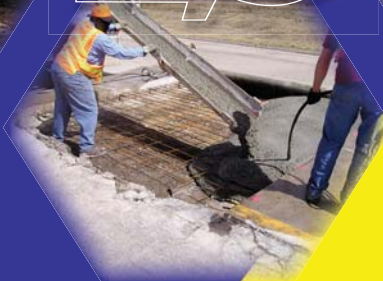
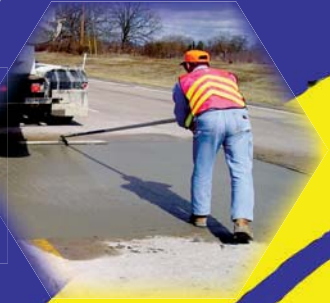
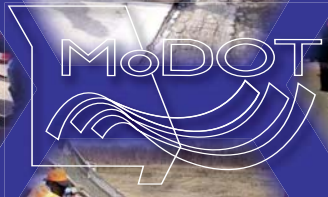


# Concrete Replacement Training



April 2011



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# Full-depth Concrete Replacement

## Purpose

When routine maintenance operations can no longer correct the effects of ordinary pavement wear or use, full-depth repairs may become necessary to restore damaged areas to their original condition. Full-depth repairs are generally necessary when joints or cracks have failed or deteriorated to such an extent that the safe support of the required load is no longer possible.

This manual provides guidance for repairing concrete pavement slabs with structural and joint deterioration. These recommendations apply to surfaces of roads and highways constructed with jointed concrete. Prior to operating any equipment employees shall complete the appropriate required training.

## Objectives

After completing this training, participants will be able to:

- Identify when to perform full-depth repairs
- Identify types of distresses
- Select proper patching materials
- Understand steps in constructing full-depth repairs

## Introduction

Full-depth repairs involve removing and replacing at least a portion of a slab to the bottom of the concrete in order to restore areas of deterioration. Full-depth repairs can improve pavement smoothness, structural integrity, and can extend the service life of the roadway.

**Need for Full-depth Repair** - There are several types of distresses that occur at or near joints or cracks, which may require full-depth repair when classified as medium- or high-severity, level distress. (**Table 1**)

- Joint deterioration
- Transverse cracking

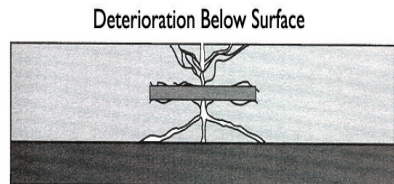
- Longitudinal cracking
- Patch deterioration
- Durability or “D” cracking
- Shattered slab (A slab broken into four or more pieces with some or all cracks of medium or high severity)
- Corner cracking
- Joint or crack spalling (if spalling is one-half the slab thickness or deeper)

Note: Many rigid pavements are also subject to spalling and faulting at intermediate cracks. This may be caused by repeated heavy traffic or long joint spacing failures of doweled joints to function properly and/or the intrusion of incompressible materials in the open cracks.

Type and severity of distress that requires full-depth repair (1,2).

Table 1 Distress Type	Minimum Severity Level Requiring Full-depth Repair
<b>Jointed Pavement:</b>	
Blowup	Low
Corner Break	Low
Durability (D-Cracking, Alkali-Silica Reactivity)	Moderate
Joint Deterioration	Moderate with 0.25 in
Random Transverse Cracking	Moderate with faulting $\leq$ 0.25 in
Random Longitudinal Cracking	High with faulting $\leq$ 0.5 in

**Joint Deterioration** - Joint deterioration includes any cracking, breaking, or spalling of slab edges on either side of a transverse or longitudinal joint and is the most common problem that requires full-depth repair (**Figure 1**). Excessive compressive stresses that result from the presence of incompressibles in these joints often cause this deterioration. Incompressibles can prevent joint closure when slabs expand in warm weather. In extreme cases, very high compressive stresses can cause blowups at the joint. Joint deterioration also occurs from concrete durability problems like low air content, poor slump, or alkali-silica reactivity.



More severe deterioration below the surface.

Figure 1

Visible spalls that extend 3-6 inches from the joint are moderately severe and may indicate that more deterioration is taking place below the slab surface. It is the below surface spalling and cracking that requires full-depth replacement. In most cases, below-surface spalling exists where underlying stress cracks are present. If there is not an obvious durability problem, coring may be necessary to determine if deterioration exists below the slab surface.

