Mustansiriyah University / College of Engineering

Highway &Transportation Engineering Department

Highway Maintenance Course

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Lecture Three

Maintenance Techniques

Important issues to determine the maintenance technique:

- A condition rating of the pavement will help determine what pavement maintenance technique is necessary.
- How much maintenance funding is available?
- The expected service life of the pavement in general will determine the frequency and level of maintenance it will receive.
- The expectations of the pavement owner also determine the maintenance level and frequency. For example, the owners of a hospital parking lot may require an annual application of a pavement sealer to the parking lot. The owners' expectations are that the parking lot has a new, clean, esthetically pleasing appearance at all times.

Pavement maintenance can be described by two different categories:

1- **Preventative maintenance**: Activities that prevent or reduce further damage to the pavement.

Preventative maintenance activities include:

- Pavement sealers or seal coats
- Crack filling and sealing
- Surface treatments.

2- **Structural maintenance**: Activities that repair or improve the structural integrity of the pavement.

Structural maintenance activities include:

- Pothole filling
- Patching
- Overlays
- Reconstruction.

The type of maintenance technique or procedure used depends on the type and severity of the pavement distress being repaired.

Crack sealing and filling

The most common and widely used maintenance activity for pavements, regardless of use, is crack sealing or filling.

- Crack sealing and filling is an inexpensive maintenance procedure that will significantly delay further deterioration of the pavement.
- Expressways, motorways, and small parking lots all benefit and undergo the application of crack sealing or filling.
- Cracks less than 3 mm wide are too narrow to be sealed or filled. A pavement sealer or surface treatment is adequate to treat these narrow cracks.
- Cracks that are 3–25mm can be sealed or filled with an application of a **crack sealant** or **filling material**.
- Cracks that are greater than 25mm wide are generally too wide to be sealed or filled and should be repaired through the use of a patching mixture or they should be cut out and replaced with a full depth patch.

Crack sealing and crack filling is actually two separate procedures:

Crack sealing is the installation of a specially formulated crack sealing material either above or into **working** cracks using unique configurations to **prevent the intrusion of water** into the crack.

Crack filling is the placement of crack filling material into **non-working** cracks to substantially reduce the intrusion of water into the crack.

- The significant differences are that:
  1- Crack sealing is applied to working cracks and crack filling is applied to nonworking cracks.

  2- Crack sealing involves placing sealing material in or on top of the crack. Crack filling involves placing filling material in the crack.

A working crack is a crack that has horizontal or vertical movements of 2.5mm or more.

A non-working crack is a crack that has no horizontal or vertical movements or the movements are less than 2.5 mm.

- Horizontal movements describe the crack expanding or contracting.
- Vertical movement describes deflections or fault movements that the crack may make.
- Whether a crack is working or not (moving or not), can usually be determined by the type of crack. Most transverse and reflective cracks are working cracks. Some longitudinal and diagonal cracks may also meet the 2.5mm movement criterion.
- Materials that are placed in working cracks must adhere to the crack's sidewalls and be able to flex as the crack expands and contracts. The crack sealant must remain adhered to the crack walls after the crack expands and contracts.
- Non-working cracks include diagonal cracks, most longitudinal cracks, some block cracks, and some alligator cracks.
- Because of the relatively close spacing between non-working cracks, little movement occurs. Minimal movement permits the use of less specialized and less expensive crack filling materials.
- If the alligator cracking is **severe** enough, removal and replacement with a full depth patch is usually warranted.
- Since a working crack can expand and contract with temperature, the crack should be sealed during moderate ambient temperatures, in the range of 7–20 ^{0}C. At this temperature range, the working crack is partially expanded, allowing a sufficient amount of crack sealer to be placed in the crack. The crack is also at the middle width of its working range, allowing the correct amount of crack sealer into the crack, so that the sealer will not have to undergo excessive expansion or contraction due to both temperature and horizontal or vertical movements.
- Crack filling can be completed at a much wider range of ambient temperatures. The properties of the filling material generally limit how cold of a temperature crack filling can occur at. At colder temperatures the non-working crack is at its greatest width, allowing more crack filler to be placed into the crack. In crack filling, the purpose is to fill the crack and not bridge or cover, as when cracks sealing.

Table 9.1 provides details on deciding whether to seal or fill a crack (SHRP 1994).

