Resurfacing Concrete Floors

Resurfacing old, worn concrete floors can restore strength, improve abrasion resistance, create a like-new appearance, and make normal maintenance easier and more economical. These benefits can usually be achieved with conventional concrete overlays. Other options include polymer-modified cementitious mixtures, with or without fibers; thin-slurry or trowelable resurfacing products; and self-leveling underlayments or thin toppings.

CONVENTIONAL CONCRETE OVERLAYS

A concrete floor may be resurfaced with a fully bonded, partially bonded, or unbonded conventional concrete overlay.

A *fully bonded* overlay is placed on the existing concrete floor after the surface has been textured and cleaned. A sand-cement grout is used to develop strong bond, making the overlay an integral part of the repaired slab. Bonding is necessary for thin resurfacing that is less than 2 in. (50 mm) thick, but it also can be used for thicker layers.

A *partially bonded* overlay is placed directly on the base slab without purposely destroying or creating bond between the slabs.

An *unbonded overlay* is placed over a layer of material that's purposely intended to separate the existing floor and overlay, preventing bond between them. The existing floor serves as a base, but the overlay and base slab function as separate structural elements.

Fully bonded overlays can't be used in all floor restorations. There are circumstances in which unbonded construction must be used—for example, the oil-contaminated floor of a machine shop or vehicle repair shop. There may also be reasons to remove completely and rebuild one or more panels (bays) or parts of large-area industrial floor slabs. Three common reasons are (1) serious deterioration of a limited area of floor while the remainder is in good condition, (2) no tolerance for an increase in finished floor elevation, or (3) uneven settlement or consolidation of the subgrade, often with hard areas remaining above the surrounding soft areas and causing rocking of the slabs. Slabjacking may be an alternate solution for the latter problem.

Preliminary Considerations

Floor category, whether light- or heavy-duty, may determine the resurfacing method chosen. The distinction between light- and heavy-duty isn't always clear. However, *light-duty floors* generally include residential, office, institutional, and light commercial uses. *Heavy-duty floors*, typically in industrial buildings, are subjected to heavy moving and static loads, abrasion, and sometimes aggressive chemical attack. In some cases these floors are exposed to extremely hot or cold temperatures, as in steel foundries, where molten iron reaches a temperature of about 2795°F (1535°C), and around liquid oxygen tanks, the contents of which have a temperature of about -362°F (-183°C).

Floors subjected to chemical attack must be considered individually. The nature of the aggressive chemicals must be known and appropriate measures taken to protect the concrete. The more common aggressive substances and protective treatments are described in *Effects of Substances on Concrete and Guide to Protective Treatments* (IS001T), available from the Portland Cement Association (see page 8).

Before making a final decision on the feasibility and method of resurfacing, the building owner or manager must consider the following factors:

1. The general condition of the existing floor slab; strength and thickness of the concrete slab; presence of badly worn areas; condition of joints and cracks; and contamination of the surface by grease, oil, or other spillage.
2. The future use for the floor after resurfacing. In some cases this will be quite different from its previous or present use and may require an increase in load-carrying capability.
3. Restrictions on raising the finished floor level (due to adjoining slabs, door openings, or limited headroom).
4. Time allowed for resurfacing work.

General Repairs and Cleaning

Irrespective of the floor thickness or overlay method, general repairs to the base slab are desirable. Repair and cleaning operations may include improving the subgrade; patching joints and cracks; removing oil and grease contamination when a fully bonded overlay is used; cutting out and replacing weak and defective concrete; vacuuming loose particles and dust; and overnight prewetting of the newly cleaned, exposed surface before a new bonded concrete overlay is placed.

RECOMMENDED OVERLAY THICKNESS

Fully Bonded Overlay

The minimum recommended thickness is 1 to 2 in. (25 to 50 mm) for a fully bonded concrete overlay placed on a base slab that is practically free of cracks and in which the concrete is sound, clean, and of good quality. The use of welded wire fabric reinforcement is usually not warranted under these conditions. In general, cracks appearing in the existing base slab can be expected to reflect through bonded overlays.

Placing conventional concrete overlays less than 1 in. (25 mm) thick requires using small aggregate (maximum size 3/8 in. (10 mm) or less) and a high sand content. Because of the high water demand, these thinner-than-recommended overlays shrink more than thicker overlays and are more likely to crack, debond, and curl.