Other contributors to joint deterioration include subbase-pumping, dowel-socketing, and keyway failure. These are load-induced distresses that occur at joints with inadequate load transfer for trucks, or other heavy vehicles.

**Transverse Cracking** - Some cracks that extend through the depth of a slab can begin moving and functioning as joints. Transverse cracks that function as joints are “working cracks” and are subject to about the same range of movement as transverse joints. When sealed properly, these cracks can perform well for many years (**Figure 2**). However, it may be necessary to restore pavement integrity with full-depth repairs and to remove working cracks that develop severe spalling, pumping or faulting. (concrete by nature will crack)

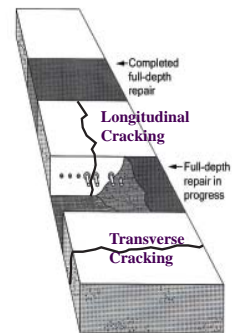


Figure 2

Working cracks develop from one or more of these causes:

- Lock-up of the dowel bars in a nearby joint
- Rupture or corrosion of steel in jointed-reinforced slabs
- Poor joint spacing design
- Loss of aggregate interlock along the crack face
- Excessive load-deflection from poor subbase or subgrade support
- Inadequate joint sawing

Transverse cracks that remain tight (hairline) and do not extend to the bottom of a slab do not require any special treatment, sealing, or repair. These hairline cracks do not allow much water to penetrate the pavement substructure and rarely deteriorate or influence the serviceability of the concrete.

**Longitudinal Cracking** - When longitudinal cracks deteriorate to a high-severity condition, they warrant full-depth patching. A high-severity condition indicates that a crack is greater than 0.5 inches wide, spalling extends more than 6 inches from the crack, and faulting is greater than 0.5 inches.

**Shattered Slabs & Corner Breaks** - Corner breaks and intersecting cracks develop in slabs receiving marginal support from the subgrade. Any heavy loads that pass over these slabs cause large vertical slab movement and high tensile stresses in the concrete. Overtime the movement of the slabs will pump subgrade fines out from beneath the slab leading to voids and eventual cracking over the uneven support. Shattered slabs also may result from frost heave or swelling soil problems.

Full-depth repair is necessary to repair corner breaks and slabs with more than one intersecting crack. These are both signs of support problems and lack of structural strength.

## **Design**

With appropriate design and construction practices full-depth repairs should perform for as long as the surrounding concrete slabs are serviceable. Many full-depth repairs are made during restoration projects that include procedures like slab stabilization, diamond grinding, and joint resealing. The surfaces of these repairs are exposed to traffic. Some full-depth repairs are covered by a layer of material like concrete or asphalt overlay. However, the same design considerations apply to either situation.

The following are important design considerations:

- Pavement type
- Patch size (for distress and subgrade conditions)

- Load transfer
- Concrete materials (requirements for opening to traffic)

## Size

To appropriately size a repair, it is necessary to know the extent of deterioration on the pavement and/or the subgrade. Each repair should replace the concrete and all considerable distress. It is beneficial to set repair sizes to go beyond the limits of any voids created from the erosive action of pumping (See **Figure 3, Page 5**). Guidelines on how to define repair areas for a range of distresses on concrete pavements are provided in the charts.

Excellent judgment is necessary in defining the limits for full-depth repairs, particularly where more deterioration exists than is visible on the slab surface. Some attempt to cut costs by limiting patch size despite the expanse of deterioration, which can reduce the repair's ability to extend pavement service life. In freeze-thaw climates below-slab deterioration may extend 3 feet beyond visible distress.

