Preserving Historic Ornamental Plaster

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A NOTE TO OUR USERS: The web versions of the Preservation Briefs differ somewhat from the printed versions. Many illustrations are new, captions are simplified, illustrations are typically in color rather than black and white, and some complex charts have been omitted.

From the time America struggled for a new identity as a constitutional republic—and well into the 20th century—its architecture and its decorative detailing remained firmly rooted in the European classicism of Palladio, Wren, and Mansart.

Together with skilled masons and carpenters, ornamental plasterers saw their inherited trade flourish from the mid-18th century until the Depression years of the 1930s. During this two hundred year period, as the Georgian and Federal styles yielded to the revivals—Greek, Rococo, Gothic, Renaissance, and Spanish—decorative plaster reflected each style, resulting in the wide variety of ornamentation that survives. The traditional methods of producing and installing interior decorative plaster were brought from Europe to this country intact and its practice remains virtually unchanged to this day.

Like flat walls and ceilings, historic ornamental plaster is made of gypsum and lime which are stable and durable materials. An extremely versatile material, plaster can be modeled, cast, incised, colored, stamped, or stencilled. However, as an integral part of the building system it is subject to the typical problems of water intrusion, structural movement, vibration and insensitive alterations, both incrementally and from adaptive use projects.

This Preservation Brief has been prepared to assist property owners, architects, contractors, and Federal agency managers in identifying the causes of ornamental plaster failure, specifying repair and replacement techniques and engaging qualified professionals to do the work. The scope of this Brief is limited to the repair and restoration of existing ornamental plaster; certain forms of decorative
plaster such as scagliola, composition ornament, and artificial Caen Stone are not addressed, nor is the design and installation of ornamental plasterwork in new construction. Finally, guidance on using substitute materials to match the historic appearance of ornamental plasterwork—a legitimate option within the Secretary of Interior's Standards for the Treatment of Historic Properties—is not discussed here, but will be the subject of another Brief on interiors.

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The Ornamental Plaster Trade

**Shop Personnel.** As builders and architects were hired by an increasingly affluent clientele, ornamental plaster shops developed from the single artisan operations of the 18th century into the complex establishments of the early 20th century. American plaster studios employed immigrant and, later, native craftsmen. Plasterers' guilds were in existence in Philadelphia in the 1790s. In 1864, a plasterers' union was organized in the United States with members from the British Isles whose work there had been limited to palaces and churches. English and European craftsmen came to America where the demand for their skills had increased by the decade, offering them the unparalleled opportunity to open their own shops. Over the years, plaster elements became so popular in decorating interior spaces that a major industry was established. By the 1880s, catalogs were available from which property owners could select ornamentation for their splendid new buildings.

**Methods of Production.** Historically, ornamental plasterwork has been produced in two ways: it would be run in place (or on a bench) at the site; or cast in molds in a workshop. Plain plaster molding without surface ornamentation was usually created directly on the wall, or run on a flat surface such as a plasterer's workbench and attached to the wall after it set. Ornament such as coffering for ceilings, centers for light fixtures (medallions), brackets, dentils, or columns were cast in hide glue (gelatin) or plaster molds in an offsite shop, often in more than one piece, then assembled and installed in the building.

**Decorative Plaster Forms—Cornices, Medallions, Coffers.** Three decorative plaster forms in particular—the cornice, the ceiling medallion, and the coffered ceiling—historically comprised much of the ornamental plasterers' business. These forms appear individually or in combination from the 18th to 20th century, irrespective of stylistic changes.

For example, an elaborate parlor cornice consisted of plain moldings made of gypsum and lime run atop temporary lattice strips around the room. Tooling for plain-run moldings called for a sheet metal template of the molding profile mounted on a wooden "horse". Mitering was accomplished using a plaster and lime putty gauge (mix) tooled with miter rods at the joints. Decorative
"enrichments" such as leaves, egg and dart moldings, and bead and reel units were cast in the shop and applied to the plain runs using plaster as an adhesive. Painting, glazing, and even gilding followed. Large houses often had plain run cornices on the upper floors which were not used for entertaining; modest houses also boasted cornice work without cast enrichment.

Among the most dramatic of ornamental plaster forms is the parlor ceiling medallion. Vernacular houses often used plain-run concentric circles from which lighting fixtures descended, usually hung from a wrought iron hook embedded in the central ceiling joist. More elaborate medallions were composed of shop-cast pieces, such as acanthus foliage often alternating with anthemia or other decorative designs. Medallions usually related stylistically to the cornice ornament found in the room and could be created with or without a plain-run surround. Of particular importance to the art of ornamental plaster was the mid-19th century double parlor plan. Architects often specified matching medallions of robust proportions and ornamentation. Later, in 20th century American Colonial Revival architecture, architects called for Federal style ceiling medallions. Some of the more successful were graceful one-piece units, utilizing classical motifs such as garlands and swags, and in their simplicity, reminiscent of Adamesque designs of the 1760s.

Yet another significant decorative form is the coffered ceiling. Cofferings units were cast in the shop or onsite, then installed with hanging wires to form the ceiling. Ceiling design varied from period to period as to depth, panel shape, and ornamental complexity. Not always flat, coffering is seen inside domes, within barrel vaults and groin ceilings, along overhead ribs and soffits. Rosettes are usually centered in the panels and often enrich the intersections of elaborate stiles bordering the panels. Flat ceiling coffers are generally identical in reflected plan; on domed or barrel ceilings, coffers differ from course to course so as to appear identical from various sight lines. The finish treatment of a coffered ceiling frequently exhibits the height of the painter’s craft.

Foremost examples of ceiling coffering include the United States Capitol, and Washington DC’s Union Station. As a popular decorative form with inherent acoustical benefits, the coffered ceiling is seen across the United States in many large public spaces such as theaters, courthouses, railroad stations, and hotels.

Unfortunately, these supposedly enduring decorative forms created by ornamental plaster tradesmen are subjected to the ravages of both nature and man and, consequently, seldom remain as originally designed. Minor changes of taste are perhaps the least injurious to plasterwork. Considerably greater damage and deterioration are caused by radical changes in building use and poor maintenance practices. Fortunately, in most cases, the form, detailing, and finish of historic ornamental plaster can be recaptured through careful repair and restoration.

Causes of Ornamental Plaster Damage

Ornamental Plaster Substrate. For flat plaster walls and ceilings, as well as decorative forms, the system to attach interior plaster to walls and ceilings primarily consisted of 1/4" x 1-1/4" wooden lathing strips nailed 3/8" apart against studs and joists. First a scratch coat consisting of sand, lime, and cattle hair was troweled on the lath and pressed through the slots so as to slump over and form "keys." Next, a brown coat was applied to establish flat and plumb surfaces. The earliest plasterwork consisted of two coats of lime and sand plaster; later in the 19th century, a third or finish coat was applied that consisted of both lime and gypsum. Decorative units were generally attached to the substrate using plaster as an adhesive.

Signs of Failure. Failure of the substrate is more typical than failure of the plaster ornament itself. Among the reasons for deterioration, structural movement and water intrusion are the most deleterious. Buildings move and settle, causing deflection and delamination which result in stress cracking. These cracks often begin at the corners of windows and doors and extend upward at acute angles. Roof or plumbing leaks make finishes discolor and peel and cause efflorescence, especially on plain-run or enriched cornices. Unheated buildings with water intrusion are subject to freeze-thaw cycles which ultimately result in base coat and ornamental plaster failure.

In addition, keying and adhesive properties may be further jeopardized by weak original mixes that were improperly applied. Substrate failure typically results from faulty lathing or rusty lath nails, causing ceilings to fall. In the 20th century, vibration from heavy vehicular traffic, nearby blasting, and even repeated sonic booms may contribute to damaging ornamental plaster. Inadequate support in an original design may also be to blame when particularly heavy units have simply broken off over time. Finally, new mechanical systems, suspended ceilings and partition walls insensitively installed in adaptive use projects, show little regard for the inspired decorations of earlier periods.

Repairing and Replacing. Plaster failure is a matter of degree. For example, top coat failure can be repaired by applying a new finish coat over a sound early substrate. Also, if cracking or loss of all three coats has occurred and is not combined with major structural failure, it can be repaired much like flat wall plaster. For ornamental plaster, however, repair beyond patching is often equivalent to targeted replacement of entire lengths or portions of run-in-place and cast ornamentation. Pieces that are deteriorated or damaged beyond plain patching must be removed and replaced with new pieces that exactly match the existing historic plaster. For this reason, partial restoration is often a more accurate term than repair. But whichever term is used, it is not recommended that repair of ornamental plaster be undertaken at any level by property owners; it is a craft requiring years of training and experience. A qualified

http://www.nps.gov/history/hps/TPS/briefs/brief23.htm

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professional should always be called in to make an inventory of ornamental plaster enrichments and to identify those details which are repairable onsite and which should be removed for repair or remanufacture in the shop.

### Immediate Action

Once the cause and extent of damage have been determined, treatments such as shoring, stabilization, and limited demolition can begin, preparatory to repairing or restoring historic ornamental plaster.

First, roof or plumbing leaks must be repaired to eliminate the problem of water intrusion. General structural repairs should be undertaken to arrest building movement, which weakens the base coat plasters to which the ornamental enrichments are attached. Ornamental plaster deflection should be corrected by shoring from below followed by re-anchoring.

Testing for poor adhesion of base coat to lath or ornament to base coat, should be conducted to reduce further loss of enrichment. Adaptive use intrusions should be carefully removed to protect the existing decorative plasterwork.

Code-required fire suppression systems should be evaluated at this time. Modern building codes may require heat/smoke/flame detectors and automatic sprinkler systems of various types and applications. Fire suppression systems as well as all mechanical systems (HVAC, plumbing and electrical) systems should be designed so that they accomplish their purpose with minimal impact on the decorative plaster. Plumbing for an automatic sprinkler system, for example, can be run above new and existing coffering so that the sprinkler heads barely protrude from the rosette centers in the coffered design. Access should be provided for future system maintenance or repair.

