

Surface Preparation of the Concrete Substrate

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Surface preparation is a critical factor in the performance of coatings and repair materials applied to concrete. This Update discusses the technical requirements and the various methods for preparing a surface.

The surface preparation of concrete in readiness for the application of a coating or repair material includes all the steps taken after the removal of the deteriorated concrete. Many of the same steps apply when little or no concrete is removed. Proper preparation provides a dry, even and level surface free of dirt, dust, oil and grease. Removal of surface contaminants allows primers and repair materials to have direct contact with the substrate, increasing the surface area and roughness of the surface, and providing increased anchorage of the applied material.

The optimal condition of the concrete surface, however, depends on the type of repair being undertaken and the condition of the substrate. Also, it is not always possible to determine which material must be

removed, because the zones of damaged or deteriorated concrete are sometimes not well defined. Thus, the best approach is to remove material until aggregate particles are being broken rather than simply being pried loose from the matrix.

Before applying cement-based repair materials, the substrate should be saturated and the surface then dried to prevent the rapid loss of water from the repair material (to the substrate) and subsequent shrinkage and cracking. However, for resin-based materials the concrete surface must be dry for maximum adhesion to be achieved.

Prior to the application of coatings, the moisture content of the substrate should be checked by one of the following methods:

- 1) using an electrode-type moisture meter. For this method, readings of <5% moisture content by mass are required before the coating can be applied.^{2,3}
- 2) placing a sheet of plastic on the concrete surface for the same length of time the repair material would take to cure (normally 24 hours). If, after this time, there is visible moisture, a poor bond may result if “non-breathable” materials are applied.

Whenever deteriorated concrete is removed using impact tools, the surface of the remaining concrete may be damaged. If this latter damaged layer is not removed, the repair material will debond from the substrate.^{1,3,7} The remaining concrete should therefore undergo further preparation using wet sandblasting or high-pressure water jetting to remove this damaged

In order to choose the best concrete removal method or combination of methods, the following safety, environmental and job-related information should be obtained:¹

- Is the repair job to take place inside a building?
- Are there any restrictions with respect to noise, dust, vibration, exhaust fumes and disposal of wastewater?
- If the work is to be done on elevated decks, are there any weight restrictions on the proposed repair equipment?
- How thick is the concrete or coating that has to be removed?
- What is the condition of the concrete? If it is sound, what is its estimated compressive strength?
- Is the reinforcing steel close to the surface?
- What kind of new surface will be applied and how thick will it be?
- Is there an existing coating that has to be removed? If so, what kind is it?

surface material. Usually the removal of limited areas of concrete to permit a repair requires the sawcutting of the perimeter of the areas to minimize feather-edging.

Methods of Surface Preparation

Chemical Cleaning

Concrete contaminated with oil, grease or dirt can be cleaned with detergent, trisodium phosphate or various proprietary concrete cleaners. The use of these materials should be followed by vigorous scrubbing and thorough rinsing with water to remove all residue. Solvents should not be used to clean concrete since they will dissolve the contaminate and carry it deeper into the concrete. Muriatic acid is relatively ineffective in removing oil and grease.^{3,4}

Mechanical Cleaning

Mechanical cleaning devices are of two types, rotary and impact. Rotary equipment includes discs and grinders usually used on low compressive strength concrete substrates that do not have a steel trowelled finish. These devices are not effective on hard dense concrete, which they are likely to polish rather than abrade.^{5,6}

Impact tools and scabblers. Devices such as bush hammers, scabblers and needle guns will effectively remove several millimetres of surface. Scabblers use compressed air to hammer piston-mounted bits into the concrete surface; this roughens the surface more than either abrasive blasting or shotblasting. Varying degrees of surface preparation may be achieved, depending on which hammer heads are used. Scabbling operations are dusty and noisy and produce some vibration. Because impact tools pulverize the concrete and can cause fracturing of the concrete substrate, it may be necessary to use water jetting or wet sandblasting for a final surface cleaning.⁵

Scarifiers. Scarifying machines apply a rotating circular cutting wheel to the concrete surface. Depth of cut can be more precisely controlled than with a scabbler. Different styles of interchangeable cutter assemblies can be used for cleaning, grinding and light or heavy milling. Like scabblers, scarifiers are noisy, produce vibrations and generate a great deal of dust, although the latter can be controlled by using a dust collector attachment. These machines are

effective on old floors, and will successfully remove old paint or curing compounds, but are relatively expensive and heavy, and require skilled operators.²

Blast Cleaning

Blast cleaning includes abrasive sandblasting, both wet and dry, shotblasting, and water-jet cleaning.

Sandblasting. Sandblasting machines use compressed air to eject a high-speed stream of sand (particle size ranging from No. 8–10 mesh) or some other abrasive from a nozzle. A finer sand (No. 20 mesh) is used to remove laitance, and an angular sand that cuts better than rounded sand is used to remove a coating from the concrete. The air source of a sandblasting machine must be equipped with an effective oil trap to avoid contamination of the concrete surface during the preparation phase.⁵

The hardness of the concrete is important in determining whether sandblasting is the most economical method of cleaning for applications requiring more than light cleaning. Sandblasting can be used for final surface preparation to remove laitance, dirt, oil and other contaminants. When the dry method of sandblasting is used, dust and clean-up are problems. The large volumes of abraded concrete and sand are collected by an industrial vacuum and workers usually wear air-fed helmets. Because of dust and associated health problems, dry sandblasting is now used sparingly.

