Fast full-depth pavement repair

To open a pavement to traffic quickly, it takes more than just fast-setting concrete

By Gerald F. Voigt

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The methods used to remove old concrete, install dowels, and place and cure the repair concrete can greatly affect total repair time.

Full-depth pavement repair entails 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 rideability and structural integrity and can extend pavement service life. A major factor when installing full-depth repairs is opening them to traffic quickly. Several key factors that will help reduce the time necessary to install a full-depth repair in a concrete pavement include:

- Choice of repair size
- Method of old concrete removal
- Dowel installation equipment
- Patching material selection
- Placing and curing provisions
- Opening-to-traffic criteria

Repair size

The size and geometry of a repair can affect the speed of completion. Accurately defining repair boundaries is essential to completing a project quickly. Deterioration that is found outside of original repair boundaries after work has begun requires additional time-consuming sawcuts and concrete removal.

Except for on low-traffic roadways, all full-depth repairs should extend the full width of one lane. Under heavy traffic, full-width patches are large enough to avoid rocking, a problem often seen in smaller patches. Full-width patches also provide adequate room in the removal area for time-saving dowel-hole drill rigs and compaction equipment.

To simplify concrete removal, remove the concrete in rectangular sections. Don't make notches or diagonal cuts in the pavement. Doing so may reduce material costs, but it complicates sawcutting and concrete removal operations.

A time-consuming and costly step in the pavement patching process is preparing the transverse joints, which includes sawing the perimeter, drilling and grouting dowel holes, placing the dowels, and sealing the joint. It's often cheaper and faster to combine two adjacent patches into one large patch, because this reduces the number of transverse joints you have to prepare. Table 1 provides an estimate of the distance between patches when the cost of additional patching and curing is equivalent to the cost of preparing two patch joints (one from each patch). When two patches are closer than the distances shown in the table, it is probably more cost-effective to combine them into one large patch.

Removing old concrete

Before removing deteriorated concrete, isolate the area from adjacent concrete and shoulder materials using full-depth sawcuts. The full-depth cuts separate the segment of deteriorated concrete and allow room for its removal with minimal damage to surrounding material. To expedite the repair, make the sawcuts well in advance of concrete removal and placing operations, so that removal and placing operations will never be held up while waiting for sawing. Traffic can continue over sawcut sections that are waiting to be removed, but avoid keeping the area open longer than about two days. This will reduce the chance of traffic punching the patches into the subgrade.

Whenever possible, lift deteriorated concrete out of place rather than breaking it. Lifting the old concrete imparts no damage to the subbase and usually is faster and requires less labor than breaking the concrete before removal. The most common liftout method uses a steel chain connected to lift pins (Figure 1). Other time-saving lift equipment includes forklift devices, vertical bridges, and torque claw attachments for front-end loaders.

Figure 1. **Whenever possible, lift deteriorated concrete out of place rather than breaking it. Lifting the old concrete imparts no damage to the subbase and usually is faster and requires less labor than breaking the concrete before removal.**

Installing dowels

For most full-depth repairs of jointed pavements (except light-traffic plain pavements less than 7 inches thick), doweled transverse joints are essential for load transfer. Generally, 1½-inch-diameter dowel bars provide effective load transfer for full-depth repairs in airport, interstate highway, or industrial pavements. For light-traffic highways and pavements less than 10 inches thick, 1¼-inch-diameter dowels are acceptable.

Dowel bars slip into holes drilled into the edge of the existing slab. Automatic dowel drilling rigs produce straight, consistent holes faster than single, hand-held drills (Figure 2). Modern dowel drilling rigs mount on a boom or on a frame with wheels and are maneuverable on a jobsite. However, single, frame-mounted, or hand-held drills are necessary where there is not enough room for the multiple-drill rigs.

Both standard pneumatic or hydraulic percussion drills are acceptable for drilling dowel holes. Both drill a typical dowel hole in about 30 seconds. Avoid electric-pneumatic rotary drills where speed and production are essential because they take three to four times longer to drill each hole.