Most thin-bonded overlays are placed to restore the wearing surface, not to add strength to the slab. This may be all that is needed to restore serviceability of light-duty floors. When a slab must be strengthened, the strength of the overlaid slab can be approximated from formulas found in "Design of Concrete Overlays for Pavements," *Journal of the American Concrete Institute,* August 1967, pages 470-474. Although the formulas were developed for highway and airport pavements, they can be adjusted for use with floors. Strengthening might be required, for instance, if a heavy-duty floor in good condition must now carry loads that are larger or more frequent than the original design loads.

Partially Bonded or Unbonded Overlay

Unbonded construction with a minimum thickness of 4-in. (100-mm) is recommended if there are cracks in the base slab or if good bond is only partially attainable or totally lacking. Both light- and heavy-duty floors can benefit from unbonded construction because the existing slab provides a good base for the new floor surface. These overlays are usually thicker than bonded overlays, and the higher final floor elevation may interfere with other service requirements such as doorway clearances.

Even if cracks in the base slab are repaired, they may eventually reflect through a partially bonded overlay. Properly designed welded-wire fabric reinforcement can hold the overlay slab together at any cracks that may form. Placement of the fabric in a thin, partially bonded or unbonded overlay requires special precautions to ensure that it is positioned at the proper level below the surface. Reflective cracking can be reduced by using thicker overlays.

CONSTRUCTING FULLY BONDED OVERLAYS

Bond between a concrete substrate and overlay has a chemical and a mechanical component. A clean base slab allows development of the best chemical bond, and proper texturing allows maximum physical bond development.

Preparing the Base Slab

Dry preparation methods. Dry removal of impacted grease, oil, paint and weak concrete is the best surface preparation technique, particularly when all surface contamination or substandard concrete can be cut away. However, since contaminants such as petroleum products are highly penetrating, some residue may be present after dry removal is complete.

Dry removal of the old concrete surface is most effectively accomplished by abrasive blasting to remove the contaminated concrete and weak concrete, while providing a textured surface for bonding. Abrasives include steel shot, silica sand, mineral slags, and other natural, manufactured, or by-product materials (Reference 1).

Some specifiers require roughening the substrate to produce ridge-to-valley relief of about 1/4 in. (Reference 2). Abrasive blasting won't produce a substrate profile this deep, so high-pressure waterblasting (see wet preparation methods) or impact-type mechanical devices are needed. Use impact-type methods that don't cause microcracking in the layer below the prepared surface. Studies and experience have shown that the dynamic impact of some concrete removal methods may cause microcracking to depths up to 3/8 in. (References 3, 4). To minimize this kind of damage, some milling machines are equipped with small, pointed impact heads that impact the concrete at three different angles (Reference 5).

Special devices are needed to remove elastomeric floor coatings before applying concrete overlays. These devices employ metal cutters mounted on rotating heads or metal scraping blades that shave off the coatings (Reference 6). Further treatment such as shotblasting completes the surface treatment process.

Flame blasting is sometimes used to remove elastomeric membranes, paints, and coatings up to 1/4-in. thick. It may also be used to remove oil or grease spots. Devices for this purpose consist of several gas jets with rosebud tips that are mounted on a wheeled undercarriage. After cleaning oil or grease spots, sprinkle a little water on the surface to check for residual contamination. Oil or grease is still present if the water forms small globules. If the water is quickly absorbed, the concrete is oil-free.

After any dry preparation method, the surface should be swept and vacuumed or air blasted with oil-free compressed air to remove dust and weakly bonded base concrete.

Wet preparation methods. Wet preparation may be done with low- or high-pressure water, cleaning chemicals, or a combination of the two. Based on the pressures generated, pressure methods may only clean the surface or slightly etch it, or they may texture it to a significant depth.

When the concrete texture is such that adequate physical bond can occur, wet cleaning methods can be used. Often called power washing or pressure washing, this method employs devices to spray water at pressures less than 5000 psi (34 MPa). The most commonly used operating pressures are in a 2000- to 3000-psi (14- to 21-MPa) range (Reference 7). Proprietary cleaning products can be used with pressure washers to remove oil, grease, and other contaminants. Check the composition and toxicity of any cleaning products before using them. Surface cleaning methods are more fully explained in *Removing Stains* *and Cleaning Concrete Surfaces* (IS214T), available from the Portland Cement Association (see page 8).

At pressures of about 3000 to 5000 psi (21 to 35 MPa), low-pressure washers may etch the concrete surface. This is desirable when the existing surface is too smooth to provide adequate physical bond to the overlay.