Shotblasting. 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. This method is typically used for cleaning or scarification of the concrete to depths of up to 3 mm (1/8"). When the floor is to be coated with an epoxy or urethane coating, fine shot is used to produce a very light etching (brush blast) of the surface. The profile for this type of blast is typically 4 or 5 mils (0.1–0.2 mm) deep. A brush blast breaks the glazed surface of a concrete floor and provides a rough texture to improve adhesion of the coating.

When a topping or overlay is to be placed, a more vigorous blast is used to expose sand particles. The more aggressive blast abrades deeper, removing the mortar

matrix down to the coarse aggregate, sometimes to a depth that leaves protruding coarse particles. There are three factors that influence the depth of blast:¹

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

These factors, in addition to the cleaning path width, the desired removal depth, the hardness of the concrete, and the presence of previous coatings, affect production rates. For example, a heavy elastomeric coating on an old floor will cause shots to bounce off the surface rather than to scour it. Additionally, if the existing coating has worn off in spots, the bare concrete will become more deeply etched, producing an irregular surface. When a thick topping is to be applied, the irregular surface will not be a problem, but when a coating is to be used, a uniform surface is needed.

If the previous coating is thicker than 3 mm (1/8"), or has worn off in spots, it should be removed with a scarifier or stripping machine before the surface is shot-blasted.^{1,4} Being able to control dust is one of the major advantages of shotblasters. And since no water is used, the surface is immediately ready for the application of coatings that require a dry surface.



Figure 1. Ultra high-pressure cavitation jet
Photo courtesy CRC Press⁷

Waterblasting. This method consists of directing a high-velocity, high-pressure water jet to the concrete surface through a specially designed nozzle that travels transversely along a boom, sweeping back and forth across the concrete surface as the equipment advances incrementally. The equipment can be used in applications ranging from laitance removal to hydromolition of concrete to depths of up to 30 mm (12").

The water pressure, the speed of the nozzle as it moves along the boom, and the speed of the machine — all of which can be adjusted — control the depth of removal.

The jet cuts a series of grooves and water pressure breaks up the concrete between the grooves. This method is very effective when used as a final step in surface preparation. Its main limitation is the collection and disposal of wastewater. Waterblasting debris must be removed daily to prevent it from hardening. Frequently this method is used on bridge and parking garage decks to remove the concrete surface to a depth of up to 50–75 mm (2–3").

The advantages of this method are:

- There is no dust, and noise is minimal.
- There are no mechanical vibrations that might cause structural damage.
- The machine selectively removes deteriorated concrete and leaves good concrete intact.
- The reinforcing steel is not damaged as it could be by scarifiers or scabblers.
- The removal of deteriorated concrete is faster than by conventional methods such as jackhammers. Removal rates can range from 0.28–0.85 m³/h (10–30 ft³/h) and 46.45–74.32 m²/h (500–800 ft²/h) when used as a scarifier to remove surface material to a depth of 6 mm (1/4").

Acid Etching

Acid etching removes enough cement paste to provide a roughened surface, which improves the bond between the replacement materials and the substrate. Because of the potential for corrosion, ACI Committee 515 recommends that acid etching only be used when no alternative means of surface preparation is acceptable.^{2,7}

Flame Cleaning

Flame cleaning is generally used to clean concrete surfaces that are to receive coatings or resinous overlays. This method is particularly useful for oil-stained floors because it permits the application of coatings to the concrete immediately after. A special multi-flame oxy-acetylene blowpipe is passed over the concrete surface at uniform speed. The thickness of the concrete layer removed depends on the speed at which the blowpipe is moved and the properties of the concrete. The most suitable blowpipe speed lies between 0.02 m/s (0.066 ft/s) and 0.03 m/s (0.099 ft/s). Concrete and coating removal involves both the spalling and melting off of the surface. The laitance layer is usually removed to a depth of 1 or 2 mm (0.04" or 0.08") and in a few

instances up to 4 mm (0.16"). The moisture content of the concrete has the greatest effect on concrete removal — completely dry slabs do not produce much spalling, while slabs soaked in water prior to flame cleaning produce uniform concrete removal.

European experience⁷ indicates that flame cleaning does not promote the migration of deep-seated oil to the surface, does not remove the alkalinity of the matrix — the surface gradually attains alkalinity similar to that of new concrete — and does not promote the development of any visible cracks in the surface.

The method has proven useful for such applications as the recoating of concrete floors or the removal of defective elastomeric waterproofing membranes from parking decks.

Summary

The limitations of each surface preparation method — the dust, noise and vibration generated; the potential for corrosion; and the possibility of driving oil and grease deeper into the concrete — will determine the applicability of a given method to a particular type of building or occupancy (e.g., hospital, office building) and to the state of deterioration of the structure. Also, the advantages afforded by a particular method to achieve a specific result (such as light surface abrasion) will help clarify the appropriate option.

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