# Finishing Concrete with Color and Texture

PCA Portland Cement Association

**Keywords:** architectural concrete, color, decorative concrete, exposed aggregate, finishes, patterns, stains, surface treatments, textures, white concrete

**Abstract:** This guide provides the basics for planning and constructing decorative concrete slabs, including exposed aggregate finishes, textured finishes, geometric patterns, and stained finishes.

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# Finishing Concrete Slabs with Color and Texture

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An organization of cement companies to improve and extend the uses of portland cement and concrete through market development, engineering, research, education, and public affairs work.

**Foreword:** This publication is a basic guide for planning and constructing decorative surfaces on concrete slabs. While intended primarily for concrete contractors, it also will be useful to concrete finishers, concrete finisher apprentices, homebuilders, general contractors, architects, engineers, landscape architects, homeowners, vocational education students, specification writers, inspectors, and many others.

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**WARNING:** Contact with wet (unhardened) concrete, mortar, cement, or cement mixtures can cause SKIN IRRITATION, SEVERE CHEMICAL BURNS (THIRD DEGREE), or SERIOUS EYE DAMAGE. Frequent exposure may be associated with irritant and/or allergic contact dermatitis. 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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# Introduction

*Figure 1. Exposed-aggregate finish. (IMG7053)*

**Pleasing decorative finishes can be built into concrete during construction. Variations in the color and texture of concrete surfaces are limited only by the imagination of the designer and the skill of the concrete craftsman.**

Color may be added to the concrete through the use of white cement and pigments, exposure of colorful aggregates (Figure 1), or addition of score lines to create borders for the application of penetrating or chemically reactive stains. Textured finishes can be varied as desired, from a smooth polish to the roughness of gravel. Geometric patterns can be scored, stamped, rolled, or inlaid into the concrete to resemble stone, brick, or tile paving (Figure 2). Other interesting patterns are obtained by using divider strips (commonly redwood) to form panels of various sizes and shapes – rectangular, square, circular, or diamond. Special techniques are available to make concrete slip-resistant and sparkling. The possibilities are unlimited.

*Figure 2. Pattern-stamped finish. (IMG7054)*

These surface treatments are just as pleasing in the interior as they are on the exterior of a home or commercial building. Colored and imprinted concrete is an excellent flooring material combining the economy, durability, decorative qualities, and strength of concrete and the thermal mass needed for passive solar buildings. From a real estate marketing standpoint, these special concrete finishes – interior or exterior – enhance the prestige and value of any property.

When choosing a finished texture or coloring method for any concrete surface, careful consideration should be given to the service conditions of the application to assure that the proposed texture will be compatible with the application. For example: smooth troweled surfaces should be avoided for

exterior applications and wet areas such as garage slabs and entryways as these surfaces may pose safety hazards due to reduced slip resistance, or stained concrete surfaces may not be appropriate for exterior applications in cold climates where they would be damaged by snow removal operations.

This publication focuses on decorative finishes for concrete slabs. For step-by-step instructions on how to provide normal floated and troweled finishes, prepare the subgrade and forms, order, place, and cure concrete, refer to PCA's *Cement Mason's Guide,* PA122 and *Building Concrete Walks, Driveways, Patios, and Steps,* IS209.

Always observe proper skin safety precautions when working with fresh concrete. (See "Safety Precautions" in Appendix B.)

Following are brief descriptions of some decorative and special finishes.

# Section 1
# Exposed-Aggregate Finishes

Exposed aggregate offers a wide range of textures and an unlimited color selection, making it one of the most popular and attractive decorative finishes for concrete slabs. Exposed-aggregate finishes are rugged, slip resistant, and highly immune to wear and weather. They are ideal for sidewalks, driveways, patios, pool decks, and other applications where concrete slabs are cast horizontally.

Sample panels may be made to assess the workability and finishing properties of the mix and to determine the appearance of the finished surface and depth of exposure that will be the basis for the work. Normally, the architect selects the aggregate source and specifies its size within one or more of the gradations shown in Table 1. Depth of exposure should not exceed one-third of the average diameter of the aggregate and not more than one-half of the diameter of the smallest aggregate.

There are three ways of obtaining exposed-aggregate finishes on concrete slabs: seeding a select aggregate into the concrete surface, the monolithic technique where a select aggregate, usually gap-graded, is mixed throughout the batch of concrete, and exposing gap-graded aggregates in a special topping course.

***Table 1. Aggregate Sizes for Exposed-Aggregate Slabs***

| | | |
|---|---|---|
| 6.3 mm (¼ in.) | to | 12.5 mm (½ in.) |
| 9.5 mm (⅜ in.) | to | 16 mm (⅝ in.) |
| 12.5 mm (½ in ) | to | 19 mm (¾ in.) |
| 16 mm (⅝ in.) | to | 22.4 mm (⅞ in.) |
| 19 mm (¾ in.) | to | 25 mm (1 in.) |
| 25 mm (1 in.) | to | 37.5 mm (1½ in.) |
| 31.5 mm (1¼ in.) | to | 50 mm (2 in.) |

## Seeded Exposed-Aggregate Concrete

### Base Concrete

Concrete requirements are covered under ASTM C 94, *Specifications for Ready Mixed Concrete*. A maximum size coarse aggregate of 19 mm (¾ in.) for the base concrete mix is specified to assist in embedment of the select seeding aggregate. Care should be taken to ensure that 4.75 mm (No. 4) and smaller sizes of aggregate are eliminated from the base mix when crushed stone or an aggregate whose color is not compatible with the select seeding aggregate is specified. Failure to take this precaution may allow these fine materials to be exposed on the slab surface lowering the aesthetic quality of the slab finish.

It is important that the slump of the base concrete be not less than 75 mm (3 in.) when the concrete temperature is 21°C (70°F), or lower, so that the seeded aggregate can be worked into the slab (Figure 3). This minimum slump should be increased as the concrete temperature increases above 21°C (70°F), but the maximum slump should not exceed 125 mm (5 in.).

If the concrete will be exposed to freezing and thawing and deicing salts in service, air-entrained concrete containing 5% to 8% total air content and a maximum water-cement ratio of 0.45 should be specified. These durability requirements also apply to other concrete applications discussed in this publication.

## Seeding Aggregate

The select aggregate to be exposed must be carefully chosen to ensure that it does not contain deleterious substances such as iron oxides and iron pyrite, which can stain the surface. Washed seeding aggregate should be used and the screening should be such that its openings are one size smaller than the minimum specified aggregate size. The select seeding aggregate may be specified as rounded river gravel, cubical-shaped stone, or crushed stone, and a particular source may be specified.

*Caution:* When crushed stone is specified, additional cost in labor can be expected. Crushed stone has a greater tendency to stack during the seeding operation than rounded aggregate. Also the exposed surfaces can have sharp edges that would be undesirable in some applications (pool decks, for instance).

The quantity of select seeding aggregate required will vary from approximately 15 kg/m$^2$ (3 lb/ft$^2$) for 9.5-mm (3⁄8-in.) aggregate to 30 kg/m$^2$ (6 lb/ft$^2$) for 50-mm (2-in.) material. It is very important to have a sufficient supply of the seeding aggregate available to complete the work.

## Forms

Edge forms are usually set for a minimum longitudinal slope of 20 mm per meter (1⁄4 in./ft) to allow for drainage of slabs, with a minimum slope of 1%, 10 mm in 1 m (1 1⁄4 in. in 10 ft). Permanent forms (left in place) are generally made of 25x100-mm (1x4-in.) or 50x100-mm (2x4-in.) redwood, cypress, or cedar. Plastic forms are also available.

## Placement of Base Concrete

The work output per concrete finisher for exposed-aggregate finishes will vary greatly according to the individual's skill, weather conditions, and the workability of the mix. In general, a concrete finisher can produce only about one-third of the area that he would normally finish for a steel-troweled surface. The strikeoff operation on the base slab (Figure 4) should be such that a flat surface is obtained 3 mm to 11 mm (1⁄8 in. to 7⁄16 in.) below the desired final finish grade to allow the addition of the seeding aggregate (see Table 2).

## Seeding and Embedment

The seeding operation is usually started immediately after the concrete has been placed, struck off, and darbied or bullfloated (Figures 5 and 6). For large applications it may be necessary to provide separate concrete placement and

*Table 2. Strikeoff Allowance and Aggregate Size for Seeding Method*

| Strikeoff allowance | Aggregate size |
|---|---|
| 3 mm (1⁄8 in.) | 9.5 mm (3⁄8 in.) to 16 mm (5⁄8 in.) |
| 5 mm (3⁄16 in.) | 12.5 mm (1⁄2 in.) to 19 mm (3⁄4 in.) |
| 6 mm (1⁄4 in.) | 19 mm (3⁄4 in.) to 25 mm (1 in.) |
| 8 mm (5⁄16 in.) | 25 mm (1 in.) to 37.5 mm (1 1⁄2 in.) |
| 11 mm (7⁄16 in.) | 31.5 mm (1 1⁄4 in.) to 50 mm (2 in.) |

*Figure 3. Concrete to receive a seeded exposed-aggregate finish should have a slump of between 75 mm and 125 mm (3 in. and 5 in.). (13921)*

*Figure 4. The slab is struck off in the usual manner except that the level of the surface should be left 3 mm to 11 mm (1⁄8 in. to 7⁄16 in.) lower than the top of forms to accommodate the seeded aggregate (see Table 2). (13922)*

*Figure 5. After strikeoff, the surface is leveled and smoothed with a wood darby. A bullfloat also may be used. (13923)*

*Figure 6. The select aggregate is spread uniformly by shovel and hand. Here a mixture of black and white crushed stone is used. (13924)*

*Figure 8. The aggregate is initially embedded by tapping or tamping with a wood darby. A hand float or a straightedge may also be used. (13926)*

*Figure 10. Final embedment is done with a hand float until appearance of the surface is similar to that of a normal slab after floating. (13928)*

*Figure 7. The entire surface must be completely covered with just one layer of the select stone. (13925)*

*Figure 9. Further embedment of the aggregate is done with a bullfloat. (13927)*

finishing crews to accommodate proper aggregate embedment, or it may be possible to break large surface areas into a number of smaller concrete placements.

The select aggregate is carefully seeded by shovel, hand, or mechanical means to cover the entire surface with one layer of stone (Figure 7). Seeding by hand may be necessary at difficult locations such as corners and edges. Care must be taken to see that stacked stone and flat, elongated particles are removed.

The seeded aggregate is normally embedded in the concrete by tapping with a wooden hand float, a darby, or a bullfloat (Figures 8 and 9). Sometimes a straightedge or rolling device such as a large diameter pipe is used. Final embedment can be obtained with a magnesium float or darby until all the aggregate is entirely embedded and mortar completely surrounds and slightly covers all particles (Figure 10). Appearance after final embedment should be similar to a normal slab after floating with all voids and imperfections removed. Special care must be taken to see that the aggregate is not overembedded and that the finished surface is not deformed. If too high a slump is used for the base mix, the seeded aggregate will settle and the completed surface may be below the final finish grade and below the top of any permanent left-in-place forms.

A layer of mortar about 2 mm (1⁄16 in.) thick over all embedded aggregate is desired. Care should be taken that none of the seeding aggregate become mixed with the base concrete in order to get sufficient mortar to complete the embedment. If this happens the color of the coarse aggregate in the base concrete will show up in the finished surface. The need for additional mortar is generally due to improper mix design or too long a delay in the seeding and embedment operation. When very small areas require additional mortar, excess mortar from nearby areas may be used.

## Exposing the Aggregate

Timing of the start of the aggregate exposure operation is critical and is usually based on previous experience. In general, this operation should be delayed until the slab will bear the weight of a concrete finisher on kneeboards with no indentation. At this time the slab is lightly brushed with a stiff nylon bristle broom to remove excess mortar (Figure 11). If aggregate is dislodged, the operation must be delayed until none of the aggregate is dislodged. To test for the proper time of exposure when large areas are involved, a sample panel, say 1 meter (1 yard) square, can be prepared at the same time that the project is cast.

Next, brushing combined with a fine water spray can begin (Figure 12). Adequate delay is required between each pass, the length of delay depending upon the rate of set of the slab. As the slab sets, washing and brushing can proceed at a more vigorous pace. Soft and hard bristle brooms and special exposed-aggregate brooms with water jets are available to complete the job. Occasionally, wire bristle brooms may be needed for a particularly stubborn area, but such brooms should be used with caution as they may stain the aggregate.

It is extremely important that the aggregate have a uniform exposure at the end of the washing and brushing operations. Some areas may need special attention. Several passes will be required before the proper exposure is obtained. Continue washing and brushing until exposure is uniform and at the proper depth, the flush water runs clear, and there is no noticeable cement film on the aggregate (Figures 13 and 14).

*Figure 11. In exposing the aggregate, timing is critical. Work should begin as soon as the mortar can be removed without over-exposing or dislodging the aggregate. The first step is to brush the surface lightly with a stiff, nylon bristle broom to remove excess mortar. (13929)*

*Figure 12. Next, fine spray the surface with water along with brushing. Special exposed-aggregate brooms with built-in water jets (pictured) are available. (13930)*



*Figure 13. (a) Continue washing and brushing until flush water runs clear and there is no noticeable cement film left on the aggregate. (b) Close-up view of the completed exposed-aggregate surface. (13931, 13932)*

## Surface Retarders

Surface set retarders may be used to advantage. For example, because of placing conditions it may be necessary to use a retarder on large jobs or during hot weather to delay the time of washing and brushing. When using smaller aggregate sizes, it is desirable to delay the time of set of the surface matrix by using a surface retarder to allow the base concrete to attain its initial set. This procedure will help prevent dislodgment of the small-size aggregate.

The retarder is sprayed over the surface according to manufacturer recommendations with an ordinary, low-pressure garden sprayer, after the seeded concrete is floated (Figure 15d). After the concrete sets, the procedure of washing and brushing the surface is performed to expose the aggregate. During periods of high temperature or when high-early-strength concrete is used, areas where the retarder has not been properly applied may set and resist aggregate exposure. The surface should be checked regularly, and the aggregate exposed within a few hours after the retarder application. When ambient conditions require, the surface

*Figure 14. This attractive patio combines contrasting areas of plain broom-textured concrete with panels of black and white exposed aggregate. (13933)*


***Figure 15. Monolithic exposed-aggregate concrete made with gap-graded aggregate. (a) This gap-graded mixture containing 9.5-mm (3/8-in. ) maximum sized aggregate, is placed by conventional practices. (b) Because of the gap-graded aggregate, the concrete has a coarse, yet uniform appearance. (c) The concrete is screeded and then bullfloated and hand floated. (d) A surface retarder is sprayed on the surface to ease mortar removal. (e) After the concrete is hard enough to walk on and retain the coarse aggregate, the surface is washed and brushed to expose the aggregate. (13956, 13957, 13958, 13959, 10098)***

should be covered with plastic sheeting to assure proper curing.

When using surface retarders the following tips are helpful:

1. Choose a reliable surface retarder.
2. Make certain that the surface retarder is compatible with the concrete materials to be used (see No. 6).
3. Apply the surface retarder uniformly; this is essential for good results.
4. Know the effects of concrete temperature on length of delay of set for the particular retarder used (see No. 6).
5. Read the instructions and literature issued by the manufacturer for any brand of retarder being used for the first time.
6. Make sample panels under actual job conditions.
7. Use a colored retarder to assure observable coverage.

Retarders are usually applied at a dosage rate of 1 liter/2.5 $m^2$ to 5 $m^2$ (1 gal/100 $ft^2$ to 200 $ft^2$).

A guide specification for seeded exposed-aggregate concrete surfaces is in Appendix A at the end of this publication.

## Monolithic Exposed-Aggregate Concrete

This method does not use aggregate seeding; instead the select aggregate to be exposed is mixed throughout the concrete during batching (Figure 15).

Any exposed aggregate surface has a more pleasing appearance if it contains a maximum amount of coarse aggregate, which is of one size or has a narrow size range. The use of continuously graded coarse and fine aggregates in the usual percentages generally results in nonuniform distribution of the coarse aggregate when exposed in the surface. Thus, mixes that satisfy architectural requirements contain a large percentage of coarse aggregate and a small percentage, sufficient for workability, of fine aggregate, with no aggregate in the intermediate size range. This results in what is known as gap-grading (sometimes called "skip" or "jump" grading). See PCA's *Gap-Graded Mixes for Cast-in-Place Exposed-Aggregate Concrete,* DX090.

For cast-in-place work, typical gap-graded aggregates consist of only one size of coarse aggregate with all particles of the sand being able to pass through the voids in the compacted coarse aggregate. Maximum size of aggregate is limited by the spacing of reinforcing steel in structural elements, but the maximum size usually is about 37.5 mm (1½ in.) depending on architectural considerations. For driveways, sidewalks, and patios, 9.5-mm (⅜-in.) pea gravel is commonly used.

For an aggregate of 19-mm (¾-in.) maximum size, the 4.75-mm to 9.5-mm (No. 4 to ⅜-in.) particles can be omitted without making the concrete unduly harsh or subject to segregation. In the case of 37.5-mm (1½-in.) aggregate, the 4.75-mm to 19-mm (No. 4 to ¾-in.) sizes should be omitted. Eliminating the material under19 mm (¾ in.) prevents separation of sizes in the bins, thus giving a more uniform product resulting in a higher quality finished appearance.

Fine aggregate generally consists of material passing the 2.36-mm (No. 8) screen. The percentage of sand should be chosen carefully. A wrong choice — too low, for example — may result in segregation or honeycombing due to an excess of coarse aggregate. An excess of sand results in a less desirable architectural appearance and higher drying shrinkage potential. Concrete with a low density and high water requirement can also result from too much sand. *Sand is usually 25% to 35% by volume of the total aggregate.* The lower percentage is used with rounded aggregates and the higher with crushed material. The sand content depends upon the cement content, type of aggregate, and workability considerations.

Since low-slump, gap-graded mixes use a lower percentage of sand producing harsh mixes, air entrainment is a standard requirement for workability, with added durability as a bonus. Workability and placeability generally require a minimum cement content of 335 kg/m$^3$ (564 lb/yd$^3$). Mixes with less cement are difficult to consolidate properly, and honeycomb can occur. A water-cement ratio by weight of 0.50 (0.45 for deicer exposures) should be considered the maximum. Any water used above the absolute minimum needed for placing may cause segregation and paste accumulations, which in turn may result in imperfections in the exposed aggregate surface.

For adequate consolidation of the concrete, the desirable range of mortar (cement, sand, water, and air) is about 45% to 51% by volume depending on the angularity of the one-size coarse aggregate. Rounded aggregate, such as gravel, requires about 45% to 48% mortar, while crushed limestone requires slightly higher values, such as 48% to 51%. Most continuously graded concretes have mortar percentages of 55% or more.

Segregation must be prevented by restricting the slump to the lowest value consistent with good consolidation. This may vary from zero to 75 mm (3 in.) depending on the thickness of the section and amount of steel, if present. A 50-mm (2-in.) slump would be about right for a sidewalk, driveway, or patio. Because of their low sand volumes and water-cement ratio, gap-graded mixes might be considered as unworkable for cast-in-place construction. When properly proportioned, however, these concretes are readily consolidated.

