Practice Points NUMBER 24

Versatility in Design: History, Installation, Assessment, and Repair of Terrazzo

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Terrazzo is a pavement system comprised of varying sizes of aggregate combined within a matrix (either cementitious or resinous) applied over a level concrete substrate. The mixture is poured in between divider strips, which control cracking. The matrix and aggregate colors can be varied, and the divider strips decoratively placed, to provide custom-designed patterns. Once set, the topping is ground and polished to the desired finish, and a protective coating is applied.

History

Modern terrazzo evolved from an ancient building technique for mosaic floor construction, where individual pieces of colored stone, ceramic, or glass tesserae (tiles) were set by hand into a lime-based cementitious base. This mosaic tradition thrived in Venice and the nearby Friuli region of northeastern Italy, where the craft has been practiced continuously from Roman times to the present day. The term "terrazzo" means "terrace" in Italian, based upon the Latin word *terra*, meaning "earth."

By the eighteenth century, the mosaic tradition had evolved into Venetian pavement (*pavimento alla Veneziana)*, in which stone fragments ranging in size from 1/2 inch to 2 inches were laid closely together in a cement matrix and then polished to an even surface.[1] Eventually, a less expensive technique called *seminato* ("sown field") was developed using larger pieces of stone measuring 3 to 4 inches across set in the base mix followed by medium-sized (1/2-inch) chips, which were often repurposed waste from larger stones. Smaller (less than 1/4-inch) chips were then sprinkled over the field to fill the gaps between the larger pieces.[2] In a third type, referred to as *palladiana terrazzo*, large, variably sized broken pieces of marble (up to 15 inches), with a thickness of approximately 3/8 inch to 1 inch, were laid over the substrate. The cementitious matrix was then poured between the marble pieces, forming a continuous flooring system.[3] The surfaces were then leveled with a heavy roller to set the pieces firmly in the matrix and, once set, were ground and polished. These techniques generally came to be known as terrazzo.

Fig. 1.
Fine Arts Building (Studebaker Building), 410 S. Michigan Ave., Chicago, Illinois, built 1898. Detail of terrazzo flooring in the elevator lobby on the tenth floor, showing a tesserae border surrounding a terrazzo field. Photograph by the author, 2022.

In the last quarter of the nineteenth century, most Italian immigrants to North America were from the regions of Veneto, Friuli, Piedmont, and Lombardy in northern Italy.[4] Among them were craftsmen skilled in the art of terrazzo. Originally referred to as concrete mosaic, the method was introduced to North America starting in the late nineteenth century, in both geometric and more fluid designs, particularly in lobbies of public buildings and in residential entryways. The 1890s and early 1900s saw a style of

Fig. 2.
Cook County Hospital Administration Building, 1835 W. Harrison St., Chicago, Illinois, built 1916. Detail of the floor and baseboard on the first floor, showing how terrazzo tile was utilized to create decorative floor patterns in the early decades of the twentieth century. Photograph by the author, 2021.

Fig. 3.
Garfield Park Fieldhouse, 100 N. Central Park Ave., Chicago, Illinois, built 1928, showing colorful geometric terrazzo floor of the rotunda of the entrance pavilion. Photograph by David Wilson, 2017, CC BY 2.0, https://commons.wikimedia.org/wiki/File:20170225_15_Garfield_Park_Fieldhouse_(32352593347).jpg, via Wikimedia Commons.

Fig. 4.
Clifton's Brookdale Cafeteria, 648 S. Broadway, Los Angeles, California, built ca. 1934, showing terrazzo sidewalk in front of the building. This inset, one of a series, depicts the Los Angeles City Hall. It was created by Arthur D. Pizzinat, Sr., the eventual owner of the Venetian Terrazzo and Mosaic Company, Inc., Alhambra, California. Photograph by James E. Peters, 2018.

hybrid flooring that combined mosaics and terrazzo. A mosaic border, for instance, might surround a terrazzo field, or a mosaic medallion might be set in the middle of a terrazzo field (Fig. 1). Single rows of hand-set mosaic tesserae were used to subdivide larger terrazzo panels in the years before metal divider strips were developed. These early mosaic and terrazzo floors were set in place without control joints and were therefore prone to cracking, particularly over structural elements.

Precast terrazzo tiles are commonly found today, but they were also produced in the first decades of the twentieth century to create any number of floor patterns. Offset square tiles in a mix of sizes, fields of hexagonal tiles, or fields and borders comprised of terrazzo tile were laid in a mortar bed and grouted like ceramic or stone floor tiles (Fig. 2).