### A 20th Century Shop Tour—Personnel, Materials, and Processes

Before discussing how decorative forms such as cornices, medallions, and ceiling coffers are repaired onsite and in the shop by ornamental plasterers, the "shop tour" explains traditional casting processes used in conjunction with updated materials. A shop tour can be exciting, but confusing to the layman without some explanation of modeling, molding, and casting activities. For a prospective client, a visit to the plaster studio or site can be of value in choosing a qualified plastering contractor.

**Shop and Personnel.** Generally, a highly functional shop should look well organized—that is, not in disarray with remnants of past projects lying about to impede current production. Old molds may be in abundance, but hanging from the wall or otherwise "on file." Machinery (saws and drill presses) and hand tools should appear well maintained.
In short, one might evaluate such a studio as one does an auto mechanic's shop: does it inspire confidence? This is the time to look around and ask questions. What is the shop's past project work experience? Is the firm mostly involved in new construction work or total reconstruction? More important than the way the shop looks, is the personnel sufficiently experienced in making repairs to historic decorative plaster? What about training and apprenticeships? How did the staff learn the trade? The more that is known about the total operation the better.

**Molding Rubber.** Familiarity with contemporary molding rubbers is desirable. There are several formulations currently on the market. In the past, flexible molds were made with hide glue melted in a double boiler and poured over plaster originals which had been prepared with an appropriate parting agent. Of the newer rubbers, latex (painted on the model coat by coat) is time consuming and has little dimensional accuracy; polysulfide distorts under pressure; and silicone is needlessly expensive. Urethane rubber, with a 30-durometer hardness, is the current choice. Urethanes are manufactured as pourable liquids and as thixotropic pastes so that they can be used on vertical or overhead surfaces. The paste is especially useful for onsite impressions of existing ornament; the liquid is best used in the shop much as hide glue or gelatin was historically. Urethane rubber has the ability to reproduce detail as fine as a fingerprint and does not degrade during most ornamental plaster projects. No flexible molding material lasts forever, so spare casts should be maintained for future remodeling.

**Molding Plaster.** Molding plaster will also be in evidence; it is the product most similar to that used historically. This plaster is finely ground to accept the detail of the rubber molds, not so hard as to prohibit tooling, and combines readily with finish lime. High-strength plaster is available in varying densities, some with added components for specific purposes. Most shops maintain these varieties, but use molding plaster for typical work.

**Sheet Metal Templates.** The contractor's familiarity with sheet metal is critical. Accurate template blades are required to reproduce both straight and curved sections of moldings. The blades must be carefully cut, filed, and sanded in order to form exact reproductive units. A tour of a sizeable shop will include observation of running techniques and the results of this activity should be much in evidence. Regardless of size, these runs should be smooth and true when made by qualified craftsmen.

**Models.** Models, whether of capitals, cornices, medallions or cartouches, are made as whole units or in parts depending on project demands. Completeness, accurate dimensions, and attention to historic styles are essential ingredients of successful models. Each part of a model has a name, i.e., dentil, guilloche, rinceau or bolection molding, modillion, egg and dart, and the designers and restorers of these ornaments should know their names. Failure to identify these parts correctly should be of concern to a prospective client.

**Molds.** Molds are "negative forms" produced from completed models. Simple flood molds require a separator or barrier coat over the original and a surrounding fence to prevent the liquid rubber from leaking out. Larger or more complicated molds are made.
in pieces or with a layer of rubber supported by a plaster shell or mother mold attached to a wooden or metal frame. Following completion of a successful mold, the original model is discarded because it is now possible for it to be accurately reproduced.

**Casting the Molds.** Casting operations should appear clean and efficient. A skillful caster's output can be voluminous and often looks effortless as it is being produced. Raw materials are close at hand, molds are rarely without curing plaster in them, production is stored so as not to warp while it is still wet and each cycle, from mixing to pouring, setting, and demolding is accomplished so as not to waste time or break plaster casts. A good caster generally obviates the need for a finishing department.

Two other aspects should be noted. Shipping facilities are critical to move the product to the restoration site safely. Drawing and design space should be separate from the production floor. In summary, the modern ornamental plaster shop inevitably looks quite different from that pictured earlier in this Preservation Brief, but, with the exception of contemporary tools and materials, the operations are the same. The following sections discuss how repairs are made by today's plaster tradesmen.

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**Repairing Historic Ornamental Plaster**

**Cornice.** A plain run or ornamented plaster cornice which has undergone damage or severe deterioration can often be repaired. Footage which is beyond repair should be identified and be carefully demolished to expose the underlying structure beneath to which the molding was secured. To replace the missing lengths, the first step is to obtain a cross-section, or profile, through the cornice from finish ceiling to finish wall lines. This is best accomplished using one of these methods:

1. A section through the cornice may be determined by sawing through the molding, inserting a sheet metal blank in the slot and tracing the profile directly on the template. This is considerably more accurate than the profile gauge, but will require repointing the saw kerf; alternatively, the cut may be made on one of the deteriorated pieces, provided it was removed as an intact unit.

2. The section may be obtained by making a thixotropic rubber impression of the molding, casting the result in fresh plaster and sawing through the cast to transfer the cross-section to a sheet metal template.

With the section determined, it is drawn onto 22-gauge galvanized sheet metal, cut with tin snips and carefully filed to the line. The template is checked periodically against the original profile to assure a perfect match. With the template blade finally complete, it is nailed to stock and slipper, ready for running the replacement footage.

Short lengths of new cornice are best run on a bench using gypsum and lime; the reproduction molding should be somewhat longer than the required length. The new footage is cut and fit in place to match the existing cornice, then securely countersunk-screwed to studs, joists and/or blocking. The resulting joints are pointed with flat mitering rods, flush with adjacent members.

Longer lengths of cornice may be run in place, much as they were historically. Care should be taken that the position of the running mold engages with the existing work at either end of the run. Yet another method is to bench run the cornice to five or six feet, make a rubber mold of the model, and precast the replacement parts either at the site or in the shop.
If the damaged cornice is ornamented, samples of the enrichment should be removed, making sure that whole original units are obtained. This is a difficult process, since these units were stuck into plain-run recesses called "sinkages" using plaster as an adhesive. In order to insert a flat chisel behind the ornament to break the bond, some units may have to be sacrificed. Sacrifice should be minimal. The excised enrichment should then be removed to the shop for rubber molding and casting either with or without the paint buildup, depending on the demands of the project. Whereas molding with several layers of paint make it hard to discern new casts from originals, paint-stripped molding reveals the remarkable talents of the period model-makers. As noted, contemporary rubber materials have "fingerprint detail" capability. Modern casts are then applied to the new or original runs, again using plaster as an adhesive.

**Ceiling Medallion.** Ceiling medallions are often in greater jeopardy than cornices because the joist-lath-base-coat support system is susceptible to deflection and the force of gravity. The problems of ceiling failure are more frequent in the centers of parlors because circular-run and shop-cast ornament is often quite heavy and was not historically attached with any additional mechanical fasteners such as bolts and screws.

If the lath or keys have failed, plaster ceiling ornament may be saved, in whole or in part, by removing floor boards above, then drilling and injecting each lath with an elastic acrylic or epoxy material to reattach plaster to lath, and lath to the joists. This is a recently developed procedure which should only be undertaken by experienced professionals. The consolidation and reattachment process has been used successfully in period structures with dramatic results when important plaster and painted surfaces would otherwise have been lost.

Historic lighting fixtures often hung from elaborate ceiling medallions. When these fixtures were later converted to gas and electrical service, the central ornamental plaster canopies were sometimes damaged by insensitive tradesmen. More recent adaptive use projects may have caused additional damage.

Damaged ceiling medallions can be repaired by carefully removing representative plaster ornamentation, molding and recasting in the shop and replacing the new enrichments so that they align perfectly with the original pattern. Polyvinyl acetate bonding agents are applied to the background and ornament so that the adhesive plaster grips tightly. Alternatively, a severely damaged medallion can be replaced using the fragments as physical documentation to cast a visually accurate replacement.

Sections of plain-run circular molding may also be repaired by determining a section through the run and the radius from molding to pivot point. As with cornices, the run should be made on a bench to a length greater than required, then cut and fit in place. Circular run sections are installed using plaster adhesives on bonded surfaces or modern construction adhesives after referring to manufacturers' instructions as to whether the adhesive is recommended for use on wet or dry materials. Coarse-threaded, galvanized screws are often countersunk to aid the bond; if possible, the screws should be inserted at points that will ultimately be covered with cast enrichments.

Ceiling medallions frequently appear in matching double parlors. It is not unusual for one ceiling to fail while its mate remains undamaged. The flat plastered ceiling over the location of the missing medallion often has a "ghost," confirming that a ceiling medallion
once ornamented the parlor. The missing medallion may be remanufactured by securing a section, dimensions, and samples of cast enrichments from the surviving ornament and accurately following the original procedure. The ceiling on which the new work is to be set should be examined for its soundness and, if necessary, relathed (with self-furring metal lath) and plastered. The pivot point for a circular run is screwed into a wooden block, force-fit into the center electrical box, and removed after the run is completed.

After 1850, particularly in the South, ceiling medallions were often designed with cast ornament only; no plain-run surround was used. Repair of such medallions proceeds as described above but without bordering molding.

An important point needs to be made about adding ceiling medallions (or any other kind of ornamental plaster element) when there is a lack of historical evidence. If there is no ghost mark or other documentation, indicating a medallion once existed, then the room should remain unornamented as it was historically. Adding conjectural ornamentation of any type or material (i.e., shop-cast or glass fiber reinforced plaster or polystyrene foam substitutes) can create a false sense of historical development contrary to the preservation principles stated in The Secretary of the Interior's Standards for the Treatment of Historic Properties. However, if there is clear indication that a ceiling medallion once existed, but there is inadequate documentation for its replacement, a medallion compatible with the room's historic character may be considered. Professional advice should be sought.