The standard slump test may be inadequate as a measure of the workability of concretes with such high proportions of coarse aggregate. A better measure of consistency than slump for such concrete is obtained with the Vebe consistometer (ASTM C1170). The Vebe apparatus subjects the concrete to a vibrating table. The criterion of this test is the time in seconds required to consolidate the concrete into a 241-mm (9½-in.) diameter cylindrical mass. Concretes that require a Vebe time of more than 6½ seconds may be difficult to consolidate properly with internal vibration. Concretes with Vebe times of less than 4½ seconds may be judged as having excellent consolidation characteristics.

Placing, striking off, bullfloating, or darbying follow the usual procedures. Care should be taken not to overfloat the surface, as this may depress the coarse aggregate too deeply. The aggregate is ready for exposing when the water sheen disappears, the surface can support a finisher's weight on kneeboards without indentation, and the aggregate is not dislodged by washing and brushing. When using the smaller aggregate sizes, it is helpful to use a surface retarder to delay

the time of set of the surface matrix to allow the subsurface concrete to harden. This procedure will help prevent dislodgment of the small-size aggregates.

As soon as the surface water sheen has disappeared, the retarder is sprayed over the surface with an ordinary, low-pressure garden sprayer (Figure 15). The surface should then be covered with plastic sheeting to continue curing.

If the retarded area is to remain undisturbed overnight, check a small area in the morning to determine if the concrete has hardened sufficiently. The same washing and brushing procedure for aggregate exposure used in the seeding method is used to expose the aggregate in the monolithic method (Figure 15).

## Topping Exposed-Aggregate Concrete

In this method, a thin topping course of concrete containing the select aggregate is placed over a base slab of conventional concrete. The topping normally is 25 mm to 50 mm (1 in. to 2 in.) thick depending on the aggregate size. The base slab is struck off low so that the final floated surface of the topping is at finish grade. The topping thickness must be at least three times the diameter of the maximum coarse aggregate size used in the topping concrete mixture.

The surface of the base course should have a rough-broomed finish and be firm enough to support a finisher's weight before the topping is placed.

This method of constructing an exposed-aggregate finish is most suitable when the smaller aggregate gradations are specified: 6.3 mm to 12.5 mm (¼ in. to ½ in.) or 9.5 mm to 16 mm (⅜ in. to ⅝ in.). The topping concrete is a specially designed mixture of select gap-graded aggregates and masonry sand instead of normal concrete sand. In a gap-graded mix, one or more intermediate-size fractions are substantially absent between the essentially one-size coarse aggregate and the fine aggregate, so that the aggregate to be exposed will be of the desired uniformity and quantity (see previous discussion on "Monolithic Exposed-Aggregate Concrete"). Use of a surface retarder is advisable with these smaller aggregate sizes. The same washing and brushing procedure of aggregate exposure is used in this type of construction as with the seeding method.

More information on the proportioning and properties of gap-graded mixes is available in PCA's *Gap-Graded Mixes for Cast-in-Place Exposed-Aggregate Concrete,* DX090.

## Weather Conditions

During hot, dry, windy days, the surface may set prematurely (sometimes called crusting). Covering the slab with damp burlap, waterproof paper, plastic sheeting, or an evaporation retarder immediately after embedding the select aggregate will prevent this and help retain surface moisture until the start of washing and brushing. Placing concrete over a cold base material may also contribute to crusting issues since at lower temperatures the concrete in the bottom of the slab sets more slowly, causing a longer period of vulnerability for drying and crusting of the surface.

## Surface Treatments

### Acid Wash

The use of an acid wash is not a necessity, but it removes any cement film left from the washing and brushing operation. It also helps to brighten the appearance of an exposed-aggregate surface, especially those made with darker aggregates.

For best results, acid washing should be delayed a minimum of two weeks after the concrete has been placed; a longer delay is better. Caution should be exercised when using acid on some aggregates such as limestones, dolomites, and marbles, which may discolor and dissolve in the muriatic acid. Workers should wear protective clothing and eye protection, and adjacent areas and materials should be protected from the acid. During the mixing of the solution, acid should ALWAYS be added to water (instead of adding water to acid) to prevent splashing of concentrated acid. Residue from acid washing should be flushed with clear water and drained away from areas that might be damaged (Figure 16).

Surfaces to be cleaned with a weak acid solution should be thoroughly saturated with water, and any excess water should be removed before application of the acid.

An efficient acid washing solution can be made with 1 part muriatic acid (20°Baume), and 2 to 4 parts fresh water. If a chloride-free acid etching solution is required, 85% phosphoric acid diluted with 2 to 3 parts of fresh water may be used. Stronger acid solutions may be used if the cleaning action is insufficient, but care should be taken not to etch the concrete so deeply that bond of the exposed aggregate is weakened. The acid is brushed onto the surface with a broom, then thoroughly rinsed off. The rinsing operation


*Figure 16. Acid washing to clean the surface. (a) First, a small quantity of muriatic acid (dilute hydrochloric acid) is applied to the hardened, two week old exposed-aggregate surface, which should be in a moist state. (b) The acid solution and brushing will clean the surface of any cement film remaining from the aggregate exposure operation. The acid is then washed away from the surface with water. (13960, 13961)*

*Figure 17. Sealer application. (13962)*

should begin when the bubbling action of the acid begins to subside.

### Sealers

Clear coatings bring out the true color of the aggregate and help keep the exposed matrix from discoloring with use. However, care is needed in the selection of a coating material. Some coating materials, such as linseed oil, may darken the matrix, and some may oxidize from exposure to sunlight and become a dirty yellow or possibly brown. Many better coatings consist of methyl methacrylate, silane, or siloxane (Figure 17).

### Specifying Exposure Depth

Specifications should define the desired finished appearance while leaving the methods for achieving that final appearance to the contractor. Preconstruction mockups (test panels) are critical in choosing an acceptable final finish. These panels can then be used for comparison for final acceptance and payment. While it may be difficult to achieve identical appearance throughout the final surface, the test panels assure that there is reasonable uniformity of the surface of the completed project.

Common degrees of aggregate exposure may be described as:

**Light Exposure:** Removal of surface skin of cement and sand, exposing only the edges of the uppermost coarse aggregate particles.

**Medium Exposure:** Removal of sufficient cement and sand such that the exposed aggregate and the mortar joints appear to be approximately equal in area.

**Deep Exposure:** Removal of sufficient cement and sand such that the coarse aggregate becomes the predominate surface feature.

Of equal importance to the degree of aggregate exposure is the issue of depth of exposure. The depth of exposure should never exceed ⅓ the diameter of the coarse aggregate. ACI 303, Guide to Cast-in-Place Architectural Concrete Practice, contains further discussions of sand-blasted and surface retarded finishes in terms of degree or depth of reveal.

## Applications

Exposed-aggregate concrete is a popular decorative finish for concrete slabs because of its durability and its wide range of texture and color in unlimited applications. It is used both

indoors and outdoors and is commonly used for driveways, sidewalks, patios, steps, plazas, streets, malls, swimming pool decks, and in countless other residential, commercial, industrial, and public works applications. Figure 18 illustrates some of the many textures, colors, and applications for exposed-aggregate concrete flatwork. Refer to PCA's, *Color and Texture in Architectural Concrete,* SP021, and *White Cement Concrete,* EB217 for extensive illustration and discussion of exposed aggregate in precast and cast-in-place concrete walls.

***Figure 18 . Various applications and textures obtained with exposed-aggregate concrete. (l to r, IMG: 7055, 7060, 7065, 7056, 7061, 7066, 7057, 7062, 7067, 7058, 7063, 7068)***

*Figure 18 (continued). Various applications and textures obtained with exposed-aggregate concrete. (l to r, IMG7059, IMG7064, 13963, IMG7053, IMG7070, NA)*

## Alternate Exposure Techniques

The aggregate in exposed-aggregate concrete also can be exposed by methods other than those already discussed. The techniques presented earlier rely on removal of surface mortar while the mortar is still plastic. The following techniques expose the aggregate after the concrete has hardened to a compressive strength of around 28 MPa (4000 psi).

Mechanical abrasion techniques to remove surface mortar include sandblasting, water blasting, shotblasting, scarifying, and bushhammering. The latter three methods usually produce a rough-fractured aggregate appearance, while sandblasting can dull an aggregate's appearance. Water blasting does not necessarily damage the aggregate particles (see Figure 19). (See Appendix B for safety precautions on sandblasting and abrasive techniques.) More

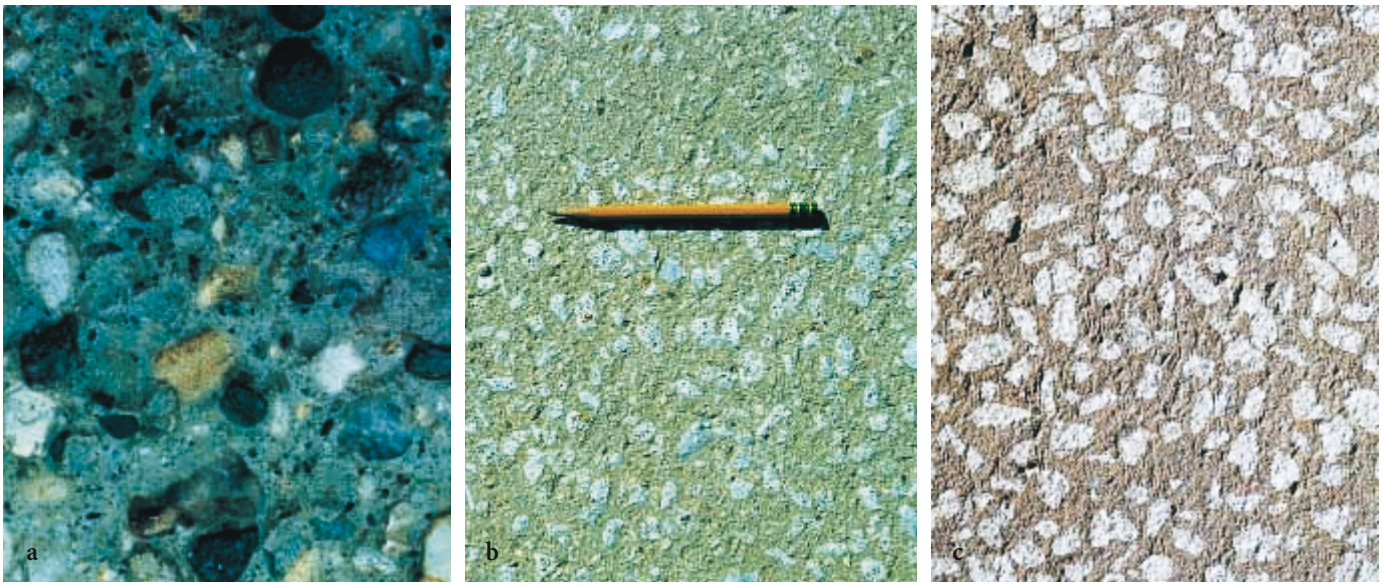


*Figure 19. Exposed-aggregate surfaces produced by (a) sandblasting, (b) scarifying, and (c) bushhammering. (IMG: 7071, 7072, 7073)*


***Figure 20. (a) Polished terrazzo floor. (b) Rustic terrazzo (c) Diamond embedded abrasive pads of varying fineness (d) Hand-held planetary grinder (e) Buffer-size planetary grinder. (l to r, 70873, IMG7075, NA, NA, NA)***

information on these techniques, including illustrative color photographs, is available in PCA's *Color and Texture in Architectural Concrete,* SP021.

## Polishing Concrete

Terrazzo, with its ground and polished surface, is also an exposed-aggregate concrete, which is primarily used indoors. Exterior use of terrazzo without grinding is known as rustic terrazzo. It is similar to conventional exposed-aggregate concrete.

Polishing is an abrasive process. As with any abrasive process the material surface is ground, or in effect "sanded" starting with coarse grit diamond impregnated pads and progressively changing to finer grit pads until the final surface aesthetic is achieved. At present, polishing concrete is accomplished with the use of planetary grinders ranging in size from hand held units upward to machines resembling large buffers (Figure 20). (See Appendix B for safety precautions on sandblasting and abrasive techniques.)

## Aggregates for Exposed-Aggregate Concrete

Aggregates should be selected on the basis of color, hardness, size, shape, gradation, method of exposure, durability, cost, and availability. Popular decorative aggregates include natural materials such as quartz, granite, marble, limestone, and gravel, and manufactured materials such as glass and ceramics.

### Color

The colors of natural aggregates vary considerably according to their geological classification and even vary among rocks of one type.

Quartz aggregates are generally available in several varieties — clear, white, yellow, green, gray, and light pink or rose. Clear quartz is used widely as a sparkling surface to complement the color effect created by the use of pigmented concrete. Clear quartz also is used in combination with other colored aggregates to emphasize the color of the matrix. White quartz ranges from a translucent white verging on the clear type to a deep milky white. Rose quartz provides finishes ranging from a delicate pink to a warm rose color.

Granite, long known for its durability and beauty, is available in shades of pink, red, gray, dark blue, black, and white. Trap rocks such as basalt can be used for gray, black, or green colors. Among the natural aggregates, marble probably offers the widest selection of colors ranging from green, yellow, red and pink to gray, white, and black. Crushed limestone is available in white, gray, or pink colors.

Certain gravels, after being washed and screened, can be used to provide attractive brown or reddish-brown finishes. Yellow ochers, umbers, and sandy shades are abundant in riverbed gravels. An almost pure white gravel comes from several sedimentary rock formations. Gravels vary widely in color depending upon the area in which the pits are located.

Ceramic aggregates and vitreous materials such as glass offer the most brilliant and varied colors available for exposed-aggregate work. Almost any color can be produced. Producers of glass aggregates should warrant low reactivity of their materials with portland cement. While the colors of ceramic aggregates are bright and clear, they are characteristically soft.

Expanded shale lightweight aggregates meeting ASTM C 330 may be used to produce colors that are reddish-brown, yellow, gray, or black. These materials are porous and crushable producing a dull surface with soft colors. These aggregates should be tested for iron staining characteristics, and careful consideration of durability in harsh environmental exposures is advised.

An architect or contractor involved with an exposed aggregate concrete job should select an aggregate that is decidedly darker in color than that specified by the customer. The reason given is that the general appearance of large areas after installation tends to be lighter than indicated by the trial samples.

The relative importance of aggregate versus cement in determining the color of exposed-aggregate concrete depends largely upon the treatment given to the surface of the concrete. In most exposed-aggregate finishes, the color of the cement is less important because a major part of the visible area is covered by the aggregate. Nevertheless, the cement has an effect on the general tone value of the finish; for this reason, it should be considered when the aggregate is chosen. While gray cement can be combined very effectively with a number of aggregates, the use of white cement, with or without color pigments, greatly extends the range of possible color combinations.

### Hardness

Aggregate hardness and density must be compatible with structural requirements and with durability under anticipated weathering conditions. Quartz aggregates are very hard, with a hardness rating of 7 on Moh's scale–about equal to carbon steel. Granite, composed of 30% quartz and 70% feldspar, has a rating nearly as high as quartz. Gravel and marble may vary from 3 to 7 on Moh's scale. Vitreous aggregates rate at approximately 5.5. Ceramic aggregates may be about equal to gravel.

### Size

Aggregates may vary from 6.3 mm (¼ in.) up to stone and rubble sizes of 180 mm (7 in.) in diameter and larger. The extent to which they are exposed or "revealed" is largely determined by their size.

### Shape

Aggregate shape will affect surface pattern and texture and may affect color slightly. Large, irregular shaped aggregate may permit more of the concrete matrix to show, changing the overall effect. Cubical or rounded aggregates will give

the best area coverage. Flat pieces and slivers do not hold well in the concrete matrix and should not be used.

Aggregates with a rough surface have better bonding properties than those with smooth non-porous surfaces. Bond is more important in cases where small size aggregates are used, as some of the aggregate pieces may have limited embedded surface area in the cement matrix. With large aggregate sizes, say 13 mm (½ in.) or larger, enough of each piece will be embedded to ensure against loss of bond, even in the case of glassy, smooth aggregates.

Aggregate shape affects the tone of a surface after weathering. Rounded aggregates are largely self-cleaning while angular aggregates of rough texture tend to collect dirt, but this dirt pickup is generally confined to the matrix. For this reason, as well as architectural appearance, the area of exposed matrix between the pieces of stone should be minimized. It may be advisable for the matrix to be darker than the aggregate for regions of the country subjected to considerable atmospheric pollution. Sharp, angular crushed aggregate should be avoided in barefoot use areas, such as swimming pool decks, to avoid foot injury.

## Gradation

Close control over gradation of aggregates is essential to avoid variations in surface texture of the finished product. Sieve analysis tests are required to ensure uniformity of materials received and to check consistency of gradation with the aggregate supplier's reported sieve analysis, taking into account expected changes in gradation that may be caused by rough handling in shipment. Sieve analyses are advisable once weekly when receiving more than one carload per week of a given aggregate type and size, or for each car when receiving less than a carload within a week.

## Exposure Technique

The method used to expose the aggregate in the finished slab should be considered when selecting the type of aggregate. Natural gravels are inclined to shatter, leading to bond failure and loss of aggregate particles when bushhammered. Certain aggregates such as granite and quartz are difficult to bushhammer uniformly because they are very hard. Aggregates such as marble, calcite, and limestone are softer and more suitable for bushhammered surfaces. For sandblasting, hard aggregates such as quartz, granite, and siliceous gravels are generally used although limestones are also suitable., Softer aggregates, such as marble, may be used for ease of grinding and polishing applications; however, harder aggregates such as granite, quartz, and some river gravels can be used and produce a higher quality polished finish.

When a solution of muriatic acid is used to wash an exposed aggregate surface to bring out its full color, only acid-resistant aggregates, such as quartz or granite, are recommended. Aggregates with high calcium content such as limestone, dolomite, and marble will discolor and dissolve in muriatic acid. Even a relatively mild acid solution may affect the color of marble or limestone and may cause crumbling or popping of the chips. If acid must be used, it should be applied with care and thoroughly washed off immediately with plenty of water to remove all traces of acid. (See precautions in "Acid Wash" section.)

## Durability

Any aggregate for exterior use should be thoroughly evaluated for the climatic conditions to which it will be exposed. The specific gravity and absorption of the coarse aggregates should be determined according to ASTM C 127 and a petrographic analysis should be made according to ASTM C 295, to ensure that the aggregates selected are durable, inert, and free from iron oxide and other deleterious materials.

Moisture absorption rates for quartz, granite, marble, and gravel generally vary from 0.05% to 1.50%, a negligible amount. The moisture absorption qualities of ceramic aggregates are related to their chemical composition and length of burning.

Wet-dry sensitive coarse aggregates may crumble and may be noticeable even if used in small quantities. Aggregates that have a wet-dry sensitivity, such as some shales, are generally detected in the unconfined aggregate freeze-thaw test.

The mineralogical and physical properties of the aggregate play important roles in providing restraint against shrinkage. Aggregate type will affect concrete shrinkage. Generally speaking, hard dense aggregates with low absorption and high modulus of elasticity produce concrete with minimum shrinkage.

## Cost and Availability

Cost is a factor when selecting an aggregate, and cost comparisons must be made on a consistent basis. For example, don't compare cost per ton of a dense aggregate with cost per ton of a lightweight aggregate. Instead, compare volume cost in dollars per cubic meter (cubic yard).