High-pressure wet preparation methods usually operate at pressures between 5000 and 25000 psi (35 to 170 MPa). They will remove water-soluble contaminants, laitance, and other weak material from concrete surfaces. Deteriorated concrete may be removed to depths of 1/4 to 1/2 in. (6 to 13 mm). This produces a roughened surface without excessive microcracking. In some applications, however, high- or low-pressure wet methods may not be permitted because of possible damage to building contents. High- or low-pressure wet preparation methods are usually feasible only if the floor surface is large enough to justify mobilization costs and the costs of containing, removing, and disposing of water.

Acid etching is another wet cleaning method for concrete floors, but isn't recommended for preparing surfaces for concrete overlays. Used alone, it doesn't produce the deep profile and aggregate exposure needed for proper bonding. It also may weaken the surface by dissolving portions of the hydrated cement paste while leaving residual soft materials. Acid etching won't remove petroleum-based products or animal and vegetable oils (Reference 8). Detergent scrubbing by either manual or mechanical methods will remove oil, grease, and other deposits on concrete surfaces.

For further information on surface preparation see Reference 9, which is published by the International Concrete Repair Institute.

Maintaining Floor Elevation

Where the floor elevation must be retained, a partial-depth bonded overlay is used. The perimeter of the floor area to be overlaid is sawcut to full overlay depth. This vertical saw cut is essentially a butt joint that provides a straight edge where old and new slabs meet. It serves as a form against which the new concrete can be placed and consolidated.

Forms for Bonded Overlays

Edge forms and screed guides for bonded overlays vary from job to job. Solid support is usually required along the sides of the area resurfaced so the overlay can be accurately struck off to the desired elevation.

If only parts of a factory or warehouse floor are resurfaced with a partial-depth overlay, the remaining floor surrounding the resurfaced areas may serve as a form and screed guide. If the overlay is more than 10 to 12 feet wide and is being screeded by hand, intermediate screed guides may be needed. When the entire floor is to be resurfaced, wood-batten or steel-angle forms of proper depth and adequate strength can be placed on a carefully leveled area and held in place by power-driven studs. Tubular steel screed guides set in pads of mortar have been used successfully by some contractors. Where possible, align forms with joints in the base slab.

After the forms and screeds have been set, check their elevation with an engineer's level or laser and adjust them as needed to ensure the desired surface tolerance, slope for drainage, and minimum overlay thickness at all locations.

Fig. 1. Just prior to placing the concrete topping mix, broom a grout into the surface to provide a bonding course between the old and new surfaces.

Bonding Grout

Immediately before a fully bonded overlay is placed, scrub a thin coating of bonding grout into the cleaned, dry surface or cleaned, damp (but not wet) surface if it has been prewetted overnight. Make the grout with approximate proportions of 1 part portland cement, 1 part concrete or masonry sand, and 1/2 part water mixed to give a thick, creamy, paintlike consistency. Tensile strength of the bonding grout should equal or be slightly greater than the tensile strength of the concrete substrate—typically 300 to 500 psi (2 to 3 MPa) for 3000- to 4000-psi (20- to 30 MPa) concrete. For higher strength concrete substrates, it may be necessary to add latex or epoxy modifiers to the grout to produce adequate tensile strength.

Place the grout in a 1/16- to 1/8-in. (2- to 3-mm) layer. When brooming the grout into the surface (see Fig. 1), make sure that the entire surface receives a thorough, even coating and that no excess grout collects in pockets. Don't apply grout faster than the overlay concrete can be placed and never let the grout dry to a whitish appearance before the overlay concrete is placed. If it dries, the grout will act as a debonding layer instead of improving the bond. If the grout does dry before the overlay can be placed, remove the grout completely by sandblasting, sweeping, and then waterblasting.

Concrete Proportions

Concrete for resurfacing floors must have a reasonably low water-cement ratio to ensure adequate strength and abrasion resistance, and, most importantly, low drying shrinkage. Mix proportions will vary depending on the thickness of concrete to be placed. Generally, the maximum aggregate size should be no more than one-third the thickness of the layer. In 1-in.-thick bonded overlays,

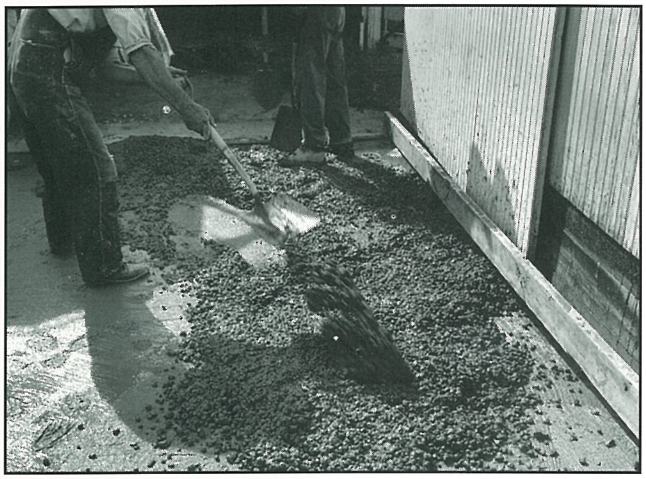

Fig. 2. Place the concrete topping mixture with as little water as possible.