After drilling, clean out the dowel holes. Insert an air nozzle into the hole to force out all dust and debris. Dust and dirt prevent the epoxy or nonshrink grout from bonding to the concrete around the hole perimeter. Oil also prevents good bonding. Therefore, always check the air for oil and moisture contamination from the compressor by blowing some air into a piece of dry cloth.

Place the anchoring material using a long nozzle that feeds the material to the back of the hole. This ensures that the anchoring material will flow forward along the entire dowel embedment length during insertion and decreases the likelihood of leaving voids between the dowel and the concrete. Prefabricated epoxy cartridges are available that supply enough material for one or two holes, but a faster and cheaper system for large projects is to use a pressurized injection system from bulk epoxy containers.

Patches in continuously reinforced pavements require splicing to the existing steel embedded in the old concrete. Splicing the old steel requires careful hand chipping with light jackhammers, which slows production. To reduce patching time, some agencies avoid splicing to the

Table 1. Criteria for Combining Adjacent Patches

Minimum cost-effective distance in feet between two patches

Slab Thickness (inches)	Patch (Lane) Width			
	9 Feet	10 Feet	11 Feet	12 Feet
7.0	17	15	14	13
8.0	15	13	12	11
9.0	13	12	11	10
10.0	12	11	10	9
11.0	11	10	9	8
12.0	10	9	8	8
15.0	8	8	7	6

It's often cheaper and faster to combine two adjacent patches into one large patch because this reduces the number of transverse joints that need to be prepared. If two patches are closer than the distances shown above, it is probably more cost-effective to combine them into one large patch.

old steel by drilling holes and anchoring all new reinforcing bars into the old concrete. This procedure makes the repair faster because it does not require hand chipping to expose the lap length of existing reinforcing bars. Hole cleaning and grouting steps should conform to those for dowel bars in jointed pavements.

Selecting a repair material

Patch mixes for full-depth repairs often use ASTM C 150 Types I, II, or III portland cement. The target slump ranges from about 2 to 4 inches to provide adequate finishibility. Most patch mixes require 4.5% to 7.5% entrained air, 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.

Mix proportions will depend on the pavement opening requirements. Mixes containing Type III cement or calcium chloride accelerators are common for the early strength gain necessary for quick opening. Proprietary cements also are available that gain strength very quickly. Using insulating blankets (or boards) during the first few hours after placement also improves the strength development of any mix by holding in the heat from cement hydration. Table 2 provides the approximate time necessary for different mixes to reach 2000 psi, a strength often required before opening the pavement to traffic.

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 can cause the concrete to suffer from high shrinkage during curing. Consider using a water-reducing admixture to disperse cement particles and reduce the extra water necessary for thorough mixing.

Precautions are necessary when using a calcium chloride accelerator. Initial set may occur within 30 minutes on warm days, so use only 1% calcium chloride by weight of cement when air temperature exceeds 80° F. Up to 2% is acceptable in lower temperatures. For on-site mixing, add calcium chloride in liquid form to the mixer before adding other admixtures.

Placing and curing

Place concrete into the repair area from ready mix trucks or other mobile batch vehicles. The chute operator should distribute the concrete evenly to avoid the need for excessive shoveling. Attaining good concrete consolidation around dowel bars and along the patch perimeter is important to achieve long-term performance. Vertical penetrations of a standard spud vibrator will adequately mobilize the patching concrete. Do not drag the vibrator through the mix because this may cause segregation and loss of entrained air.