Natural aggregates vary in price in relation to their availability. Marble aggregates are generally available throughout North America and are relatively low in price for most types. Quartz and granite are slightly higher since their hardness makes them more difficult to quarry and crush. Gravel is the lowest priced of all aggregates since it requires only washing and screening. Manufactured aggregates cost more to produce than natural aggregates. Transportation charges also figure heavily in the final cost of any aggregate. However, even the most expensive aggregates are often practical in exposed-aggregate concrete, especially when they are used only in thin facing mixes (seeded or topping applications). In monolithic exposed-aggregate concrete, the cost of the select aggregate will be more significant.

In general, aggregates used in concrete of any type represent only a small part of the cost of concrete in place. Any mistakes made through use of an inferior aggregate cannot readily be corrected. So, it is often wiser to use high-quality aggregates from a distant source, if need be, rather than a local material of questionable quality.

# Section 2
# Textured Finishes

Practical, yet decorative, textures can be produced by using floats, trowels, and brooms. More elaborate textures are possible with special techniques, like using a mortar dash coat or rock salt.

The forming, subbase preparation, placement, finishing, and layout sequences for slabs with textured surfaces fall within standard practices described in the *Cement Mason's Guide,* PA122 and *Building Concrete Walks, Driveways, Patios, and Steps,* IS209.

## Float and Trowel Textures

A swirl finish makes for visual interest as well as surer footing. To produce a swirl float texture, the concrete is struck off, bullfloated (or darbied), and then hand floated in the usual manner, except that the float should be worked flat on the surface in a swirling motion, using pressure. Patterns (Figure 21) are made by using a series of uniform arcs or twists. Coarse textures are produced by wood floats, medium textures by metal or fiber glass floats.

***Figure 21. Swirl finish produced with a hand float. (29269)***

To produce a swirl trowel texture (a fine-textured swirl also known as a "sweat finish"), the concrete is finished as above, then troweled in the usual manner. Sometime after the first troweling, a trowel should be worked flat on the surface, using a swirling motion and pressure. An older trowel works best since the blade of a "broken in" tool has a slight curvature, allowing it to be worked flat without the edges digging into the concrete.

Timing is important. After the first troweling, whether by power or hand, there should be a lapse of time — the length depending on factors such as temperature and humidity — to allow the surface to become harder. Don't wait too long, however, because the swirl should be applied while it is still possible to work a small amount of fine mortar to the surface. This material creates a "drag" on the trowel, leaving the surface with a fine-textured, matte-like finish. Care should be taken to allow the concrete to set sufficiently so that the texture is not marred during curing.

## Broomed Textures

Broomed finishes are attractive, non-slip textures secured by pulling damp brooms across freshly floated or troweled surfaces. Coarse textures suitable for steep slopes or heavy traffic are produced by stiff bristle brooms on newly floated concrete (Figure 22). Medium to fine textures (Figure 23) are obtained by using soft bristle brooms on floated or steel-troweled surfaces. For best results, the broom should be rinsed in water after each pass and tapped to remove excess water. Sharp, uniform textures are obtained when using a broom that is specially made for texturing concrete, as shown in Figures 23 and 24. For traversing long distances, a pull broom is helpful (Figure 25).

*Figure 22. Coarse textured broomed finish. (P-19684-A)*

*Figure 23. Medium to fine broomed texture on a bullfloat-finished driveway. (13946)*

*Figure 24. Broom especially made for producing fine textured finishes. The broom shown has 60-mm (2¼-in.) long plastic bristles set into a 460 mm (18 in.) wide by 22 mm (⅞ in.) thick wooden holder. Other models up to 1.2 m (4 ft) wide, with extendable handles, are available. (P-24749-T)*

*Figure 25. Special double pull broom used to broom long distances. (13943)*


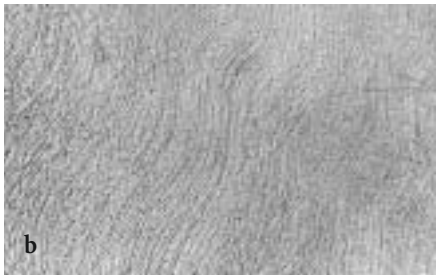


*Figure 26. (a) Applying a wavy broomed texture and (b) close-up view. (13910, P-29268)*

A broomed texture can be applied in many ways — straight lines, curved lines, wavy lines, or sawtoothed patterns. General and close-up views of a wavy broomed texture are shown in Figure 26. Driveways and sidewalks are usually broomed at right angles to direction of traffic. Each pass of the broom can be contiguous to the previous one, or an area of unbroomed concrete can be left between passes. To create a checkerboard effect, the slab is divided into square or rectangular panels of contraction joints, and each panel is broomed at a 90-degree angle to the brooming of immediately adjacent panels.

Fine to medium broomed textures are commonly used to make nonslip surfaces for exterior walks, driveways, garage floors, sidewalks, pedestrian bridges, and parking structures. Medium to coarse broomed textures are used for livestock facilities, steep pedestrian and vehicular inclines at street intersections, sharp highway curves, and other locations requiring maximum skid resistance.

## Imprinted Surface Textures

Used with increasing frequency are methods to simulate natural stone and other textured surfaces. Two such methods are texturing rollers and surface imprinting mats. These methods may be used to create texture over full panel surfaces, or in combination with stenciling or inlaid pattern techniques (Figure 27).

## Travertine Texture

A travertine finish, sometimes called keystone, requires a more elaborate procedure. After the concrete slab has been struck off, darbied, or bullfloated, and edged in the usual manner, the slab is broomed with a stiff bristle broom to ensure bond when the finish (mortar coat) is applied.

*Figure 27. Texture Roller.*

*Figure 28. Travertine texture. (P29267)*

*Figure 29. Random scored travertine finish. (22755)*

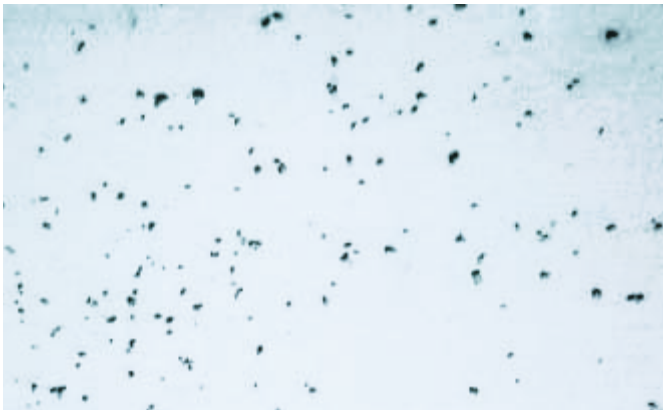

*Figure 30. Rock salt texture. (29265)*

The finish coat is made by mixing 1 bag of white portland cement and 0.06 $m^3$ (2 $ft^3$) of sand. Yellow pigment is generally used to tint the mortar coat, but any mineral oxide color may be used. Care must be taken to keep the proportions exactly the same for all batches. Enough water should be added to make a mixture having the consistency of thick paint.

This mortar is placed in pails and thrown vigorously on the slab with a dash brush to make an uneven surface with ridges and depressions. The ridges should be about 6 mm to 13 mm (¼ in. to ½ in.) high. The mortar is allowed to set enough to permit a concrete finisher to work on the surface with kneeboards. The slab is then flat troweled to flatten the ridges and spread the mortar. This leaves the surface smooth in some places, with voids and rough low areas that resemble the appearance of travertine marble when the mortar is made with white cement and yellow pigment. By varying the amount of mortar thrown on the slab and the extent of troweling, many attractive texture variations can be produced (Figures 28 and 29). The slab may then be scored into random geometric designs before curing.

## Rock Salt Texture

A rock salt texture is frequently used as an economical, decorative surface finish for concrete slabs (Figure 30). This texture is produced by scattering rock salt over the surface after floating, troweling, or brooming. The salt grains are rolled or pressed into the surface with only the tops of the grains left exposed. Over finishing or covering the salt grains with a layer of mortar paste will seal the salt grains in the surface, preventing individual grains from being dissolved in the washing process, causing a failure to expose the desired final texture. After 7 days of curing under waterproof paper, the surface is washed and brushed, dislodging and dissolving the salt grains and leaving pits or holes. The surface between the holes may be left slightly rough to give better traction in outdoor applications. The swirl float, swirl trowel, or broomed texture may be used in combination with the rock salt texture.

The salt crystals used are ordinary sodium chloride (kiln-dried water softener salt) with a coarse gradation that permits 100% to pass a 9.5-mm (⅜-in.) sieve and 85 percent to be retained on a 2.36-mm (No. 8) sieve. An extra coarse gradation may be used to obtain a greater percentage of larger holes in the finished surface texture; however, holes larger than 6 mm (¼ in.) are not desirable for foot traffic.

The salt grains normally are distributed at a rate of about 0.2 kg/$m^2$ (5 lb/100 $ft^2$) of slab surface, but a range of 0.1 to 0.6 kg/$m^2$ (3 to 12 lb/100 $ft^2$) may be used to create a light to heavy pattern. The heavier concentrations produce textures that resemble travertine.

Hand tools or pipes may be used to press or roll the salt grains into the surface, but a 40-kg (90-lb) floor tile roller has been found to work best. The grains must be spread and worked into the surface before the concrete becomes too hard.

Curing compounds may be used in lieu of waterproof curing paper, but the salt-dissolving operation will be more difficult. A water cure is not satisfactory for use with the rock salt procedure. Plastic sheeting may cause discoloration if it is not kept flat and wrinkle-free on the concrete surface.

Neither the rock salt nor the travertine finish is recommended for use in areas subject to freezing weather. Water trapped in the recesses of these finishes tend, when frozen, to spall the surface.

## Nonslip and Sparkling Finishes

Surfaces that are frequently wet or that would be dangerous if slippery can be given special nonslip finishes. These finishes are achieved most commonly by hand tools such as floats, trowels, or brooms or with dry-shake applications of abrasive grains. The latter method provides a long-lasting, nonslip surface suitable for areas with heavy foot traffic.

The two most widely used abrasive grains are silicon carbide and aluminum oxide. Silicon carbide grains are sparkling black in color and also are used to make "sparkling concrete." The sparkle is especially effective under artificial light. Aluminum oxide may be gray, brown, or white, and it is used where the sparkle of silicon carbide is not required. Clear quartz aggregates may also be used to give a sparkling effect to a concrete surface.

Application of the abrasive grains follows essentially the same procedure as for a color dry-shake. The grains should be spread uniformly over the surface in a quantity of from 1 to 2 kg/m$^2$ (¼ to ½ lb/ ft$^2$) and lightly troweled (Figure 31). Manufacturer's directions should be followed if available.


***Figure 31. (a) Silicon carbide grains are lightly troweled into the surface of a municipal sidewalk. (b) Nonslip aggregate on steps. (P-23352-B, IMG7078)***

# Section 3
# Geometric Patterns

Another method of embellishing sidewalks, driveways, patios, and other slabs is to use patterns that are stamped or tooled into fresh concrete surfaces to resemble stone, brick, or tile paving. Other interesting patterns are obtained by using divider strips of wood, plastic, metal, or masonry to form panels of various sizes and shapes. A wide variety of designs, ranging from simple to complex, can also be scored into the surface of slabs by using concrete saws, hand held grinders, concrete routers, or specialty scabbulating (pneumatic hammering) or engraving equipment. Descriptions of some of these decorative treatments follow.

## Pattern Stamping

Cobblestone, brick, and tile finishes in a variety of sizes and patterns can be impressed deeply into partially set concrete with special imprinting tools (Figure 32). The concrete also may be colored integrally or by the dry-shake method or


*Figure 32. Patterns are stamped while the concrete is still in a plastic condition. (a) Wooden bullfloat is used to even the surface in preparation for coloring. (b) One half to two-thirds of the dry-shake color compound is cast onto the surface in a uniform layer. (c) Wood bullfloating the first dry-shake application. The balance of the dry shake is then applied at right perpendicular to the first application. (d) Wood floating and steel troweling the second dry-shake application. (e) Imprinting tools are stamped into the concrete surface through a thin plastic sheet. Although optional, the plastic sheet provides a smoother surface and prevents concrete from sticking to the stamping tool. Assuming that the joints will be left open and other curing techniques are not used, a colored curing compound is applied immediately after stamping is complete. (a through e: 13947, 13948, 13949, 13950, 13951)*

both. The joints may be filled with plain or colored mortar to create any number of striking effects.

To receive a stamped pattern, concrete should contain small size coarse aggregate such as pea gravel, 9.5-mm (⅜-in.) top size. Finishing follows the normal procedures; however, the surface should not be troweled more than once. After the surface is troweled or floated to the desired texture, platform stamping pads are used. One pad is placed next to the other so that the pattern is accurately aligned; at least two pads are required. The finisher simply steps from one pad to the next, stamping the design to depth of about 25 mm (1 in.). Brush a form release agent on the pads to keep them free of mortar if the pad is in direct contact with the concrete.

In addition to the weight of the worker, a hand-tamper is sometimes used to ensure adequate indentation of the stamping pad.

For many patterns, especially those with a smooth surface, a sheet of 0.025-mm to 0.05-mm (1-mil to 2-mil) polyethylene plastic is placed over the slab, then the stamping pads are placed on the plastic sheet (Figure 32). The plastic stretches during stamping, rounding the edges of the incised pattern. Also, the plastic minimizes the possibility of concrete sticking to the stamp and then tearing the surface when moved to its next location. Textured surfaces may require the use of powdered release agents for greater detail to the surface.

After stamping, a tool similar to a brick mason's jointer may be used to dress edges and cause some artificial imperfections, thereby imparting a natural look.

A small hand stamp is used to complete the pattern next to slab edges or inaccessible locations (Figure 33). Light tapping with a hammer may be required. This operation can be eliminated or greatly minimized by choosing slab sizes that are equal to even multiples of the platform stamping tool dimensions. Timing is critical since all stamping must be completed before the concrete is fully hardened. See Appendix A for guide specification.

Stamped impressions in the pattern (joints) are usually left open, although they can be grouted for contrast (Figures 34

*Figure 33. Locations that are inaccessible for the large stamping tools, can be imprinted with a small hand stamp. (13955)*

*Figure 34. The stamped impressions may be left open or grouted with a contrasting mortar. For a grouted pattern, a grout is poured onto the 3- to 7-day old slab. A wide squeegee is drawn across the surface at an angle, working the gout into the joints, avoiding excess surface grout. Curing compounds that would interfere with the bonding of the grout should not be used on the slab prior to grouting. (13952)*

*Figure 35. A wet piece of foam rubber is drawn across the surface to distribute and pack the grout into the joints, and, when rinsed, the foam is used to remove grout from the surface as shown. (13953)*

to 36). Air-entrained grout should be used in frost environments.

Other interesting relief patterns can be stamped into the surface of concrete slabs to resemble a wood-grained boardwalk, a basket weave, or seashells, to name just a few (Figure 37).



*Figure 36. (a) After the grout in the joints has set, a rotary floor polisher is used to remove the grout residue from the surface. (b) Pictured is grouted fish scale cobblestone pattern used for both interior flooring and exterior paving. (13954, IMG7079)*

*Figure 37. Patterned, textured, and colored concrete can be used anywhere tnan an attractive durable finish is needed. Several types and applications of pattern stamped finishes are shown. (IMG: 7080, 7081, 7082, 7083, 7084, 7085, 7086, 7087, NA, 7089, 7090, NA, 9001, 9002, 9003, 9004)*

*Figure 37 (continued). Patterned, textured, and colored concrete can be used anywhere than an attractive durable finish is needed. Several types and applications of pattern stamped finishes are shown. (IMG: 9005, 9006, NA, 9008, 9009, 9010, 9011, 9012)*

## Pattern Rolling

Pattern rolling is similar to pattern stamping in appearance. Unlike traditional pattern stamping, which uses stationary imprinting tools, pattern rolling uses a hollow cylinder to impress a pattern on the surface (Figure 38). The cylinder, usually with a brick or cobblestone relief (Figures 39 and 40), is rolled across the surface to create the pattern. Water can be added inside the cylinder to adjust its weight to control depth of imprint or adjust to the stiffness of the concrete.

Normal slab construction procedures are followed in preparing the subbase and slab. Integral color admixtures are added to the concrete or dry-shake coloring agents are applied to the surface to color the concrete. After the initial bleedwater has evaporated and the surface has been floated, the slab is covered with a thin plastic sheet stapled to the wooden edge forms. The plastic, which prevents the concrete from sticking to the cylinder, should be placed as flat as possible to prevent wrinkle impressions from disrupting the pattern. If a rough texture is desired, especially at impressed joints or edges, the cylinder should be applied directly to the concrete surface without the plastic sheet.

Before rolling, a chalk line or straightedge should accurately mark the rolling location on the plastic to keep the cylinder

*Figure 38. Pattern rolling uses a cylinder with a pattern relief on it to impress a design into the concrete surface. (13977)*

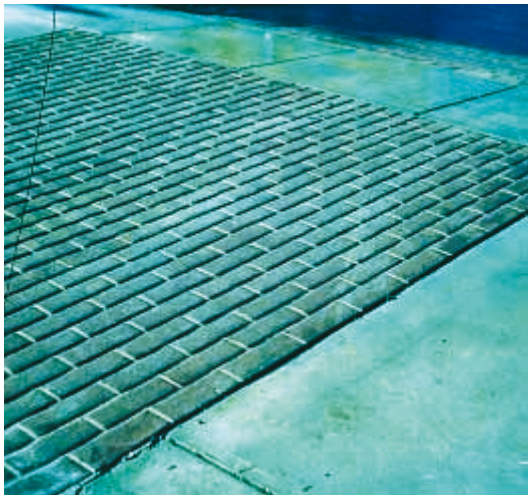

*Figure 39. Brick design produced by pattern rolling.*

*Figure 40. Cobblestone design produced by pattern rolling. (IMG9019)*

*Figure 41. Mottled brick pattern rolled surface produced by grinding off some of the surface. (IMG9020)*

*Figure 42. An attractive driveway finished with a float texture and a random flagstone pattern.*

and pattern in alignment. The size of the slab to be patterned should be a whole multiple of the cylinder width, usually 1 m (3 ft). Forms at locations where the last pass is less than a roller width should be set 6-mm (¼-in.) lower than the elevation of other forms. A 6-mm (¼-in.) wood strip is nailed to the top of this form to provide the proper slab elevation when screeding the slab. Prior to rolling, the wood strip is removed and the roller extends beyond the edge to provide a full, complete imprint. Rolling usually begins within ½ to 1 hour after floating.

With jointed patterns, such as brick, the cylinder forms a solid bed joint at one end and an open joint at the other end to eliminate seams between passes. Locations not accessible, such as those near columns, can be imprinted with hand tools. The plastic sheet is removed before the concrete hardens completely. Surface smoothness increases with the length of time the plastic is left in place.

Although only a limited number of patterns are available compared to traditional pattern stamping, a wide variety of colors and textures can be achieved. A pitted surface can be obtained by sprinkling water or small size aggregate onto the plastic sheet prior to rolling and a mottled surface can be attained by grinding off some of the dry-shake applied color (Figure 41). The primary advantage of pattern rolling is the speed at which a pattern can be imprinted.