a 3/8-in. (10-mm) maximum-size aggregate is commonly used. The concrete should usually have a water-cement ratio of 0.45 or less, and a minimum cement content of 600 lb per cubic yard (360 kg per m^3). The concrete should attain a 28-day compressive strength of 5000 psi (35 MPa) or more, depending on the severity of abrasive exposure. High-compressive-strength concrete alone does not guarantee high surface abrasion resistance. Resistance to abrasion is also a function of the toughness of surface aggregate, surface water-cement ratio, finishing method, and curing methods (Reference 10).

Concrete overlays will shrink when they dry, but the older substrate concrete will shrink very little. Because too much differential shrinkage can cause a bond failure, it's important to minimize shrinkage of the overlay concrete. This can be done by using concrete with a low water content and high coarse aggregate content (see Fig. 2) and using vibration for consolidation during placing. A slump of 3 in. (75 mm) or less will permit a vibratory screed to be used without bringing excess mortar to the surface. A higher slump is needed when hand strikeoff and compaction are used to place the concrete. A rotary-disk float can compact a drier, harsher mix than can be worked by hand; vibratory roller screeds are also helpful.

A superplasticizer (high-range water reducer) can be added to the concrete to obtain a higher slump for easier placement, but there may be a tendency for coarse aggregate segregation if the slump is too high. In addition to improving placeability, a superplasticizer can also be used to reduce the water-cement ratio to 0.4 or less. The slump of the concrete before the superplasticizer is added is usually in the range of 1 to 2 in. (25 to 50 mm).

Placing and Finishing Bonded Overlays

Hand or machine methods can be used to place and finish the overlay, but machine methods are recommended. The operations are similar to those used in conventional concrete floor construction: strikeoff, compact, float, trowel, and cure.

After the topping has been struck off and compacted by a vibratory screed or other means and all excess moisture has disappeared, a float is used to produce an open and level surface. A rotary-disk float can be used both to compact and to float stiff, dry mixes.

Depending on temperature and relative humidity, a further delay after floating may be necessary for moisture to disappear. Then two or three power-troweling passes will produce the final smooth, hard, and uniform finish. Final hard troweling may be done by hand to remove any trowel marks left by the machine if these marks are objectionable. Some hand-floating and troweling may be needed along edges and joints.

Screeding, floating, and troweling should not bring free water to the surface. Don't apply a dust coat of dry cement or a mixture of sand and cement to take up excess water. This practice can cause crazing and dusting.

Jointing Bonded Overlays

If the bonded overlay will be carpeted or will receive other floor coverings that perform satisfactorily over a cracked substrate, jointing may not be needed. For uncovered floors, however, contraction joints should be used to control random cracking in the overlay.

To ensure proper functioning, give careful attention to jointing details for bonded concrete overlays. The base slab and bonded overlay should move together, so all working joints in the base slab must be reproduced in the overlay. Precisely matching the overlay and base slab joint patterns helps minimize reflective cracking.

A hand-tooled joint or a saw cut can be used as a contraction joint in the topping. These joints should be full depth, placed exactly over joint positions in the old floor, and be as wide as or slightly wider than the old joints. When contraction joints are sawed, the work must be done before random cracking can migrate up from the joints in the old slab below. Early-cut saws permit sawing the concrete soon after finishing (Reference 11). Sawcut joints are preferred to hand-tooled joints for floors that receive heavy, hard-wheeled traffic.

Expansion or isolation joints are required only where similar joints occur in the main structure. Reinforcement is seldom needed in thin-bonded overlays.

Although movement at contraction joints in a floor is generally very small, joint filling is beneficial because it increases joint edge support and helps to prevent spalling at the joint. Where there are wet conditions, hygienic and dust-control requirements, or traffic by small, hard-wheel vehicles such as forklifts, joint filling is necessary.

In some locations, an elastomeric sealant such as polyurethane is satisfactory, but to provide support to the edges and prevent spalling at saw-cut joints, a good quality, semirigid epoxy filler with a minimum Shore A hardness of 80 or a minimum Shore D hardness of 50 (ASTM D 2240) should be used. The material should be installed full depth in the saw cut, without a backer rod, and flush with the new floor surface.