The use of terrazzo became widespread after 1919, when the L. Del Turco and Brothers Company of Harrison, New Jersey, introduced the use of brass divider strips set within the cementitious matrix to subdivide the terrazzo into sections.[5] The technique had not been well publicized in trade journals prior to that time.[6] These strips both helped control cracking and were well suited to expressing the curvilinear designs and expressive graphics of the art deco and art moderne styles of the period (Figs. 3 and 4).[7]

Another factor that contributed to the rapid growth of terrazzo in the early twentieth century was the invention of the electric grinder in 1924. Previously, both terrazzo and mosaic floors were ground down to a smooth surface by hand, using a "gallera," or a long pole, onto which a pumice-like stone was attached. Costs were reduced when this laborious method was mechanized. Terrazzo was utilized for commercial, institutional, and residential applications and in both interiors and exteriors, particularly at protected entryways or for larger plazas in warmer climates (Fig. 5). It has remained a common flooring material since the mid-twentieth century and has remained to this day an economical choice for durable flooring surfaces in large public spaces, such as airports, schools, and hospitals.

As the terrazzo industry expanded throughout the 1920s and 1930s, there was need for organizational support for the growing number of installers and suppliers. The National Terrazzo and Mosaic Contractors Association was formed in 1924; it became the National Terrazzo & Mosaic Association (NTMA) in 1931.

The NTMA defines terrazzo as consisting of "marble, granite, onyx, or glass chips [*sic*] in [a] portland cement, modified portland cement or resinous matrix. The terrazzo is poured, cured, ground and polished. Terrazzo is primarily used for flooring and stairs, but precast panels can be installed on walls or as decorative panels if desired."[8]

Matrix Types

Prior to the nineteenth century, terrazzo was comprised of marble chips set in a lime matrix over a stable substrate. The development of terrazzo as understood today took place after the invention of portland cement (ca. 1820); today's terrazzo has a matrix that is cementitious or, more recently, either resinous or modified-cementitious.

Cementitious. Terrazzo in North America was generally installed from the 1890s onward and was comprised of a portland-cement matrix with an aggregate mixture of marble and sometimes other natural stones to provide coloration. Today, a portland-cement matrix can be either white, gray, or a mixture of the two (Fig. 6). Color-stable and alkali-resistant pigments can also be added to the mix to reach the desired matrix color.

Resinous. In the mid-1960s, a resin-based matrix was introduced, although it was not used regularly until the 1970s. It became commonly referred to as epoxy terrazzo, and since the 1990s, it has been used almost exclusively in new construction. Epoxy resin can be tinted with a wide variety of colorants and can utilize either marble chips or other aggregates, such as glass, shell, synthetic materials, or natural stone. Because epoxy terrazzo is sensitive to ultraviolet light, it is not suitable for exterior installations.

Modified-cementitious. A third matrix type, polyacrylate-modified cement, was introduced in the 1980s. It allowed for a thin veneer of modified-cementitious terrazzo to be applied directly to a concrete substrate. This system is found more frequently in the southern United States; it is seldom used farther north because it is susceptible to damage from freeze-thaw action.

Installation Types: Unbonded and Bonded

Terrazzo installations can be either unbonded or bonded to the substrate (Fig. 7). Cementitious terrazzo can be either type, but polyacrylate and resinous terrazzo finishes are always bonded. There is only one type of unbonded system, but there are several variants of bonded systems.

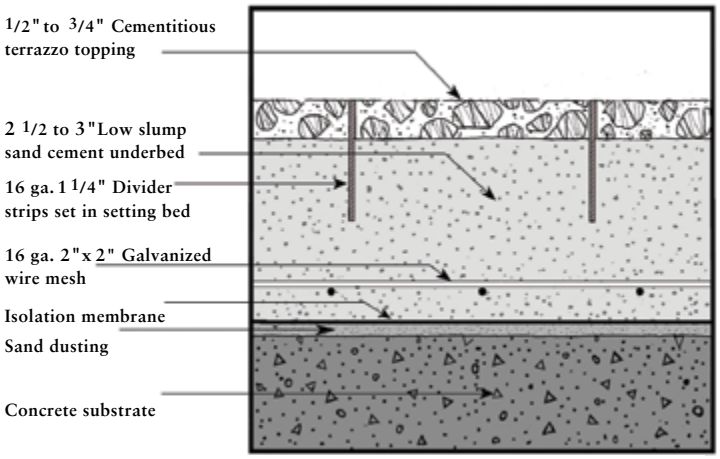
Unbonded terrazzo system. Unbonded terrazzo is also referred to as the sand-cushion method. It is the most traditional form of terrazzo and is used only for interior installations. The concrete-slab substrate is separated from the underbed by sand. In the first half of the twentieth century, the sand bed was 1/4-inch thick and did not incorporate an isolation sheet. Today, the concrete slab receives a dusting of sand, over which an isolation membrane (polyethylene sheeting or non-perforated roofing felt) is laid. The cementitious underbed is then poured over galvanized welded-wire reinforcing laid on top of the isolation sheet. The divider strips are set into the underbed, which has been screeded to an elevation of 1/2 inch to 3/4 inch below the intended finished floor level. The terrazzo topping mixture is placed in the panels created by the divider strips and then troweled and compacted. Once the system has cured, the surface is ground and finished. Most pre–World War II installations utilized the sand-cushion method of construction.

