘hide’ the sealant for better aesthetics and prevent pick-up or tracking by traffic of any overband. To ensure a high-quality blotter coat, only clean and dry sand should be used. Excessive loose sand is a hazard, especially to motorcycles. So, it must be swept up prior to opening to traffic. Figure 4-20 illustrates the brooming of a sand blotter coat over a treated crack.



Figure 4-20 Brooming Blotter Sand Coat Over a Treated Crack

4.4.6 Trafficking and Subsequent Treatments

Sealants and fillers undergo a curing cycle depending on the type of material used. Asphalt emulsions cure by water loss and reduce in volume. This process usually takes several days and creates a concave surface in the crack. Traffic should not be allowed until after the emulsion has set sufficiently so that tires passing over the sealant/filler won’t pick it up. Caltrans normally sands emulsion sealers prior to opening to traffic.

Hot-applied materials are set when they cool, provided no diluents or solvents are used in their formulation. These materials usually produce a non-tacky finish once the material

cools to ambient temperature. A sand blotter coat can assist in reducing visual appearance and tackiness. It should be noted that hot-applied asphalt sealants require a 3-4-month 'cure' time prior to being covered with a thin HMA overlay or surface treatment (e.g., chip seal).

4.4.7 Job Review – Quality Issues

Quality issues are typically related to the poor choice of sealing and filling methods and poor workmanship. Common examples of poor sealing and filling methods include excessive use of sealant and multiple uses of treatments over several years. One common example of poor workmanship includes over-filling without proper finishing.

Figures 4-21 through 4-24 illustrate these commonly addressed quality issues. These practices directly impact traffic safety (skid resistance), smoothness/rideability, and appearance/aesthetics for users, and should be avoided. More information is provided in the Troubleshooting Guide below.



Figure 4-21 Excessive Sealant



Figure 4-22 Excessive Multiple Treatments



Figure 4-23 Excessive, Raised, Bumpy Overband

Excessive crack treatment, such as sealing alligator cracking, (Figure 4-24) should also be avoided.



Figure 4-24 Sealing of Alligator Cracking (Not Recommended)

4.5 TROUBLESHOOTING AND FIELD CONSIDERATIONS

This section provides information to assist maintenance personnel with troubleshooting problems with crack sealing and crack filling projects.

4.5.1 Troubleshooting Guide

The troubleshooting guide presented in Table 4-4 associates common problems with their potential causes. For example, sealant separating from the sides of a crack may be caused by application to a wet crack surface, dirty crack surface, poor material finishing technique, application of cold sealant, insufficient material, rain during the application, or application during cold weather. Manufacturers should be consulted as to the proper handling and application of their materials.

Table 4-4 Trouble Shooting Crack Sealing and Filling Projects

Cause	All Seals Tacky Picks Up	All Seals Re-Cracks Quickly	All Seals Bumpy Surface	Emulsion Seals Only Separation from Crack Sides	Emulsion Seals Only Emulsion Sealer Not Breaking	Emulsion Seals Only Emulsion Sealer Breaks Too Fast	Emulsion Seals Only Emulsion Sealer Washes Off
Crack Wet					•		•
Sealant Not Cured	•			•			
Crack Dirty	•	•		•			
Insufficient Sanding	•			•			
Poor Finish, Wrong Tools	•	•	•	•			
Sealant Too Cold		•	•				
Sealant Too Hot	•			•			
Application Too High	•		•	•			
Application Too Low		•	•				
Sealant Degraded Due to Overheating	•	•		•			
Rain During Application					•		•
Cold Weather		•			•		
Hot Weather	•		•	•		•	

In addition to the troubleshooting guide, Table 4-5 lists some commonly encountered problems and their recommended solutions.

Table 4-5 Common Problems and Related Solutions

Problem	Solution
Tracking	<ul style="list-style-type: none"> • Reduce the amount of sealant or filler being applied. • For hot applied materials, allow to cool or use sand or other blotter. • Allow sufficient time for emulsions to cure or use a sufficient amount of sand for a blotter coat. • Ensure the sealer/filler is appropriate for the climate and placed at proper temperature
Pull-out of the Sealer	<ul style="list-style-type: none"> • Ensure cracks are clean and dry. • Increase temperature of application. • Use the correct sealant for the climate. • Allow longer cure time before trafficking • Consider routing of cracks
Bumps	<ul style="list-style-type: none"> • Check squeegee and ensure it is leaving the correct flush finish. • Have squeegee follow more closely to the application. • Decrease the amount or viscosity of the sealer. • Change the rubber on the squeegee. • Stop using overbanding.

4.5.2 Field Considerations

The following field considerations are a guide to the important aspects of performing a crack sealing project. The various tables list items in a successful job outcome. The, the answers to these questions should be determined before, during, and after construction. The staff to do this work will vary by job type and size. Some topics may need attention from several staff members. The field supervisor should be acquainted with its contents. The intention of the tables is not to form a report, but to bring attention to important aspects and components of the project process. Some information is product specific and contained in the relevant standard specifications, special standard provisions, or special provisions.