**Coffered Ceiling.** Like cornices and medallions, coffered ceilings suffer from poor maintenance practices and structural problems; however, these individually cast ceiling units are particularly vulnerable when a building is being rehabilitated and great care is not taken in executing the work. In the most serious of cases, portions of a roof can collapse, dropping heavy debris through the hanging coffering panels, and demolishing large portions of the ornamentation.

But even this level of damage can usually be remedied by restoration professionals. Immediate action calls for shoring the areas adjacent to the damage, and inspecting the hanging apparatus for unforeseen detachment and deflection. New channel iron is used to stabilize the existing coffers and ties reinforced, as necessary. An intact coffering unit is then identified and carefully removed to a casting shop for molding and casting. When rehung, the units are painted to match the historic coffering.

Coffered ceilings appear with plain run or enriched cornices. In most cases it is recommended that the cornice be repaired first in order to achieve straight and level moldings. Then the damaged coffers should be replaced with the matching new coffers and the joints between pointed. Access from above is critical.

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**Finding and Evaluating a Contractor**

When ornamental plaster damage or deterioration has
been identified, the historic property owner, architect, or developer should secure the services of a reputable restoration contractor before proceeding further. It is clear as more and more projects are undertaken, that there is a wide disparity of skills within the trade today. This is partly due to the introduction of gypsum board as a substitute for traditional plastering. As gypsum board became popular after World War II, plasterers saw the demand for their skills decline. Plastering techniques were forgotten because they were often not passed down within shops and families. However, ornamental plaster studios have seen a resurgence in demand for their services in the last decade, particularly as more historic buildings are rehabilitated.

Locating an experienced contractor who is suitable for your particular project is the goal. First, many professional preservation organizations can provide references for suitable restoration contractors. Local plasterers' unions should also be able to identify contractors with experience in ornamental plaster restoration projects. Architects with preservation and restoration project experience may recommend contractors they feel have done a good job for them in the past. Museums with period rooms have engaged craftsmen to assemble the backgrounds for display of antique furniture and decorative arts. Finally, historical societies, either national, state, or municipally organized, may have funded projects which repaired and restored ornamental plaster.

Once several contractors have been identified, their specific abilities need to be evaluated. Prospective contractors should be invited to visit the job site to see and define the scope of work; written proposals, including prices, from all bidders, are essential for comparison. References should be provided and investigated. An outside consultant may be engaged or an informal adviser designated to aid in evaluating the experience and proposals of the bidders. To get a total picture, a completed project should ideally be visited by the prospective client with the contractor present to answer questions which often arise.

Finally, although this may not always be achievable, the bidder's studio may be visited, preferably on a normal working day (see A 20th Century Shop Tour, above.) Alternatively, the bidder may be visited while working onsite. Some ornamental plasterers simply do not have shops. They prefer to cast onsite, adhering the casts while the plaster is wet, and coordinating the job closely with the architect, who inspects each unit as it is cast and before it is installed.

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**Conclusion**

Decorative plasterwork is usually a component of the historic character of interiors and, consequently, The Secretary of the Interior’s Standards for Historic Preservation Projects call for its protection, maintenance, and repair. Where decorative plasterwork has deteriorated beyond repair, it should be replaced to match the old. Based on physical documentation, both repair and replacement can be accomplished using traditional molding plaster and casting procedures, together with the best of the modern molding materials available. Once a "lost art" after the Depression years, the skills of today's ornamental plasterers are increasingly in demand as part of historic preservation project teams. The ingenious and inspired decorative work created by our earlier architects and artisans can now be assured an extended life.
Bibliography


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Home page logo: Running and enriching a ceiling medallion. Photo: Peter Sanders.

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Painting Historic Interiors

Sara B. Chase

Constituents of Historic Paint
Oil-Based and Water-Based Paints
Pre-1875 Paints
Factory-Made Paints after 1875
20th Century Paints
Paint Investigation
Choosing a Treatment
Identifying Deteriorated and Damaged Paint Surfaces
Choosing Modern Paint Types/Finish Coats
Applying Interior Paints
Additional Reading

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The paint Americans used in the past is undeniably part of a technological and commercial record. But beyond that, the colors we have chosen and continue to select for our interior living and working spaces--bright and exuberant, purposefully somber, or a combination of hues--reflect our nation's cultural influences and our individual and collective spirit. Paint color is a simple, direct expression of the time, and of taste, values, and mood. To consider paint only as a protective coating is to misunderstand its meaning as an important aspect of America's heritage.

This Brief is about historic interior paints and choosing new paints for historic interiors if repainting is necessary or desirable. It addresses a variety of materials and features: plaster walls and ceilings; wooden doors, molding, and trim; and metal items such as radiators and railings. It provides background information about some of the types of paint which were used in the past, discusses the more common causes and effects of interior paint failure, and explains the principal factors guiding decisions about repainting, including what level of paint investigation may be appropriate. Careful thought should be given to each interior paint project, depending on the history of the building and its painted surfaces. Treatments may range from protecting extant decorative surfaces, to ordering custommade paint that replicates the original paint color, to using today's paint straight off the shelf and out of the can.

http://www.nps.gov/history/hps/TPS/briefs/brief28.htm
Finally, stripping old paints or applying new oil/alkyd paints poses serious health and safety concerns; the State Historic Preservation Officer should be contacted for current legal and technical information on removal, disposal, and health and safety precautions.

Constituents of Historic Paint: Pigment, Binder, and Vehicle

Paint is a dispersion of small solid particles, usually crystalline, in a liquid medium. Applied to a surface, this liquid has the special quality of becoming a solid, protective film when it dries. Paint also enhances the appearance of surfaces. A late Victorian writer observed that the coming of a painter to a house was cause for celebration. Indeed, these statements not only indicate the chemical and physical complexity of paint, but also its emotional impact.

Pigment. Pigment made the paint opaque, thus preventing deterioration of the substrate caused by ultraviolet light, and added color, thus making the paint attractive. White lead, a whitish corrosion product of lead, was most often used to provide opacity. The white pigment in a colored paint is often called the "hiding" pigment. In addition to preventing the sun's damaging rays from hitting the surface of the substrate, the white lead also helped prevent the growth of mold and mildew. Not until early in the 20th century was a successful substitute, titanium dioxide (TiO2), patented, and even then, it did not come into prevalent use by itself until the mid-20th century (earlier in the century, titanium oxide and white lead were often mixed). Zinc oxide was used briefly as a hiding pigment after 1850.

Early tinting pigments for house paints consisted of the earth pigments--ochres, siennas, umbers made from iron-oxide containing clay--and a few synthesized colorants such as Prussian blue, or mercuric sulfide (crimson). From the early 1800s on more pigments were developed and used to offer a wider and brighter variety of hues.

Binder. The most common binder in interior paints was, and still is, oil. Chalk was sometimes added to waterbased paints to help bind the pigment particles together. Other common binders included hide glue and gelatin.

Vehicle. The fluid component was termed the vehicle, or medium, because it carried the pigment. Historically, vehicles included turpentine in oil paints and water in waterbased paints, but other vehicles were sometimes used, such as milk in casein paints.

Oil-Based and Water-Based Paints

The two major types of paint are termed oil-based and water-based. For oilbased paints, linseed oil was frequently chosen because it is a drying oil. When thinned with an organic solvent such as turpentine for easier spreading, its drying speed was enhanced. To make the drying even faster, drying agents such as cobalt compounds were frequently added. Because the addition of driers was most successfully done in hot or boiling oil, boiled linseed oil was preferable. The drying rate of linseed oil paints was
relatively rapid at first, for several days immediately after application, and paint soon felt dry to the touch; it is important to remember, however, that linseed oil paint continues to dry—or more precisely, to crosslink—over decades and thus continues to a point of brittleness as the paint ages. Strong and durable with a surface sheen, oil-based paints were mainly used for wood trim and metal.

Whitewashes and distemper paints differed from oil paints in appearance primarily because the vehicle was water. Waterbased paints were always flat, having no gloss of their own. Because the paint film dried to the touch as soon as the water evaporated, driers were not needed. Waterbase paints were fairly strong, with the pigments well bound as in hide glue distempers, but they did not hold up to abrasion. Wood trim, therefore, was rarely painted with these types of paint historically, though interior plaster surfaces were frequently coated with whitewash and calcimine. Distemper paints were commonly used for decorative work.

**Recent Changes to Paint Constituents.** Until the mid-20th century, almost all paints used in America could be divided according to the type of binder each had. Chemists sought to improve paints, especially when the two world wars made traditional paint components scarce and expensive. Modern paints are far more complex chemically and physically than early paints. More ingredients have been added to the simple threepart system of pigment, binder, and vehicle. Fillers or extenders such as clay and chalk were put in to make oil paints flow better and to make them cheaper as well. Mildewcides and fungicides were prevalent and popular until their environmental hazards were seen to outweigh their benefits. New formulations which retard the growth of the mildew and fungi are being used. As noted, lead was eliminated after 1950. Most recently, volatile organic solvents in oil paint and thinners have been categorized as environmentally hazardous.

A major difference in modern paints is the change in binder from the use of natural boiled linseed oil to an alkyd oil which is generally derived from soybean or safflower oil. Use of synthetic resins, such as acrylics and epoxies, has become prevalent in paint manufacture in the last 30 years or so. Acrylic resin emulsions in latex paints, with water thinners, have also become common.

**Types of Historic Paints**

Historic paints were often made with what was available, rather than adhering to strict formulas. Recipes for successful formulas can be found in historic documents, such as newspapers, illustrating the combinations of ingredients which could be used to produce a paint.

*Oil-based paints: Linseed oil, a volatile thinner such as turpentine; a hiding pigment (usually white lead) and coloring pigments.*

*Enamels:* natural resin varnish was added to oil-based paint to provide a hard, more glossy surface.

*Glaze:* a translucent layer applied to protect the paint and to impart a more uniform gloss surface. Usually made from linseed oil with natural resin varnish added. Some glazes have small quantities of tinting pigments such as verdigris or Prussian blue; some had no pigments added.