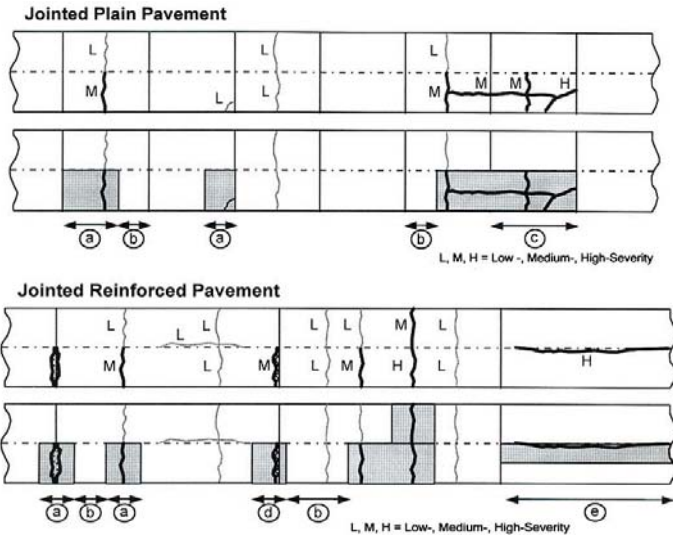


Figure 3

- End at existing joint if possible; minimum length is 6 feet for doweled joints.
- Check distance between patches and nearby joints (see **Table 2 on Page 7**).

- c. Replace the entire slab if there are multiple intersecting cracks.
- d. Extend the patch beyond joint by 1 foot to include dowels, even if there is not any deterioration on one side of the joint.
- e. For high-severity cracks only; begin and end longitudinal patches on transverse joints; keep the joint off known wheel paths.

Except for some low-traffic situations, full-depth repairs of transverse distresses should extend the full width of one lane to ease sawing, and removal operations. Repair margins should be parallel and should not form interior corners in the old concrete. Cracks may develop from interior corners of patches with irregular shapes. Parallel, full-width repair boundaries should perform better.

The minimum patch length for repairing transverse joints and cracks depends on the use of dowels in the transverse patch joints. A minimum patch length of 6 feet in the longitudinal direction is acceptable where the patch joints use dowel bars. This provides a patch large enough to resist rocking under heavy traffic, and provides adequate room in the removal area for dowel-hole drill rigs and other equipment. Smaller patches can rock under heavy traffic and can punch into the subbase if load transfer is inadequate.

It may be necessary to extend the size of patches beyond the minimum length when marking the pavement removal areas just before construction. The following are recommendations for common layout situations:

- If the patch boundary at minimum width falls within 6 feet of an existing transverse joint or crack that does not require repair, extend the patch to the transverse joint
- If the boundary at minimum width falls on an existing doweled transverse joint, and the other side of the joint

does not require repair, extend the patch beyond the transverse joint by about 1 foot to remove the existing dowels

- If the boundaries of two minimum-width patches are within the distances noted in **Table 2**, combine two patches into one large patch

<b>Table 2</b>	<b>Minimum cost-effective distance between two patches</b>			
<b>Slab Thickness Inches</b>	<b>Patch (Lane) width feet</b>			
	<b>9</b>	<b>10</b>	<b>11</b>	<b>12</b>
7	17	15	14	13
8	15	13	12	11
9	13	12	11	10
10	12	11	10	9
11	11	10	9	8
12	10	9	8	8
15	8	8	7	6

Combining two smaller patches into one large patch often can lower repair cost. Transverse joint perimeters are a fixed cost in full-depth repairs. These costs, which increase slightly for thicker pavements, include: sawing, sealing, and drilling and grouting dowel bars in the holes or chipping the patch face. The costs of materials (patching and curing concrete) vary on the patch thickness, width and length. **Table 2** provides an estimate of the distance between patches when the cost of additional patch material is equivalent to the cost of removing two patch joints (one from each patch). When two patches will be closer than the distances shown in the table, it is probably more cost-effective to combine them into one large patch. However, the longest patch length should not exceed the pavement’s longest slab length.

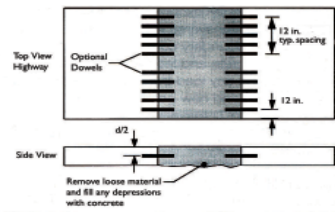
Transverse patch size recommendations do not apply for patches repairing high-severity longitudinal cracks. Longitudinal patches should begin and end at existing transverse joints unless this is impractical for long jointed reinforced pavements. The patches should be wide enough to remove the crack and

any accompanying distress. However, consider locating the longitudinal joint off the known wheel paths to avoid edge loads.