Table 4-6 Field Considerations

Preliminary Considerations	
Project Review	<ul style="list-style-type: none"> • Is the project a good candidate for crack sealing? • What type of cracking exists? Crack width? How much is there? • If thermal cracks exist, is 'routing' of the crack being required? • If wider cracks, should mastic products be used? Backer rod? • Is aesthetics a major concern? Require sanding & sweeping? • What is the traffic level and speed? (Is smoothness a concern?) • Is major pavement rehabilitation planned? When? • Would a membrane (e.g., SAM, SAMI) or scrub seal treatment be a better solution? • Review project for bid/plan quantities.
Document Review	<ul style="list-style-type: none"> • Crack activity (movement) information • Applicable specifications • Construction manual • Special provisions • Traffic control plan • Material specifications / AML / Suppliers' input
Determining Application Type	<ul style="list-style-type: none"> • What type of application is already being used? • Are agency guidelines and requirements being followed? • What is the climate? Should the cracks be routed? • Should backer rod be used? • Should mastic material be used (wide cracks)?
Material Checks	<ul style="list-style-type: none"> • Has the amount of filler/sealer material required been calculated for the number and length of cracks being treated? • Has the sealer or filler been produced by an approved source? (on AML?) • What is the application temperature and the safe heating temperature? • What special handling requirements are needed: heating rate, allowable storage time at high temperatures, cold application (consult supplier) • Has the sealer or filler to be used been sampled and submitted for testing? • Is a sand blotter coat required? Is clean, dry sand available?

Table 4-6 Field Considerations (Continued)

Pre-seal Inspection Considerations	
Surface Preparation	<ul style="list-style-type: none"> • Do the cracks need to be routed? • Are secondary cracks to be routed? • Have the cracks been cleaned? Are they dry? • Is a hot lance required?
Weather Requirements	<ul style="list-style-type: none"> • Air and surface temperatures have been checked at the coolest location on the project. • Air and surface temperatures meet agency and sealant manufacturer requirements. • Application should not begin if rain is likely. • Application should not begin if freezing temperatures are expected.
Traffic Control	<ul style="list-style-type: none"> • The signs and devices used match the traffic control plan. • The work zone complies with Caltrans traffic control policies as described in the Caltrans Safety Manual. • Flaggers do not hold the traffic for extended periods of time. • Unsafe conditions, if any, are reported to a supervisor. • Signs are removed or covered when they no longer apply.
Equipment Inspection and Considerations	
Routing Unit	<ul style="list-style-type: none"> • Is a router to be used? • Are the cutting bits sharp to avoid spalling or cracking? • Are the cutting bits the correct size for width & depth? • Is all equipment free of leaks? (Hydraulic oil, diesel, motor oil etc.) • Is a backup machine available?
Sealing Unit	<ul style="list-style-type: none"> • Is the sealing unit fully functional? Do a demonstration? • Are the moisture and oil filters on the compressor clean and functioning? • Does the unit have temperature control (for hot applied sealants)? Is the temperature controller working properly and is the measuring device calibrated? • Does the sealing unit provide adequate pressure to deliver material to the crack at an appropriate rate? • Is a kettle applicator being used? Is the kettle being kept at least partially full at all times? • Is the applicator unit re-circulating during idle periods? • Is all equipment free of leaks? (Hydraulic oil, diesel, motor oil etc.) • For cold (emulsion) sealers, is a gravity 'pour pot' adequate? (for a neat job)

Table 4-6 Field Considerations (Continued)

Project Inspection Considerations	
Crack Sealing or Filling Application	<ul style="list-style-type: none"> • Does the operator have safety gear appropriate for the job? • Does the routing follow the crack as closely as possible? • Are routing dimensions (width & depth) satisfactory? • Are the cracks clean & dry at the time of sealing? • The sealing operation must follow directly behind the cutting/cleaning/drying operations? • Sealant flows evenly with no surging. Vat to be kept at least part full at all times. • Is the sealant at the correct application temperature? • Check sealant temperature at nozzle using high temperature thermometer or infrared thermometer. • Is the squeegee shape correct and not worn, clean and free of carbon or filler build up, operated at the correct distance from the crack, and centered on the crack? • Sealant consistency is correct and has not been reheated more than the allowable number of times and for the recommended periods of time. • Are there excessive bubbles in the material caused by water? • Confirm that crack channel is filled from the bottom up and not overfilled. • Is backer rod in place (if required)? • Does the application have an even and uniform finish, flush with the pavement surface? • No excessive smearing or overbanding? • Reapply sealant to any areas that are under filled. • The application is stopped as soon as any problems are detected. • Check for bond by peeling the filler or sealant. • No traffic until the sealant or filler does not track under traffic. Use sanding?
Clean Up	<ul style="list-style-type: none"> • All material spills are cleaned up. • All loose sand is removed from the traveled way - for safety!

4.6 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.