Bonded terrazzo systems. Bonded terrazzo systems are adhered directly to the substrate and can be used in both interior and exterior installations.

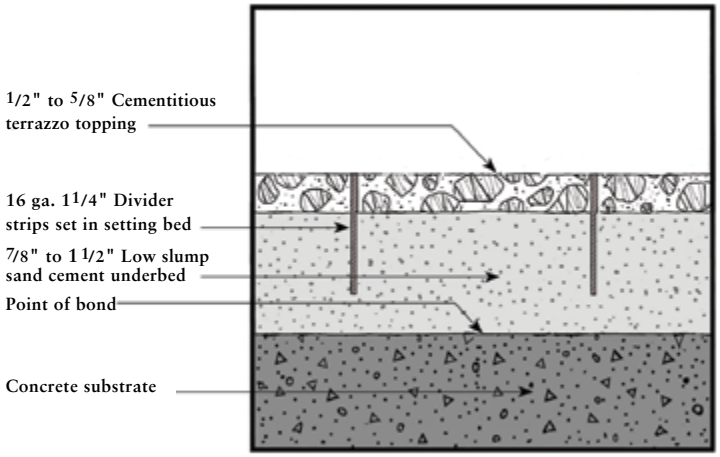
Fig. 5.
Former Chase Furniture Store, 414 King St., Charleston, South Carolina, built 1946, showing a terrazzo recessed entryway floor. Photograph by James E. Peters, 2019.

Fig. 6.
Trade catalog for the Medusa Portland Cement Co. This trade catalog illustrates the benefits of using white portland cement to emphasize the use of lighter colored aggregate in terrazzo compositions. Terrazzo with Medusa: White Portland Cement (Plain and Waterproofed) *(Cleveland, Ohio: Medusa Portland Cement Co.), 1931, 8, from the APT Building Technology Heritage Library.*

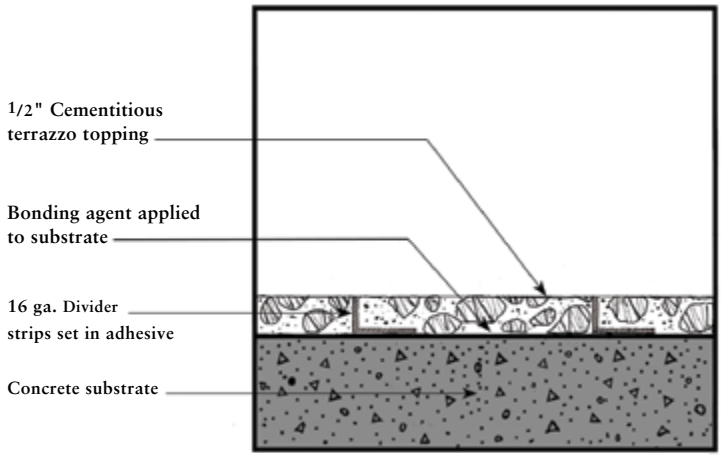
Fig. 7.
Comparison of unbonded and bonded terrazzo types, below and at right. Courtesy of Umer Bhatti and Sullivan Preservation.



SAND CUSHION TERRAZZO



BONDED TERRAZZO



MONOLITHIC TERRAZZO

If there are pre-existing cracks in the substrate, they are covered with a crack-isolation membrane, which absorbs movement so that the cracks are less likely to telescope through the finished terrazzo topping. These bonded systems can be subdivided into four categories: bonded, monolithic, polyacrylate-modified cement, and thinset epoxy. Generally speaking, bonded systems date from after World War II, although there may be some early exceptions.

Bonded terrazzo. Bonded terrazzo is comprised of a cement-matrix topping poured over an unreinforced cementitious underbed measuring between 7/8 inch and 1 1/2 inch. Divider strips are set into the underbed and then the 1/2-inch to 5/8-inch terrazzo topping is poured into the panels created by the divider and control strips. Once the system has cured, the surface is ground and finished. This system can be utilized for both interior and exterior installations.

Monolithic terrazzo. Monolithic terrazzo is comprised of individual layers of cementitious material bonded together, which then behave monolithically. This type is comprised of a 1/2-inch-thick cement-matrix terrazzo topping poured over a bonding agent (a liquid polymer modified with epoxy) applied to the substrate. The topping is installed between the divider and control strips set in adhesive on the substrate. Once the system cures, the surface is ground and finished. This system is used for interior installations only.

Polyacrylate-modified cement terrazzo. Polyacrylate terrazzo is a polymer-modified cement-matrix terrazzo topping bonded directly to a concrete-slab substrate, which must be abraded beforehand. Divider and control strips are set in adhesive onto the substrate before a 1/4-inch-thick to 3/8-inch-thick polyacrylate-modified cement matrix is placed and troweled. Once the system cures, the surface is ground and finished. This system can be used in both interior and exterior applications, but its exterior use is limited to warmer climates.