Curing Bonded Overlays

Proper curing is even more important in bonded resurfacing than in ordinary concrete work because of the potential for rapid, early drying of the thin concrete overlay due to its high surface-to-volume ratio. Start curing as soon as possible after finishing operations have been completed. If drying occurs soon after concrete is placed it may cause surface crazing and cracking. Use a fog spray immediately after finishing, if necessary to protect against rapid drying, and cover with wet burlap, plastic sheets, or waterproof paper as soon as these materials can be placed without marring the surface. Keep the concrete covered and wet for at least 7 days when using normal-portland-cement concrete at air temperatures above 50°F (10°C).

Good curing is vital to producing a satisfactory floor overlay. Good curing not only increases strength and wear resistance, but reduces early drying shrinkage and cracking. Curing must be started early.

CONSTRUCTING UNBONDED OR PARTIALLY BONDED OVERLAYS

When an existing floor slab is not in suitable condition to receive a fully bonded overlay, it is often adequate to overlay the old floor with an unbonded slab. The thickness of such a topping must be greater than that of a bonded overlay. Base slabs are helpful in reducing deflection in the new slab but they don't reduce stresses. Because of this, unbonded overlays subjected to very heavy moving loads or severe impact usually require a thickness of 6 in. (150 mm) or more. Thinner overlays aren't recommended for these conditions because forklift loads can cause reflective cracking and corner cracking of curled slabs. For less severe conditions, a 4-in. (100 mm) thickness may be satisfactory.

Preparing the Base Slab

Sweep the old base slab clean and fill badly worn areas, spalls, and holes with a cement-sand mortar to bring the surface to a reasonably flat plane.

Separation Layer (Bondbreaker)

A separation layer prevents bond between the old and new concrete. Layers of polyethylene sheet, roofing felt, or waterproof building paper will serve as bondbreakers. They should be spread as wrinkle-free as possible. Wax-based liquid curing compounds will also break the bond between the overlay and base slab. If a vapor barrier is needed under the overlay, membranes used for this purpose can also serve as bondbreakers. Materials such as plastic sheeting reduce friction between the overlay and base slab so that movements in the new topping caused by drying shrinkage and thermal contraction aren't restrained by the concrete below.

When a separation layer is used, the two slabs are independent of each other, and contraction and construction joints in the old slab can be ignored. Thus, joints in the new topping can be laid out in bays (panels) to the most convenient size and shape, taking into account the thickness of the topping and the amount of reinforcement provided (if any). When planning the jointing pattern for heavy-duty warehouse floor overlays, consider rack spacing and traffic patterns for forklifts. Wherever possible, position joints beneath racks or in low-traffic areas since joints are most vulnerable to damage by hard-wheeled traffic. For partially bonded overlays, precisely match joints to those in the old slab to minimize reflective cracking. In all cases, isolation (expansion) joints in the old slab should be extended up through the new topping.

Reinforcement

In partially bonded or unbonded overlays, reinforcement serves the same purpose as it does in any floor construction—holding crack faces tightly together so wide cracks don't cause a maintenance problem. If the old floor is extensively cracked, the use of distributed steel reinforcement may be the most dependable method of controlling cracking in unbonded overlays.

The required percentage of distributed reinforcement can be computed using the subgrade drag formula (Reference 12). The computed amount of steel reinforcement varies with the slab length and thickness, friction between the overlay slab and bondbreaker, and working stress of the reinforcement. Slab length can be taken as the continuously reinforced distance between joints of the new overlay. Some bondbreakers—wax-based curing compounds, building paper, or asphalt—may increase the interface friction. This additional friction could create enough restraint stress to cause yielding of the reinforcement. To reduce the possibility of steel yielding, you can assume a coefficient of friction for use in the subgrade drag formula that is higher than normally assumed values for slabs over aggregate subbases. Some authorities specify a minimum ratio of reinforcement area to gross concrete area, regardless of the amount calculated by the subgrade drag formula. Recommended minimum values usually fall between 0.001 and 0.0015 (References 13, 14).

When reinforcement is used, the steel is usually chaired so it's 2 in. (50 mm) below the surface (Reference 15), or the overlay is placed in two layers with welded wire fabric sandwiched between the layers. When using the two-layer method, the wire fabric must be laid and the top concrete layer placed before the bottom layer has set. Welded-wire fabric purchased in sheets rather than rolls is easier to position correctly in the slab. The depth of cover is a compromise between ability to control crack width at the surface and potential corrosion of the reinforcement. Reinforcement near the surface holds crack faces together more effectively, thus minimizing crack width. However, in wet or corrosive environments, greater cover depths reduce the possibility of reinforcement corrosion.