## Inlaid Patterns

### Flagstone Patterns

Random flagstone patterns make an attractive finish for patio, sidewalk, driveway, or poolside slabs (Figure 42). Such patterns are made easily by embedding prepared "joints" made of wood, felt, or plastic, which are removed after the slab has hardened. Wood lattice stock 6x40 mm (¼x1½ in.) or 25-mm (1-in.) wide strips of roofing felt are cut into lengths varying from 100 mm to 800 mm (4 in. to 32 in.). Individual pieces are finished by cutting the sides into irregular jagged shapes to resemble the edges of paving stones. When wood is used, edges must be undercut to ease removal and prevent locking of the wood into the slab surface (Figure 43). Curling of wood strips may be prevented by thoroughly soaking them in water prior to use or by waterproofing with two complete coats of varnish or polyurethane.

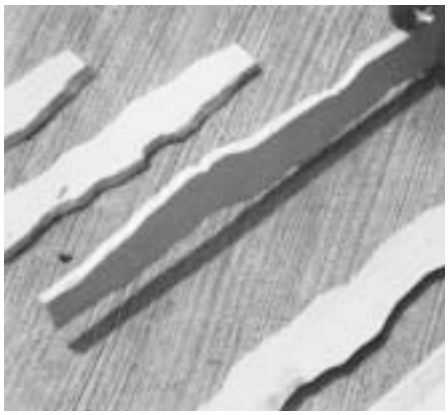

*Figure 43. Wood "forms" for inlaid flagstone patterns. (22758J)*

*Figure 44. Laying out random flagstone pattern with wooden strips. (22758-K)*

*Figure 45. Floating in wooden strips.*

*Figure 46. Cleaning wooden strips. (22758-G)*

*Figure 47. Removing strips after concrete has hardened. (22758-I)*

*Figure 48. Filling joints with contrasting mortar. (22758-H)*

After the slab has been struck off and bullfloated or darbied, it is allowed to set until ready for finishing — in this case finishing begins somewhat earlier than is usual. The strips are laid out on the slab in the desired pattern (Figure 44). Very small or complex shapes should be avoided.

As soon as the pattern is laid out, the strips are pressed into the concrete and the surface is floated. Felt strips, if used, may be patted into the surface using a hand float. In any case, the top of the strips should be just flush with the surface of the concrete (Figure 45). The concrete then may be finished in its normal color, or if desired, a different color can be added at this time using a dry-shake material.

The dry-shake method consists of applying a factory prepared dry color material over the concrete surface after preliminary floating. Two applications of the dry-shake are made. The first one, using one-half to two-thirds of the total amount specified by the manufacturer, is floated into the surface. Then the remaining material is distributed over the surface perpendicular to the first pass to improve the consistency of the applied color and it too is floated into the surface. After floating the second application, the tops of the strips are cleaned of any paste that may have been carried over them. A margin trowel or putty knife can be used to scrape the strips clean (Figure 46). If a smooth, hard surface is desired, troweling follows floating in the usual manner. A final steel troweling will then bring the strips and concrete to a uniform surface, which can be left smooth or be lightly broomed. Steel troweling is usually not performed on exterior applications. Smooth troweled surfaces are undesirable for two reasons: they create slick surfaces when wet and have reduced freezing and thawing durability because repeated troweling operations damage the air content near the surface. Felt strips are carefully removed before the slab is cured. Wood strips are removed the following day. The curing cover can be taken off and the wooden strips removed by lifting with a margin trowel (Figure 47). The slab may be left with depressed joints (Figure 42) or joints may be filled with a contrasting mortar. A natural gray slab with white mortar joints is very attractive; a colored slab looks good with natural gray joints. Mortar filled joints may require future maintenance.

Before filling the joints, the slab should be flooded with water to keep it cool and the joints damp, but not wet with

*Figure 49. Tooled or incised flagstone. (a) Striking off the concrete. (b) Darbying the surface. (c) Tooling joints into slab to form a flagstone pattern. (IMG9054, 13901, 13909)*

*Figure 50. Troweling after jointing and floating. A floated surface is usually satisfactory for exterior applications. (22758)*

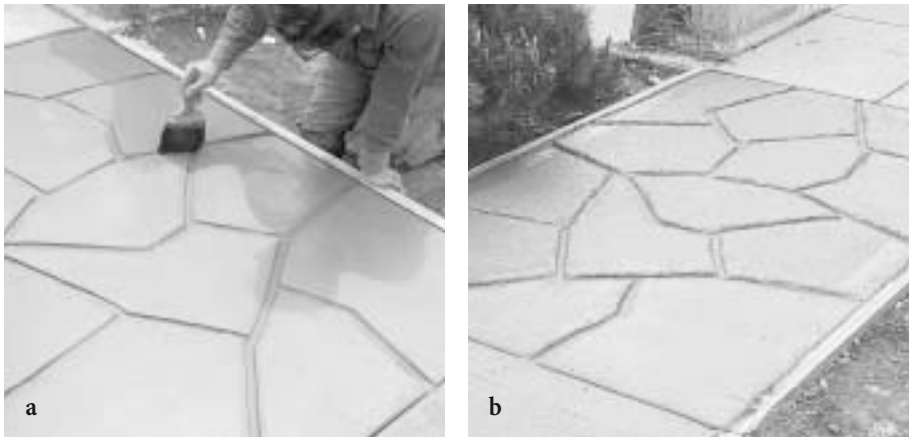


*Figure 51. (a) Touching up joints with soft brush. (b) Finished view of flagstone pattern. (22758-E, NA)*

surface water. Immediately before troweling in the mortar, the joints should be brushed with a grout of portland cement and water, mixed to the consistency of thick paint (Figure 48). Care must be taken to prevent smearing mortar outside the joint area. A sponge and a bucket of water will be useful in cleaning the joint edges. In this operation it is best for two finishers to work together, with one brushing in the cement grout ahead of the mortar and cleaning up the joint edges, while the other concentrates on packing the mortar firmly and neatly into the joint.

## Alternate Flagstone Method

Another way to produce the random flagstone pattern makes use of a 450-mm (18-in.) long piece of 13-mm or 19-mm (½-in. or ¾-in.) diameter copper pipe bent into a flat S-shape. After the concrete has been struck off and bull-floated or darbied, and after the water sheen has left the surface, the slab is scored in the desired pattern. This tooling must be done while the concrete is still quite plastic, because coarse aggregate must be pushed aside as the tool is pressed into the surface (Figure 49).

The first tooling will leave burred edges. After the water sheen has completely disappeared, the entire area should be floated and the jointing tool run again to smooth the joints. Floating produces a texture that has good skid resistance and is relatively even (but not smooth). It is usually used as a final finish. In such cases, it may be necessary to float the surface a second time, after some hardening has taken place, to impart the desired final texture. If a smooth, hard surface is desired, a careful steel troweling follows (Figure 50). The final operation is a light brooming of the troweled surface, along with a careful touching up of the joints with a soft bristle paint brush (Figure 51).

*Figure 52. (a) Strips of roofing paper are embedded into the surface with a float. (b) A dry shake coloring mixture is broadcast uniformly over the surface. (c) The dry shake is scraped off the strips. (d) The surface is floated (right hand) to work the dry-shake into the original surface. (e) Floating (left hand) and troweling (right hand) are continued until a dense and uniform surface is achieved. (f) The strips are carefully removed to expose the joint pattern. (g) A trowel may be used to further densify the surface and correct imperfections after the strips are removed. Light brooming or other texturing can also be performed. (h) Close-up of joint detail. (i) View of completed surface. (13934, 13935, 13936, 13937, 13939, 13940, 13938, 13941, IMG9021)*

## Ashlar and Tile Patterns

Ashlar and tile patterns provide attractive surfaces for indoor and outdoor concrete slab applications. These patterns can be made by embedding strips of felt, roofing paper, or construction (kraft) paper into the surface in a manner similar to that used for flagstone patterns (discussed earlier).

After the slab is struck off and bullfloated or darbied, the strips are laid out in the desired pattern. The length, width, and thickness of the strips are dictated by the desired pattern. The strips are then floated into the slab with the top of the strips just flush with the concrete surface. A dry-shake color compound may be applied to the surface to provide color contrast. A step-by-step procedure for this technique is

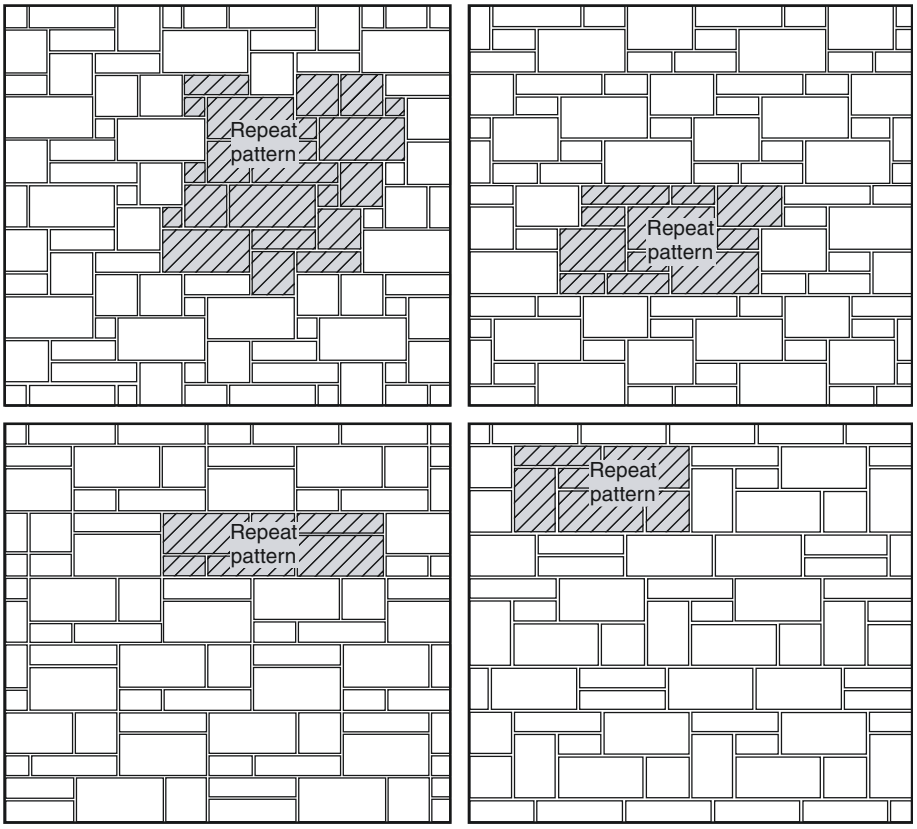


*Figure 53. Illustration of various ashlar patterns that can be produced using the technique shown in Figure 52.*

*Figure 54. Making circle patterns. (IMG9050)*

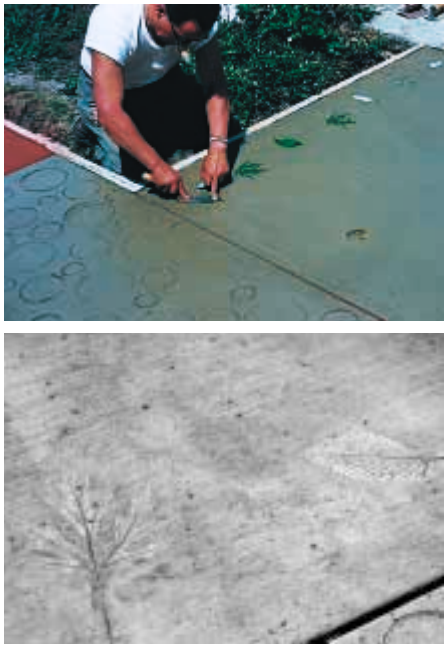

*Figure 55. (a) Making leaf impressions. (b) Finished view of leaf impressions. (IMG9051, 22759-D)*

presented in (Figure 52). Examples of ashlar designs are illustrated in (Figure 53).

## Geometric Designs

Attractive geometric designs can be produced by marking circles or other designs on the slab after the final smooth finish has been completed. This can be done with a variety of sizes of tin cans in random pattern, or by one or more sizes in a definite regular pattern. Large metal cookie cutters of various shapes also may be used for this purpose.

Wherever a large area is to be finished in this fashion, a large crew will be required. Immediately after the final troweling, the surface will be quite hard but still easily marked (Figure 54). However, as the slab continues to harden, it will become more and more difficult, and finally impossible, to make impressions to the same depth and appearance. In cases where more than one worker is involved, all must carefully coordinate their efforts so that the finished pattern will be uniform. A good method for determining the design to be followed is the production, on a nearby driveway or sidewalk, of a sample pattern. This is done by dipping the cans in powdered chalk and marking an area large enough to serve as a guide. The sample can easily be washed away later. If no slab is convenient, a large sheet of wallboard may be used.

## Leaf Patterns

A pattern giving the effect of fossils can be produced by pressing leaves into the slab surface, either singly as a border, or in groups or sprays as a focus of interest. Fresh leaves are carefully pressed into the surface immediately after it has been floated and troweled (Figure 55). The leaves should be so completely embedded that they may be troweled over without dislodging, but no mortar should be deposited over the leaves. After the concrete has set sufficiently, the leaves are removed. Hand crafted and custom preformed leaf imprint castings are also available.

*Figure 56. To produce an inlaid brick pattern, a paper template is first trimmed to the width of the slab. (13964)*

*Figure 57. Each piece of template is positioned onto the bullfloated slab adjacent to the previous piece until the entire slab is covered with the template. (13965)*

*Figure 58. The paper template is embedded with a bullfoat. (13966)*

*Figure 59. Dry-shake coloring compound is broadcast onto the surface. (13967)*

*Figure 60. The color is worked into the surface with a hand float, as shown, or a bullfloat, depending on the size of the slab. (13968)*

*Figure 61. For smooth textures, the surface is then troweled. Broomed, floated, and other textures can also be used. (13969)*

*Figure 62. The paper template is removed when the concrete has set sufficiently. (13970)*

*Figure 63. Completed inlaid brick finish after the template has been removed and the surface cleaned of loose particles. (13978)*

*Figure 64. Special designs, such as this circle pattern, are also available. (IMG9022)*

*Figure 65. Examples of applications and colors possible with inlaid paper brick pattern method. (l to r, IMG: 9024, 9027, 9025, 9028, 9026)*

*Figure 66. (a) Stencil and sandblasting operation. (b) Finished sandblast stencil example.*

## Inlaid Paper Patterns

Inlaid patterns also can be made using the surface paper forming technique (Figures 56 to 63). A paper pattern is supplied in rolls about 1 m (3 ft) wide by 150 m (500 ft) long. Some special designs for small areas also are available (Figure 64). Although almost any pattern can be made, brick is the most common.

After the concrete is placed and floated, the paper pattern is laid on the surface and cut to the slab dimensions (Figures 56 and 57). The paper form is then floated into the slab surface (Figure 58). The number of passes made with the float controls the depth of relief of the brick joints. The paper should be thick enough and strong enough to resist tearing during the floating operation.

After the paper is properly embedded, a dry-shake color mix is usually broadcast and floated onto the slab surface to create a color contrast between the imitation brick and mortar joints (Figures 59 to 61). After the concrete has hardened sufficiently, the paper form is pulled off the surface (Figure 62). The paper form is not reusable. A portable air blower, vacuum cleaner, or broom may be used to remove loose concrete particles. The concrete is then cured.

## Sandblast Stencil

Effective coloring and patterning may be achieved on new or existing concrete slabs using this technique. New concrete must be cured an appropriate length of time. The curing time must be compatible with the stain that is to be applied.

The concrete is colored using color pigments, stains, dyes, or tints. In new construction a light color may be applied to the base concrete with an integral color pigment. Darker colors are applied to hardened concrete (new or existing) using stains, dyes, or tints. A hard rubber or plastic stencil is placed at the chosen location on the (hardened, cured) slab. Exposed areas are sandblasted to remove the near-surface color, creating intricate surface patterns and clean relief patterns as plain mortar joints (when the base concrete has not been treated with color) or exposing the typically lighter colors used in the base slab (Figure 66). (See Appendix B for precautions, safety with sandblasting and other abrasive techniques.)

## Divider Strips

Divider strips and borders of wood, plastic, metal, stone, or masonry serve a number of purposes (Figure 67). Unusual patterns and designs can be created with rectangles, squares, and diamonds; concrete work can be segmented into small areas for better control of placing and finishing; combinations of various surface finishes are possible; and most important, random cracks are greatly reduced or eliminated because divider strips act as contraction joints.

Wood divider strips and side forms that are to remain in place permanently for decorative purposes are usually made

*Figure 67. Divider strips. (a) This attractive driveway uses wood divider strips to create a pattern of varying sizes of rectangles and squares. (b) Divider strips make an attractive entrance and sidewalk for this home. (c) Masonry units laid flat serve as divider strips and borders for an attractive driveway. (d) Concrete paving stones are used as dividers for this exposed-aggregate concrete plaza. (e) Polished granite strips divided this stamped concrete. (l to r, IMG: 9029, 9032, 9030, 9033, 9031)*

*Figure 68. Masking the top surfaces of wood divider strips.*

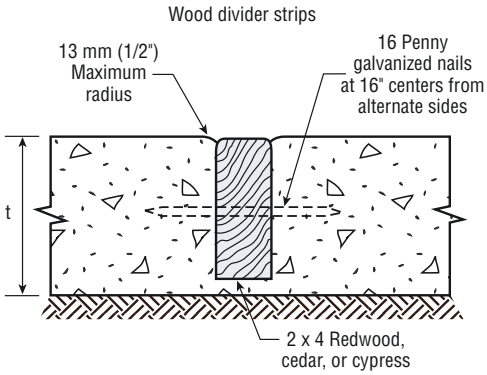


*Figure 69. Divider strips should have nail anchors driven at 400-mm (16-in. ) intervals, horizontally and from alternate sides of the board.*

*Figure 70. Masonry units of concrete, brick, or rock, used as divider strips and borders may be set in a sand bed with or without mortar joints. (13920)*

*Figure 71. When scoring or jointing with a groover, the use of a straightedge such as a board 25-mm (1-in.) thick and at least 150-mm (6-in. ) wide is recommended as a guide. (23227-B)*

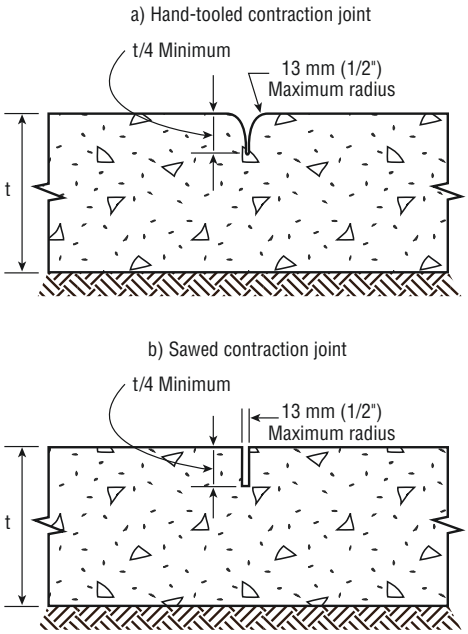


*Figure 72. If the groove is to serve as a contraction joint, a groover with a bit deep enough to cut the slab a minimum of one-fourth its depth is mandatory. A shallow groover may be used for decorative scoring.*

of 25x100-mm (1x4-in.) or 50x100-mm (2x4-in.) rot resistant lumber such as redwood, cypress, or cedar.