Thinset epoxy terrazzo. Epoxy terrazzo is a resinous terrazzo system that is also referred to as thinset epoxy. The matrix contains no portland cement. It is bonded directly to the substrate and is used for interior applications only. The thickness of the epoxy terrazzo can measure between 3/8 inch and 1/4 inch, based upon the aggregate size. The concrete substrate is mechanically abraded before setting the divider and control strips in adhesive and then placing the epoxy terrazzo in the panels created by the divider strips. The surface is troweled, and once cured, it is ground and finished.

Special Applications

Rustic terrazzo. Rustic terrazzo is a cementitious system, which is distinguished from traditional terrazzo in that it is not ground or polished after being poured and thus retains its texture, providing a nonslip surface. It is generally used on exteriors

and can be installed using a bonded or monolithic terrazzo technique. When used for exterior installations, the cement matrix may require an air-entrainment agent.[9] Once the terrazzo topping mix sets, it is acid-washed or scrubbed with a cleaner and a stiff broom to remove the laitance and expose the aggregate.[10] This type of installation is particularly characteristic of the brutalist period of architecture from the 1950s to the 1970s.

Base trim and stairs. Terrazzo base trim is usually coved and is installed where the flooring meets the wall. It can be either poured-in-place or precast and set after the floor has been laid. When poured-in-place, a divider strip is placed near the wall to separate the floor from the base, and the terrazzo is poured and screeded up the wall to the desired height and terminated with a metal bead strip. When precast, the element is set either in a latex portland-cement thinset mortar or in a water-cleanable tile-setting epoxy. Terrazzo stairs can either be poured-in-place or precast and installed in sections on-site.

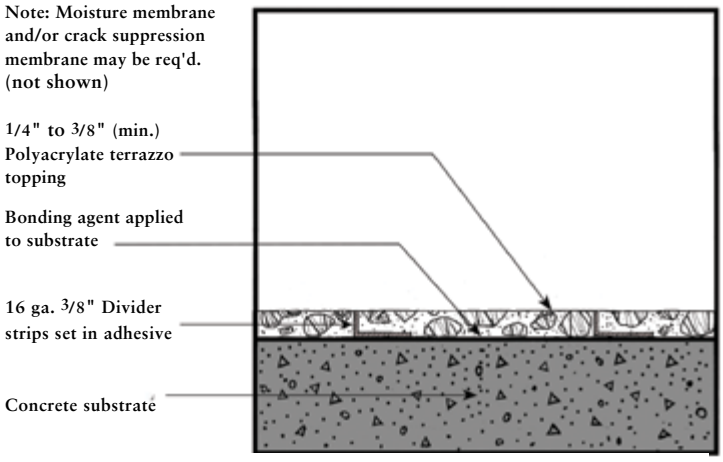
Nonslip surfaces. Where it is necessary to create a nonslip surface, such as on stair treads or a ramp or at an entryway, abrasive aggregate nonslip strips can be set into the terrazzo surface, positioned perpendicular to the line of traffic and about 6 inches apart from one another. Each strip is set within a cut groove that rises 1/16 inch above the terrazzo surface, stopping about 8 inches from the wall line. Another method involves saw-cutting voids in the terrazzo, into which a mixture of epoxy and graded nonslip aggregates, such as aluminum-oxide or silicon-carbide (carborundum) particles, are poured.

Aggregate Types

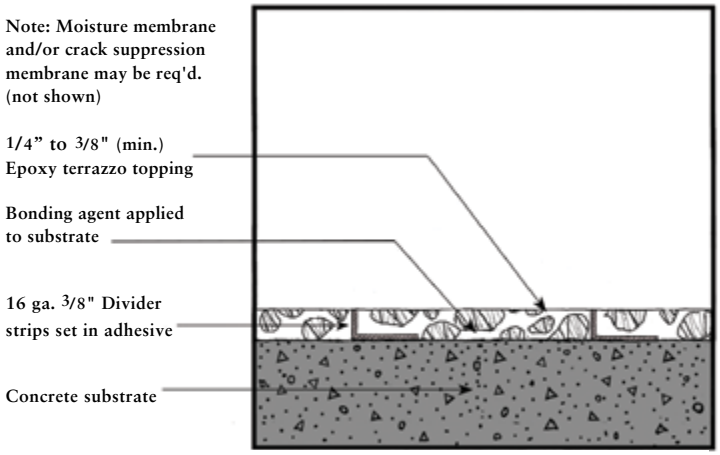
The distinctive appearance of terrazzo is due to the incorporation of aggregates of various types, colors, and sizes. “Chip” is the term used in terrazzo installations for marble granules screened to various sizes. “Aggregate” is the term used for any granule other than marble used in the topping.