## Load Transfer

The boundary joints of full-depth patches require provisions for load transfer. Load transfer refers to the ability of a joint to transfer a portion of a load applied on one slab to an adjacent slab.

**Jointed Pavements** - For most full-depth repairs of jointed pavements, doweled transverse joints are essential for load transfer. Patch boundary cuts usually go all the way through the concrete and leave a smooth face that does not provide any load transfer; dowels connect the existing slab and new patch together and provide the needed load transfer. In addition, smooth dowel bars are essential for lateral movement at these locations to allow for expansion and contraction of the concrete pavement due to temperature changes, and thereby prevent damage to the existing pavement by not restricting such movement. For that reason, deformed tie bars should not be used in lieu of dowel bars.



Spacing and layout of dowels for full-depth repair of roadway. Note the use of concrete to fill depressions left in the subbase after removing the old concrete.

Figure 4

In the past, pavement repair standards have required placement of 11 dowel bars on each side of the pavement repair. However, this policy was reviewed because of the problems encountered in placing this many dowel bars in existing pavements and because of the cost savings that could be realized if the number of dowel bars in a pavement repair could be reduced. From that review, research indicated that the need of dowel bars is essential in the wheel paths to provide adequate

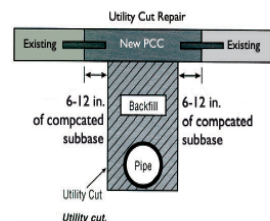


Figure 5

load transfer and at the edge of the pavement to prevent corner cracking, and the number and size of dowel bars required was dependent on existing truck traffic. Experience on highway pavements showed that patches with three or fewer dowel bars per wheel path would eventually fault, rock and pump base and subgrade material. Excessive dowel-bearing stresses cause these problems because the concrete around each dowel bar can crush under fatigue. The result is a loss of load transfer over repeated load cycles because the dowel holes elongate or socket, and no longer hold the dowel bars tightly. Therefore, for most applications a minimum of four dowel bars in each wheel path is recommended to provide good load transfer for roadway patches, and five dowel bars in each wheel path should be considered for very heavy traffic or where weak subgrade material is encountered. Based on that information and good engineering judgement, the standard plans were revised accordingly and should be adopted for all full-depth pavement repair work. The recommended dowel bar configurations should reduce damage to the existing pavement during dowel bar placement operations, yet provide adequate load transfer.

Additional dowel baskets in longer patches are also necessary to prevent mid or third point panel cracks to occur within those pavement patches. For that reason, patches 30 feet or greater, but less than 60 feet in length, should have a dowel basket and sawed joint in the middle of the patch, and patches 60 feet or greater should have two dowel baskets and sawed joints within the patch, located equal distances apart.

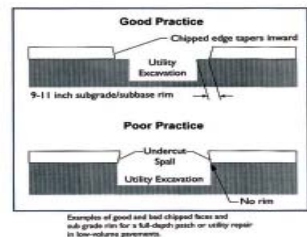


Figure 6

Revisions to the standards on full-depth pavement repair have also eliminated the placement of wire mesh within a patch. The reason being, the primary purpose of wire mesh is to limit cracking to occur within long concrete pavement repairs, thus

by limiting the length of repair as now recommended and removing the probability of transverse cracks developing within a patch, the need for wire mesh is no longer valid for normal applications. Therefore, the use of wire mesh should now only be considered on a limited basis, based on past experience where the wire mesh has proven to be beneficial for other reasons than crack control.

Tie bars along longitudinal patches are recommended only when the patch is greater than 30 feet in length, and when required, the tie bars should be spaced at 30 inch centers as currently required for new construction. The reason being, dowel bars along the transverse joints of repairs 30 feet or less in length will provide adequate strength/support to prevent faulting to occur along the longitudinal joint between the pavement repair and the adjacent pavement, eliminating the need for tie bars in the longitudinal direction for such repairs.

In freezing climates and regions where deicing chemicals are used, such as in Missouri, tie and dowel bars need to be corrosion resistant and need to be in accordance with Section 1037 and Section 1057.3 of the *Missouri Standard Specifications For Highway Construction*.

