When concrete flatwork has to be resurfaced, the first steps in the process are often the most critical. Repairs won't last long if overlays or coatings don't bond properly to the underlying concrete. Deteriorated concrete must be removed and the surface scarified and cleaned. Sometimes all of these objectives may be achieved with a single piece of equipment. In other cases, separate operations and different types of equipment may be needed.

Scarifiers, scabblers, abrasive blasters and waterblasters are some of the machines used for surface preparation. Most scarifying machines and scabblers are mechanized versions of a hammer and chisel. Hard metallic bits impact the surface or circular cutters rotate over and flail the surface. Abrasive blasters use sand, metallic shot or grit to abrade the surface, while waterblasters use high-pressure jets of water that sometimes also contains abrasives.

Uses of these machines aren't confined to repair applications. They can also be useful for removing carpet backing, tile adhesives, poorly applied polymer materials or paints from concrete surfaces.

Choosing the right equipment

Several questions have to be answered before choosing the equipment for a job.

• What thickness of concrete or coating has to be removed?
• What is the condition of the concrete? If it's sound concrete, what is the estimated compressive strength?
• Is there reinforcing steel close to the surface?
• What kind of new surface will be applied and at what thickness?
• Does an existing coating have to be removed? If so, what kind of a coating is it?

Failure to consider some of these questions may lead to overly optimistic predictions of production rates. For instance, the condition of the concrete to be removed on bridge or parking decks may vary considerably. If it is delaminated or crumbling because of freezing and thawing damage, production rates can be high. But if the concrete is being removed only because it's full of chlorides, strength may still be high and production rates low.

Other needed information deals with environmental and safety concerns.

• Is the job inside a building?
• If work is to be done on elevated decks, how thick is the concrete slab? Are there any weight restrictions on equipment?

Once these questions have been answered, you're in a better position to pick the best removal method or combination of methods.

Abrasive blasters

Sandblast—Most contractors are familiar with sandblasting machines which are a type of abrasive blaster. The machines use compressed air to eject a high-speed stream of sand or other abrasive from a nozzle. In repair applications, sandblasting can be used for final surface preparation to remove laitance, dirt, oil or other contaminants. Hardness of the concrete surface is a key factor in determining whether sandblasting is the most economical removal method for applications other than
light cleaning. The best way to estimate production rates is to actually do a test run with the blasting equipment and abrasive recommended by the manufacturer.

The abrasive used for sandblasting concrete must be coarser than that used for sandblasting metal surfaces. An 8- to 10-mesh sand is recommended. To remove laitance only, a 20-mesh material may be adequate. If a coating is to be removed from the concrete, an angular sand will cut better than one with rounded particles. Some repair specialists say that if the sand is too soft it will polish the concrete surface instead of roughening it.

Dust is a problem when sandblasting is used. Workers must wear air-fed helmets because breathing heavy concentrations of dust over an extended period is harmful. Some sandblasting systems inject water with the abrasive stream. This not only holds down the dust but also provides a washdown of the cleaned surface. The operator flips a switch to cut off the abrasive so water alone can be used for final washdown operations.

Cleanup is another problem. Brooms and shovels are still used on some jobs to remove sand and the abraded concrete, but industrial vacuums are more efficient and do a better job.

Shotblasters—A metallic abrasive (steel shot) is used in shotblasting machines to scour the concrete surface. Shot is propelled by a rotating wheel, impacts on the concrete surface and rebounds into a recovery unit. A pneumatically driven vacuum system collects dust and the shot, separating and recycling the usable shot and removing the dust through a filtering system.

Both push-type manual models and self-propelled riding shotblasters are available. Self-propelled units are powered by gas, propane or electric motors ranging from 10- to 100-horsepower. Different machine speeds enable the operator to slow down during surface preparation work and speed up for movement around the job site.

Good control of dust is one of the major advantages of shotblasters. The machines have been used immediately adjacent to operating computers without causing problems. Since no water is used, the surface is immediately ready for the application of coatings that require a dry surface.

Shotblasting is typically used for cleaning or scarification to depths up to \( \frac{1}{8} \) inch (Figure 1). In preparation for epoxy or urethane coatings, fine shot is used to produce a very light etching (brush blast) of the surface. The profile for this type of blast is typically only 4 or 5 mils deep (a business card is about 10 mils thick). A brush blast breaks the shiny surface on a concrete floor and opens the pores to improve adhesion of the coating.

When a topping or overlay is to be placed, an aggressive blast exposes sand particles. Or a deeper exposed aggregate blast removes the mortar matrix down to the coarse aggregate, sometimes to a depth that leaves protruding coarse particles. Three factors control the depth of blast:

- size of the abrasive (coarser shot etches the surface more deeply)
- amount of abrasive (an abrasive control valve allows the operator to increase the flow of abrasive for a deeper etch)
- speed of the machine (slower speed is needed for a deeper etch).