Marble chips were most commonly used in traditional cement-based terrazzo, although in modern times, any stone capable of taking a polish, including onyx, travertine, and serpentine, can be utilized.[11] Polyacrylate-modified-cementitious terrazzo utilizes a combination of aggregate types, including marble chips, glass, and synthetic or metal aggregates. Epoxy terrazzo can incorporate a wide variety of aggregate types including mother-of-pearl, pre- and post-recycled glass, porcelain, mirrored and windshield chips, and vibrantly colored synthetic chips.

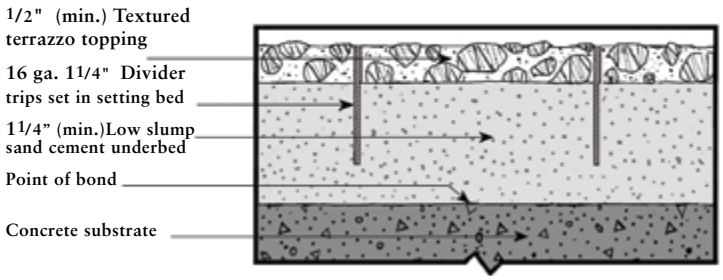
Aggregates and marble chips are graded in size and categorized with a numbering system that ranges from zero to eight depending upon size. The NTMA provides an aggregate, or chip, gradation chart. The customary aggregate sizes for standard terrazzo are one and two; intermediate terrazzo utilizes sizes



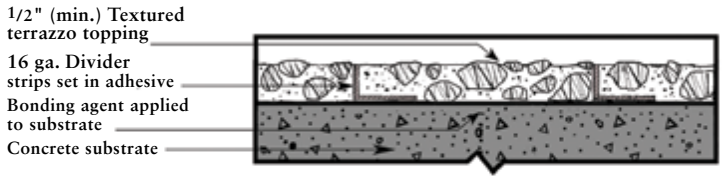
POLYACRYLATE TERRAZZO



THINSET EPOXY TERRAZZO



RUSTIC BONDED TERRAZZO



RUSTIC MONOLITHIC TERRAZZO

one through four; and Venetian terrazzo can use chip sizes one through eight.

Divider Strips

Divider strips minimize or control shrinkage and structural cracking, permit the creation of a custom design, and provide a transition between different colors of terrazzo or between terrazzo and other materials. The strips also allow for more easily worked panels during installation and ensure uniformity in the topping thickness. Control, or expansion, joints for terrazzo are placed directly over saw-cut control joints in the substrate and should extend through the entire depth of the underbed. The locations of control joints and divider strips are determined by the specifying designer but are generally positioned at column lines, over major structural elements, or anywhere there is a break in continuity of the substrate. Divider strips also contribute to crack prevention but are for the most part decorative. Recommendations and guidance for the placement of divider strips for both unbonded and bonded systems are available in the NTMA's *Terrazzo Specification & Design Guide*.[12]

The divider strips for cementitious terrazzo are either brass or a white alloy of zinc and are typically 16 gauge in thickness, although heavier gauges are available. Aluminum divider strips are not recommended for use in a portland-cement matrix because the alkaline environment can exacerbate corrosion and promote cracking. For epoxy systems, strips can be white alloy of zinc, aluminum, or plastic, in colors to coordinate with the epoxy matrix. Brass divider strips are not recommended for epoxy terrazzo as they can lead to blue-green staining in reaction to the epoxy-curing agents. Aluminum divider strips are safe to use in epoxy installations if the aluminum does not come into direct contact with the uncured portland-cement substrate. For exterior rustic terrazzo installations, sections can be subdivided by temporary wood strips that are removed once the terrazzo has set and are then filled with flexible sealant or with cementitious grout if the joints are non-moving.

Installation and Finishing

Pouring. With cementitious terrazzo, once the concrete slab substrate is prepared, the underbed is poured, and the divider strips are placed before the matrix sets. After the underbed is sufficiently saturated with water, the terrazzo topping mixture is troweled firmly into each panel to meet the top of the divider strips. A "seeding" (a sprinkled distribution) of additional chips can be added. The terrazzo is then compacted in place by mechanical rollers, which extract the excess water out of the mixture. The surface is troweled again into a dense, uniform surface. With epoxy terrazzo, the substrate is not pre-wetted. It is mechanically abraded, cleaned, a bonding agent applied, and the epoxy terrazzo topping poured between the divider strips. There is no need to compact epoxy terrazzo with mechanical rollers.

Curing. Once the cementitious terrazzo reaches its initial set, it is covered with water or polyethylene sheeting and allowed to cure for three to four days before grinding. It fully cures in 28 days. Epoxy terrazzo does not need to be covered. It takes between 18 and 24 hours to cure. Polyacrylate-modified cement terrazzo requires a 24-hour cure before grinding may begin.

Grinding. The cured terrazzo, whether cementitious or epoxy, is first rough-ground with 24 or finer grit or with comparable diamond-polishing discs. It is then rinsed with clear water before machine- or hand-grouting to fill any voids. Epoxy grout is used for epoxy systems; cementitious grout for traditional terrazzo. After the grout has cured, the surface is ready for polishing with 120-grit or comparable diamond abrasives until all the excess grout is removed from the surface. The terrazzo is rinsed once again with clear water to remove any residue and dried thoroughly before sealing.