*Water-based paints: Water, pigment, and a binder, such as hide glue, other natural glues, or gums. Usually used on interior plaster surfaces.*

*Whitewash:* often used on interior plaster surfaces in utilitarian spaces and, at times, used on interior beams; consisted of water, slaked lime, salt, and a variety of other
materials. Occasionally a pigment (usually an ochre or other earth pigment) was added to provide tint or color.

**Distemper:** used for interior applications, were made from water, glues (one or more different natural glues, gelatine, and gums) with whiting as the basic white pigment to which other tinting pigments were added.

**Calcimine, or kalsomine:** often used on interior surfaces and is another common name for distemper.

**Tempera:** paint prepared with pigment, egg yolk or white and water; used almost exclusively for decorative treatments.

Gouache: a waterbased paint made of whiting, pigment, water, and gum arabic as the binder; used almost exclusively for decorative treatments.

**Milk-based paint:**

Casein: also called milk paint, was made with hydrated (slaked) lime, pigment, and milk. Most often oil was added, making a strong emulsion paint. Various recipes call for a large variety of additives to increase durability. Casein paints were also used for exterior surfaces.

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**Pre-1875 Paints**

**Production and Appearance.** How were paints made prior to the widespread use of factory-made paint after 1875? How did they look? The answers to these questions are provided more to underscore the differences between early paints and today's paints than for practical purposes. Duplicating the composition and appearance of historic paints, including the unevenness of color, the irregularity of surface texture, the depth provided by a glaze top coat, and the directional lines of application, can be extremely challenging to a contemporary painter who is using modern materials.

The pigments used in early paints were coarsely and unevenly ground, and they were dispersed in the paint medium by hand; thus, there is a subtle unevenness of color across the surface of many pre-1875 paints. The dry pigments had to be ground in oil to form a paste and the paste had to be successively thinned with more oil and turpentine before the paint was ready for application. The thickness of the oil medium produced the shiny surface desired in the 18th century. In combination with the cylindrical (or round) shaped brushes with wood handles and boar bristles, it also produced a paint film with a surface texture of brush strokes.

**Geographical Variation.** The early churches and missions built by the French in Canada and the Spanish in the southwestern United States often had painted decoration on whitewashed plaster walls, done with early waterbased paints. By the mid-17th century oil paint was applied to wood trim in many New England houses, and whitewash was applied to walls. These two types of paint, one capable of highly decorative effects
such as imitating marble or expensive wood and the other cheap to make and relatively easy to apply, brightened and enhanced American interiors. In cities such as Boston, Philadelphia, New York, and later, Washington, painters and stainers who were trained guildsmen from England practiced their craft and instructed apprentices. The painter's palette of colors included black and white and grays, buffs and tans, ochre yellows and iron oxide reds, and greens (from copper compounds) as well as Prussian blue. That such painting was valued and that a glossy appearance on wood was important are substantiated by evidence of clear and tinted glazes which may be found by microscopic examination.

**Brush Marks.** Early paints did not dry out to a flat level surface. Leveling, in fact, was a property of paint that was much sought after later, but until well into the 19th century, oil paints and whitewashes showed the signs of brush marks. Application therefore was a matter of stroking the brush in the right direction for the best appearance. The rule of thumb was to draw the brush in its final strokes in the direction of the grain of the wood. Raisedfield paneling, then, required that the painter first cover the surface with paint and afterward draw the brush carefully along the vertical areas from bottom to top and along the top and bottom bevels of the panel horizontally from one side to the other.

In the 19th and early 20th centuries, for very fine finishes, several coats were applied with each coat being rubbed down with rotten stone or pumice after drying. A four to five coat application was typical; however nine coats were not uncommon at the end of the century for finishes in some of the grand mansions. Generally, they were given a final glaze finish. Though expensive, this type of finish would last for decades and give a rich, smooth appearance.

**Color.** Color matching is complicated by the fact that all early paints were made by hand. Each batch of paint, made by painters using books of paint "recipes" or using their own experience and instincts, might well have slight variations in color—a little darker or lighter, a little bluer and so on. The earliest known book of paint formulations by an American painter is the 1812 guide by Hezekiah Reynolds. It gives instructions for the relative quantities of tinting pigments to be added to a base, but even with proportions held constant, the amount of mixing, or dispersion, varied from workman to workman and resulted in color variations.

Knowing all of the facts about early paints can aid in microscopic paint study. For example, finding very finely and evenly ground pigments, equally dispersed throughout the ground or vehicle, is an immediate clue that the paint was not made by hand but, rather, in a factory.

By the first decades of the 19th century more synthetic pigments were available—chrome yellow, chrome green, and shades of red. Discoveries of light, bright, clear colors in the plaster and mosaic decoration of dwellings at Pompeii caught the fancy of many Americans and came together with the technology of paint to make for a new palette of choice, with more delicacy than many of the somewhat greyeddown colors of the 18th century. Of course, the blues which could be produced with Prussian blue in the 18th and 19th centuries were originally often strong in hue. That pigment—as were a number of others—is fugitive, that is, it faded fairly quickly and thus softened in appearance. It should be remembered that high style houses from the mid-17th to late 19th centuries often had wallpaper rather than paint on the walls of the important rooms and hallways.

**Glossy/Flat.** Another paint innovation of the early 19th century was the use of flatter oil paints achieved by adding more turpentine to the oil, which thus both thinned and flattened them. By the 1830s the velvety look of flat paint was popular.

Wherever decorative plaster was present, as it frequently was during the height of the
Federal period, distemper paints were the coating of choice. Being both thin and readily removable with hot water, they permitted the delicate plaster moldings and elaborate floral or botanical elements to be protected and tinted but not obscured by the buildup of many paint layers. (The use of water based paints on ceilings continued through the Victorian years for the same reasons.)

Unfortunately, flat paints attract dirt, which is less likely to adhere to high gloss surfaces, and are thus harder to wash. Victorians tended to use high gloss clear (or tinted) finishes such as varnish or shellac on much of their wood trim and to use flat or oil paints on walls and ceilings.

**Decorative Painting.** In interiors, paint could be used creatively and imaginatively, most often to decorate rather than to protect. Decorative forms included stencilling, graining and marbleizing, and trompe l’oeil. Stencilling. Stencilled designs on walls were often used in the first half of the 19th century in place of wallpaper. Old Sturbridge Village, in Massachusetts, has paintings showing the interiors of a (c. 1815-1820) farmhouse which has both stencilled walls--imitating wallpaper--and painted floors or oiled and painted floor cloths, imitating fine carpets. By 1850 and for the next 60 years thereafter, stencilled and freehand painted decoration for walls and ceilings became a high as well as a humble art. Owen Jones' *Grammar of Ornament*, published in 1859, provided the source for painted decoration from Portland to Peoria, Savannah to San Francisco.

**Graining and marbleizing.** If floors, walls, and ceilings were decorated by paint in a variety of styles, the wood and stone trim of rooms was not omitted. The use of faux bois, that is, painting a plain or common wood such as pine to look like mahogany or some finer wood, or faux marbre, painting a wood or plaster surface to look like marble—realistically or fantasticaly—was common in larger homes of the 18th century. By the early 19th century, both stylized graining and marbleizing adorned the simple rural or small town houses as well. Often baseboards and stair risers were marbleized as were fireplace surrounds. Plain slate was painted to look like fine Italian marble. In many simple buildings, and, later, in the Victorian period, many prominent buildings such as town halls and churches, the wood trim was given a realistic graining to resemble quarter sawn oak, walnut, or a host of other exotic woods.

**Trompe L'oeil.** Churches, courthouses, and state capitols frequently received yet another remarkable use of paint: trompe l'oeil decoration. Applied by skilled artists and artisans, painted designs—most often using distemper paints or oils—could replicate threedimensional architectural detailing such as ornate molded plaster moldings, medallions, panels, and more.

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**Factory-Made Paints after 1875**

An enormous growth of the paint industry began in the 1860s, stimulated by the invention of a suitable marketing container—the paint can. The first factory-made paints in cans consisted of more finely ground pigments in an oil base; after purchase, additional oil was added to the contents of the can to make up the paint. Such paints saved the time of handgrinding pigments, and were discussed at length by John Masury in his numerous books. After 1875, factory-made paints were available at a reasonable cost and, as a result, greater numbers of people painted and decorated more of their buildings, and more frequently. The new commercial market created by ready-mixed paint became the cornerstone of our modern paint industry.

20th Century Paints

By the early decades of the 20th century, popular taste turned away from exuberant colors and decoration. Until the late 1920s both the Colonial Revival and Arts and Crafts styles tended toward more subdued colors and, in the case of Colonial Revival, a more limited palette. The use of faux finishes, however, continued. Residential architecture often featured stencilling, such as painted borders above wainscoting or at ceiling and wall edges to imitate decorative wallpaper. Institutional buildings in both cities and small towns used wood graining on metal clad doors, door and window frames, and staircases, and had stencilled ceilings as well. Many high style public buildings of the 1920s had painted ceilings which imitated the Spanish and Italian late medieval and Renaissance styles.

Although stenciling, gilding, and faux finishes can be found, they did not express the modern style of the time. On the other hand, glaze treatments were often used in the early 20th century to "antique" walls and trim that had been painted with neutral colors, especially in Spanish Colonial Revival and Mission architecture. The glazes were applied by ragging, sponging, and other techniques which gave an interesting and uneven surface appearance. Colored plasterers were sometimes used, and air brushing employed to give a craftsman-like appearance to walls, trim, and ceilings. During the same period, Williamsburg paint colors were produced and sold to people who wanted their houses to have a "historic Georgian look." Churches, country clubs, and many private buildings adopted the Williamsburg style from the late '20s onward.

Often decorated with simple molded plaster designs of the Art Deco and Art Moderne styles, interiors of the 1930s and 1940s were frequently accented with metal flake paints in a full range of metallic colors, from copper to bronze. And enamels, deep but subdued hues, became popular. Paint technology had progressed and varying degrees of gloss were also available, including the mid-range enamels, variously called satin, semigloss, or eggshell. In contrast to Victorian paint treatments, this period was characterized by simplicity. To some extent, the Bauhaus aesthetic influenced taste in the 1950s; interior paints were frequently chosen from a palette limited to a few "earth" colors and a "nearly neutral" palette of off-whites and pale greys.