Properly sized and placed reinforcement will hold the fractured faces of overlays tightly together when cracks form due to early thermal contraction or drying shrinkage. This allows aggregate interlock to transfer loads without vertical movement at the cracks. Discontinue steel reinforcement at joints to allow joints to function properly.

Concrete Proportions

Concrete quality for unbonded toppings is determined by serviceability requirements. Mix proportions are identical to those for new concrete floor construction.

For floors subject to severe wear and where dust must be kept to a minimum, abrasion-resistant aggregates should be used. It may also be necessary to increase the cement content and reduce the water-cement ratio of the mix to produce higher-strength concrete, or to use dry-shake surface hardeners.

Placing and Finishing Unbonded Overlays

The procedures for placing, finishing, and curing the overlay are similar to those described for original construction in Concrete Floors on Ground, EB075D, available from the Portland Cement Association (see page 8). The publication discusses important factors in the design, construction, and maintenance of a concrete floor. Unlike new slab-on-ground construction, where the subgrade or aggregate subbase can absorb water, partially-bonded or unbonded overlays are placed on a relatively nonabsorptive material. Because of this, they tend to bleed longer and finishing operations must be delayed.

Jointing Unbonded Overlays

For unbonded overlays, proper jointing practice is identical to that used for new construction. It provides for contraction, construction, and isolation joints to prevent unsightly cracking when the overlay shrinks upon drying or cooling. When thin— 4 in. (100 mm)—unbonded overlays are used, joints in the topping slab should precisely match those in the base slab to minimize reflective cracking.

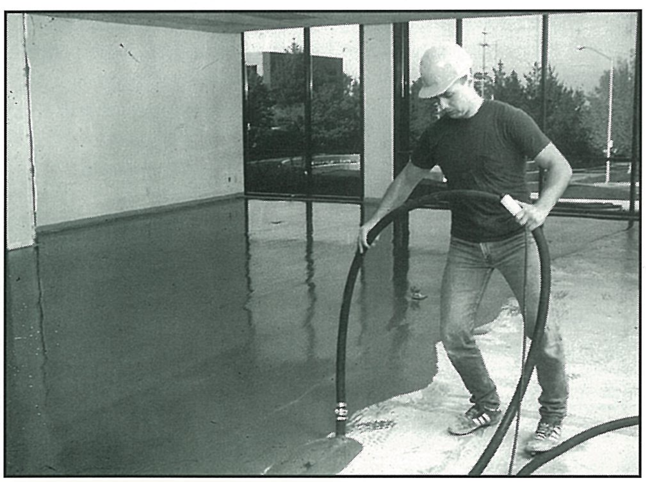

Fig. 3. Self-leveling floor toppings and underlayments are used to provide a smooth, level floor surface and to repair floors that have deteriorated, sagged, scaled, or become worn.

THIN TOPPINGS AND UNDERLAYMENTS FOR FLOORS

Many portland-cement-based thin toppings and underlayments are available for resurfacing concrete floors (Reference 16). These proprietary products are often referred to as self-leveling (non-troweling) or trowelable materials (see Fig. 3). They are used primarily to provide a smooth, level floor surface and to repair floors that have deteriorated, sagged, scaled, or become worn. Toppings provide the wearing surface for a floor, whereas underlayments require a floor covering material such as tile or carpet. When using these products, carefully follow the manufacturer's recommended mixing and application procedures.

Composition

Lightweight cellular concrete is an underlayment material (floor fill) that usually contains normal grout or concrete ingredients along with a preformed aqueous foam. The resulting high air content provides low weight and added fire and sound resistance. Specialized production equipment permits making cellular lightweight concrete in batch mixers or in high-volume continuous mixers that may also pump the material. Cellular concrete can also be made in standard ready-mixed concrete truck mixers. When used as a floor fill, it is usually not completely self-leveling and requires some screeding.

Other self-leveling or trowelable toppings or underlayments are proprietary mixtures of portland cement, sand, air, water, admixtures, and sometimes coarse aggregate, polymer modifiers, or fibers. The mixtures are formulated to provide easy placement, rapid setting, resistance to indentation under concentrated loads, and minimal shrinkage and cracking. The dry materials can be blended together and packaged in bags for easy use on small to large projects. Alternatively, some products can be delivered in trucks, ready to place.