Figure 1. Shotblasting is typically used for cleaning or scarification to depths up to \( \frac{1}{8} \) inch. Depth of blast is affected by size and amount of abrasive used, and by speed of the machine. Darker area at the top of the photo hasn’t been shotblasted.

Figure 2. A stripping machine can be used to remove elastomeric coatings prior to shotblasting. Two slow-turning blades follow the slab contour as they cut away the coating.
Available machines provide cleaning path widths ranging from 6 to 20 inches. Production rates are affected not only by path width but by desired removal depth, hardness of the concrete, shot size, presence and properties of previous coatings and travel speed of the machine. Rates in excess of 2500 square feet per hour for a brush blast have been reported, but the attainable rates are strongly dependent on the factors mentioned above. For instance, a heavy coating of grease or an elastomeric coating on an old floor will cause the shot to bounce rather than scour the surface. And if the existing coating has worn off in some spots, the bare concrete will be more deeply etched causing an irregular surface. When a thick topping is to be applied, the irregular surface won’t be a problem, but for thin urethane coatings a uniform surface is needed. If the existing coating is ⅛ inch thick or more, or if part of it has worn off, it should be removed with a scarifier or stripping machine (Figure 2) before the surface is shotblasted.

Obstructions will considerably slow the production rate of shotblasters. Typical self-propelled machines will clean to within 1 to 2 inches of a wall, machinery base, column or other obstruction. Edging to within ½ inch of vertical surfaces can be done with smaller units or handheld tools but this slows job progress. The machines work most efficiently in wide open spaces.

There are no wear parts in direct contact with the concrete surface but under continuous use the throwing wheel must be frequently replaced and abrasive particles will gradually be pulverized.

Scabbler and scarifiers

Scabblers—Scabblers use compressed air to hammer piston-mounted bits into the concrete surface. They tend to roughen the concrete surface more than either abrasive blasting or shotblasting (Figure 3). Hand-held, push-type and self-propelled scabblers are available. The push and self-propelled machines are suitable only for horizontal or slightly inclined surfaces whereas the hand-held machines can be used for vertical surfaces.

Self-propelled scabblers have some of the same features of shotblasters—mobility, speed, and optional vacuum and filter systems. Also, their production rate for cleaning (approximately ⅛ of an inch penetration) is about the same as for shotblasters. They can remove up to ¼ inch of concrete surface in a single pass, but the production rate in square feet per hour depends on the strength of the concrete. A typical removal rate for a machine with a 12-inch working width is 45 to 80 square
feet per hour (¾-inch depth). Self-propelled scabblers can’t remove concrete immediately adjacent to walls; manufacturers have developed manually operated 1 or 2 bit scabblers for this purpose. Some attach to a larger machine enabling them to be operated from the same power unit (Figure 4).

The push or walk-behind scabblers consist of from 2 to 11 bits, piston-mounted, which operate from compressed air. An air compressor is required which can deliver air at a rate of 100 to 300 cubic feet per minute and a pressure of 90 psi. The working width of the scabblers varies from 4 to 19 inches.

Hand-held scabblers usually consist of only one bit and therefore have a reduced air consumption requirement and also a lower productivity. The air requirements are 20 to 35 cubic feet per minute and a pressure of 80 psi. Productivity will vary depending on application and operator skill but will usually range from 25 to 50 square feet per hour.

Scabbling operations are dusty unless a vacuum system is used. Wetting the surface to be scabbled will help control dust if vacuum attachments aren’t available. Scabblers are also noisy and produce some vibration.

Scabbler bits wear out and must be replaced. Most bits are constructed of tungsten carbide with 5 to 9 points or tips on each bit (Figure 5). Tungsten carbide bits have an average working life of 80 hours.

Scarifiers—Machines for scarifying concrete are sometimes called planers, milling machines, rotary cutters or simply surface preparation machines. Unlike scabblers, in which bits move vertically to hammer the concrete surface, scarifying machines apply a rotating circular cutting wheel to the concrete surface (Figure 6). Depth of cut can be more precisely controlled than with scabblers. The machines have different styles of interchangeable cutter assemblies (Figure 7) that are used for cleaning, grinding and light or heavy milling. The cutting path is typically 2 to 18 inches wide and the machines can remove concrete to within 1/2 inch of a wall or other vertical surface. A hand-held bit scabbler can finish the narrow strip adjacent to the wall.

Scarifiers with rotary cutters are available in push-type or self-propelled models powered by compressed air, gasoline or electricity. A fine adjustment knob is used to control cutting wheel height, and in some models cutters can be quickly changed when a different texture is needed or when they wear out.