While the trend in colors and decorative treatments was defined by its simplicity, paint chemists were developing paints of increasing complexity. Experimentation had started early in the 20th century and accelerated greatly after World War II. Of greatest
significance was the manufacture of the latex paints for consumer use. Synthetic resin emulsions carried in water offered advantages over the traditional oil paints, and even over the oil/alkyd paints: they did not yellow; they permitted water cleanup until dried; and they emitted no toxic or hazardous fumes from solvent evaporation.

### Paint Investigation

Understanding each project's historic preservation goal and knowing what level of information needs to be collected to achieve that goal is an important responsibility of the purchaser of the service. Before someone is hired, the owner or manager needs to decide if a thorough investigation of painted surfaces is actually needed, and how to use the results when one is done.

Specialists with both training and field experience conduct paint investigations. These experts use sophisticated instruments and procedures such as field sampling, cross-section analysis, and fluorescent and chemical staining to learn about the components and behaviors of historic paints. In addition, they utilize written documentation, verbal research, and visual information about past painting in the building in conjunction with findings in the field.

Paint investigation can make several contributions to a project. A complete analysis of the paint layers on surfaces within a structure can tell a great deal about the sequence of alterations that have occurred within a building, as well as potentially providing ranges of dates for some of these changes. By establishing a full sequence of paint layers (termed a chromochronology), together with other research, alterations of various building spaces and features can be associated with specific paint layers. It is by establishing this association that the correct layer is identified; when the correct layer has been identified, the color may be matched.

In addition to its archeological value, paint analysis can determine the types and colors of paint on a given surface (identification of thin glazes, decorative paint schemes, binders and pigments). Beyond color identification, then, paint analysis is also recommended to diagnose causes of paint failure. Knowing a paint binder can often explain causes as well as guide appropriate preservation or conservation treatments.

Owners and managers should identify all of these needs before deciding on the extent of analysis. For example, a complete paint investigation is usually recommended as part of an historic structure report. For buildings with little documentation, additions and alterations can often be identified, and possibly dated, through analysis. Often the use of such seemingly expensive techniques can save money in the long run when determining the history of building change.
It is possible to do some analysis on site; this is a much simpler process that can be undertaken for less cost than the complex laboratory procedures described above. However, the usefulness of onsite analysis is limited and the results will not be as precise as results from samples that are analyzed in a laboratory with a good microscope. Any shortcut approaches to paint analysis that do not follow scientific procedures are generally not worth the expense. In summary, if preservation and restoration treatments are being undertaken, a complete investigation is recommended; for a rehabilitation project, onsite analysis and color matching may provide an adequate palette.

Choosing a Treatment

Most projects involve repainting. It is the historic appearance of the interior and the visual impression that will be created by new paint treatments that must be considered before choosing a particular course of action. The type and colors of paint obviously depend on the type of building and the use and interpretation of its interior spaces. A consistent approach is best.

Preservation. When the treatment goal is preservation, a building's existing historic features and finishes are maintained and repaired, saving as much of the historic paint as possible. Sometimes, cleaning and washing of painted surfaces is all that is needed. Or a coating may be applied to protect important examples of history or art. If repainting is required, the new paint is matched to existing paint colors using the safer, modern formulations. Recreating earlier surface colors and treatments is not an objective.

Rehabilitation. In a typical rehabilitation, more latitude exists in choosing both the kind of new paint as well as color because the goal is the efficient reuse of interior spaces. Decisions about new paint often weigh factors such as economy and durability—use of a high quality standard paint from a local or national company and application by a qualified contractor. Color choices may be based on paint research reports prepared for interior rooms of comparable date and style. More often, though, current color values and taste are taken into account. Again, the safer paint formulations are used.

Interiors of institutional buildings, such as university buildings, city halls, libraries, and churches often contain rich decorative detailing. During rehabilitation, careful choices should be made to retain or restore selected portions of the decorative work as well as match some of the earlier colors to evoke the historic sense of time and place. At the least, it is important to use period-typical paint color and paint placement.

Restoration. In a restoration project, the goal is to depict the property as it appeared during its period of greatest significance. This may or may not be the time of its original construction. For example, if a building dated from 1900 but historians deemed its significance to be the 1920s, the appropriate paint color match would be the 1920s layer, not the original 1900 layer.
Based on historical research, onsite collection of paint samples, and laboratory analysis, surface colors and treatments can be recreated to reflect the property at a particular period of time. It should be noted that scholarly findings may yield a color scheme that is not suited to the taste of the contemporary owner, but is nonetheless historically accurate. In restoration, personal taste in color is not at issue; the evidence should be strictly followed.

In the restoration process, colors are custom-matched by professionals to give an accurate representation. If an artist or artisan can be found, the historically replicated paint may be applied using techniques appropriate to the period of the restoration. Although custom paint manufacture is seldom undertaken, color and glazing are capable of being customized. In some projects, paint may be custom-made using linseed oil and, if building code variances allow it, white lead. For example, the repainting of a number of rooms at Mount Vernon demonstrates that it is possible to replicate historic paints and applications in all aspects; however, as noted, replication of historic paint formulation is not practical for the majority of projects.

Identifying Deteriorated and Damaged Paint Surfaces

Because painted surfaces are subject to abrasion, soiling, water damage, sunlight, and application of incompatible paints they generally need to be repainted or at least reglazed appropriately from time to time.

**Abrasion.** From the baseboards up to a level of about six feet off the floor, wood trim is constantly subjected to wear from being touched and inadvertently kicked, and from having furniture pushed against it. Chair rails were in fact intended to take the wear of having chairs pushed back against them instead of against the more delicate plaster wall or expensive wallpaper. Doors in particular, sometimes beautifully grained, receive extensive handling. Baseboards get scraped by various cleaning devices, and the lower rails of windows, as well as window seats, take abuse. The paint in all of these areas tends to become abraded. Two things are important to bear in mind about areas of abraded paint. Samples taken to determine original paint colors and layer sequences will not be accurate except at undamaged edges. Also, dirt and oil or grease need to be removed before applying any new paint because new paint will not adhere to dirty, greasy surfaces.

**Dirt.** Soiling is another problem of interior paint. Fireplaces smoked; early coal-fired furnaces put out oily black soot; gas lights and candles left dark smudges. Sometimes the dirt got deposited on plaster walls or ceilings in a way that makes the pattern of the lath behind the plaster quite clear. Another source of dirt was polluted outside air, from factories or other industries, infiltrating houses and other nearby buildings. Until smokestacks became very high, most air pollution was caused by nearby sources.

In paint investigation, dirt on the surface of paint layers; as seen under the microscope, can be very useful in suggesting the length of time a given paint layer remained exposed, and in distinguishing a finish layer from a prime or undercoat layer. This kind of soiling can happen on any painted surface in a room, but may be slightly heavier in the recesses of moldings and on upward-facing horizontal edges. Using dirt as a sole measure, however, may be misleading if the surfaces have been cleaned. The fracture or bonding between paint layers is often used by professionals as a better means of indicating time differences between layers as well as indicating those layers that are part of a single decoration or painting.

**Water.** Water, the usual source of deterioration for many kinds of material, is also a prime cause of interior paint failure. As a liquid, it can come from roof leaks, from faulty
plumbing or steam heating systems, or from firesuppression systems that have misfired. As a vapor, it may come from such human activities as breathing, showering, or cooking. Plaster walls sealed with unpigmented hideglue are notably susceptible to water damage because it forms a watersoluble layer between the plaster and the paint. This can cause the paint to lose adhesion when even small amounts of moisture come into contact with the watersoluble sealer.

**Age/Sunlight.** Finally, in historic interiors, especially where there is heavy paint buildup, paint can weaken and fail due to chemical or mechanical reasons. For example, the older linseed oil is, the more brittle it is. It also darkens when it is covered and gets no ultraviolet exposure. In rooms where there is more sunlight on one area than on others, the oil or even oil/alkyd paint will get discernibly darker in the less exposed areas in as short a time as six months. Painted over, the oil medium in older paints gets quite yellowbrown, thus changing the color of the paint. Prussian blue is one of the tinting pigments that is particularly vulnerable to fading.

**Incompatible Paints.** Understanding some basic differences in the strength of various paints helps to explain certain paint problems. Paints that dry to a stronger film are incompatible with those which are weaker. Acrylic latex paints are stronger than oil/alkyd paints. Oil or oil/alkyd paint is stronger than waterbased paint such as calcimine. When a stronger paint is applied over a weaker paint, it will tend to pull off any weaker paint which may have begun to lose its bond with its substrate. Thus, on many ceilings of older buildings where oil/alkyd paints have been applied over old calcimine, large strips of paint may be peeling.

Oil or varnish glazes over older paints become brittle with age, and can make removal of later paints rather easy. Sometimes it is possible to take advantage of this characteristic to reveal an earlier decorative treatment such as graining or marbleizing. Getting under the edge of the glaze with a scalpel blade can make the removal of later paints relatively simple, and relatively harmless to the fancier paint treatment. Sometimes, paints separate from each other simply due to poor surface preparation in the past or the hardening of the earlier surface paint. Use of alkaline paint strippers can cause paint to lose adhesion. When insufficiently neutralized, they leave salts in wood which cause oil or oil/alkyd paints to fail to adhere to the surface. If dirt or oily residues are not cleaned from the surfaces to be painted, new paint will not remain well adhered.

**Surface Preparation**

First, it is important to note that the earlier, linseed oil-based paints were penetrating type paints, forming a bond by absorption into the substrate. Often these thin oil coatings were slightly tinted with an ironoxide pigment so coverage could be seen; the next coating applied would adhere to this first oil layer. Modern paints, on the other hand, are primarily bonding paints with little ability to penetrate a substrate. For this reason, surface preparation is extremely important for today's paints.

Before preparing the interior for repainting, all moisture penetration from failing roofs or gutters or from faulty plumbing or interior heating elements should be identified and corrected. A paint job is only as good as the preparation that goes before it. The surface to be painted, old or new, wood, plaster, masonry, or metal must be made sound and capable of taking the paint to be applied.