For further resistance to weathering, these woods should be treated with a clear wood sealer. Also it is good practice to mask the top surfaces with tape to protect the wood from abrasion and staining by concrete during construction (Figure 68). Corner joints should be mitered neatly, and intersecting strips should be joined with neat butt joints. Wood divider strips will require periodic maintenance.

Outer forms that are to remain in place permanently should be anchored to the concrete with 16 penny galvanized nails driven at 400-mm (16-in.) intervals horizontally through the forms at midheight. Divider strips should have nail anchors similarly spaced but driven from alternate sides of the board (Figure 69). Drive all nailheads flush with the forms. Never drive nails through the top of side forms or divider strips. All form stakes that are to remain in place permanently should be driven or cut off 50 mm (2 in.) below the surface of the concrete. At comparable spacing, 50-mm to 100-mm (2-in. to 4-in.) exterior deck screws are a viable alternative method of attachment for edge forms and divider strips.

Metal divider strips of the type used in terrazzo are suitable only for two-course construction where the topping thickness varies from 13 mm (½ in.) to 19 mm (¾ in.).

Masonry units of concrete, brick, or rock used as divider strips and borders may be set in a sand bed with or without mortared joints (Figure 70). Unmortared joints are usually filled with sand to provide an interlocking action between units.

## Scoring and Sawing

Straightline patterns may be scored into concrete slabs with an ordinary concrete finisher's grooving tool when the concrete is fresh, or cut with a saw after the concrete hardens.

When scoring with a groover, the use of a straightedge such as a board 25 mm (1 in.) thick and at least 150 mm (6 in.) wide is recommended as a guide (Figure 71). The bit, or cutting edge, of the groover should be deep enough to cut the slab to a depth of about 6 mm (¼ in.) for decorative work. However, if the groove is also to serve as a contraction joint, a groover with a bit deep enough to cut a minimum of one-fourth of the depth of slab is mandatory (Figure 72).

For small jobs, an electric handsaw equipped with a masonry cutting blade can be used to cut decorative grooves. Sawing should be done as soon as the surface is firm enough not to be torn or damaged by the blade. This is normally within 4 to 12 hours after the concrete hardens.

Sawing may begin shortly after finishing using drycut technology, which reduces the potential for raveling of the joint edges due to the up-cut blade combined with the skid plate that provides additional support for the concrete

surface as it is cut. Intricately shaped cuts should be avoided at an early age due to the uncertainty associated with the effect the cuts may have on random cracking. Straight line cuts at appropriate spacing effectively establish working control joints, while intricate cuts may produce random cracking of the slab at an early age.

Advances in scoring and engraving tools have made it possible to produce a wide variety of shapes and patterns in concrete surfaces. Hand held grinders with diamond tipped blades are used for rounded or arched shapes as well as adding finer detail to patterns than has previously been possible (Figure 73). Concrete routers are also available to produce more intricate design patterns in hardened concrete surfaces. (See Appendix B for safety precautions on sandblasting and abrasive techniques.)

## Engraving

Engraving tools (scabbulating equipment) are used in conjunction with stencils to create intricate designs with unlimited possibilities for fine detail and artistic imprints in concrete surfaces. In many cases, a slab is placed with normal techniques, color is added to the surface, and following curing, a thin layer of concrete is removed to provide both color variation and relief patterns. The relief patterns may also be stained with color to provide the final finished aesthetics.


***Figure 73. (a) Scoring patterns with a hand held grinder equipped with a diamond blade. (b) Mechanically controlled concrete router for intricate design work.***

# Section 4
# White Concrete Floors

Architecturally bright white concrete floors are stunning. White cement concrete can be used to advantage to create contrasting color schemes in decorative applications, base concrete mixtures which more readily highlight color from stains, and concrete which provides richer color with the use of pigments (Figure 74). White concrete also provides opportunity for economic benefits, environmental advantages, and increased safety when used for light reflective floors.

## Light Reflective Floors

Light reflective floors decrease lighting costs through reductions in equipment and labor during initial installation, reduction of maintenance, and lower energy usage for the life of the lighting system (Figure 75). Light colored exterior concrete applications reflect more light, and in doing so absorb less heat, leading to a decrease of heat island effects. The increased visibility of light reflective materials also provides greater safety for public, workplace, and industrial settings. More detailed information is available in *White Cement Concrete,* EB217.

## White Concrete Mixtures and Materials

White portland cement has essentially the same properties as gray portland cement. In cement manufacture the use of raw materials low in iron and manganese controls the final white color of the cement.

***Figure 74. Concrete floors, richly colored with pigments or stains, enhance any interior.***

***Figure 75. Light reflective floors are well suited to large warehouse complexes and retail stores. (70110)***

Choosing appropriate aggregates for white concrete mixtures is important. Fine aggregates can act like pigment in the mortar fraction of the mixture. For this reason the use of white or light yellow sand should be considered. Many natural sands are too dark to be used in white concrete, which may necessitate the use of manufactured sands produced from crushed limestone (dolomite or calcite) or quartzite. Proper gradation and quantity of sand is also important. Dark coarse aggregates can shadow through white concrete surfaces, a condition called aggregate transparency. White or other light colored coarse aggregates eliminate this risk to the finished concrete surface aesthetic. Coarse aggregates containing iron oxide should be avoided as these materials promote unsightly rust stains.

Most chemical admixtures may be used in white concrete mixtures, but admixture producers must be consulted to assure compatibility on a case-by-case basis. Two admixtures that must be avoided are calcium chloride accelerators and water reducers containing lignosulfonates, both known to cause discoloration.

## Mixing, Placing, Finishing, Curing, and Protection of White Concrete

Mixing equipment must be clean and mixtures must be protected from contamination by oil, grease, dirt, or other materials that produce staining. Longer mixing times may be required to achieve a homogeneous mixture due to typically higher cement content of white mixtures, and maintaining consistent proportions and water-cement ratio is critical. Water containing iron or rust must be avoided.

Placing white concrete should follow normal good practice for flat slab construction. Concrete slump should range from 75 mm (3 in.) at temperatures less than 21°C (70°F) and increase with higher temperatures, not to exceed 125 mm (5 in.). Strength, durability, and consistent batching for projects requiring multiple concrete placements will determine whether slump can be increased using water or water reducers. Any changes to the proportions may cause color variations.

Finishing practices of white concrete require little deviation from normal gray concrete finishing practice with one exception. Concrete that is to receive a smooth troweled surface must receive special consideration. Hard troweling to produce glassy burnished finishes should be avoided as late troweling can produce dark discolorations on the finished surface. Proper timing of the final finishing pass of white concrete dictates that the work take place somewhat earlier than it does for gray concrete (Figure 76).

Curing of white concrete requires special attention. Acceptable methods include durable non-staining waterproof paper properly lapped and sealed, plastic backed moist burlap, fogging, ponding, and clear non-yellowing spray applied curing compounds. The high quality surface aesthetics of white concrete surfaces also require protection from damage caused by construction activities after placement. This may include protective layers of sand, plywood sheathing, or canvas.

***Figure 76. Clean tools are essential for creating light reflective concrete floor surfaces. Hand finishing is recommended for the final pass, as machine finishing can create a burnished appearance, which may not be acceptable. (70104)***

For additional information on white and colored concrete, go to www.cement.org/decorative.

# Section 5
# Colored Finishes

Many decorative effects can be achieved by the use of colored concrete for patios, floors, stepping-stones, walks, driveways, pool decks, and other concrete flatwork. There are numerous methods of producing colored concrete finishes. Five common methods are: (1) the one-course or integral method, (2) the two-course method, (3) the dry-shake method, (4) overlays and (5) paints and stains. Methods 1 through 3 are used for new construction, method 4 is used on existing slabs, and method 5 may be used on existing slabs and new construction.

The choice of method for any particular application should be made considering final aesthetics, economy, service conditions, and practicality for the intended project, for example:

If the aesthetics call for a single consistent color, the use of pigments or paint may be more appropriate choices; however, if the intent is to create color variation, stains may be a better coloring method.

If an integral color pigment is chosen, the thickness of the slab design may dictate the best application method. For instance, integral color is more cost effective for thin sections less than 125 mm (5 in.) or 150 mm (6 in.), whereas for slabs of greater thickness, the dry-shake or two-course methods may be more economical.

Service conditions can also dictate the best method to achieve colored concrete. Paint is not recommended for exterior concrete flatwork, and in cold weather regions exterior surface coloring may be inappropriate due to potential for surface damage from the use of equipment for snow removal and/or freezing and thawing cycles.

When applying any coloring method to concrete, the manufacturer's specifications must be followed closely.

## One-Course (Integral) Method

In the one-course method, the appropriate amount of color pigment is added to the mixer as the concrete is batched. The concrete is then thoroughly mixed to provide a uniform color throughout the full depth of the slab when it is placed. The pigment can be a pure mineral oxide or a natural or a synthetic iron-oxide colorant especially prepared for use in concrete. It may be available in the form of a powder, liquid or, prills. When possible, it is recommended that color pigments and cement be blended prior to adding the material to the concrete mixture. Both natural and synthetic pigments are satisfactory if they are insoluble in water, free from soluble salts and acids, unaffected by ultra violet light, alkalies and weak acids, limited to small amounts of calcium sulfate, and ground fine enough so that 90% passes a 45 µm screen. Color pigments should meet the requirements of ASTM C 979, *Specification for Pigments for Integrally Colored Concrete*. Table 3 gives examples of some mineral pigments.

***Table 3. Guide to Mineral Pigments for Colored Concrete Finishes***

| Color desired | Materials to use |
|---|---|
| White | White portland cement, white sand |
| Black | Iron oxide |
| Brown | Burnt umber or brown oxide of iron (yellow oxide of iron will modify color) |
| Buff | Yellow ocher, yellow oxide of iron |
| Gray | Normal portland cement |
| Green | Chromium oxide |
| Blue | Cobalt oxide |
| Pink | Red oxide of iron (small amount) |
| Rose | Red oxide of iron |
| Cream | Yellow oxide of iron |

The amount of pigment used should be the minimum amount necessary to produce the desired color, but never more than 10% by weight of the cement. Full-strength pigment will normally produce a good color when 3 kg (7 lb) is mixed with one bag of cement; 0.7 kg (1½ lb) per bag normally produces a pleasing pastel color. White portland cement will produce cleaner, brighter colors and should be used in preference to normal gray portland cement, except for black or dark gray colors. To obtain a uniform color throughout the slab, all materials in the mix must be carefully proportioned by weight. Mixing time should be longer than normal to ensure uniformity. To prevent streaking, dry cement and color compound should be thoroughly blended before they are added to the mix.

## Two-Course Method

The base slab in the two-course method is placed in the usual manner. The surface of the base slab should have a rough texture to provide a better mechanical bond with the topping. The colored topping course can be placed on the base slab concrete as soon as it is firm enough to support a concrete finisher's weight. If the concrete has hardened, the topping course can be bonded to the base concrete by either a cement-water grout or a cement-sand-water grout. (For more details see PCA's *Resurfacing Concrete Floors,* IS144).

The topping mix is normally 12.5 mm (½ in.) to 25 mm (1 in.) thick, with a ratio of cement to sand of 1:2 ¼ or 1:3. Color pigments are added to the medium-consistency mixture according to the manufacturer's specifications. The concrete surface is floated and troweled in the prescribed manner. Allowance must be made in the base-slab thickness to accommodate the topping course and bring it to proper grade.

The two-course color finish is frequently used in place of the one-course method for economy. The savings in materials normally more than offset the higher labor costs.

## Dry-Shake Method

The dry-shake method consists of applying a prepared, packaged, dry color material that can be purchased from various manufacturers ready for use. Its basic ingredients are a pigment, white portland cement, and specially graded silica sand or fine aggregate. Proportioning and mixing a dry-shake material on the jobsite is not as satisfactory as using a prepared mix.

Proper personal protection should be used when working with dry-shake materials. Dust masks and eye protection should be required for all concrete finishers when working with powdered materials. (See Safety Precautions, Working with Fine Powder Cement-Based Materials in the Appendix B.)

After the concrete has been screeded and darbied or bullfloated, and excess moisture has evaporated from the surface, the slab should be power or hand-floated. If by hand, a metal or fiberglass float should be used. Preliminary floating should be done before the dry-shake material is applied to bring up enough moisture for combining with the dry material. Floating also removes any ridges or depressions that might cause variations in color intensity. Immediately after the floating operation, the dry material is shaken evenly by hand or machine over the surface (Figure 77). If too much color is applied in one spot, nonuniformity in color and surface peeling may result.

The first application of the colored dry-shake material should use one-half to two-thirds of the total amount needed (kg/$m^2$ or lb/$ft^2$ as specified). In a few minutes this dry material will darken indicating it has absorbed moisture from the plastic concrete; it should then be thoroughly floated into the surface. Immediately, the balance of the dry-shake material should be distributed evenly, at a right angle to the original placement, over the surface for more consistent coverage. After darkening, this should also be thoroughly floated and made part of the surface, taking care that a uniform color is obtained. All edges and joints should be tooled before and after each color application.

For interior floors using normal dosages that will be hard troweled, the first application is floated into the surface. After the surface has hardened sufficiently (able to support the weight of a concrete finisher leaving heal prints of no more than 6 mm [¼ in.]), the remaining dry-shake material is distributed over the floor surface perpendicular to the first application and is then machine troweled.

Hard troweled floors that receive high dosages of dry-shake materials may require a three-part application process. One-third of the material is distributed immediately after strikeoff, followed by bleeding and bleed water evaporation; the second third of the material is spread and floated into the surface; and when ready for machine troweling, the final third is placed and troweled. Each successive pass of dry-shake material should be applied perpendicular to the previous pass.

The concrete specified for projects that will be hard troweled should not contain air-entraining admixtures as they may cause blisters or delamination of the concrete surface.


***Figure 77. Dry-shake coloring. (a) Concrete is placed, screeded, and floated using conventional techniques. (b) Dry-shake coloring compound is broadcast onto the surface. (c) The dry shake is floated and troweled into the surface. (d) Brooming the surface. (e) Completed dry-shake surface. Also see Figures 52, 59, 60, and 61. (l to r, 13913, 13914, 13902, 13904, 13917)***

If a smooth surface is desired, as is common for indoor applications, the surface should be power-troweled shortly after the final floating operation. If work is being done by hand, troweling should immediately follow the final floating. After the first troweling, whether by power or by hand, there should be a lapse of time the length depending upon such factors as temperature and humidity to allow the concrete to increase its set. Then the concrete may be troweled a second time to improve the texture and produce a denser, harder surface. A third hard troweling could be specified. This final troweling should be done by hand to eliminate any washboard or trowel marks. This final hand troweling produces a smooth, dense, hard-wearing surface, as is commonly needed for commercial and industrial floors. The timing of the final troweling pass is critical; trowel too early and the surface may lack the proper smoothness: trowel too late and risk creating darkened areas (burns) on the finished surface.

For exterior surfaces, a single troweling pass is usually sufficient. Then a soft bristle concrete broom can be drawn over the surface to produce a slightly roughened texture for better traction under foot. Smooth surfaces are slippery and hazardous when wet; therefore, hard steel-troweled surfaces are not recommended for exterior slabs.

Colored slabs, as with other types of freshly placed concrete, must be cured thoroughly. After thorough curing and surface drying, interior surfaces may be given at least two coats of special concrete floor wax containing the same pigment used in the dry-shake material. Nonwax, polymeric sealers also are available. Care should be taken to avoid any staining, such as by dirt or foot traffic, during the curing and drying period and before waxing or sealing. Exterior surfaces do not need sealing; however, sealing does accentuate the color and make cleaning easier.

## Bonded Overlays

*Resurfacing Concrete Floors,* IS144 and *Concrete Floors on Ground,* EB075 provide proper guidance for surface preparation and application of overlays with traditional concrete materials.

The condition of the original slab must be compatible with overlay systems. Random cracks in existing slabs will mirror through this type of surfacing technique, so the slab must be sound — have sufficient strength, durability, and stability for its intended service conditions. Careful consideration should be given to choosing a maximum coarse aggregate size for these applications. Colored overlays may use a coarse aggregate size of up to one-third the thickness of the topping material, while stamped overlays may require much smaller aggregates to accommodate penetration of the stamping tools (see Appendix A for guide specification).

Additional instructions or specifications may be available from manufacturers of thin specialty toppings and must be followed closely.

## Bonded Stamped Overlays

Renewing the surface of an existing slab may be accomplished through the use of a bonded stamped overlay. Traditional concrete materials may be used for section thicknesses of 25-mm (1-in.) or more, and specialty topping materials are available for thinner sections of 3 to 19 mm (⅛ to ¾ in.). It is important to choose an overlay thickness that will allow for the full depth penetration of the chosen pattern stamp, or to choose a stamp specifically designed for the shallow overlay processes (Figure 78). The stamping process is much the same as the stamping processes previously described.

## Bonded Stenciled Overlays

Existing slabs may also be renewed with the use of stenciled overlays. The surface preparation for the overlay follows standard overlay processes. Paper stencils are placed on the slab surface, and a thin specialty overlay material containing color pigments and possibly polymers is then sprayed or troweled onto the surface (Figure 79). After a time delay to allow some hardening to take place, the surface may be floated, troweled, or textured with a broom or roller (Figure 27). Allow the concrete an additional waiting period for strength gain and then carefully remove the stencil to reveal the pattern as mortar joints. After additional hardening the surface is cleaned of debris and cured by fogging or the application of a clear or color-pigmented curing compound.