A number of floor underlayment materials contain large amounts of water-sensitive materials such as gypsum in quantities much greater than the small amounts used to control setting of portland cement. These underlayments generally should not be used in moist environments such as laundry rooms, bathrooms, or kitchens unless coatings are applied to keep out moisture. Even then, the coatings must be well maintained or the underlayment may disintegrate when exposed to moisture. This deterioration is caused by dissolution of the gypsum or by an expansive reaction between sulfate in the gypsum and aluminate compounds in the hydrated portland cement. The latter reaction can lead to cracking and strength loss (References 17, 18).

Properties

Self-leveling toppings and underlayments are formulated for minimal shrinkage, high bond strength, rapid strength gain, and flowability without segregation. However, these and other properties can be adversely affected by an excessive amount of mixing water. Too much water will cause dusting, low strength, and shrinkage cracks. Self-leveling toppings and underlayments must be pumpable and be able to level off after minor screeding. Trowelable mixes have a stiffer, less watery consistency.

Portland-cement-based materials weigh from 100 to 120 pcf (1600 to 1900 kg/m^3) when dry. Cellular concrete has a minimum strength of 1000 psi (7 MPa) for residential applications or 1500 psi (10 MPa) or more for commercial underlayments. The strength of cellular concrete can be increased to about 3000 psi (21 MPa) or more by reducing air and sand content. Noncellular portland-cement-based underlayments range in 28-day strength from 3000 to 6000 psi (21 to 41 MPa). Topping mixes tend to have strengths around 5000 to 7500 psi (35 to 52 MPa) after 28 days and working times that vary from 10 to 60 minutes. The toppings can be walked on in 2 to 24 hours and a floor covering can be placed in 1-1/2 hours to 7 days or more after placement, depending on the product. There is a risk of trapping moisture under impermeable floor coverings that are placed before the underlayment has dried to the moisture content recommended by the floor covering manufacturer.

The shrinkage characteristics of various topping and underlayment products can vary considerably. To control cracking, strictly observe manufacturer's recommendations regarding joint spacing and underlayment thickness. Depending on the floor size, some products require no joints and some require joints at spacings ranging from 10 to 30 ft (3 to 9 m). Joints in the base slab must be duplicated in the topping or underlayment.

Minimum and maximum recommended thicknesses depend upon the individual product and where or how it is used. Thin applications—less than 1 in. (25 mm) deep—are usually bonded. The range of allowable thicknesses varies from 1/4 to 4 in. (3 to 100 mm), with self-leveling products being applied at a maximum thickness of 1/2 in. For thicknesses greater than 1/2 to 1-1/2 in. (13 to 38 mm) more aggregate is added to reduce shrinkage. The minimum thickness for a cellular concrete fill is about 1-1/2 in. (38 mm) or 3/4 in. (19 mm) if it's bonded over precast concrete. Cellular concrete is placed over bonded or unbonded moisture barriers.

Application and Installation

Application of a primer is normally recommended before the topping or underlayment is placed. The primer improves bond to the concrete floor surface. Pay strict attention to the manufacturer's recommendations for surface preparation and placement.

Before toppings or underlayments are placed, the floor surface must be cleaned. Abrasive blasting is commonly used for cleaning. Other common methods are scarifying, scabbling, sanding, grinding, and wet scraping. Cleaned floors must be dust-free, solid, and free of coatings (paint, wax, and so forth). ASTM standards D 4258, D 4259, D 4260, and D 4262 can be helpful guides for preparation of the existing concrete floor. If a primer is recommended, it's applied by roller, brush, sprayer, or squeegee after the floor has been cleaned. For cellular concrete underlayments, the floor may only need to be broom clean with holes filled prior to applying an unbonded moisture barrier (such as a waterproofing membrane) or a bonded moisture barrier (such as liquid latex).

The topping or underlayment is then mixed by traditional or special mixing equipment, depending on the product. Small quantities of some products can be mixed in a pail or drum with an electric drill and paddle and poured directly onto the floor. Large jobs use automatic equipment to mix and then pump the mixture to the desired location. A rake, squeegee, strikeoff device with adjustable leveling screws, or a prickly roller is used to spread the poured or pumped mixture, after which most self-leveling materials need no further finishing as they are self-smoothing. Perimeter chalk lines and plastic guides on the subfloor help control the depth on thicker installations. Some coating and concrete resurfacing products are designed to be spray-applied. Metal reinforcement is usually not used or needed.

The mixture must then be allowed to set and harden before any further work can be done on the floor. See the earlier discussion and consult the manufacturer as to the time required before the product can be walked on, construction continued, or a floor covering applied.