**Scraping and Sanding.** The first step in preparing interior wood and plaster surfaces which are coherent and sound is to remove any loose paint (see Paint Hazards sidebar). Careful hand scraping is always advisable for historic surfaces. Use of mechanical sanders usually leaves traces of the sander's edges, visible through the new paint film. Hand sanding is also necessary to feather the edges of the firmly adhering layers down to the bare areas so that shadow lines are avoided. Preparing previously painted interior
masonry for new paint is basically similar to preparing plaster. Metals elements, such as radiators, valences, or firebacks are somewhat different. In order to get a sound paint job on metal items, the work is primarily that of sanding to remove any rust before repainting. If the existing paint is well adhered over the entire metal surface, then it may be necessary only to sand lightly to roughen the existing paint, thus providing some "tooth" for the primer and new paint layer. On wood, garnet sanding papers work well. Aluminum oxide and silicon carbide sandpapers are effective on other surfaces as well as wood; emery papers should be used on metals.

**Paint Removal.** When should surfaces be completely stripped? Obviously, new paint is wasted when applied on old paint which is loose, that is, extensively damaged and deteriorated. Sometimes paint on an architectural feature needs to be removed if it obscures delicate detailing. For the most part, however, if the surface is intact—and the presence of lead paint has been shown to present no health dangers to building occupants—the existing paint can be overpainted.

Well-adhered, intact paint layers (in at least one area of each room) should be covered with a sturdy protective tape, then painted over with the new paint and left in place to inform future research. The next owner may be interested in the building's past history, and methods of gleaming information from old paints grow more sophisticated all the time.

**Heat/Scraping.** Propane torches should never be used because they can damage historic wood features. Also, charred areas of wood will not hold the new paint. Use of a heat gun or heat plate may be relatively fast, but has both health and safety drawbacks. Heat oxidizes lead paint, causing poisonous fumes. And old walls may contain fine debris which acts like tinder and smolders when heated, bursting into flame hours after the stripping. (Heat methods are best limited to those interior elements that can be safely removed from the building for stripping and reinstalled). Finally, scraping to remove heatloosened paint may gouge and scar the wood or plaster substrate if not done carefully. Rotary wire brushes cut into wood and should be avoided altogether.

**Chemical stripping.** Removing paint from wood and plaster features can be done with either caustic strippers (potassium or sodium hydroxide) or solvent strippers (organic compounds such as methylene chloride, methanol, or toluol). Caustic strippers are fairly fast acting, but can weaken wood fibers if left on too long, causing them to raise and separate. They also leave alkaline residues which must be neutralized by an acidic wash (usually white vinegar which contains 4% acetic acid). It is difficult to make the neutralizing 100% effective and, when it is not, chemical reactions between the alkaline residues and the new paint may cause the paint to lose adhesion.

Methylene chloride and other organic compounds are as effective as caustic strippers, but their fumes may be both flammable and toxic. While they may leave wood and plaster surfaces free from harmful residue, the newly cleaned surface must be washed down with mineral spirits or denatured alcohol before priming in order to remove additives, such as wax, that were put in the stripper to retard its drying. All hazard warnings on the labels of chemical strippers should be heeded.

**Detergent or vinegar and water.** Waterbased paints can usually be scrubbed off with hot water with a detergent added. Calcime and whitewash are difficult to remove; because of the lime or whiting content (calcium carbonate), however, they can be broken down with acids. While strong acids may work quickly, they are very dangerous. Acetic acid in its most common form, vinegar, (4% acetic acid) is often used instead. In areas where any calcime remains and is evident as chalk, the area can be coated with white shellac, which provides a stable surface for the new paint.

**Air pressure.** Air pressure of 200-500 psi is effective for flat surfaces if there is a weak
substrate surface bond. A flat nozzle is inserted between the paint layer and substrate, and the air pressure simply lifts the loose paint up for easy removal. When used carefully, this method is fast and causes little damage.

**Patching and Repair.** Once the substrate and its surface are sound and clean, free from crumbling, loose material or dust, the next step is to undercut and fill any cracks in plaster surfaces. Plaster which has lost its key and is sagging should be reattached or replaced. Friable plaster and punky wood need to be consolidated. Wood surfaces should be made as smooth as they were historically so that the paint film will cover a relatively uniform surface. Rotted wood must be removed and new wood carefully spliced in. Finally, gypsum plaster finishes can be painted as soon as the water has evaporated; a lime putty coat or traditional finish plaster can be primed almost immediately after drying as well, using alkali-resistant primers such as acrylic latex.

**Priming.** The importance of a primer can hardly be overstated. It is the intermediary material between the immediate substrate, which may be an old paint layer or may be bare wood, plaster, or metal (rarely stone, as around a fireplace opening), and the fresh paint itself. The primer must be capable of being absorbed to some extent by the material underneath while being compatible and cohesive with the paint to be applied on top. Most paint manufacturers will provide explicit instructions about which primers are most compatible with their paints. Those instructions should be followed.

The question of a primer for latex paint continues to be debated. Traditionalists recommend that the primer between an old oil paint and a new latex paint be an oil primer, but the improvements to latex paint in recent years have led many experts to the conclusion that today's top grade latex primers are best for latex finish paints. If a latex primer is selected, the label on the can should specify clearly that it is one which can bond to an older oil or oil/alkyd paint.

The most important general rule to remember is that softer or weaker paints should always go over harder and stronger paints. For instance, because latex is stronger than oil, an oil or oil/alkyd paint can go over a well adhered latex, but the reverse will run the risk of failure. Using primer and finish paints by a single company is a good way to guarantee compatibility.

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**Choosing Modern Paint Types/Finish Coats**

Most frequently today, the project goal is preservation or rehabilitation. Because of the impracticality of replicating historic paints, restoration is least often undertaken. Given current laws restricting the use of toxic ingredients, such as lead, solvents, and thinners, contemporary substitute paints using safer ingredients need to be used. Many paint companies make latex paints in colors that are close to historic colors as well as appropriate gloss levels, but contain no white lead and no hazardous volatile organic compounds.

Work on historic properties generally requires the services of a qualified paint contractor who has had at least five years of experience and who can list comparable jobs that a potential client can see. Then, too, getting a sample or a mockup of any special work may be advisable before the job starts. While less experienced workers may be acceptable for preparing and priming, it is wise to have the most experienced painters on the finish work.

**Oil-based/alkyd paints.** Today's version of oil paint has a binder that usually contains some linseed oil (read the paint can label), but also has one of the improved synthesized oils, frequently soybased, known as alkyls. They dry hard, have flexibility, and discolor

far less than linseed oil. They can also be manufactured to dry with a high sheen, and can take enough tinting pigment to create even the very deep Victorian period colors. However, they all contain volatile organic compounds, and thus are forbidden by law in some parts of the United States. They are also less simple and more dangerous to use, as cleaning up involves mineral spirits.

Acrylic waterborne paints (latex). Latex paints are synthetic resins carried in water. Before the paint dries or crosslinks, it can be cleaned up with water. Early in the history of latex paints, some contained styrene/butadiene resins. Now nearly all top grade latex paints contain acrylic resins, which are superior. Also, until fairly recently, the latex paints, while offering great strength, quick drying, and water cleanup, had some disadvantages for jobs which needed to have an historic look. Today, there are latex product lines with better gloss characteristics and more historic colors from which to choose. In addition, latex paints often have excellent color retention with very little fading. Still, it is always a good idea to buy a quart and "test paint" the color chosen for the job on site before making a total commitment.

Calcimine/whitewash. Modern waterbased paints such as calcimine can be purchased today and have much the same appearance as the early ones. The same is true of modern whitewash, although today's whitewashes do not leave the same ropy surface texture as the early ones.

Glazes. Glazes were often part of historic paint treatments. Traditionally oil and turpentine, sometimes with a scant amount of pigment, today's glazes can be formulated with a water base and are relatively simple to apply by brush. An experienced decorative painter should be consulted before deciding whether to use a glaze coat rather than a high-gloss enamel. The glaze is capable of providing protection as well as a more accurate historic appearance that includes a greater depth to the finish.

Epoxies/Urethane. These were not available until relatively recently and thus are not appropriate for replication of traditional finishes.

Applying Interior Paints

Because flat wall surfaces generally dominate an interior painting job, some flexibility in applicators is suggested below:

Brushes. Natural bristle brushes now have competition from synthetic brushes made of nylon or polyester which work well for applying either oil/alkyd or latex paints. Being harder than natural bristles, they tend to last longer. Since brushes come in a wide and very specific variety of types suited to different types of work, it is important to have a painter who will use the appropriate brush for the paint selected and for each portion of the job. One strong advantage of brushing paint on is that the paint is forced onto the surface and into all of its imperfections. Thus a good brushedin paint job may last longer if the substrate is sound and the primer and finish coats are compatible and of top quality.
Rollers. There is no harm in using a roller, or even an airless sprayer, to apply a prime coat to a large flat area. Since all contemporary commercial paints dry with a smooth surface anyway, use of a roller or sprayer is acceptable for priming, and even for a first finish coat. However, to get paint well pushed into articulated surfaces and to add some texture to larger flat surfaces, a brush is best.

Types of Modern Paint

Oilbased/alkyd: Nonvolatile oils and resins, with thinners. (Alkyds are synthetic, gelatinous resins compounded from acids and alcohol.) Accept almost any type of coloring/hiding pigments. For use on interior wood and metal.

Acrylic waterborne paints (latex): Suspension of acrylic or polyvinyl resins in water, with other resins, plus hiding and coloring pigments and extenders. Dries by evaporation. Commercially produced acrylic or latex enamels are also available in a complete range of gloss levels which are produced with the addition of various acrylic polymers. Use on interior plaster especially.

Enamels: Modern alkyd paints are adjusted with the addition of synthetic varnishes to produce a complete range of gloss levels.

Metal finishes: Paints marketed for use on metals, can either be alkyd, latex, or epoxy based, or combinations. The primers used for metals are formulated with rustinhibiting ingredients.