Table 9.1 Sealing or filling cracks

Crack characteristics	*Crack repair procedure*	
	Sealing	*Filling*
Crack width, mm	4–19	4–25
Annual horizontal movement (mm)	⩾2.5	⩽2.5
Crack type	Transverse Reflective Longitudinal	Longitudinal Widely spaced block

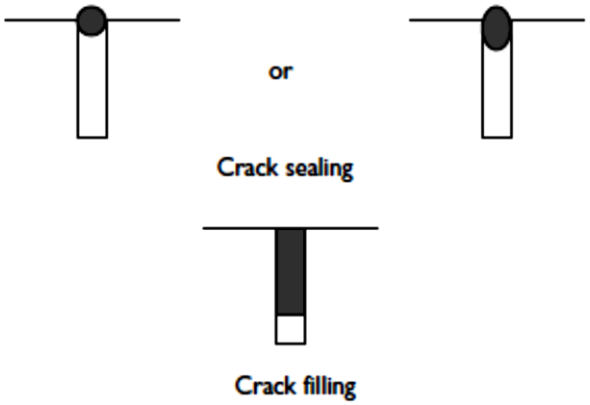

Figure 9.1 Crack sealing and filling differences.

Crack sealing and filling materials

Cracks sealing or filling materials are usually formulated specifically for such use.

- There are many proprietary formulations available and in select cases, generic materials such as asphalt emulsions can also be used.
- The term **sealant** can be used to describe both **crack sealers** and **crack fillers** or just crack sealers.
- **Crack sealant:** Is specifically engineered to remain flexible at low temperatures so it does not crack or split open and remains stable at higher temperatures so that it does not track or bleed on the pavement.
- Crack sealers and fillers are either applied hot or applied cold. Hot or cold applied crack materials are also known as hot or cold pour sealant.
- They also are either thermoplastic or thermosetting. **Thermoplastic** materials become soft when heated and hard when cooled. **Thermoset** materials are permanently hard, even when heated.
- Examples of **crack sealant** are **Crafco Roadsaver, Polyflex and Asphalt Rubber hot-applied sealants.**

- Examples of **crack filler** are **asphalt cements**, **liquid asphalt**, **cutback asphalts**, or **asphalt emulsions** that may be **mixed with sand**, which occasionally is referred to as '**oil and sand**'.

Table 9.3 Crack sealers and fillers

Material type	*Product type*	*Application*	*Typical crack width* (mm)	*Typical specification*
Asphalt cement	AC-10, AC-20, AC-30, AC-40, PG52-xx to PG76-xx	Filling	≤6	ASTM D3381 ASTM D5078 ASTM D6373
Polymer modified asphalt cement	AC-20, AC-30, AC-40, PG64-xx to PG82-xx	Sealing Filling	≤25	ASTM D3381 ASTM D3406 ASTM D5078 ASTM D6373
Asphalt emulsion	CRS-2, RS-2, CMS-2, MS-2, HFMS-1	Filling	≤6	ASTM D977 ASTM D2397
Polymer modified asphalt emulsion	CRS –2P	Sealing Filling	≤6	ASTM D2397
Mineral filled asphalt binder		Filling	6–25	ASTM D5078 ASTM D6690
Fiberized asphalt binder	Proprietary products	Filling	6–25	ASTM D5078 ASTM D6690
Asphalt rubber	Asphalt rubber Proprietary products	Sealing Filling	6–25	ASTM D3406 ASTM D5078 ASTM D6690
Rubberized asphalt sealant	Proprietary products	Sealing	6–25	ASTM D1190 ASTM D3406 ASTM D6690
Low modulus rubberized asphalt sealant	Proprietary products	Sealing	6–25	ASTM D1190 ASTM D3406 ASTM D6690
Chemically reactive	Proprietary products	Sealing	≤25	ASTM D5893

Crack sealant properties that should be provided:

- Flexibility
- Thermal stability
- Adhesivity
- Durability
- Resistance to flow.

Crack sealant installation:

- Crack sealant can be installed into a reservoir and is often referred to as a crack sealing installation.
- When crack sealant (specialized material) is installed into a **reservoir** it can have a variety of finishing techniques, and to name a few:

(a) standard recessed band-aid,

(b) shallow recessed band-aid, and

(c) standard reservoir and flush.

- Crack sealant can also be installed without a reservoir and is often referred to as a '**blow and go**' also known as '**crack filling**' installation where the finishing technique are:
(a) capped or overband, or

(b) simple flush fill.

So, for a simple conclusion, crack sealing is generally installing crack sealant (specialized material) which may or may not include a reservoir. Crack filling is generally installing crack filler (non-specialized material).

Crack sealant has been proven in independent studies to perform in asphalt pavement from 2 to over 10 years depending on pavement condition of poor to good, respectively. Crack sealant has proven to perform in concrete up to 21 years. Crack filler has proven generally to perform from 1 to 2 years. Crack sealing is a long-term pavement preservation solution while crack filling is a band-aid. Pavement is always moving horizontally or vertically to some degree and therefore sealing is preferred over filling so that you can truly preserve the gigantic investment in our roads.

Stages of crack sealant installation:

A complete crack preparation program would consist of the following:

- Routing or sawing of the crack (cutting),
- Cleaning and drying,
- Application of the sealer or filler,
- Finishing and shaping of the sealer or filler, and
- Blotting of the sealer or filler.