Sealing. To protect the terrazzo surface, a clear, non-yellowing, and chemically neutral sealer is applied. It must be water-based with a pH factor between 7 and 10 and should be UL-rated for slip resistance. Generally speaking, acrylic sealers are used on all terrazzo systems: cementitious, polyacrylate, and epoxy. Urethane sealers can be used on epoxy systems but not on cementitious terrazzo.[13] Such products should be procured from companies specializing in terrazzo applications.

Methodology for Assessing Terrazzo Surfaces

The first step in assessing terrazzo surfaces is to review and document existing conditions by creating a "crack map" and documenting both typical and atypical conditions. If cracking or displacement patterns suggest structural movement, a structural engineer should be consulted to determine and address the root cause. Another important early consideration is to identify the type of terrazzo system: unbonded or bonded and whether it has a traditional cementitious, modified-cementitious, or thinset epoxy matrix. Historic documentation from such sources as original detailing, shop drawings, specifications, or knowledge of the original installer, can be helpful. More typically, a probe opening will need to be performed to establish the installation type and depth. Material samples should also be taken for analysis.

Depending on the installation type and design complexity, samples can be submitted to a petrographer who can identify the binder type; aggregate or chip size; and the type, distribution, and proportion of paste to aggregate, as well as the air content. A petrographer can also determine whether a pigment was utilized and its composition. Samples for match-

ing repair-matrix mixtures can then be developed based upon the petrographer's report. An architectural conservator can design a laboratory-testing program for more in-depth analysis if unusual site conditions exist, if there is a need for stain remediation, or if other circumstances require chemical analysis of the terrazzo.

In less complex cases, the design professional may decide to rely upon the skill and experience of an experienced terrazzo contractor to identify the appropriate matrix type, color, mix, and chip proportion for the submission of samples to match the original terrazzo mix. Some older terrazzo companies retain formulas from larger jobs completed in previous decades, which can be helpful when trying to match the original terrazzo mix. Some older terrazzo companies can retain formulas from larger jobs completed in previous decades, which can be helpful when trying to match terrazzo in large or prominent buildings.[14]

Common Distress Problems

Cracking. Terrazzo floor systems, whether bonded or unbonded, are susceptible to movement of the substrate. Early systems placed without divider strips were more subject to shrinkage cracking and exhibited expansion and contraction cracking at regular intervals when applied to large areas or long hallways (Fig. 8). After divider strips were introduced in 1919, unexpected cracking was reduced but not eliminated.

Shrinkage cracking and other non-moving hairline cracks (less than 1/4 inch per NTMA) are often left as is, while larger cracks are widened by removing damaged chips and filled with a grout mixture and hand-placed new aggregates, selected to both match adjacent terrazzo and fit within the width of the routed area. Patches of this type can be either cementitious or epoxy for voids within a cementitious matrix. If cracking in a historic installation appears at regular intervals, the design professional can choose to integrate new saw-cut intentional control joints where the movement is prone to occur.

Displacement. If displacement has occurred on either side of a crack, there are several factors to consider: If the difference is less than 1/8 inch, the crack can be routed and filled and the surrounding terrazzo ground to even out the surface. If the crack is any larger, such a repair may pose a tripping hazard, and more thorough intervention is in order. In that case, 1 or 2 feet of terrazzo on either side of the crack is removed, the surface prepared, and new terrazzo fill poured to "level out" between the high and low points. The surface is ground to blend the patch with adjacent terrazzo and refinished.

Material loss. Material loss can occur in conjunction with cracking, debonding of the topping from the substrate, impact damage, excessive or unusual abrasive wear, aggregate loss, or erosion of the binder. In these cases, the deteriorated areas of terrazzo are removed and replaced with a new topping mix to match the original. From a preservation point of view, it is most desirable to replace as little original material as possible. If satisfactory small-scale infill repairs can be made, that approach may be sufficient, but large-scale damage may require that an entire panel (defined by divider strips on all sides) be replaced.

Poor original detailing or installation. Sometimes excessive cracking or material loss can be attributed to poor original detailing, most commonly related to insufficient placement of divider strips. Structural settlement can also be a contributing factor and must be considered during the assessment period and resolved before repairs. Surface deterioration can also be attributed to a problem that occurred during initial installation, such as the terrazzo was not sufficiently rolled or worked properly to remove excess moisture before curing. If there was too much water in the initial mix, the terrazzo can shrink, crack, or delaminate, resulting in a surface that lacks resilience and is prone to failure.