Special finishes: finishes such as urethane and epoxy-based paints, marketed for very high gloss surface treatments.

Finally, decorative paint work in an historic interior—whether simple or highstyle—is well worth preserving or restoring, and when such fancy work is being undertaken, traditional tools should always be used. To simplify by using shortcut methods or rejecting painted decoration is indeed to dismiss or skew history as well as to lose the enjoyment of a true historic finish.

Summary

First, it is most important to understand the range of approaches and treatments and to make choices with as much knowledge of the original and subsequent historic paints as possible, using the Secretary of the Interior’s Standards for the Treatment of Historic Properties as a framework.

A paint’s patina of age expresses decades or centuries of endurance in the face of changing climate and conditions. Documenting the sequence of interior paint layers and protecting this information for future investigation should be an integral part of any historic preservation project.

Except for the rare, scholarly restorations of historic interiors, most repainting jobs done today will employ modern paint formulations. Modern paints can recreate the appearance of historic colors, gloss and texture in varying degrees, but
CAUTION: Before Painting Know Paint Hazards and Take Action

Before undertaking any project involving paint removal, applicable State and Federal laws on lead paint abatement and disposal must be taken into account and carefully followed. State and Federal requirements may affect options available to owners on both paint removal and repainting. These laws, as well as any requirements prohibiting volatile organic compounds (VOCs), should be requested from the State Historic Preservation Officer in each State.

Below is a summary of the health hazards that owners, managers, and workers need to be aware of before removing paint and repainting:

Lead and other heavy metal compounds. In virtually all paints made before 1950, the white or "hiding" pigment was a lead compound, or more rarely, zinc oxide. Work to remove lead paint such as scraping and dry sanding releases the lead—a highly damaging heavy metal—in dust. Lead dust then enters the human system through pores of the skin and through the lungs. The use of heat for stripping also creates toxic lead fumes which can be inhaled.

To mitigate the hazards of lead paint ingestion, inhalation, or contact, it is extremely important to prevent the dust from circulating by masking room openings and removing all curtains, carpeting, and upholstered furniture. Drop cloths and masking containing lead dust should be carefully enclosed in tight plastic bags before removal. Workers and others in the room should wear High Efficiency Particulate Air (HEPA) filters for lead dust (fume filters if heat stripping is being used), change clothing just outside the room leaving the work clothes inside, and avoid any contact between bare skin (hands) and the paint being removed. Workers should also not eat, drink, or smoke where lead dust is present. Finally, anyone involved in lead paint removal should undergo periodic blood testing. After work, ordinary vacuuming is not enough to remove lead dust; special HEPA vacuums are essential. The surfaces of the room must also be given a final wash with a solution of trisodium phosphate and water, changing the washing solution often and rinsing well.

In addition to lead, early oil paints also had cobalt or other heavy metal compounds in them to accelerate drying. A small amount of mercury is also included in some latex paints to help prevent mildew and mold formation.

Volatile organic compounds (VOCs). Organic paint strippers, such as methylene chloride, and oil/alkyd paints have VOCs as their solvent base. Inhaling these fumes can lead to respiratory and other illnesses, and to cancer. Especially in closed spaces (but in the outdoor environment as well) these compounds pollute the air and can damage health.

Additional Reading


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**Organizations**

**National Paint and Coatings Association**
1500 Rhode Island Ave. N.W.
Washington, D.C. 20005

**Painting and Decorating Contractors of America**
3913 Old Lee Highway, Suite 33B
Fairfax, VA 22030

**Federation of Societies for Coatings Technology**
492 Norristown Rd.
Blue Bell, PA 19422-2350

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Home page logo: Restoration of decorative paint finishes. Photo: Sara B. Chase.

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Making Historic Properties Accessible

Thomas C. Jester and Sharon C. Park, AIA

» Planning Accessibility Modifications
» Review the Historical Significance
» Assess Existing and Required Accessibility
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A NOTE TO OUR USERS: The web versions of the Preservation Briefs differ somewhat from the printed versions. Many illustrations are new, captions are simplified, illustrations are typically in color rather than black and white, and some complex charts have been omitted.

Historically, most buildings and landscapes were not designed to be readily accessible for people with disabilities. In recent years, however, emphasis has been placed on preserving historically significant properties, and on making these properties and the activities within them more accessible to people with disabilities. With the passage of the Americans with Disabilities Act in 1990, access to properties open to the public is now a civil right.

This Preservation Brief introduces the complex issue of providing accessibility at historic properties, and underscores the need to balance accessibility and historic preservation. It provides guidance on making historic properties accessible while preserving their historic character; the Brief also provides examples to show that independent physical accessibility at historic properties can be achieved with careful planning, consultation, and sensitive design. While the Brief focuses primarily on making buildings and their sites accessible, it also includes a section on historic landscapes. The Brief will assist historic property owners, design professionals, and administrators in evaluating their historic properties so that the highest level of accessibility can be provided while minimizing changes to historic materials and features. Because many projects encompassing accessibility work are complex, it is advisable to consult with experts in the fields of historic preservation and accessibility before proceeding with permanent physical changes to historic properties.

Modifications to historic properties to increase accessibility may be as simple as a small, inexpensive ramp to overcome one entrance step, or may involve changes to exterior and interior features. The Brief does not provide a detailed explanation of local or State accessibility laws as they vary from jurisdiction to jurisdiction. A concise explanation of several federal accessibility laws is included below.

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**Planning Accessibility Modifications**

Historic properties are distinguished by features, materials, spaces, and spatial relationships that contribute to their historic character. Often these elements, such as steep terrain, monumental steps, narrow or heavy doors, decorative ornamental hardware, and narrow pathways and corridors, pose barriers to persons with disabilities, particularly to wheelchair users.

A three-step approach is recommended to identify and implement accessibility modifications that will protect the integrity and historic character of historic properties:

1) Review the historical significance of the property and identify character-defining features; 2) Assess the property's existing and required level of accessibility; and 3) Evaluate accessibility options within a preservation context.

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1) **Review the Historical Significance of the Property**

If the property has been designated as historic (properties that are listed in, or eligible for listing in the National Register of Historic Places, or designated under State or local law), the property's nomination file should be reviewed to learn about its significance. Local preservation commissions and State Historic Preservation Offices can usually provide copies of the nomination file and are also resources for additional information and assistance. Review of the written documentation should always be supplemented with a physical investigation to identify which character defining features and spaces must be protected whenever any changes are anticipated. If the level of documentation for a property's significance is limited, it may be necessary to have a preservation professional identify specific historic features, materials, and spaces that should be protected.

For most historic properties, the construction materials, the form and style of the property, the principal elevations, the major architectural or landscape features, and the principal public spaces constitute some of the elements that should be preserved. Every effort should be made to minimize damage to the materials and features that convey a property's historical significance when making modifications for accessibility. Very small or highly significant properties that have never been altered may be extremely difficult to modify.

Secondary spaces and finishes and features that may be less important to the historic character should also be identified; these may generally be altered without jeopardizing the historical significance of a property. Nonsignificant spaces, secondary pathways, later additions, previously altered areas, utilitarian spaces, and service areas can usually be modified without threatening or destroying a property's historical significance.
2) Assess the Property's Existing and Required Level of Accessibility

A building survey or assessment will provide a thorough evaluation of a property's accessibility. Most surveys identify accessibility barriers in the following areas: building and site entrances; surface textures, widths and slopes of walkways; parking; grade changes; size, weight and configuration of doorways; interior corridors and path of travel restrictions; elevators; and public toilets and amenities. Simple audits can be completed by property owners using readily available checklists (See Further Reading). Accessibility specialists can be hired to assess barriers in more complex properties, especially those with multiple buildings, steep terrain, or interpretive programs. Persons with disabilities can be particularly helpful in assessing specific barriers.

All applicable accessibility requirements—local codes, State codes and federal laws—should be reviewed carefully before undertaking any accessibility modification. Since many States and localities have their own accessibility regulations and codes (each with their own requirements for dimensions and technical requirements), owners should use the most stringent accessibility requirements when implementing modifications. The Americans with Disability Act Accessibility Guidelines (ADAAG) is the document that should be consulted when complying with the Americans with Disabilities Act (ADA) requirements.

3) Identify and Evaluate Accessibility Options within a Preservation Context

Once a property's significant materials and features have been identified, and existing and required levels of accessibility have been established, solutions can be developed. Solutions should provide the greatest amount of accessibility without threatening or destroying those materials and features that make a property significant. Modifications may usually be phased over time as funds are available, and interim solutions can be considered until more permanent solutions are implemented. A team comprised of persons with disabilities, accessibility and historic preservation professionals, and building inspectors should be consulted as accessibility solutions are developed.

Modifications to improve accessibility should generally be based on the following priorities:

1) Making the main or a prominent public entrance and primary public spaces accessible, including a path to the entrance; 2) Providing access to goods, services, and programs; 3) Providing accessible restroom facilities; and, 4) Creating access to amenities and secondary spaces.

All proposed changes should be evaluated for conformance with the Secretary of the Interior's "Standards for the Treatment of Historic Properties," which were created for property owners to guide preservation work. These Standards stress the importance of retaining and protecting the materials and features that convey a property's historical significance. Thus, when new features are incorporated for accessibility, historic materials and features should be retained whenever possible. Accessibility modifications should be in scale with the historic property, visually compatible, and, whenever possible, reversible. Reversible means that if the new feature were removed at a later date, the essential form and integrity of the property would be unimpaired. The design of new features should also be differentiated from the design of the historic property so that the evolution of the property
is evident.

In general, when historic properties are altered, they should be made as accessible as possible. However, if an owner or a project team believes that certain modifications would threaten or destroy the significance of the property, the State Historic Preservation Officer should be consulted to determine whether or not any special accessibility provisions may be used. Special accessibility provisions for historic properties will vary depending on the applicable accessibility requirements.