Crack preparation

Prior to the application of the crack sealer or filler, the crack needs to be prepared to receive the sealant or filler. Proper preparation of the crack provides for better adhesion of the material to the crack. At the very minimum, the crack should be cleaned and dried prior to sealing or filling.

Crack cutting

Cracks are cut through the use of a pavement saw or router. Crack routing is the preferred terminology when the cracks are cut with a router. The purpose of cutting or routing the cracks is to prevent the wearing a way of loose crack edges and to provide a reservoir for the crack sealant. Cracks are typically cut when they are 6mm wide or greater.

Crack cleaning and drying

Adequate cleaning and drying of the crack is the most important procedure in the crack preparation program.

A crack sealant or filler will adhere the best to a clean and dry crack. If the crack is dirty the sealant will adhere to the dirt particles and not to the sides of the crack. If the crack is wet, the sealant will not be able to displace all of the water and adhere to the sides of the crack.

There are four methods to cleaning and drying a crack:

- Air blasting
- Hot air blasting
- Sand blasting
- Wire brushing.

Application of the sealer or filler

One aspect of any crack filling or sealing application is determining the required amount of material to complete the operation.

The required information for determining the sealant quantities is:

- Average crack width and depth
- Total length of cracks to be filled
- The density of the sealant
- Wastage factor, usually 15 percent.

The average crack width and depth provides the average cross-section area of the crack. Multiplying this value by the length of the crack provides the volume of the crack to be filled. Multiplying this value by 1.15 provides the required amount of sealant in terms of volume. The volume can then be converted to weight by using the density of the sealant.

Example

Cracks in a shopping center parking lot were measured after cutting and cleaning. The average crack width is 13 mm. The average crack depth is 25 mm. The length of all the cracks to be filled is equivalent to 326 m. The specific gravity of the crack sealant is 1.12.

Solution

The average cross section of the crack is: 13mm*25mm=325mm^2 or 0.000325m^2.

The total volume of the cracks to be filled is: 326m*0.000325m^2=0.106m^3.

The total required amount of sealant, including wastage is: 0.106m^3*1.15=0.122m^3.

0.122m^3 of sealant is equivalent to 122 L.

The weight of sealant required is: 122 L* 1.12 g/cm^3 *(1000/1000) =136.6 kg.

- When the cracks vary substantially in depth or width, the project can be broken into sections and the total crack volume can be estimated by grouping similar sized cracks together and determining the volume in each similar section and then adding the groups together.

Blotting of the sealer or filler

- Blotting of the crack sealant after application reduces the pickup of the sealant by traffic and pedestrians.
- Blotting of the crack should be done immediately after the finishing or shaping of the sealant.
- Blotting can consist of applying a coating of sand on top of the crack, or by spreading a light layer of sand throughout the crack sealing project. This will also provide some abrasive texture for improved skid resistance.
- Blotting the crack with paper is also effective.

Pothole filling and patching

Potholes are the result of a rapid disintegration portion of the pavement that was not repaired in time.

Pothole filling is a somewhat temporary measure, which can also be considered patching.

- Filling of the pothole will not correct the deficiency in the pavement.
- The purpose of pothole filling is to temporarily eliminate the pothole as a road hazard and nuisance.

The patching of a pavement is a permanent solution to a pavement distress, usually a high severity distress.

The purpose of patching is to permanently repair the portion of the pavement that is damaged due to:

1- Pavement distress, such as alligator cracking, severe transverse cracking, severe block cracking, etc.
2- Repair a cut in the pavement due to a utility cut or repair.

Pothole filling is a very simple process. There are four recognized procedures for pothole filling:

1- Throw and go,
2- Throw and roll,
3- Semi-permanent, and
4- Injection.

"Throw and go" is the least permanent practice in pothole filling. It is also the most common practice. Throw and go is simply placing a patching mixture or material into a pothole and proceeding or going onto the next pothole. The patching mixture is put into the pothole usually without cleaning or drying the pothole out. The term throw comes from the maintenance crew throwing the patching mixture from the back of a dump truck into the pothole.

- The mixture used is a cold patch or stockpile mixture.
- The compaction of the mixture comes from traffic.
- Throw and go is a high production method of filling potholes.
- It is also usually done as a pothole filling program during the cool weather months.

"Throw and roll" uses the same procedure as throw and go, but with one additional step. After putting the patching mixture into the pothole, the dump truck rolls over the patch one or two times. The tires of the dump truck compact the patching mixture into the pothole. The somewhat compacted patch will remain in the pothole for a longer period of time than the throw and go patch. The traffic is also less likely to force the mixture out of the pothole. The compacted mixture is dense and less susceptible to moisture damage, than the uncompacted mixture in the throw and go pothole. The mixture used is a cold patch or stockpile mixture.