Production rates for scarifiers depend on the strength of the concrete, hardness of the aggregate and depth of removal needed. One manufacturer estimates that production rates will range from 250 to 500 square feet per hour for a ¾-inch removal depth of 3500 psi concrete.
more than \( \frac{1}{2} \) inch of concrete is to be removed, the manufacturer recommends making several passes over the area rather than making one slow pass. This reportedly prolongs cutter life and increases production rates. Some contractors make at least two passes with the scarifier one at right angles to the other, for nearly all of their scarifier work.

Scarifying machines generate a lot of dust. Wetting the surface will help to control dust, but a more effective means is an optional dust collector that can be purchased for use with some models. Like scabblers, scarifiers are noisy and produce vibrations. If there’s an ornamental coating on the underside of the concrete being scarified, vibrations may cause it to flake off.

The primary wear parts on scarifiers are the cutters. Depending on properties of the surface being scarified, cutter life may vary from 4 hours to 24 hours according to one contractor. He uses worn cutters to knock off hard existing coatings such as epoxies. This has two advantages. He gets more use out of his cutters, and the hammering action of the worn cutters breaks the epoxy without putting teeth marks in the concrete. This is particularly important when the final treatment will be a brush blast in preparation for a thin coating.

For jobs involving large areas and removal of several inches of concrete, large milling machines (rotomills) are a more economical alternative than the lightweight push-type or self-propelled scarifiers. The larger machines, commonly used on highways and bridge decks, can remove several inches of concrete in one pass up to 12 feet wide. However, they are generally too large and heavy to be used in buildings.

Waterblasters

 Newly developed high-pressure waterblasters are now being used to prepare concrete surfaces for repair. The units have been used in applications ranging from laitance removal to hydrodemolition of concrete to depths up to 12 inches. On bridge and parking decks, removal depths of 2 or 3 inches are most common.

High-pressure water jets used for concrete removal typically develop pressures in the 16,000 to 25,000 psi range although pressures this high aren’t always needed. Pressures in excess of 60,000 psi are possible. Water consumption is at a rate of about 20 to 26 gallons per minute. On some machines the jet moves back and forth along a beam (Figure 8). Depth of removal is controlled by adjusting water pressure, speed of the nozzle as it moves along the beam, and speed of the machine itself. The jet cuts a series of grooves and water pressure breaks up the concrete between grooves. Another type of machine operates like a lawn mower but instead of a blade there are rotating nozzles that clean the concrete in circular paths. The results of using this type of machine for membrane removal are shown in Figure 9.

Some machines use a robot cutter (photo on page 927) and a high-pressure pump placed at a remote location. Other machines include the water jet assembly,
• Removal of deteriorated concrete is faster than by conventional methods such as jackhammers.

The production rate for waterblasters is affected by strength and condition of the concrete. Carbonation of concrete, particularly in parking garages, produces an extremely hard and low porosity surface which can make initial penetration of the jets difficult. This slows production. On the other hand, delaminated or deteriorated concrete will break out rather easily. Removal rates can range from 10 to nearly 30 cubic feet per hour. When waterblasters are used as scarifying machines (1⁄4-inch depth), reported productivity rates are 500 to 800 square feet per hour. Laitance removal rates can exceed 2000 square feet per hour.

Waterblasting debris must be removed daily to prevent it from setting up. This is usually accomplished by shoveling followed by one or two washouts with a high pressure wand (powered by the pump). Waste water can be removed by an industrial vacuum unit. More commonly the water is drained into settling tanks located underneath the work area. The water can be a nuisance, especially if a parking garage is still in use while repair work is being done. Garage users have to get around the water and drains may have to be rodded out occasionally.

Problems with a shadowing effect under rebar have been reported on some jobs. The jets removed concrete on each side of the rebar but didn't leave enough clearance beneath the bars. Extra work was involved in removing concrete by hand in these areas.

The primary wear part in the cutting assembly is the water jet nozzle. Nozzle life can range from 20 to 200 hours depending on the nozzle material, water quality and pressures used. Water quality is a critical factor affecting nozzle life because any impurities in the water will cause the nozzle to wear out faster. If water is supplied from a fire hydrant, water filter cartridges on the pumps may have to be changed daily. When cleaner water is supplied, cartridge life can exceed 100 hours. Pump packing usually lasts at least 500 hours.

Be careful in bidding for surface preparation work

Contractors who do concrete surface preparation work unanimously agree on two points. No two jobs are alike. And production rates will vary considerably with the job to be done. To avoid losing money because of a poorly prepared bid, first find out exactly what end result is expected. Also discuss allowable noise, dust and vibration levels. Ask how quickly the work has to be done. Look at the concrete, estimate the compressive strength and, if it's possible, do a test run with your equipment before completing bidding. Then choose the best equipment for the job and you've considerably increased the chance of doing it profitably.

Editor's note

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