It should also be noted, that the need for sawing and sealing concrete patch joints is no longer considered necessary. The joints on each side of the concrete patch is a cold construction joint and is sufficiently tight enough to prevent incompressible material to enter the joint and to minimize water infiltrating into the pavement structure at these locations, thereby eliminating the need to saw and seal these joints. This has been the practice by many within MoDOT for several years, and those repairs have performed equivalently to patches with sawed and sealed joints.

## Patch Materials

Selecting a durable patch material is an important design element. In general, repairing concrete pavements with a concrete patching material will provide the best performance. Experience has shown that asphalt-patching materials do not last as long and can lead to further deterioration of concrete pavements. Asphalt patches can compress and heave when the surrounding concrete slabs expand during warm temperatures. The humped patches create a poor ride and allow nearby joints to open wide permanently. These joints may deteriorate because of diminished aggregate interlock and poor load transfer. Asphalt patch material is used for temporary or emergency purposes.

The relative strength as well as the durability of a concrete pavement is directly affected by:

1. Quality of cement
2. Purity of water
3. Cleanliness, durability, strength, and gradation of the aggregates
4. Water/cement ratio
5. Density of concrete
6. Amount and types of admixtures
7. Proportioning and mixing of materials; and
8. Placement, finishing, and curing methods

Concrete patching materials are durable and have thermal properties similar to the existing concrete. Patch mixes for full-depth repairs often use Types I, II or III Portland cement. The target slump ranges from about 2 to 4 in for the best finished product. Most patch mixes require 4.5-7.5% air content, but this may vary by climate and the maximum size of the coarse aggregate. Laboratory testing of each patching mix is necessary to ensure that it meets the field requirements.

MoDOT often wants to open full-depth repairs as soon as possible to alleviate traffic congestion. Mix proportions will depend on the opening requirements. Mixes employing Type III cements or calcium chloride ( $\text{CaCl}_2$ ) accelerators are common for the early strength gain necessary for opening. Proprietary cements that gain strength very quickly also are available. Using insulating blankets or coverings during the first few hours after placement can improve the strength development of any mix.

Mixes using Type III cement may require slightly more mix water than a similar mix with Type I Portland cement. However, too much extra water may cause the concrete to suffer from high shrinkage during curing. A water-reducing additive will disperse cement particles and reduce the extra water necessary for thorough mixing.

Using a calcium chloride accelerator ( $\text{CaCl}_2$ ) requires some special considerations during mixing and field use. Initial set may occur within 30 minutes on warm days, therefore, use only 1% (approximately 2 gallons per yard) of calcium chloride by weight of cement when air temperature exceeds 80°F. Up to 2% (4.5 gallons per yard) is acceptable in lower temperatures. For on-site mixing, add calcium chloride in liquid form to the mixer before adding other agents (except the air entraining additive). Specific quantities are based on experience and sometimes are a judgement call.

Plant mixing can be even more difficult to control the workability of concrete containing calcium chloride accelerators. Trial runs may be necessary to determine how high the slump must be at the plant sometimes up to 6 inches to produce a reasonable workability for placement at the site. If the air temperatures are moderate, less than 68°F, then plant mixing is acceptable for calcium chloride accelerators, as long as the plant is less than 15 minutes from the project site. This also applies for other accelerators and super plasticizers.

## Construction

The seven main steps in constructing a full-depth patch in concrete pavement are:

1. Identifying the areas in need of repair
2. Planning
3. Sawing
4. Concrete removal
5. Prepping the area and subgrade
6. New concrete placement
7. Finishing the repair

**Identifying areas in need of repair** – For most repair projects, it is essential that the agency perform a distress survey as close to the construction schedule as possible. Long periods between the field survey, plan preparation and actual work may lead to an inaccurate description of the actual distress existing when construction begins. In that case, the project plans, time estimates and proposed quantities will not reflect the repairs necessary for a successful project. This can become a source of confusion and can lead to neglect in marking distress limits or lead to poor selection of repair areas.

A survey by the supervisor or project manager before construction will define any inaccuracies between the locations and quantities of repairs described on the plans, and the actual conditions in the field.

During this survey, all distresses and repair areas must be marked clearly on the pavement with a bright-colored spray paint. However, the engineer and the contractor should still refer to the plans for specific locations of distress that might not be visible from the surface.