*Figure 78. Thin specialty material is applied to accommodate a stamped overlay.*

## Paints and Stains

In the past, stains and paints were used when it is necessary to color an existing slab. Now it is also becoming more common to use stains to create in-slab color variation, simulate stone in new construction, and a wide variety of other colored effects. It is important to remember that concrete stains react with a degree of variation. This variation is an inherent part of stained concrete applications. For this reason the customer must expect a final outcome that may not have the same consistency of color as other floor finishes. In some cases it is the non-uniformity of the color that adds the natural appearance to the concrete. Stains are produced in two basic types; acid-based chemically reactive stains and water or solvent-


*Figure 79. (a) Overlay material is sprayed over a paper stencil to create a relief pattern. (b) A texture roller applied to the surface of a stenciled bonded overlay.*

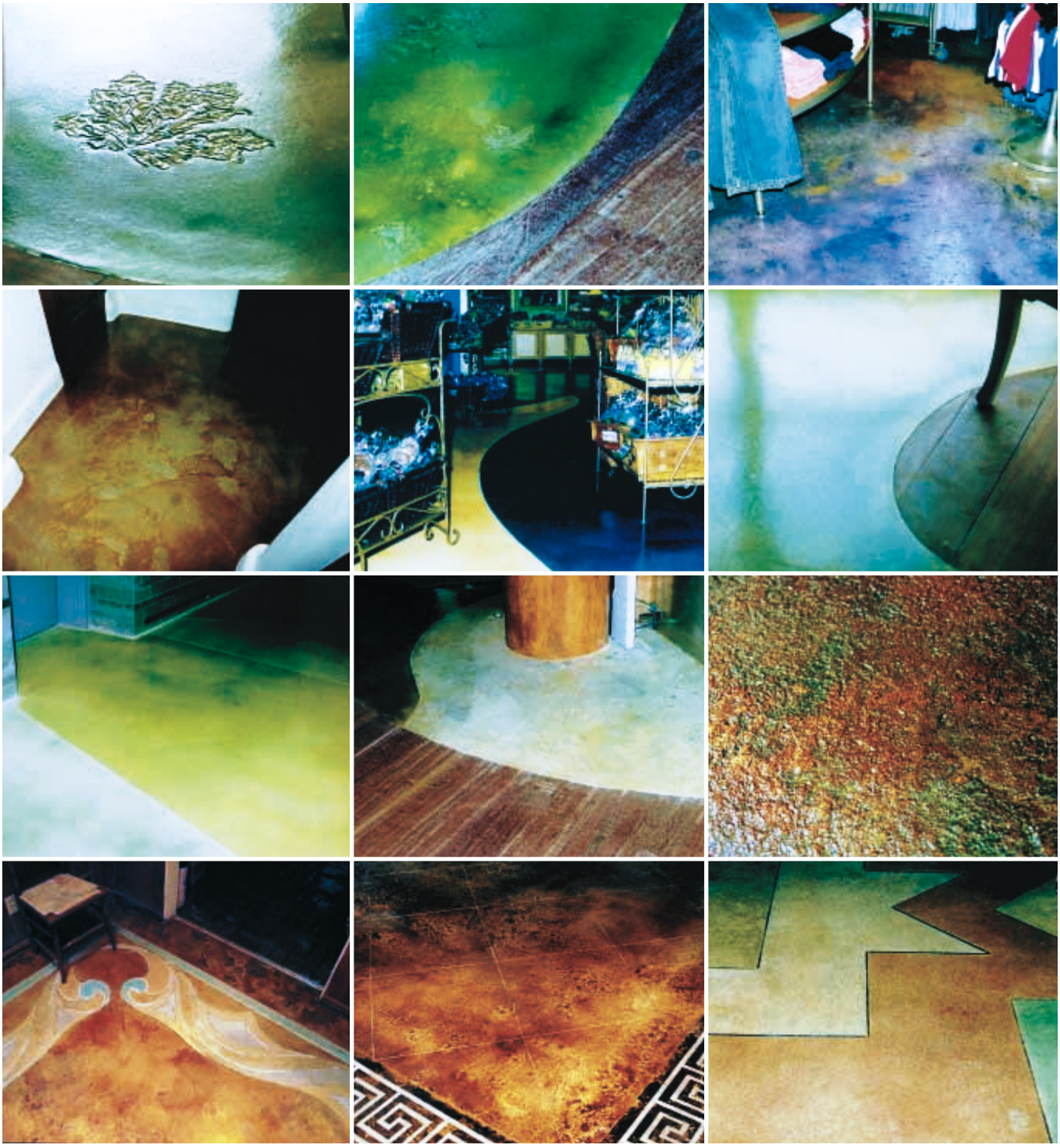

*Figure 80. Examples of colored surfaces using chemical stains, dyes, and tints in combination with a variety of other decorative concrete strategies.*

*Figure 80 (continued). Examples of colored surfaces using chemical stains, dyes, and tints in combination with a variety of other decorative concrete strategies.*

based dyes and tints. It may be difficult to obtain a uniform color with dyes or stains; therefore, the manufacturer's directions should be closely followed (Figure 80).

## Paints

Paints have been used to create consistent colored surfaces for many decades. New techniques have been developed for purely decorative applications to allow paints to create the look of marble, stone, or slate. The method uses epoxy resins for base and color coats and then may be covered with a protective non-yellowing sealer such as a urethane.

Epoxies containing aggregates for surface traction are used frequently for industrial and commercial applications such as automotive shop areas, industrial food processing plants, and assembly line facilities. These coatings provide surfaces that allow ease of cleaning, stain resistance, and improved safety. In addition, the use of multiple colors can delineate distinct work areas, helping to direct the flow of processes for industrial applications. The use of paints may require special consideration of moisture vapor transmission issues including vapor retarders beneath slabs and drying time prior to paint application. Some paints may also be sensitive to high-alkalinity, high-pH environments at the time of paint application.

On areas subject to heavy traffic and especially on outdoor paving, paints wear away soon and must be renewed periodically if a good appearance is to be maintained. (For more information see PCA's *Painting Concrete,* IS134).

## Chemically Reactive Stains

Chemically reactive stains are water-based acidic solutions. They contain metallic salts that react with calcium hydroxide in hardened concrete to produce insoluble colored compounds of blue-green, black, brown, or gold. These compounds become a permanent component in the paste structure near the surface of the concrete. Stains may be applied to plain concrete, or they may be used on surfaces of colored concrete with the colored surface creating a background for the effects of the stain. An important attribute of stains is that it can be applied to old or new concrete.

The acid in the solution is intended to open the concrete surface for easier and deeper stain penetration; however some hard-troweled surfaces may need to be sanded for successful stain penetration. A number of variables that should be considered when using chemically reactive stains include cement properties and content of the concrete mixture, aggregate type, effects of chemical admixtures, finishing and curing practices, construction schedules, and moisture content during stain application.

Stain reacts only with the paste fraction of the concrete mixture or with calcium based aggregates such as limestone. For this reason it is recommended that lean concrete mixtures and mixtures with low cement contents be avoided when stains are used. Low-alkali cement or cement that produces lower levels of calcium hydroxide, may be of less advantage when using chemically reactive stains. One exception may be white cement concrete which provides a neutral background and requires less color to achieve positive results.

Most chemical admixtures have little negative effect on chemically stained concrete. However calcium chloride accelerators may lead to discoloration or mottling issues and in poorly mixed concrete or used at higher dosages, may leave areas that the stain cannot color. Calcium chloride accelerators should be avoided in all colored concrete applications.

There are two opposing opinions on appropriate finishing practices for stained concrete applications. The first suggests that a floated surface will more readily accept penetration of the stain. This type of surface may achieve denser color. The potential drawback of this finishing technique is that a floated surface may not be durable in high traffic areas, which would then require a higher degree of sealer maintenance to prevent color loss, or over time the potential for additional color application. The alternate finishing technique calls for a hard troweled surface which, being more durable, will hold the color for a longer period of time. This method may require additional sanding or stronger acid solutions to open the surface for stain application, leading to additional labor costs at the time of installation.

The recommended curing method for new concrete placements to receive stains is unwrinkled, non-staining, high quality curing paper. Water curing may be appropriate, but there have been reports of efflorescence problems attributed to water transporting soluble salts to the slab surface. Curing compounds are incompatible with staining applications since these materials prevent stain penetration.

Construction schedules can be an important consideration when using stains. A minimum recommended curing period prior to staining is 14 days, and the use of blue, green, and gold colors may require a 30-day to 60-day curing period.

Moisture content of the slab at the time of stain application also plays a role in the final color achieved. Higher moisture contents tend to deliver more calcium hydroxide to the slab surface allowing more reaction products to form, but some colors may darken or even turn black if excess moisture is available for too long a period of time. On the other end of the moisture scale, slabs in direct sunlight may become hot and dry, allowing very little stain penetration.

## Applying Chemical Stains

Chemical stains may be spray applied to a concrete, then scrubbed into the surface to facilitate penetration, or they may be simply brushed into the surface. In some cases additional stain may be spray applied after brushing for more uniform color distribution. The stain is allowed to react with the surface for a minimum of 4 hours, and then is washed with a commercial grade detergent to remove all residues. Multiple coats of more than a single color will require thorough washing and drying between coats to evaluate the color prior to additional application. After washing, the surface is rinsed and rinse water is vacuumed or absorbed with an inert material (Figure 81).

The slab surface is allowed to dry before the application of a clear sealer. (See guide specification in Appendix B.) Individual stain manufacturers should also be consulted for guidance regarding application and specifications.


*Figure 81. (a) Sanding a concrete surface in preparation to receive stains, dyes, or tints. (b) Washing the surface prior to stain, dye, or tint application. (c) Vacuuming wash water to assure a clean surface. (d) A typical application method when a single color stain is used.*

## Dyes and Tints

Dyes and tints do not react chemically with concrete yet are frequently used in conjunction with chemically reactive stains. These materials produce colors that are not available with chemical stains such as reds and yellows, and may be used to correct deficiencies in color of acid stain by filling areas that did not stain well or by lightening color that has become too dark. The look created by this material is often described as translucent or opaque.

They may be water or solvent based inorganic or organic materials having good to poor ultraviolet light resistance. Consideration of appropriate sealers to protect these materials must be made on a case-by-case basis, based on the specific application, related aesthetics, and service environment.

## Applying Dyes and Tints

The use of dyes and tints require clean surfaces free of materials that would prevent penetration of the color-pigmented stains and sealers, and contamination materials which could cause unwanted color variation. Typical slab preparation includes in order (1) treating the moistened concrete slab with a degreaser, (2) scrubbing the surface with a buffer equipped with a nylon brush, (3) applying mineral acid solution per manufacturer's instructions while still moist, (4) scrubbing, (5) rinsing, (6) reapplying degreaser, (7) scrubbing, and (8) rinsing. The surface must be tested using pH indicator strips or a pH pen to assure the recommended pH level between 7 and 8 has been achieved. The selected dye or tint may then be spray or brush applied depending on the final desired patterns or finish (see Appendix B for guide specification).

After drying, a clear or color-pigmented sealer must be applied as the wearing surface.

# Section 6
# Jointing and Curing

## Jointing Concrete Slabs

In 100-mm (4-in.) and 125-mm (5-in.) slabs, such as those used in driveways and walks, contraction joints should be spaced at intervals about equal to the slab width to control cracking. Drives and walks wider than 3 m (10 ft) to 4 m (12 ft) should also have a longitudinal joint down the center. Joint spacing in patios should not be more than 3 m (10 ft) on center in either direction.

If possible, the panels formed by contraction joints should be approximately square. Panels with excessive length-to-width ratios, more than 1½:1, are likely to crack. As a general rule, the smaller the panel, the less likely it is to crack randomly. Joints should be continuous, not staggered or offset, unless divider strips or isolation joint material is used.

Contraction joints can be sawed (Figure 82) or formed with metal, plastic, hardboard, masonry, or divider strips (Figure 67 through 70). Hand-tooled joints (Figures 71, 72 and 82) may not be practical for use with some exposed-aggregate finishes.




***Figure 82. (a) Saw cutting a contraction joint in a driveway. (b) Saw-cut joint in pattern stamped concrete. (c) Hand-grooved joint in an exposed-aggregate concrete. (a through c: 13971, 13972, IMG9040)***

*Figure 83. (a) This fibrous joint material has a removable top portion. Used here as an isolation joint at a curb, the joint material is installed flush with the slab surface. After the concrete is cured, the top 25-mm (1-in.) portion is removed and an elastomeric joint sealant is applied. (b) A doweled butt-type construction joint. Although not usually necessary, dowels were used on this shopping mall project to prevent faulting at the construction joints. (c) View of the sealed joints in exposed-aggregate concrete. Other views of this project are shown in Figures 15 to 17. (13944, 13974, IMG9041)*

When forming isolation joints (Figure 83a) or construction joints that also act as contraction joints (Figure 8b), special fiberboard jointing material is available to ease joint sealant application (Figure 83c). The joint should extend into the slab at least one-fourth of the slab thickness. More information on jointing is available in PCA's, *Cement Mason's Guide,* PA122 and *Concrete Floors on Ground,* EB075.

## Curing

Standard moist-curing procedures should be followed, but careful consideration of the specific application may prohibit some curing methods. Moist curing of color-pigmented concrete may increase the potential for efflorescence, and plastic sheet materials may promote discoloration of white or colored concrete.

The use of sprinkling, covering with waterproof paper or plastic sheeting, continuous saturation of burlap coverings, or plastic sheet over wet burlap, are all acceptable (Figure 84). A 7-day curing period is usually adequate for normal concrete. A shorter curing period can be used for high-early-strength concrete.

To avoid potential staining and prevent interference with possible future sealer applications, it is better not to use conventional curing compounds on this type of work. If a curing compound must be used, it should be specially formulated for colored, patterned, or exposed-aggregate concretes and be compatible with certain sealers that may be used on the surface. Also avoid curing with damp sand that contains silt and clay because of the difficulty of cleaning the slab afterward.

In addition to curing, it is assumed that the concrete is properly designed for durability with a low water-cement ratio and air entrainment where necessary (see "Base Concrete" under "Seeded Exposed-Aggregate Concrete").

Although not necessary for most applications, a sealer can be applied if desired to enhance the surface appearance, ease surface cleaning, and improve resistance to deicers. Sealers are commonly applied to dry-shake pattern stamped concrete and exposed-aggregate concrete. Sealers are applied after the curing period, often 28 days after placement as per manufacturer's directions. Sealers must be compatible with curing compounds that may be used to cure the slab (see "Sealers" under "Exposed-Aggregate Finishes").


*Figure 84. Concrete must be cured to achieve the desired strength and durability. (a) Burlap covering kept continuously moist with a sprinkler. (b) Plastic sheeting prevents moisture from leaving the slab. Plastic sheeting can also be used over wet burlap to keep the burlap moist. (c) A curing compound retards the evaporation of water from the concrete. (12263, 13907, 13973)*

# Section 7
# Combinations

When concrete is used decoratively, striking effects can be obtained by combining colors and textures with one or more of the patterns described in this publication. For example, alternate areas of exposed aggregate can be eye-catching when combined with plain, colored, or textured concrete (Figure 85). Ribbons and borders of concrete masonry or brick add a distinctive touch when combined with exposed aggregate. Light colored strips of exposed aggregate may divide areas of dark colored concrete or vice versa. Scored and stamped designs are enhanced when combined with integral or dry-shake color.

These are just a few combinations; the possibilities are unlimited. With a little imagination, a concrete driveway, sidewalk, plaza, floor, patio, or pool deck can be tailored to fit the mood and style of any architecture or landscape.


*Figure 85. Combinations. (a) An imposing entry walk combines wood divider strips to separate bands of smooth colored concrete and expanses of exposed-aggregate concrete. Various combinations of plain concrete, textures, exposed aggregate, pattern stamping, divider strips, and borders are shown in the other views. (l to r, 21724, IMG: 9046, 9042, next page, l to r, IMG: 9044, 9045, 9043, 9047, 9048)*

# Appendix A
# Guide Specifications

Guide specifications are provided here to assist you in developing specifications for decorative concrete projects. These guide specifications do not address local issues, proprietary product concerns, or specific project needs. These specification guides should be used only by qualified professionals who are competent to evaluate the significance and limitations of the guide specification and who will accept responsibility for the application of its requirements to the structure under consideration. Additional information on specifying concrete can be found in ACI 301, *Specifications for Structural Concrete for Buildings,* published by American Concrete Institute, Farmington Hills, Michigan, www.concrete.org.

## Guide Specification for Horizontal Exposed-Aggregate Concrete Surfaces (Seeding Method)

### 1. General

This section shall apply to all surface finishes indicated as 'exposed aggregate' on the plans. The contractor shall furnish a 1x1-m (3x3-ft) sample panel (or larger) for approval by the architect prior to construction of the designated areas. This panel shall be made from samples of the specified material using the methods and workmanship proposed for the project. Source, type, color, and range of gradation of the select seeding aggregate shall be obtained from the architect prior to construction of the sample panel. The approved panel shall constitute an example of minimum workmanship for all work specified under this section. If the sample panel is disapproved, additional sample panels shall be made until approval is obtained. The approved sample panel shall be kept at the jobsite for comparison with the finished work.

### 2. Concrete

All concrete to receive an exposed-aggregate surface shall contain Type _____ portland cement (ASTM C 150) or Type _____ blended hydraulic cement (ASTM C 595) or Type _____ hydraulic cement (ASTM C 1157) [Specify white cement when necessary]. Concrete to be exposed to freezing temperatures and deicers shall have a minimum cement content of 335 kg/m$^3$ (564 lb/yd$^3$), a maximum water-cementitious ratio of 0.45, and an air content of 5% to 8%. The maximum nominal size of coarse aggregate of the base mix shall be 19 mm (¾ in.). Ready mixed concrete, if used, shall meet ASTM C 94, *Specification for Ready Mixed Concrete*. Aggregate source and cement type and brand shall not be altered once construction begins. The slump of the concrete shall not exceed 125 mm (5 in.).

### 3. Seeding Aggregate

All aggregate to be exposed shall be hard, sound, durable, and free of all deleterious materials and staining qualities. The select seeding aggregate shall be stored off the ground and protected from contamination and moisture. The color and size of the aggregate shall be selected by the architect and shall match that in the test panel. Flat, elongated particles shall not be used.

### 4. Subgrade Preparation

The subgrade shall be compacted to a uniformly dense surface and shall be in a moist condition (no standing water) at the time of concrete placement.

### 5. Forms

Forms shall be clean and free from all extraneous substances. They shall be of sound material, well braced, straight, and true to finish grade as indicated in the architectural layout. Where slope for drainage is indicated on plans, forms shall be sloped to obtain desired finish grade. Permanent left-in-place forms shall be made of _____, (weather-resistant wood of nominal size _____, grade _____, and primed with _____ or equivalent sealer), and shall be anchored to the concrete with [16 penny galvanized nails, 100 mm (4 in.) exterior deck screws] _____ [driven from outside of, inserted to a depth of _____ into] forms at approximately 400-mm (16-in.) centers.

### 6. Joints

Contraction joints shall be [wood divider strips, sawed], and located as indicated on the plans. Wood joints shall be made of the same material as that specified for permanent left-in-place forms and shall be anchored to the concrete with [16 penny galvanized nails, 100 mm (4 in.) exterior deck screws] _____ [driven from out-side of or inserted to a depth of _____ into] forms at approximately 400-mm (16-in.) centers. Where wood divider strips butt outside forms, a neat butt joint flush against the outside form shall be used. If joints are sawed, the depth of cut shall be one-fourth the slab thickness. Sawing shall be done as soon as the surface is firm enough not to dislodge any of the exposed aggregate.

### 7. Aggregate Preparation

Prior to the concrete placing operation, all select seeding aggregate shall be washed thoroughly so that it is free of all dust, dirt, and clay particles. The aggregate shall be in a damp condition but without free surface water at the time

of seeding application. There shall be sufficient select aggregate on hand to complete the seeding once it has started.

### 8. Placement of Concrete

The architect shall be notified of concrete placement sufficiently in advance of start of operation to allow the architect's representative to complete preliminary inspection of the work, including subgrade, forms, and reinforcing steel, if used. Normal concrete placement procedures shall be followed. Concrete shall arrive at the jobsite so that no additional water will be required to produce the desired slump. When conditions develop that require addition of water to produce the desired slump, permission of the architect's representative must be obtained. The concrete shall be transported from the mixer to its place of deposit by a method that will prevent segregation or loss of material.

Concrete shall be consolidated by suitable means to eliminate voids and pockets. The strikeoff and darby or bullfloat operations should be such that a level or flat, plane surface is obtained sufficiently below the final finish grade to allow for volume growth due to the addition of the seeding aggregate.

### 9. Seeding and Embedment

The seeding operation shall start immediately after the placement of concrete as described above. The select aggregate shall be carefully and uniformly seeded by suitable means so that the entire surface is completely covered with one layer of stone. Stacked stone as well as flat and elongated particles shall be removed at this time. The aggregate shall be embedded by suitable means. Care shall be taken not to over-embed and deform the surface. Under no circumstances shall areas lacking sufficient mortar be filled with small quantities of the base concrete mix.