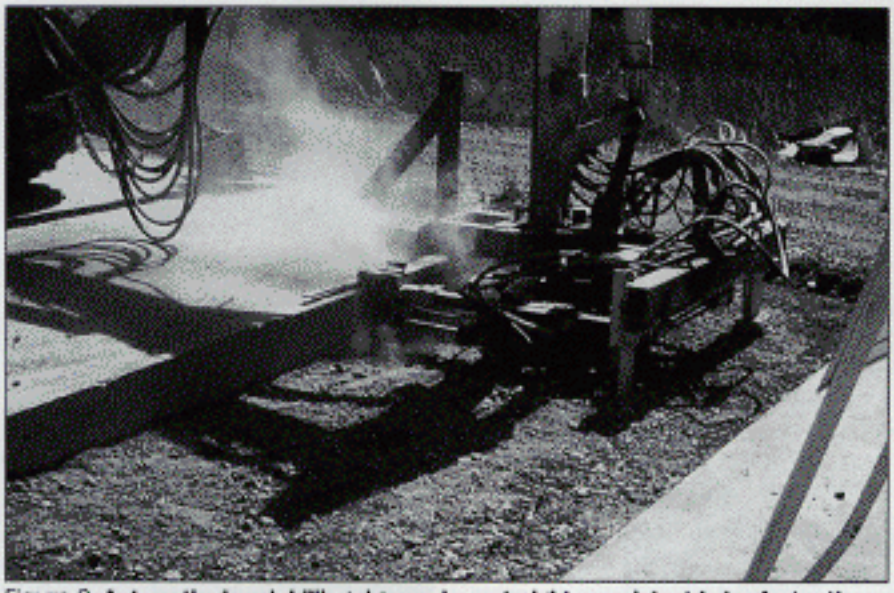

Figure 2. **Automatic dowel drilling rigs produce straight, consistent holes faster than single, hand-held drills.**

For high-early-strength patch mixes, the first few hours after placing the concrete are the most critical. Proper curing is essential to maintain a satisfactory moisture and temperature condition in the concrete after placement. As soon as possible, apply a liquid-membrane-forming curing compound at a rate of about 200 square feet per gallon and cover the patches with insulating mats. Place polyethylene sheeting between the mats and fresh concrete to avoid marring the patch surface.

Opening to traffic

Table 3 provides minimum concrete compressive strengths necessary to open the full-depth repairs to traffic. Most patch mixes fall into one of three categories depending on the time it usually takes them to reach these minimum compressive strengths: 4- to 6-hour mixes, 12- to 24-hour mixes, and 24- to 72-hour mixes. For the 4- to 6-hour and 12-

Table 2. Compressive Strength Development of Repair Concretes

For Mixes Containing:	Typical Time to Opening Strength (Approx. 2000 psi)
Certain blended cements	2-4 hours
Sulfo-aluminate cements	2-4 hours
Type III cement with nonchloride accelerating admixture	4-6 hours
Type III cement with calcium chloride accelerator	4-6 hours
Type I cement with calcium chloride accelerator	6-8 hours
Type III cement with Type A water-reducing admixture	12-24 hours
Type I cement (air-entrained paving mix without fly ash)	24-72 hours

to 24-hour mixes, the concrete strength should be measured to determine if it is ready to accept traffic. Small variations in air temperature can have a great effect on the strength development of these mixes. Portable beam or cylinder test devices, maturity meters, or pulse-velocity devices can be used.

The 12- to 24-hour mixes are conventional mixes and are often used when fast turnaround is not critical. Paying close attention to the strength development of these mixes is often not necessary—specifying a minimum time after placement is sensible in these situations.

Acknowledgment

This article is based on the newly revised American Concrete Pavement Association technical publication TB002P *Guidelines for Full-Depth Repair*. For more information, contact: ACPA, 5420 Old Orchard Rd., Suite A100, Skokie, IL 60077 (847-966-2272).

Table 3. Minimum Opening Strength Needed for Full-depth Repairs

Slab Thickness (inches)	Compressive Strength for Opening to Traffic (psi)	
	Repair Length <10 Feet	Total Slab Replacement
6	3000	3600
7	2400	2700
8	2150	2150
9	2000	2000
10 or more	2000	2000

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