Staining. Terrazzo is often subject to abrasive wear, as it is frequently installed in high-traffic areas. Properly sealed and maintained surfaces are somewhat protected from everyday staining from grease, oil, inks, blood, or food and drink. If the sealer eroded, the terrazzo can be affected by these and other, more problematic, staining agents: corrosion products from nearby metals, both ferrous or cupric; biological growth; or even graffiti. Each of these must be dealt with on an individual basis, and a testing protocol designed to identify an appropriate stain-removal material, technique, and procedure.

The various types of staining and soiling must be identified before developing a methodology for cleaning. In some cases, it may be necessary to either grind down or even replace the affected terrazzo in order to achieve the desired results.

Soiling. Sealed terrazzo is a long-lasting, low-maintenance flooring surface, but it must be maintained appropriately to prolong the finish. Daily dust mopping with a clean mop is recommended, and a water-soluble (non-oil-based) sweeping compound can be used to aid in gathering dust.

Everyday dirt, surface stains, and scuff marks can be removed by wet mopping once a week using a neutral cleaner diluted in warm water or even just clean water. More heavily soiled floors can be scrubbed using a mechanical buffing machine with a white-pad scrubber and a neutral cleaner diluted in clean water. Residue must be mopped up with clean water before it dries. It is not appropriate to use waxes or other floor polishes on sealed terrazzo, as they can cause dangerously slippery conditions, as well as create a harmful buildup that will dull the finish on terrazzo.[15]

Fig. 8.
Federal office building, Washington, D.C., built 1933, showing terrazzo cracking, material loss, and poorly matched infill repairs on the corridor floor. Photograph by Quinn Evans, 2021.

Where the gloss has been lost due to traffic, the floor surface can be restored by spray-buffing with a product specifically designed for terrazzo.[16] Scratches and stains remaining after wet mopping can be removed using a fine-grit (100) diamond pad, although using the pads on a regular basis is not recommended as they could dull the surface.

There are various approaches to stains from coffee, ink, iodine, oil, tobacco smoke, or other substances. A conservator can design a testing protocol and method to verify procedures and methods. Terrazzo contractors who hold professional memberships in the NTMA have access to the NTMA technical bulletins where approaches to problems like these are discussed. Another helpful resource is the "Historic Preservation Technical Documents" webpage on the U.S. General Services Administration's website.[17]

Eventually the sealer will need to be stripped, the surface scrubbed and rinsed with water, and a new sealer coat applied per manufacturer's recommendations. If these cleaning and maintenance techniques are not effective, a qualified terrazzo contractor may need to regrind the terrazzo, which will then require resealing.

While some manufacturers recommend that most terrazzo floors need to be stripped semi-annually, in reality, a regularly maintained terrazzo floor can remain in good service for a year or more before stripping and resealing are necessary. Simple interventions, such as placing walk-off mats to control incoming dirt and grit and regular wet mopping with clean water, will ensure the terrazzo finish is maintained.

Repair Techniques

Crack and patch repair. Replacing or repairing historic building materials, such as traditional cementitious terrazzo "in kind" with a matching matrix of portland cement (white, gray, or a mixture), pigment (if utilized originally), and an aggregate mix matching the original in type, size, and distribution is the accepted standard within the preservation and conservation community.

In many larger metropolitan areas, older terrazzo companies were family-owned, generally by Italian Americans, and the businesses were passed down through several generations. The industry has changed over the last 20 years, and as larger conglomerates are absorbing these companies, the older traditional installation methods are starting to disappear. Over the same period, thinset epoxy-based terrazzo has gained in popularity for contemporary installations. As a result, material suppliers and terrazzo contractors have become very adept at thinset epoxy installations and will advise the use of epoxy-based terrazzo for infilling cracks or patch repair within an existing cementitious terrazzo. They maintain that epoxy will produce a more accurate color match and provide the highest performance, thereby reducing the number of samples required for matching to the original. They claim that the epoxy mix will not shrink as much as cementitious if a partial patch is required. The color of portland cement varies by batch; as a result, one section of cementitious terrazzo may not match another even if the mix formulation is the same. This problem can be corrected with pigments and by mixing different shades of white or gray cement, but the process is more laborious, and more samples are required. Contractors have also indicated that modern portland cement by nature sets more quickly than its historic counterpart and is not as "workable" as it once was.[18]

Preservation professionals will need to weigh the pros and cons of whether crack and patch repair in traditional cementitious terrazzo installations should be made with a cementitious mix that matches the original or with an epoxy-based substitute. There are so many varying conditions, applications, and requirements to consider that it is impossible to make a "one size fits all" recommendation.