### 10. Exposing the Aggregate

When the concrete is hard enough to retain the embedded aggregate and the mortar is still soft enough to be removed by brushing, the surface shall be brushed and flushed with water. The exposing operation of washing and brushing with a stiff bristle broom is continued until the surface matches the approved sample panel. The final washing operation shall cease when the flush water runs clear and there is no noticeable cement film on the aggregate. Work shall be planned so that the concrete-placing and aggregate-seeding procedures are coordinated with the capabilities of the washing and brushing crew.

When a surface retarder is used, it must be approved by the architect and be of the same brand used to prepare the approved sample panel. The retarder shall be applied uniformly over the concrete surface and in accordance with the manufacturer's instructions.

### 11. Curing

As soon as the washing operation ceases, the curing operation shall begin. The concrete shall be kept in continuously moist condition by wet coverings, plastic sheeting, or continuous saturation by sprinkling, for 7 days. The temperature of the concrete shall not be allowed to fall below 10°C (50°F) during the curing period.

### 12. Acid Wash (optional)

After the slab is cured and *no sooner* than two weeks after the concrete has been placed, cement film shall be removed from the surface of the aggregate by an acid wash or suitable commercial masonry cleaner. Delaying the acid wash additional time is permissible, in fact, desirable. The slab shall be saturated with water, brushed free of standing water, and washed with a 5% to 10% solution of muriatic acid. Several flushings with clear water should follow the acid wash. The above procedure shall be followed until the surface matches the approved sample panel. (See precautions in Acid Wash section of the document and "safety precautions" in Appendix B.)

### 13. Sealer (optional)

After the slab is completely dry, a clear, nonyellowing sealer _____ as manufactured by _____ shall be uniformly applied to the surface according to the manufacturer's directions.

## Guide Specification for Pattern Stamped Concrete Surfaces

### 1. General

This section shall apply to all surface finishes indicated as 'pattern stamped concrete' on the plans. The contractor shall furnish a 1x1 m (3x3 ft) sample panel or larger for approval by the architect prior to construction of the designated areas. This panel shall be made from samples of the specified material using the methods and workmanship proposed for the project. The approved panel shall constitute an example of minimum workmanship for all work specified under this section. If the sample panel is disapproved, additional sample panels shall be made until approval is obtained. The approved sample panel shall be kept at the jobsite for comparison with the finished work.

## 2. Concrete

All concrete to receive a pattern stamped surface shall contain Type _____ portland cement (ASTM C 150) or Type _____ blended hydraulic cement (ASTM C 595) or Type _____ hydraulic cement (ASTM C 1157) [Specify white cement when necessary]. Concrete to be exposed to freezing temperatures and deicers shall have a minimum cement content of 335 kg/m$^3$ (564 lb/yd$^3$), a maximum water-cementitious ratio of 0.45, and an air content of 5% to 8%. The maximum nominal size of coarse aggregate of the base mix shall be 9.5 mm (⅜ in.). Ready mixed concrete, if used, shall meet ASTM C 94, *Specification for Ready Mixed Concrete*. Aggregate source and cement type and brand shall not be altered once construction begins. The slump of the concrete shall not exceed 125 mm (5 in.).

## 3. Subgrade Preparation

The subgrade shall be compacted to a uniformly dense surface and shall be in a moist condition (no standing water) at the time of concrete placement.

## 4. Forms

Forms shall be clean and free from all extraneous substances. They shall be of sound material, well braced, straight, and true to finish grade as indicated in the architectural layout. Where slope for drainage is indicated on plans, forms shall be sloped to obtain desired finish grade. Permanent left-in-place forms shall be made of _____, (weather-resistant wood of nominal size _____, grade _____, and primed with _____ or equivalent sealer), and shall be anchored to the concrete with [16 penny galvanized nails, 100 mm (4 in.) exterior deck screws] _____ [driven from outside of, inserted to a depth of _____ into] forms at approximately 400-mm (16-in.) centers.

## 5. Joints

Contraction joints shall be [wood divider strips, sawed], and located as indicated on the plans. Wood joints shall be made of the same material as that specified for permanent left-in-place forms and shall be anchored to the concrete with [16 penny galvanized nails, 100 mm (4 in.) exterior deck screws] _____ [driven from out-side of or inserted to a depth of _____ into] forms at approximately 400-mm (16-in.) centers. Where wood divider strips butt outside forms, a neat butt joint flush against the outside form shall be used. If joints are sawed, the depth of cut shall be one-fourth the slab thickness. Sawing shall be done as soon as the surface is firm enough not to dislodge any aggregate from the joint edges (raveling).

## 6. Placement of Concrete

The architect shall be notified of concrete placement sufficiently in advance of start of operation to allow the architect's representative to complete preliminary inspection of the work, including subgrade, forms, and reinforcing steel, if used. Normal concrete placement procedures shall be followed. Concrete shall arrive at the jobsite so that no additional water will be required to produce the desired slump. When conditions develop that require addition of water to produce the desired slump, permission of the architect's representative must be obtained. The concrete shall be transported from the mixer to its place of deposit by a method that will prevent segregation or loss of material.

Concrete shall be consolidated by suitable means to eliminate voids and pockets. The strikeoff and darby or bull-float operations should be such that a level or flat, plane surface is obtained at the final finish grade.

## 7. Integral Pigments or Dry-Shake Hardeners

(a) Color pigment complying with ASTM C 979, added at a dosage consistent with producing the desired color, shall be mixed with the fresh concrete mixture with sufficient mixing time to produce a consistent, streak free color.

(b) Dry-shake color hardeners shall be applied to the freshly screeded surface at (dosages*) of _____ kg/m$^2$ (lb/yd$^2$). After bleed water evaporation, _____ [one half, two thirds] of the dry-shake will be evenly distributed and floated into the surface. The remaining dry-shake material shall then be applied at right angle to the first application, and shall be troweled into the surface.

**Consult manufacturer for dosage recommendations.*

## 8. Imprinting

Cover the area to be stamped with _____ (0.025-mm to 0.05-mm (1-mil to 2-mil) polyethylene plastic, powdered release agent), or apply form release agent to the stamping tool if it will be in direct contact with the concrete. Fully imprint the area with the stamping tool (pattern) chosen for the application. Finish exposed slab edges and risers with the same processes used for the slab.

## 9. Curing

Apply a film-forming curing compound, compatible with any anticipated finish sealer, to the slab surface per manufacturer's recommendation. The temperature of the concrete shall not be allowed to fall below 10°C (50°F) during the curing period.

### 10. Sealer (optional)

After the slab is completely dry, a clear, nonyellowing sealer _____ as manufactured by _____ shall be uniformly applied to the surface according to the manufacturer's directions.

## Guide Specification for Stenciled Concrete Surfaces

### 1. General

This section shall apply to all surface finishes indicated as 'stenciled concrete' on the plans. The contractor shall furnish a 1x1 m (3x3 ft) sample panel for approval by the architect prior to construction of the designated areas. This panel shall be made from samples of the specified material using the methods and workmanship proposed for the project. The approved panel shall constitute an example of minimum workmanship for all work specified under this section. If the sample panel is disapproved, additional sample panels shall be made until approval is obtained. The approved sample panel shall be kept at the jobsite for comparison with the finished work.

### 2. Concrete

All concrete to receive a stenciled concrete surface shall contain Type _____ portland cement (ASTM C 150) or Type _____ blended hydraulic cement (ASTM C 595) or Type _____ hydraulic cement (ASTM C 1157) [Specify white cement when necessary]. Concrete to be exposed to freezing temperatures and deicers shall have a minimum cement content of 335 kg/m$^3$ (564 lb/yd$^3$), a maximum water-cementitious ratio of 0.45, and an air content of 5% to 8%. The maximum nominal size of coarse aggregate of the base mix shall be 19 mm (¾ in.). Ready mixed concrete, if used, shall meet ASTM C 94, *Specification for Ready Mixed Concrete*. Aggregate source and cement type and brand shall not be altered once construction begins. The slump of the concrete shall not exceed 125 mm (5 in.).

### 3. Subgrade Preparation

The subgrade shall be compacted to a uniformly dense surface and shall be in a moist condition (no standing water) at the time of concrete placement.

### 4. Forms

Forms shall be clean and free from all extraneous substances. They shall be of sound material, well braced, straight, and true to finish grade as indicated in the architectural layout. Where slope for drainage is indicated on plans, forms shall be sloped to obtain desired finish grade. Permanent left-in-place forms shall be made of _____, (weather-resistant wood of nominal size _____, grade _____, and primed with _____ or equivalent sealer), and shall be anchored to the concrete with [16 penny galvanized nails, 100 mm (4 in.) exterior deck screws] _____ [driven from outside of, inserted to a depth of _____ into] forms at approximately 400-mm (16-in.) centers.

### 5. Joints

Contraction joints shall be [wood divider strips, sawed], and located as indicated on the plans. Wood joints shall be made of the same material as that specified for permanent left-in-place forms and shall be anchored to the concrete with [16 penny galvanized nails, 100 mm (4 in.) exterior deck screws] _____ [driven from out-side of or inserted to a depth of _____ into] forms at approximately 400-mm (16-in.) centers. Where wood divider strips butt outside forms, a neat butt joint flush against the outside form shall be used. If joints are sawed, the depth of cut shall be one-fourth the slab thickness. Sawing shall be done as soon as the surface is firm enough not to dislodge any aggregate from the joint edges (raveling).

### 6. Placement of Concrete

The architect shall be notified of concrete placement sufficiently in advance of start of operation to allow the architect's representative to complete preliminary inspection of the work, including subgrade, forms, and reinforcing steel, if used. Normal concrete placement procedures shall be followed. Concrete shall arrive at the jobsite so that no additional water will be required to produce the desired slump. When conditions develop that require addition of water to produce the desired slump, permission of the architect's representative must be obtained. The concrete shall be transported from the mixer to its place of deposit by a method that will prevent segregation or loss of material.

Concrete shall be consolidated by suitable means to eliminate voids and pockets. The strikeoff and darby or bull-float operations should be such that a level or flat plane surface is obtained at the final finish grade.

### 7. Stencils

Stencils shall be designed for use with fresh concrete. They will be cut to slab _____ [width, length] (to orient the pattern direction) overlapping trailing edge mortar joint with the leading edge mortar joint of the adjoining section. Cut to fit any special patterns which provide breaks in the pattern, such as circles or edgings. Embed the stencil with a roller designed for use with stencil. After the concrete has hardened sufficiently the stencil is removed.

### 8. Dry-Shake Hardeners

Dry-shake color hardeners shall be applied to the freshly screeded surface at (dosages*) of _____ kg/m$^2$ (lb/yd$^2$). After bleed water evaporation, _____ [one half, two thirds] of the dry-shake will be evenly distributed and floated into the surface. The remaining dry-shake material shall then be applied at right angle to the first application, and shall be troweled into the surface.

**Consult manufacturer for dosage recommendations.*

### 9. Curing

Prior to the application of a curing compound the slab surface shall be cleaned of all debris using a mechanical blower. Apply a film-forming curing compound, compatible with any anticipated finish sealer, to the slab surface per manufacturer's recommendation. The temperature of the concrete shall not be allowed to fall below 10°C (50°F) during the curing period.

### 10. Sealer (optional)

After the slab is completely dry, a clear, nonyellowing sealer _____ as manufactured by _____ shall be uniformly applied to the surface according to the manufacturer's directions.

## Guide Specification for Chemically Reactive Stained Concrete Surfaces

### 1. General

This section shall apply to all surface finishes indicated as 'chemically reactive stained' on the plans. The contractor shall furnish a 1x1 m (3x3 ft) sample panel or larger for approval by the architect prior to construction of the designated areas. This panel shall be made from samples of the specified material using the methods and workmanship proposed for the project. The approved panel shall constitute an example of minimum workmanship for all work specified under the section. If the sample panel is disapproved, additional sample panels shall be made until approval is obtained. The approved sample panel shall be kept at the jobsite for comparison with the finished work. (For existing concrete applications, see Existing Concrete)

### 2. New Concrete

All new concrete to receive a chemically reactive stained surface shall contain Type _____ portland cement (ASTM C 150) or Type _____ blended hydraulic cement (ASTM C 595) or Type _____ hydraulic cement (ASTM C 1157) [Specify white cement when necessary]. Concrete to be exposed to freezing temperatures and deicers shall have a minimum cement content of 335 kg/m$^3$ (564 lb/yd$^3$), a maximum water-cementitious ratio of 0.45, and an air content of 5% to 8%. The maximum nominal size of coarse aggregate of the base mix shall be 19 mm (¾ in.). Ready mixed concrete, if used, shall meet ASTM C 94, *Specification for Ready Mixed Concrete*. Aggregate source and cement type and brand shall not be altered once construction begins. The slump of the concrete shall not exceed 125 mm (5 in.).

### 3. Existing Concrete

Existing concrete shall be inspected to assure that it is sound-has sufficient strength, durability and stability for its intended service condition. Existing joints and random cracks must be judged acceptable prior to stain application. The contractor shall furnish a 1x1 m (3x3 ft) sample panel or larger, at _____ (chose a discreet location on the existing slab) for approval by the architect prior to staining the designated areas. The approved panel shall constitute an example of minimum workmanship for all work specified under this section. If the sample panel is disapproved, additional sample panels shall be made until approval is obtained. The approved sample panel shall be kept at the jobsite for comparison with the finished work.

### 4. Subgrade Preparation

The subgrade shall be compacted to a uniformly dense surface and shall be in a moist condition (no standing water) at the time of concrete placement.

### 5. Forms

Forms shall be clean and free from all extraneous substances. They shall be of sound material, well braced, straight, and true to finish grade as indicated in the architectural layout. Where slope for drainage is indicated on plans, forms shall be sloped to obtain desired finish grade. Permanent left-in-place forms shall be made of _____, (weather-resistant wood of nominal size _____, grade _____, and primed with _____ or equivalent sealer), and shall be anchored to the concrete with [16 penny galvanized nails, 100 mm (4 in.) exterior deck screws] _____ [driven from outside of, inserted to a depth of _____ into] forms at approximately 400-mm (16-in.) centers.

### 6a. Joints (New Concrete)

Contraction joints shall be [wood divider strips, sawed], and located as indicated on the plans. Wood joints shall be made

of the same material as that specified for permanent left-in-place forms and shall be anchored to the concrete with [16 penny galvanized nails, 4 in. exterior deck screws] _____ [driven from out-side of or inserted to a depth of _____ into] forms at approximately 400-mm (16-in.) centers. Where wood divider strips butt outside forms, a neat butt joint flush against the outside form shall be used. If joints are sawed, the depth of cut shall be one-fourth the slab thickness. Sawing shall be done as soon as the surface is firm enough not to dislodge any aggregate from the joint edges (raveling).

### 6b. Joints (Existing Concrete)

Contraction joints in existing concrete are sufficient for crack control. Additional shallow saw cuts for decorative purposes shall be _____ (positioned per project drawings, at the direction of the _____ [architect, engineer]).

### 7. Placement of Concrete

The architect shall be notified of concrete placement sufficiently in advance of start of operation to allow the architect's representative to complete preliminary inspection of the work, including subgrade, forms, and reinforcing steel, if used. Normal concrete placement procedures shall be followed. Concrete shall arrive at the jobsite so that no additional water will be required to produce the desired slump. When conditions develop that require addition of water to produce the desired slump, permission of the architect's representative must be obtained. The concrete shall be transported from the mixer to its place of deposit by a method that will prevent segregation or loss of material.

Concrete shall be consolidated by suitable means to eliminate voids and pockets. The strikeoff and darby or bull-float operations should be such that a level or flat plane surface is obtained at the final finish grade.

### 8. Surface Preparation

The concrete surface shall be cleaned and tested to assure that it will readily absorb water. If testing indicates that additional surface preparation is required (water beads on the surface), it may be acid washed or sanded to open the surface to absorption.

### 9. Stain Application

Stain shall be applied per manufacturer's recommended dosage and shall remain on the surface for a minimum of 4 hours (ambient condition such as wind, temperature, and humidity affect the stain's reaction time, some conditions may require a longer contact period with the surface). Adjoining surfaces shall be protected from stain contamination (run-off, tracking, overspray, etc.). Stained concrete surfaces shall be closed to traffic for a minimum or 3 days, and be protected from potential spills until sealed to prevent discoloration stains.

### 19. Curing

New concrete slabs shall be cured, a minimum of 14 days (some colors may require 30-60 days*), using unwrinkled, non-staining, high quality curing paper. Film forming liquid curing compounds shall not be used. The temperature of the concrete shall not be allowed to fall below 10°C (50°F) during the curing period.

**Consult manufacturer for time of curing for specific colors.*

### 11. Sealer

After the slab is completely dry, a clear, nonyellowing sealer _____ as manufactured by _____ shall be uniformly applied to the surface according to the manufacturer's directions.

## Guide Specification for Application of Dyes or Tints to Concrete Surfaces

### 1. General

This section shall apply to all surface finishes indicated as 'dyes or tints' on the plans. The contractor shall furnish a 1x1 m (3x3 ft) sample panel or larger for approval by the architect prior to construction of the designated areas. This panel shall be made from samples of the specified material using the methods and workmanship proposed for the project. The approved panel shall constitute an example of minimum workmanship for all work specified under this section. If the sample panel is disapproved, additional sample panels shall be made until approval is obtained. The approved sample panel shall be kept at the jobsite for comparison with the finished work. (For existing concrete applications, see 'Existing Concrete' below.)

### 2. New Concrete

All new concrete to receive application of dyes or tints surface shall contain Type _____ portland cement (ASTM C 150) or Type _____ blended hydraulic cement (ASTM C 595) or Type _____ hydraulic cement (ASTM C 1157)[Specify white cement when necessary]. Concrete to be exposed to freezing temperatures and deicers shall have a minimum cement content of 335 kg/m3 (564 lb/yd3), a maximum water-cementitious ratio of 0.45, and an air content of 5% to 8%. The maximum nominal size of coarse aggregate of the base mix shall be 19 mm (¾ in.). Ready mixed concrete, if used, shall meet ASTM C 94, *Specification*

*for Ready Mixed Concrete*. Aggregate source and cement type and brand shall not be altered once construction begins. The slump of the concrete shall not exceed 125 mm (5 in.).

## 3. Existing Concrete

Existing concrete shall be inspected to assure that it is sound-has sufficient strength, durability and stability for its intended service condition. Existing joints and random cracks must be judged acceptable prior to stain application. The contractor shall furnish a 1x1 m (3x3 ft) sample panel or larger, at _____ (choose a discreet location on the existing slab) for approval by the architect prior to staining the designated areas. The approved panel shall constitute an example of minimum workmanship for all work specified under this section. If the sample panel is disapproved, additional sample panels shall be made until approval is obtained. The approved sample panel shall be kept at the jobsite for comparison with the finished work.

## 4. Subgrade Preparation

The subgrade shall be compacted to a uniformly dense surface and shall be in a moist condition (no standing water) at the time of concrete placement.

## 5. Forms

Forms shall be clean and free from all extraneous substances. They shall be of sound material, well braced, straight, and true to finish grade as indicated in the architectural layout. Where slope for drainage is indicated on plans, forms shall be sloped to obtain desired finish grade. Permanent left-in-place forms shall be made of _____, (weather-resistant wood of nominal size _____, grade _____, and primed with _____ or equivalent sealer), and shall be anchored to the concrete with [16 penny galvanized nails, 100 mm (4 in.) exterior deck screws] _____ [driven from outside of, inserted to a depth of _____ into] forms at approximately 400-mm (16-in.) centers.