MOISTURE CONTROL FOR OVERLAYS THAT RECEIVE A FLOOR COVERING

Moisture can interfere with the performance of many floor coverings placed on overlays or toppings. Before placing a floor covering, test the moisture condition of the surface or make a test installation of the product to be used. Floor covering manufacturers specify a maximum allowable moisture content and a method by which the moisture content should be measured. Failure to perform the specified test may void the floor covering manufacturer's warranty.

Test Methods for Overlay Moisture Condition

In one moisture test (ASTM D 4263), an 18-in. (450-mm) square plastic sheet is taped to the slab surface. If no moisture condenses under the sheet after 16 hours, the floor is considered to be dry enough for some floor coverings.

The anhydrous calcium chloride test is also a widely used measure of moisture content. A pre-weighed portion of granulated anhydrous calcium chloride is placed in a dish that is set on the floor and sealed beneath a plastic cover. After 72 hours, the dish contents are weighed and a moisture vapor transmission rate is calculated. Maximum allowable rates are specified for different floor covering materials.

Another test measures the relative humidity of the overlay, either beneath a surface air pocket created by a plastic sheet or cup or within a hole drilled into the overlay. Relative humidity is related to overlay moisture content.

Electrical resistance measurements also can be used to estimate moisture content. Resistance readings are taken by passing a low-voltage current between conductive probes buried near each other in the overlay. Electrical resistance decreases with increasing moisture content.

Other moisture-measuring methods include those based on the reaction of calcium carbide and water to form acetylene gas and those based on the absorption of radio frequency waves by water (capacitance-impedance method). These and the previously mentioned methods are described more fully in Reference 19.

Some proprietary mixes can be applied to new concrete as a means of reducing water vapor transmission. If water vapor transmission of the surface material is lower than that of the concrete, however, excess vapor pressures may cause delamination. To avoid moisture-related problems, new full-depth concrete floors may require more than 2 months of drying before floor coverings or even some underlayments can be installed.

CONCLUSIONS

Experience has shown that with proper construction procedures, thin conventional concrete overlays can be bonded to old concrete slabs to restore surfaces that have become worn or rough. For the best long-term performance, the surface on which the new concrete is placed must be sound, clean, and of a gritty texture. A portland cement bonding grout should be placed between the old concrete and the overlay. Expensive proprietary bonding agents are not required. Adequate compaction and proper curing of quality concrete placed on a well-prepared surface will ensure the satisfactory performance of thin-bonded concrete resurfacing. In most cases, when the base slab is rough, or badly cracked, or in poor vertical alignment, an unbonded concrete overlay constructed as described in this publication will restore the floor to full serviceability.

Self-leveling or trowelable cementitious mixtures can be used on new or old concrete floors to restore smoothness, flatness, and levelness. These self-leveling overlays and underlayments are often used to restore or improve floor serviceability or to smooth out slabs prior to applying floor coverings. Usually proprietary, these mixtures are formulated to have minimal shrinkage and high bond strength. They can be placed rapidly with small-line pumps and they are applied in much thinner sections than conventionally bonded or unbonded concrete overlays.

Although the practices presented in this publication are primarily intended for interior concrete floors, the resurfacing techniques, with some modifications, can also be applied to exterior concrete slabs. Highways, bridge decks, airports, parking lots, and multilevel parking structures can be restored to full service by overlaying with conventional portland cement concrete (see "Related Publications" below). Consult an experienced concrete restoration engineer for all major overlay projects.

RELATED PUBLICATIONS

Readers of this publication may also be interested in related publications that can be purchased from the Portland Cement Association. A complete listing of PCA publications, computer software, and audiovisual materials is given in the free PCA Catalog (MS254G). To request a catalog, write or call Order Processing, Portland Cement Association, PO Box 726, Skokie, IL 60076-0726; phone 800/868-6733.

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Caution: Contact with wet (unhardened) concrete, mortar, cement, or cement mixtures can cause SKIN IRRITATION, SEVERE CHEMICAL BURNS, or SERIOUS EYE DAMAGE. Wear waterproof gloves, a long-sleeved shirt, full-length trousers, and proper eye protection when working with these materials. If you have to stand in wet concrete, use waterproof boots that are high enough to keep concrete from flowing into them. Wash wet concrete, mortar, cement, or cement mixtures from your skin immediately. Flush eyes with clean water immediately after contact. Indirect contact through clothing can be as serious as direct contact, so promptly rinse out wet concrete, mortar, cement, or cement mixtures from clothing. Seek immediate medical attention if you have persistent or severe discomfort.

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