While it is the responsibility of the preservation field to keep these traditional installation methods alive, there is a very real possibility that in some areas of North America, it will become difficult to find installers equipped with the skills to repair cementitious terrazzo in the traditional manner, and thinset epoxy will be the only option for repairing historic cementitious terrazzo. Because epoxy terrazzo, which measures just 1/4 inch to 3/8 inch in depth, is replacing a cementitious terrazzo topping that previously measured between 2 1/2 and 3 inches in depth, the underbed is "built up" using epoxy-modified cement. An epoxy-based primer is then applied before the thinner epoxy terrazzo topping is installed. In either case—cementitious or epoxy—it is recommended that where deteriorated terrazzo is cut out, it is best to "shark tooth" the patch perimeter (rather than straight-cut) with hand tools to create an irregular edge so that the patch will not stand out so markedly from the remaining terrazzo. All edges should be cut at 90 degrees to the top surface, all the way through the underbed. The repair mixture is then poured, compacted, allowed to set, and then ground and polished.

Refinishing. Deteriorated or stained terrazzo surfaces can be stripped of previous sealers, grouted with a cementitious grout to fill small voids, and then ground, polished, and sealed again. For greatest uniformity, once patch repairs or crack infill has been undertaken, it is best to refinish the entire floor area rather than small areas within a larger field. Once the sealer has been applied and fully dried, a gloss can be obtained by polishing the sealer coat.

Summary

Terrazzo can provide a durable long-lived surface if it is properly detailed, installed, and maintained. It rep-

resents an immigrant craft tradition, which became an integral part to generations of American buildings from the late nineteenth century through the present day. Armed with knowledge of terrazzo typology, systems, and types, design professionals can carry this tradition forward in both new construction and historic restorations.

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Resources

The NTMA provides construction standards, recommended practices, specification, and maintenance guides, as well as over 90 *Technical Bulletins* addressing FAQs. A list of contractor, supplier, and associate members can be found on its website: www.ntma.com.

The International Masonry Institute provides specification and technical information and downloadable details on its website: www.imiweb.org.

APT's Building Technology Heritage Library contains many period trade catalogs relating to the terrazzo industry: www.archive.org/details/buildingtechnologyheritagelibrary.

Notes

1. Louis Del Turco, "The Historical Background of Terrazzo Floors, Part 1," *The Art of Mosaics and Terrazzo* 2, no. 3 (1931): 11.

2. The terms "chip" and "aggregate" are used interchangeably in literature pertaining to terrazzo, although Masterspec differentiates between "marble-chip" and "aggregate," which refers to any material other than marble. Del Turco, "Historical Background, Part 1," 11.

3. Concord Terrazzo Company, "Palladiana Terrazzo, Terrazzo History," accessed Nov. 15, 2021, https://terrazzco.com/palladiana-terrazzo/.

4. Olga Zorzi Pugliese, "The Mosaic Ceiling of 1933 at the Royal Ontario Museum and Its Craftsmen: The Untold Story," *Studies in the Decorative Arts* 11, no. 2 (2004): 59–77.

5. Louis Del Turco, "The Historical Background of Terrazzo Floors, Part 2," *The Art of Mosaics and Terrazzo* 2, no. 3 (1931): 16.

6. "How to Construct Terrazzo Floors," *Building Age* 40 (Feb. 1918): 98.

7. Louis Del Turco, "The Business of Brass Strip Design," *The Art of Mosaics and Terrazzo* 2, no. 6 (1931): 17.

8. The National Terrazzo & Mosaic Association, Inc., *Terrazzo Specification & Design Guide*, accessed Nov. 2021, https://www.naterrazzo.com/assets/resources/1528826866_Terrazzo_Specifications__amp__Design_Guide.pdf.

9. Air-entrainment agents should be specified if the installation is in a region requiring freeze-thaw resistance.

10. Laitance refers to a fine "milky" residue made up of cement and fine particles that rises to the surface and can form a skin on the surface during the setting process if not removed.

11. Daniel W. Kessler, Arthur Hockman, and Ross E. Anderson, "Physical Properties of Terrazzo Aggregates," in *Building Materials and Structures Report BMS98* (Washington, D.C.: National Bureau of Standards, May 20, 1943), 2. See also H. S. Wright, "Ornamental Concrete Floor Surfacings," *Engineering and Contracting* 65 (July 1926): 22.

12. *Terrazzo Specification & Design Guide*.

13. Steve Menconi, of Menconi Terrazzo, Bensenville, Illinois, interview with author, Oct. 2021.

14. Menconi, interview.

15. The National Terrazzo & Mosaic Association, Inc., *Terrazzo Maintenance Guide*, accessed Nov. 2021, https://www.ntma.com/wp-content/uploads/2020/08/MaintenanceBrochure-downloadable.pdf.

16. All maintenance, buffing, and finishing products should be manufactured for specific use on terrazzo. The NTMA can provide a list of qualified suppliers and instruction guidelines.

17. "Historic Preservation Technical Documents," U.S. General Services Administration website, accessed August 2022, https://www.gsa.gov/real-estate/historic-preservation/historic-preservation-policy-tools/preservation-tools-resources/technical-documents.

18. Bob Mion, of International Masonry Institute, interview with author, Oct. 2021.

APT's mission is to advance appropriate traditional and new technologies to care for, protect, and promote the longevity of the built environment and to cultivate the exchange of knowledge throughout the international community.

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