*Deterioration*

## The Planning Stage

The proper planning of concrete replacement activities is critical to the productivity, efficiency and more importantly the safety of the work crew. Allocating the proper equipment, materials, and personnel for the job is crucial to the overall success of the project. The planning stage is also where we will set up a traffic control plan. The traffic control plan should include all personnel involved in the work zone, the equipment being used and the proper devices and proper placement of said devices to be used in the temporary traffic control zone. Remember the traffic control plan is very important to the safety of all parties involved in the work zone, including the traveling public.

Another way of informing the public of activities being performed on the roadway is to involve the media. Contact your district's Community Relations Representative for help in contacting local media and radio stations.

## Sawing

Before removing deteriorated concrete, it is necessary to first isolate the area from adjacent concrete and shoulder materials using full-depth saw cuts. The full-depth cuts separate the segment of deteriorated concrete and allow room for its removal with minimal damage to surrounding material.



*Diamond Saw*

The diamond saw is the most commonly used tool for making these perimeter cuts. The diamond saw, if operated in straight lines, will produce a smooth face on the existing adjacent concrete while cutting the deteriorated concrete into more manageable pieces. It is important to use water in conjunction with the sawing process in order to extend the life of the saw blades and keep dust particles down to a minimum.

There are some safety concerns you need to be aware of that are associated with operating the diamond saw. Back or muscle strains are common injuries associated with the operation of the diamond saw. The diamond saw is a very heavy piece of equipment and care should be taken while trying to maneuver the diamond saw, especially while loading and unloading the saw. In other words never try to “horse” or “manhandle” this piece of equipment; get someone to help you. Operators should make sure all safety guards are in place and keep hands and loose clothing away from moving parts. Hearing and eye protection shall be worn when working with or around the diamond saw. As always, be aware of your surroundings in relation to traffic and co-workers when operating any piece of equipment.

The wheel saw is sometimes used to make initial concrete cuts but, normally the wheel saw is used to make relief cuts and reduce larger pieces of concrete down to more manageable pieces. The wheel saw like the diamond saw should be operated in conjunction with water to keep dust down and extend the life of the blade.



*Wheel Saw*

The drawback to using the wheel saw is that it can cause damage to the existing roadway and disturb or damage the subgrade of the repair area.

The wheel saw has its own unique areas of safety emphasis. Dust can be a real problem so respiratory protection should be worn when working around this piece of equipment. Dust produced by the wheel saw can also cause sight distance problems for the work crew and passing motorists. Hearing and eye protection should always be worn when working with the wheel saw.

The wheel saw is a very large piece of equipment. Maneuvering and blind spots can be very hazardous. Use caution at all times and always know where you are in relation to traffic and fellow employees.

## Removal

There are various pieces of equipment and techniques of removal being utilized across the state but basically there are two methods; the breakup and clean-out method and the lift-out method. No matter which method you utilize, the procedure must not spall or crack adjacent concrete or the base or subgrade.

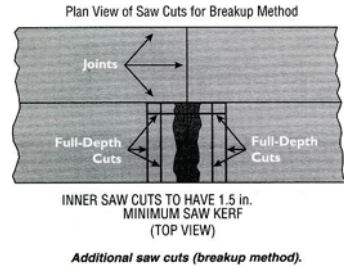


Figure 7

significantly disturb

The breakup and clean-out method usually involves using the wheel saw to breakup the concrete and then using a backhoe to clean out the repair area (**Figure 7**). Operators should be very careful when using the breakup and clean-out method. First, they should avoid damaging any existing concrete adjacent to the repair area. Secondly, they should be careful not to damage or disturb the subgrade of the repair area.

There are some safety concerns associated with the breakup and clean-out method that employees should be aware of. Because this method of removal involves on site loading of loose debris into dump trucks, employees should stay clear of the haul-out area. Again always be aware of your surroundings in relation to removal equipment, traffic and co-workers.



Loading Truck

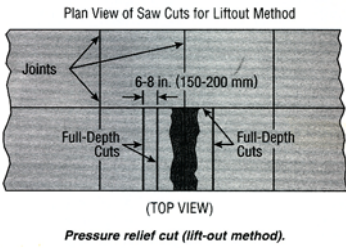


Figure 8

The lift-out method is accomplished by using either a backhoe or front-end loaders to lift whole or partial slabs of deteriorated concrete and then loading them into trucks to be hauled away (**Figure 8**). Lift-out operations should be closely monitored to prevent damaging the adjacent

concrete, although this method very rarely causes any damage to the existing concrete or the subgrade.