## 6a. Joints (New Concrete)

Contraction joints shall be [wood divider strips, sawed], and located as indicated on the plans. Wood joints shall be made of the same material as that specified for permanent left-in-place forms and shall be anchored to the concrete with [16 penny galvanized nails, 100 mm (4 in.) exterior deck screws] _____ [driven from out-side of or inserted to a depth of _____ into] forms at approximately 400-mm (16-in.) centers. Where wood divider strips butt outside forms, a neat butt joint flush against the outside form shall be used. If joints are sawed, the depth of cut shall be one-fourth the slab thickness. Sawing shall be done as soon as the surface is firm enough not to dislodge any aggregate from the joint edges (raveling).

## 6b. Joints (Existing Concrete)

Contraction joints in existing concrete are sufficient for crack control. Additional shallow saw cuts for decorative purposes shall be _____ (positioned per project drawings, at the direction of the _____ [architect, engineer]).

## 7. Placement of Concrete

The architect shall be notified of concrete placement sufficiently in advance of start of operation to allow the architect's representative to complete preliminary inspection of the work, including subgrade, forms, and reinforcing steel, if used. Normal concrete placement procedures shall be followed. Concrete shall arrive at the jobsite so that no additional water will be required to produce the desired slump. When conditions develop that require addition of water to produce the desired slump, permission of the architect's representative must be obtained. The concrete shall be transported from the mixer to its place of deposit by a method that will prevent segregation or loss of material.

Concrete shall be consolidated by suitable means to eliminate voids and pockets. The strikeoff and darby or bull-float operations should be such that a level or flat plane surface is obtained at the final finish grade.

## 8. Surface Preparation

The concrete surface shall be cleaned with a high alkali degreaser. While still damp apply mineral acid solution, and then scrub the surface and rinse. While still damp, the degreaser is reapplied, scrubbed, and rinsed again. Follow manufacturer's recommendations for dosages and timing. Test the surface for residue using a clean white cloth. Then test the pH of the surface using a pH pencil or pH strips. The pH of the surface shall be between 7 and 8 prior to applying dyes or tints.

## 9. Dyes or Tints Application

[Dyes, Tints] _____ shall be spray applied per manufacturer's recommended dosage.

## 10. Curing

New concrete slabs shall be cured a minimum of 14 days (some colors may require 30-60 days*), using unwrinkled, non-staining, high quality curing paper. The temperature of the concrete shall not be allowed to fall below 10°C (50°F) during the curing period. Film forming liquid curing compounds shall not be used.

**Consult manufacturer for time of curing for specific colors.*

### 11. Sealer

After the slab is completely dry, a clear, nonyellowing sealer _____ as manufactured by _____ shall be uniformly applied to the surface according to the manufacturer's directions.

# Appendix B Safety Precautions

## Skin Safety

Care should be taken to avoid skin irritation and chemical burns when working with fresh concrete or other products containing cement. Prolonged contact between fresh concrete and skin, eyes, and clothing may result in burns that are very severe, including third degree burns. Consult a physician for persistent skin irritation; for deep burns or large affected skin areas, seek medical attention immediately. For more information see *Working Safely with Concrete,* MS271.

## Working with Acids

Acid washing is often avoided due to safety hazards and environmental concerns. Consult local environmental regulations and requirements concerning the use of acids in construction and their appropriate disposal. Proprietary cleaning solutions designed for cleaning masonry may be safer to use and have less environmental impact.

## Safety with Sandblasting and Other Abrasive Techniques

Consult local safety and environmental restrictions concerning sandblasting and other abrasive techniques.

## Working with Fine Powder Cement-Based Materials

Exposure to airborne fine particulate materials may pose respiratory health risks. Dust masks, eye protection, and protective clothing for skin safety should be required for all workers exposed to these materials.

# Appendix C Sources of Products and Services

This partial list of manufacturers and service providers is furnished to assist in locating various products or services and does not imply Portland Cement Association endorsement or approval.

**White and Buff Colored Cement Producers/Suppliers**

See the sales office directory for local contacts at:

www.cement.org/pca/pca_directory.asp

**Color Pigment Suppliers**

Arizona Oxides LLC
12519 W Butler Drive
El Mirage, AZ 85335
623.935.9350
800.576.1500
623.935.9365 (fax)
www.arizonaoxides.com

Bayer Corporation
100 Bayer Road
Pittsburgh, PA 15205-9741
412.777.7596
800.662.2927
412.777.7626 (fax)
www.bayerus.com

Concrete Solutions Inc.
3904 Riley Street
San Diego, CA 92110
619.297.3999
800.232.8311
619.297.3333 (fax)
www.concretesolutions.com

Davis Colors
3700 E Olympic Blvd.
Los Angeles, CA 90023
323.269.7311
800.356.4848
323.269.1053 (fax)
www.daviscolors.com

Decorative Concrete Impressions, LLC
25067 Hawthorne Road
Webb City, MO 64870
866.332.7383
866.623.4793 (fax)
www.decrete.com

Dynamic Color Solutions Inc.
2024 S Lenox Street
Milwaukee, WI 53207
414.769.2580
800.657.0737
414.769.2585 (fax)
www.dynamiccolorsolutions.com

Engelhard Corporation
101 Wood Avenue
Iselin, NJ 08830
732.205.5000
800.573.4835
732.549.3011 (fax)
www.engelhard.com

Euclid Chemical Co., The
19218 Redwood Road
Cleveland, OH 44110
216.531.9222
800.321.7628
216.531.9596
www.euclidchemical.com

Fister Quarries Group Inc.
2777 Finley Road Suite 2
Downers Grove, IL 60515
630.424.6200
800.542.7393
630.424.6209 (fax)
www.fisterquarries.com

Multicoat Corporation
23061 Arroyo Vista
Rancho Santa Marg, CA 92688
949.888.7100
877.685.8426
949.888.2555 (fax)
www.multicoat.com

Renew-Crete Systems
798 Clearlake Road
Cocoa, FL 32922
321.636.8882
888.287.8962
321.636.7343 (fax)
www.plasticforms.com

Specco Industries Inc.
13087 Main Street
Lemont, IL 60439
630.257.5060
800.441.6646
630.257.9006
www.specco.com

Super Stone Inc.
1251 Burlington Street
Opa Locka, FL 33054
305.681.3561
800.456.3561
305.681.5106 (fax)
www.superstone.com

**Dry Shake Color Hardeners**

Advanced Surfaces Incorporated
2000 Banks Road
Margate, FL 33063
954.973.4528
800.952.5980
954.973.4926 (fax)
www.advancedsurfaces.com

Bayer Corporation
100 Bayer Road
Pittsburgh, PA 15205-9741
412.777.7596
800.662.2927
412.777.7626 (fax)
www.bayerus.com

Bomanite Corporation
PO Box 599
Madera, CA 93639-0599
559.673.2411
559.673.8246 (fax)
www.bomanite.com

Brickform Rafco Products
11383 Newport Drive
Rancho Cucamonga, CA 91730
909.484.3399
800.483.9628
909.484.3318 (fax)
www.brickform.com

Butterfield Color
30W711 Butterfield Road
Naperville, IL 60563
630.978.1665
800.282.3388
630.978.7941 (fax)
www.butterfieldcolor.com

ChemMasters Inc.
300 Edwards Street
Madison, OH 44057
440.428.2105
800.486.7866
440.428.7091
www.chemmasters.net

ChemRex Incorporated
889 Valley Park Drive
Shakopee, MN 55379
952.496.6000
800.433.9517
800.496.6067 (fax)
www.chemrex.com

Cobblecrete International
485 W 2000 S
Orem, UT 84058
801.224.6662
800.798.5791
801.225.1690 (fax)
www.cobblecrete.com

Conspec
636 South 66th Terrace
Kansas City, KS 66111
913.287.1700
877.348.7351
913.287.2716 (fax)
wwwconspecmkt.com

CSI ChemSystems Inc.
10110 Genard Road
Houston, TX 77041
713.329.9066
800.545.9827
713.329.9065 (fax)

Dayton/Richmond
721 Richard Street
Miamisburg, OH 45342
937.866.0711
800.745.3700
937.847.0646 (fax)
www.daytonrichmond.com

Decorative Concrete Impressions, LLC
25067 Hawthorne Road
Webb City, MO 64870
866.332.7383
866.623.4793 (fax)
www.decrete.com

Dynamic Color Solutions Inc.
2024 S Lenox Street
Milwaukee, WI 53207
414.769.2580
800.657.0737
414.769.2585 (fax)
www.dynamiccolorsolutions.com

Euclid Chemical Co., The
19218 Redwood Road
Cleveland, OH 44110
216.531.9222
800.321.7628
216.531.9596
www.euclidchemical.com

Increte Systems Inc.
1611 Gunn Highway
Odessa, FL 33556
813.886.8811
800.752.4626
813.920.1516 (fax)
www.increte.com

Kaufman Products Incorporated
3811 Curtis Avenue
Baltimore, MD 21226-1131
410.354.8600
800.637.6372
410.354.1122
www.kaufmanproducts.net

Kraft Tool Company
8325 Hedge Lane Terrace
Shawnee Mission, KS 66227
913.422.4848
800.422.2448
913.422.1018 (fax)
www.krafttool.com

L & M Construction Chemicals
14851 Calhoun Road
Omaha, NE 68152
402.453.6600
800.362.3331
402.453.0244
www.lmcc.com

L M Scofield
6533 Bandini Boulevard
Los Angeles, CA 90040
323.720.8810
800.800.9900
323.722.7826

Master Builders Inc.
23700 Chagrin Blvd.
Cleveland, OH 44122-5554
216.831.5500
800.628.9990
216.831.3470 (fax)
www.masterbuilders.com

Metalcrete Industries Incorporated
10330 Brecksville Road
Cleveland, OH 44141
440.526.5600
800.526.5602
440.526.5601 (fax)
www.metalcreteindustries.com

Precision Stamped Concrete
3750 San Gabriel River Parkway
Pico Rivera, CA 90660
562.695.3655
800.777.7063
562.695.4731 (fax)
www.maycrete.com

QC Construction Products
PO Box 599
Madera, CA 93639
559.673.2467
800.453.8213
559.673.0773 (fax)
www.qcconstructionproducts.com

Quick Imprint Systems Incorporated
PO Box 7
Goodman, MO 64843
417.364.8215
800.746.8820
417.364.7630 (fax)
www.concreteroller.com

Renew-Crete Systems
798 Clearlake Road
Cocoa, FL 32922
321.636.8882
888.287.8962
321.636.7343 (fax)
www.plasticforms.com

Solomon Colors
PO Box 8238
Springfield, IL 62702
217.522.3112
800.624.0261
217.522.6278 (fax)
www.solomoncolors.com

Specco Industries Inc.
13087 Main Street
Lemont, IL 60439
630.257.5060
800.441.6646
630.257.9006
www.specco.com

Specialty Concrete Products
PO Box 2922
West Columbia, SC 29170
803.955.0707
800.533.4702
803.955.0011 (fax)
www.scpusa.com

Stampcrete International Ltd.
325 Commerce Blvd.
Liverpool, NY 13088
315.451.2837
800.233.3298
315.451.2290
www.stampcrete.com

Super Stone Incorporated
1251 Burlington Street
Opa Locka, FL 33054
305.681.3561
800.456.3561
305.681.5106 (fax)
www.superstone.com

Surecrete Design Products
37826 Skyridge Circle
Dade City, FL 33525
813.779.7979
800.544.8488
813.715.6564 (fax)
www.surecretedesign.com

Symons Corporation
200 Touhy Avenue
Des Plaines, IL 6001
847.298.3200
800.800.7966
847.635.9287
www.symons.com

Triple-S Chemical Products Incorporated
3464 Union Pacific Avenue
Los Angeles, CA 90023
323.261.7301
800.457.4280
323.261.5567 (fax)
www.patinas.com

United Coatings East
19011 Cataldo
Greenacres, WA 99016
509.926.7143
800.541.4383
509.928.1116 (fax)
www.unitedcoatings.com

Vexcon Chemicals Incorporated
7240 State Road
Philadelphia, PA 19135
215.839.2661
215.332.9997 (fax)
www.vexcon.com

Wade Industries Incorporated
4212 Garland Road
Fort Worth, TX 76117
817.498.1954
800.247.8059
www.wadeindustries.com

**Stain Suppliers**

Advanced Surfaces Incorporated
2000 Banks Road
Margate, FL 33063
954.973.4528
800.952.5980
954.973.4926 (fax)
www.advancedsurfaces.com

American Building Restoration Products Incorporated
9720 South 6th Street
Franklin, WI 53132
414.421.4125
800.346.7532
414.421.8696 (fax)
www.abrp.com

Artcrete Incorporated
5812 Highway 494
Natchitoches, LA 71457
318.379.2000
888.328.9321
318.379.1000 (fax)
www.artcrete.com

Bayer Corporation
100 Bayer Road
Pittsburgh, PA 15205-9741
412.777.7596
800.662.2927
412.777.7626 (fax)
www.bayerus.com

Bon Tool Co.
4430 Gibsonia Road
Gibsonia, PA 15044
724.443.7080
800.444.7060
www.bontool.com

Brickform Rafco Products
11383 Newport Drive
Rancho Cucamonga, CA 91730
909.484.3399
800.483.9628
909.484.3318 (fax)
www.brickform.com

Butterfield Color
30W711 Butterfield Road
Naperville, IL 60563
630.978.1665
800.282.3388
630.978.7941 (fax)
www.butterfieldcolor.com

Chemprobe Coatings Systems
2805 Industrial Lane
Garland, TX 75041
972.271.5551
800.760.6776
972.271.5553 (fax)
www.chemprobe.com

Coating Technology
15055 Henry Road
Houston, TX 77060
281.931.0302
800.303.5503
281.931.0061 (fax)

Cobblecrete International
485 W 2000 S
Orem, UT 84058
801.224.6662
800.798.5791
801.225.1690 (fax)
www.cobblecrete.com

Conproco Corporation
17 Production Drive
Dover, NH 03820
603.743.5800
800.258.3500
603.743.5744 (fax)
www.conproco.com

CSI ChemSystems Incorporated
10110 Genard Road
Houston, TX 77041
713.329.9065
800.545.9827
713.329.9065 (fax)

Design Pro Incorporated
3967 East Calvary Road
Duluth, MN 55803
218.728.9481
888.728.9481
218.728.1730 (fax)
www.designproforms.com

Duckback Products Incorporated
PO Box 980
Chico, CA 95927
530.343.3261
800.825.5382
530.343.3283 (fax)
www.superdeck.com

Elite Crete Systems Inc.
3480 E 83rd Place
Merrilville, IN 46410
219.945.0033
888.323.4445
219.945.1982 (fax)
www.elitecrete.com

Engrave-A-Crete Incorporated
1390-G Commerce Boulevard
Sarasota, FL 34243
941.355.2114
800.884.2114
941.351.2171 (fax)
www.engrave-a-crete.com

EPRO Services Incorporated
1115 East Waterman
Wichita, KS 67211
316.262.2513
800.882.1896
316.262.2529 (fax)
www.eproserv.com

Fox Industries Incorporated
3100 Falls Cliff Road
Baltimore, MD 21211
410.243.0369
888.760.0369
410.243.2701 (fax)
www.fox-ind.com

GE Sealants and Adhesives
16325 Northcross Drive
Huntsville, NC 28078
386.409.5518
800.228.5537
386.423.7484 (fax)
www.gesealants.com

Gemite Products Incorporated
160-3840 East Robinson Road
Amhurst, NY 14228
905.672.2020
888.443.4683
905.672.6780 (fax)
www.gemite.com

Increte Systems Inc.
1611 Gunn Highway
Odessa, FL 33556
813.886.8811
800.752.4626
813.920.1516 (fax)
www.increte.com

Modac Products Company
600 Reed Road
Bromall, PA 19008
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www.modacproducts.com

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www.prosealproducts.com

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www.prosoco.com

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www.cobblecrete.com

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928.537.2003 (fax)
www.concrafter.com

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www.lilbubba.com

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www.decrete.com

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323.722.7826

**Websites Offering Decorative Concrete Training**

ASCC Decorative Concrete Council, www.ascconline.org

Bomanite Corp., www.bomanite.com

Decorative Concrete Impressions, www.decrete.com

L.M. Scofield, www.scofield.com
www.concretenetwork.com

Portland Cement Association, www.cement.org/decorative

## Related Publications

The publications cited in this text, as well as other related publications, can be purchased from the Portland Cement Association. Some are available as free downloads at www.cement.org/bookstore.

The following are particularly useful:

*Admixtures for Use in Concrete,* CD039

*Aggregates for Use in Concrete,* CD047

*Building Concrete Walks, Driveways, Patios, and Steps,* IS209

*Color and Texture in Architectural Concrete,* SP021

*Concrete Floors on Ground,* EB075

*Concrete for Small Jobs,* IS174

*Concrete Slab Surface Defects: Causes, Prevention, Repair,* IS177

"Concrete Specifications: Read and Write Them Carefully," *Concrete Technology Today,* PL942

*Design and Control of Concrete Mixtures,* EB001

*Design and Control of Concrete Mixtures,* CD100

"Discoloration of Concrete–Causes and Remedies," *Concrete Technology Today,* PL861

*Effects of Substances on Concrete and Guide to Protective Treatments,* IS001

"Efflorescence, Causes, Prevention, Repair," *Concrete Technology Today,* PL871

*Exploring the Art of Concrete,* CD028

"Factors Influencing Color," *Concrete Technology Today,* PL992

*Finishes: Creating Visual Appeal,* IS528

"Floor-Covering Materials and Moisture in Concrete," *Concrete Technology Today,* PL853

*Gap-Graded Mixes for Cast-in-Place Exposed Aggregate Concrete,* DX090

"How to Double the Value of Your Concrete (Floor) Dollar," *Concrete Technology Today,* PL852

*Introduction to Concrete Mix Design,* CD040

*Light Reflective Floors,* IS529

*Mixing and Handling White Cement Concrete,* IS530

*Observations on the Resistance of Concrete to Freezing and Thawing,* RX067

*Painting Concrete,* IS134

"Pinto Concrete: Is There a Cure?" *Concrete Technology Today,* PL961

"Popouts: Causes, Prevention, Repair," *Concrete Technology Today,* PL852

"Reader Response: Discoloration" *Concrete Technology Today,* PL962

"Reinforcing Steel in Slabs on Grade," *Concrete Technology Today,* PL921

*Removing Stains and Cleaning Concrete Surfaces,* IS214

"Repair with Thin-Bonded Overlay," *Concrete Technology Today,* PL851

*Resurfacing Concrete Floors,* IS144

*Slab Thickness Design for Industrial Concrete Floors on Grade,* IS195

*Supplementary Cementing Materials for Use in Concrete,* CD038

*Surface Discoloration of Concrete Flatwork,* RX203

*The Homeowner's Guide to Building with Concrete, Brick, and Stone,* SP038

"What is White Cement?" *Concrete Technology Today,* PL991

"White Cement and Colored Concrete Construction," *Concrete Technology Today,* PL993

*White Cement Concrete,* EB217

*Working Safely with Concrete,* MS271

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