- **The goal** of both the throw and go and throw and roll methods is to eliminate the pothole as a safety or esthetic issue and not to repair the distress permanently.
- Throw and go and throw and roll are commonly done during emergency or inclement weather repairs

"Semi-permanent": The semi-permanent pothole filling method provides a pothole repair that is almost as permanent as a full depth patch. A formal maintenance program for pothole repairs usually uses the semi-permanent filling method.
The semi-permanent pothole filling method consists of the following steps:

1- Removing excessive or loose materials from the pothole.
2- Removing excessive water from the pothole.
3- Cut or square the sides of the pothole until vertical sides exist. This may involve sawing part of the pothole out. The pothole becomes shaped like a square or a rectangular box.
4- Place the patching mixture into the hole.
5- Compact the patching mixture with a vibrating plate compactor or a small roller.

- The significant portion of this pothole filling method is the cutting out of some of the damaged or loose pavement surrounding the pothole. The repair is somewhat structurally sound and semi-permanent.
- The cleaning and drying of the pothole allows the patching mixture to adhere better to the sides and bottom of the pothole.
- In many cases the repair mixture is dense graded or fine graded hot mix asphalt (HMA) mixture.

"Injection": The spray injection procedure for filling potholes consists of the following steps:

1- With compressed air, blow out the loose material and water from the pothole.
2- Spray a tack coat of asphalt binder or an asphalt emulsion on the sides and bottom of the pothole.
3- With a specially designed injection device, blow the patching mixture into the pothole.
4- Place a blotting cover of sand or small aggregate on the filled pothole (SHRP 1994).

Pothole filling materials

Pothole filling or patching mixtures must possess **workability** characteristics over long periods of time. It is not unusual to expect a stockpile of pothole filling to remain workable for up to 12 months.
The mixtures are called "**cold mixtures**," "**stockpile mixtures**," "**depot stock**," or "**cold patch mixtures**," since no heat is needed to store, place, or compact the mixture.
The mixtures are either generically produced by a local mixing plant or they are proprietary or "branded" mixtures.

Table 9.7 Recommended asphalt binders for cold patching mixtures

Immediate use	*Stockpile use*	
Asphalt emulsion	*Asphalt emulsion*	*Cutback asphalt*
CMS –2 CMS –2h HFMS-2s	HFMS-2s	SC-250 SC-800 MC-250 MC-800

Table 9.8 Aggregate quality requirements for cold patching mixtures

Test parameter	*Requirement*
Los Angeles Abrasion, 500 revolutions (%)	⩽40
Crushed faces (%)	⩾65
Sand equivalent test (%)	⩾35

Table 9.9 Typical cold patching mixture gradation

Sieve size	*Total passing (%)*
9.5 mm	100
4.75 mm	20–60
2.36 mm	5–30
1.18 mm	0–10
300 μm	0–6
75 μm	0–2

Full depth patching

Most high severity disintegration distresses need to be repaired either by total reconstruction or the use of a full depth patch. Medium and high severity alligator cracking is one common distress that can be repaired through the use of a full depth or partial depth patch.

The process of full depth patching is as follows:

1- Excavate the distressed portion of the pavement to sound pavement at the edges and bottom. If necessary, excavate all the way to the subgrade. Create vertical sides for the patch. In case of utility cuts, the purpose of the cut will determine how much to excavate.
2- Apply a tack coat to the bottom and sides of the excavation. An asphalt emulsion or an asphalt cutback will be adequate.
3- Dump and spread the HMA or patching mixture into the excavated area. If the excavation is deep, the mixture may need to be placed and compacted in two separate lifts.

4- Compact the mixture with a vibrating plate compactor or a tamping foot compactor. Two or three passes are usually adequate. For larger patches or patches that are long and narrow, such as utility cuts, two or three passes of a small roller will provide a good compaction for the patch.

5- Place the final lift or layer slightly above the adjacent pavement and compact until flush with the adjacent pavement.

6- Seal the newly formed edges or joints with a crack sealer or an asphalt emulsion.

7- Open to traffic after cooling, or if using a cold patching mixture, allow curing before opening to traffic.

Patching materials

Hot mix asphalt is usually the best patching mixture with regard to performance. The same dense graded mixtures used for the mainline pavement will usually work for patching. However, patching is usually relatively small and requires a significant amount of handwork.

Table 9.10 Typical hot mix asphalt patching gradations

Sieve size	*Total passing* (%)	
	12.5 (mm)	*9.5* (mm)
12.5 mm	100	
9.5 mm	90–100	100
4.75 mm	60–80	80–100
2.36 mm	35–65	65–100
1.18 mm		40–80
600 μm	20–65	
300 μm	10–25	10–40
75 μm	2–10	2–10