After the repair area is isolated by means of full-depth saw cuts, holes are drilled into the concrete slab and fitted with lift pins. The slab is then lifted by chains, which are at least 70 grade and then placed in a waiting dump trucks to be hauled away. As with the breakup method, persons in the lift out area should never get under a load being lifted and stay away from trucks while being loaded.



Lift Out Method

Whatever means is used for concrete removal, the next step in the process is prepping the repair area for concrete placement.

## Repair Area Preparation

After the deteriorated and loose debris has been removed, the base course should be examined and any remaining unsuitable material removed.



Patch Area Compaction

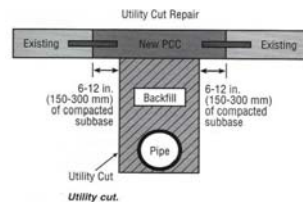


Figure 9

Occasionally, you may find a repair area which contains excessive moisture. In these cases, a porous subbase may be needed or you may have to install a drain tile (**Figure 9**) in the repair area.

If you have concerns about moisture in a repair area, ask your supervisor for advice.

Once the subgrade has been cleaned out, additional base has been added and the areas has been compacted, the next step is to drill holes to receive the dowel bars. These dowel bars are placed into holes drilled into the face of the existing concrete with a concrete drill to provide load transfer.

A pneumatic or hydraulic percussion drill rig is preferred over a hand held drill. The hand held drills are heavy and are hard to handle. Hand held drills also lack guides for alignment and make it difficult for operators to drill straight and consistent holes. No matter which type of drill is used, employees should always wear eye, hearing and should consider wearing respiratory protection when working around a drilling operation. Operators should also wear gloves and avoid wearing loose fitting clothing so as to avoid getting caught in the moving parts of the drill.



*Drilling*

Because proper size and placement of the dowel bars is critical to the integrity and durability of the patch, you should consult your supervisor as to the proper size and placement of the dowel bars. Sometimes it may be necessary to adjust the location of dowel holes due to cracking or internal obstructions such as heavy mesh reinforcement. It is better to adjust a hole away from obstacles or even eliminate a hole entirely rather than attempt to drill and place a dowel in a questionable location. Once again, if you have concerns ask your supervisor.

Next in the process is to inject the dowel hole with an epoxy or anchoring agent to seal and secure the dowel bars. There are various devices used to inject the epoxy, but it is important to place the epoxy in the back of the hole. By doing this, the adhesive will flow forward



*Injecting Epoxy*

once the dowel bar is installed and decrease the likelihood of leaving voids around the bar. Workers should be sure to insert the dowel with a twisting motion to ensure that the epoxy is evenly distributed around the circumference of the bar. Once the dowel bar is installed, workers should then place a dowel washer onto the dowel, pushing it snugly against the existing concrete face. The washer will ensure that the epoxy is kept in, while keeping moisture out.

After the dowel bars have been completely installed, it will be necessary to grease the exposed end of the dowel bar prior to the placement of the fresh concrete. This allows some movement of the dowels once the concrete has cured giving the patch some flexibility for load transfer.

In some situations, usually on larger patches, paving mesh is also used prior to placement of the concrete. The paving mesh can add some durability to the area after it has cured. Your supervisor will let you know when paving mesh is required.

Finally the entire repair area needs to be dampened just prior to the placement of the new concrete.

### **New concrete placement**

A concrete accelerant should be added to the concrete mix while it is still in the truck, just prior to unloading.



*The Chute Operator*

Concrete should be placed as soon as possible after the repair area has been prepared. A long delay can expose the area to inclement weather conditions and can pose a traffic hazard. Place concrete into the repair area using ready-mix trucks or some other form of batch vehicle. The chute operator should distribute the concrete throughout the area evenly to avoid excessive shoveling. Attaining good concrete consolidation around the dowel bars and along the patch perimeter is very important to the long-term performance of the patch.

To further consolidate the concrete, systematically manipulate the entire patch with a standard vibrator using vertical penetrations. This will adequately mobilize the concrete and eliminate any voids. **Do not drag the vibrator** through the mix; this may cause segregation and sacrifice the integrity of the patch.



*Vibrating*

There is to be no horseplay while operating the vibrator. Employees should also be aware of trip hazards associated with the hoses used to power the equipment. Hearing and eye protection should also be worn while placing the concrete.

### **Finishing the patch**

Once the patch area has been filled and any surface voids eliminated, the next step is to strike the area to a smooth surface by using a hydraulic or electric screed. The process requires at least two people to maneuver and operate the screed. It is important



*Screeding*

for the operators to work as a team and not rush through the leveling process. It takes some time and a little patience to get the desired results from the screed.

The screed, as with all equipment, has its own safety concerns. The screed itself is very heavy by design and should not be loaded or unloaded alone. Footing can be a real concern while operating the screed. Good housekeeping in your work area should be exercised. Someone should be assigned to tend the hoses of the screed while in operation. Workers should stay clear of the screed while it is operating and avoid letting the screed drift into the traffic space of the work zone.

After the appropriate leveling has been achieved, the patch will then need to be hand finished using a bull float. Using the bull float effectively and efficiently takes a lot of practice so don't get frustrated. Although bull floating can take some time, it is imperative that you not overwork the concrete. Overworking the concrete can cause patch deterioration and failures later down the road.



*Bull Floating*

After the patch has been bull floated to the desired sheen. Workers will need to edge the patch, texture or tine the patch and finally date the patch for future reference.

Curing the area of repair is the next step. First a curing agent should be applied to the area's surface and if weather conditions warrant, the area should be covered for the duration of the curing period. Curing provisions are necessary for a satisfactory moisture and temperature condition in the patching concrete after placement. In general, a liquid membrane-forming curing compound that meets ASTM C 309 material requirements is adequate. The material creates a seal that limits mix water evaporation and contributes to thorough cement hydration.

Curing duration depends a lot on the type of mix that is being utilized as well as weather factors that may hinder or speed up the drying process. Your supervisor will give you guidance on specific curing periods.

Insulation mats increase the concrete temperature and accelerate strength gain. For high-early strength patch mixes, the first few hours are the most critical for good curing. Therefore, the contractor should apply the curing compound and insulation as soon as possible after finishing the surface. To prevent moisture loss and to protect the surface, place one layer of polyethylene sheeting on the patch surface under the insulating boards or mats.

When the proper curing period has been achieved, any forms used will need to be removed and any damage to the shoulder should be repaired.

The perimeter of the patch area may then need to be sealed using a liquid asphalt to keep moisture from infiltrating the repair area and causing blow-ups in the future. Your supervisor will give you guidance on when the perimeter needs to be sealed. After the patch edge has been sealed, the area needs to be cleared of loose debris, materials, equipment, and personnel.

## **Opening to Traffic**

There are two methods to determine when to open full-depth repairs to traffic:

- Specified minimum strength
- Specified minimum time after completing

For most concrete pavement applications, it is preferable to measure the concrete strength to determine when it is acceptable for traffic. This is not always true for concrete repairs, particularly where quick opening is not critical. Most patch mixes fall into one of three categories for opening to traffic: 4 to 6 hour, 12 to 24 hour and 24 to 72 hour (conventional).

For the 12 to 24 hour and 4 to 6 hour mixes, time criteria does not provide the information necessary to allow traffic on as soon as possible. Variations in air temperature also can influence concrete strength development. Strength test is preferable. **Table 3** provides minimum opening strengths necessary for full-depth repairs.

**Table 3**

Property	Existing Slab Design Thickness	Requirement
Compressive Strength in 24 hours	8 inches or less	3000 psi min.
	9 inches	2700 psi min.
	10 inches or more	2000 psi min.
Compressive Strength in 28 days	--	4000 psi min.
Property	Existing Slab Design Thickness	Requirement
Compressive Strength in 4 hours <sup>a</sup>	8 inches or less	3000 psi min.
	9 inches	2700 psi min.
	10 inches or more	2000 psi min.
Compressive Strength in 28 days	--	4000 psi min.

<sup>a</sup>The cure time shall be the time determined to reach the 4-hour compressive strength. The roadway shall not be opened to traffic in less than 24 hours until the 4-hour compressive strength has been attained.