In some cases, programmatic access may be the only option for extremely small or unaltered historic properties, such as a two-story house museum with no internal elevator. Programmatic access for historic properties refers to alternative methods of providing services, information, and experiences when physical access cannot be provided. It may mean offering an audio-visual program showing an inaccessible upper floor of a historic house museum, providing interpretive panels from a vista at an inaccessible terraced garden, or creating a tactile model of a historic monument for people with visual impairments.

Accessibility Solutions

The goal in selecting appropriate solutions for specific historic properties is to provide a high level of accessibility without compromising significant features or the overall character of the property. The following sections describe accessibility solutions and offer guidance on specific historic property components, namely the building site, entrances, interiors, landscapes, amenities, and new additions. Several solutions are discussed in each section, referencing dimensions and technical requirements from the ADA's accessibility guidelines, ADAAG. State and local requirements, however, may differ from the ADA requirements. Before making any modification owners should be aware of all applicable accessibility requirements.

The Building Site

An accessible route from a parking lot, sidewalk, and public street to the entrance of a historic building or facility is essential. An accessible route, to the maximum extent possible, should be the circulation route used by the general public. Critical elements of accessible routes are their widths, slopes, cross slopes, and surface texture. Each of these route elements must be appropriately designed so that the route can be used by everyone, including people with disabilities. The distance between the arrival and destination points should also be as short as possible. Sites containing designed landscapes should be carefully evaluated before making accessibility modifications. Historic landscapes are described in greater detail below.

Providing Convenient Parking. If parking is provided, it should be as convenient as possible for people with disabilities. Specially designated parking can often be created to improve accessibility. Modifications to parking configurations and pathways should not alter significant landscape features.

Creating an Accessible Route. The route or path through a site to a historic building's entrance should be wide enough, generally at least 3 feet (91 cm), to accommodate
visitors with disabilities and must be appropriately graded with a stable, firm, and slip-resistant surface. Existing paths should be modified to meet these requirements whenever possible as long as doing so would not threaten or destroy significant materials and features.

Existing surfaces can often be stabilized by providing a new base and resetting the paving materials, or by modifying the path surface. In some situations it may be appropriate to create a new path through an inaccessible area. At large properties, it may be possible to regrade a slope to less than 1:20 (5%), or to introduce one or more carefully planned ramps. Clear directional signs should mark the path from arrival to destination.

**Entrances**

Whenever possible, access to historic buildings should be through a primary public entrance. In historic buildings, if this cannot be achieved without permanent damage to character-defining features, at least one entrance used by the public should be made accessible. If the accessible entrance is not the primary public entrance, directional signs should direct visitors to the accessible entrance. A rear or service entrance should be avoided as the only mean of entering a building.

Creating an accessible entrance usually involves overcoming a change in elevation. Steps, landings, doors, and thresholds, all part of the entrance, often pose barriers for persons with disabilities. To preserve the integrity of these features, a number of solutions are available to increase accessibility. Typical solutions include regrading, incorporating ramps, installing wheelchair lifts, creating new entrances, and modifying doors, hardware, and thresholds.

**Regrading an Entrance.** In some cases, when the entrance steps and landscape features are not highly significant, it may be possible to regrade to provide a smooth entrance into a building. If the existing steps are historic masonry, they should be buried, whenever possible, and not removed.

**Incorporating Ramps.**

Permanent ramps are perhaps the most common means to make an entrance accessible. As a new feature, ramps should be carefully designed and appropriately located to preserve a property's historic character.

Ramps should be located at public entrances used by everyone whenever possible, preferably where there is minimal change in grade. Ramps should also be located to minimize the loss of historic features at the connection points-porch railings, steps, and windows-and should preserve the overall historic setting and character of the property. Larger buildings may have below grade areas that can accommodate a ramp down to an entrance. Below grade entrances can be considered if the ramp leads to a publicly used interior, such as an auditorium, or if the building is serviced by a public elevator. Ramps can often be incorporated behind historic features, such as cheek-walls or railings, to minimize the visual effect.
The steepest allowable slope for a ramp is usually 1:12 (8%), but gentler slopes should be used whenever possible to accommodate people with limited strength. Greater changes in elevation require larger and longer ramps to meet accessibility scoping provisions and may require an intermediate landing. Most codes allow a slightly steeper ramp for historic buildings to overcome one step.

Ramps can be faced with a variety of materials, including wood, brick, and stone. Often the type and quality of the materials determines how compatible a ramp design will be with a historic property. Unpainted pressure-treated wood should not be used to construct ramps because it usually appears temporary and is not visually compatible with most historic properties.

Railings should be simple in design, distinguishable from other historic features, and should extend one foot beyond the sloped area.

Ramp landings must be large enough for wheelchair users, usually at least 5 feet by 5 feet (152.5 cm by 152.5 cm), and the top landing must be at the level of the door threshold. It may be possible to reset steps by creating a ramp to accommodate minor level changes and to meet the threshold without significantly altering a property's historic character. If a building's existing landing is not wide or deep enough to accommodate a ramp, it may be necessary to modify the entry to create a wider landing. Long ramps, such as switchbacks, require intermediate landings, and all ramps should be detailed with an appropriate edge and railing for wheelchair users and visually impaired individuals.

Temporary or portable ramps are usually constructed of light-weight materials and, thus, are rarely safe or visually compatible with historic properties. Moreover, portable ramps are often stored until needed and, therefore, do not meet accessibility requirements for independent access. Temporary and portable ramps, however, may be an acceptable interim solution to improve accessibility until a permanent solution can be implemented.

**Installing Wheelchair Lifts.** Platform lifts and inclined stair lifts, both of which accommodate only one person, can be used to overcome changes of elevation ranging from three to 10 feet (.9 m-3 m) in height. However, many States have restrictions on the use of wheelchair lifts, so all applicable codes should be reviewed carefully before installing one. Inclined stair lifts, which carry a wheelchair on a platform up a flight of stairs, may be employed selectively. They tend to be visually intrusive, although they are relatively reversible. Platform lifts can be used when there is inadequate space for a ramp. However, such lifts should be installed in unobtrusive locations and under cover to minimize maintenance if at all possible. A similar, but more expensive platform lift has a retracting railing that lowers into the ground, minimizing the visual effect to historic properties. Mechanical lifts have drawbacks at historic properties with high public visitation because their capacity is limited, they sometimes cannot be operated independently, and they require frequent maintenance.

**Considering a New Entrance.** When it is not possible to modify an existing entrance, it may be possible to develop a new entrance by creating an entirely new opening in an appropriate location, or by using a secondary window for an opening. This solution should only be considered after exhausting all possibilities for modifying existing entrances.

**Retrofitting Doors.** Historic doors generally should not be replaced, nor should door frames on the primary elevation be widened, as this may alter an important feature of a historic design. However, if a building's historic doors have been removed, there may be greater latitude in designing a compatible new entrance. Most accessibility standards require at least a 32" (82 cm) clear opening with manageable door opening pressures.
The most desirable preservation solution to improve accessibility is retaining historic doors and upgrading the door pressure with one of several devices. Automatic door openers (operated by push buttons, mats, or electronic eyes) and power-assisted door openers can eliminate or reduce door pressures that are accessibility barriers, and make single or double-leaf doors fully operational.

**Adapting Door Hardware.** If a door opening is within an inch or two of meeting the 32" (81 cm) clear opening requirement, it may be possible to replace the standard hinges with off-set hinges to increase the size of the door opening as much as 1 ½" (3.8 cm). Historic hardware can be retained in place, or adapted with the addition of an automatic opener, of which there are several types. Door hardware can also be retrofitted to reduce door pressures. For example, friction hinges can be retrofitted with ball-bearing inserts, and door closers can be rethreaded to reduce the door pressure.

**Altering Door Thresholds.** A door threshold that exceeds the allowable height, generally ½" (1.3 cm), can be altered or removed with one that meets applicable accessibility requirements. If the threshold is deemed to be significant, a bevel can be added on each side to reduce its height. Another solution is to replace the threshold with one that meets applicable accessibility requirements and is visually compatible with the historic entrance.

**Readily Achievable Accessibility Options**

Many accessibility solutions can be implemented easily and inexpensively without destroying the significance of historic properties. While it may not be possible to undertake all of the modifications listed below, each change will improve accessibility.

**Sites and Entrances**

- Creating a designated parking space.
- Installing ramps.
- Making curb cuts.

**Interiors**

- Repositioning shelves.
- Rearranging tables, displays, and furniture.
- Repositioning telephones.
- Adding raised markings on elevator control buttons.
- Installing flashing alarm lights.
- Installing offset hinges to widen doorways.
- Installing or adding accessible door hardware.
- Adding an accessible water fountain, or providing a paper cup dispenser at an inaccessible water fountain.

**Restrooms**

- Installing grab bars in toilet stalls.
- Rearranging toilet partitions to increase maneuvering space.
- Insulating lavatory pipes under sinks to prevent burns.

http://www.nps.gov/history/hps/TPS/briefs/brief32.htm
• Installing a higher toilet seat.
• Installing a full-length bathroom mirror.
• Repositioning the paper towel dispenser.

Moving Through Historic Interiors

Persons with disabilities should have independent access to all public areas and facilities inside historic buildings. The extent to which a historic interior can be modified depends on the significance of its materials, plan, spaces, features, and finishes. Primary spaces are often more difficult to modify without changing their character. Secondary spaces may generally be changed without compromising a building’s historic character. Signs should clearly mark the route to accessible restrooms, telephones, and other accessible areas.

Installing Ramps and Wheelchair Lifts. If space permits, ramps and wheelchair lifts can also be used to increase accessibility inside buildings. However, some States and localities restrict interior uses of wheelchair lifts for life-safety reasons. Care should be taken to install these new features where they can be readily accessed. Ramps and wheelchair lifts are described below.

Upgrading Elevators. Elevators are an efficient means of providing accessibility between floors. Some buildings have existing historic elevators that are not adequately accessible for persons with disabilities because of their size, location, or detailing, but they may also contribute to the historical significance of a building. Significant historic elevators can usually be upgraded to improve accessibility. Control panels can be modified with a "wand" on a cord to make the control panel accessible, and timing devices can usually be adjusted.

Retrofitting Door Knobs. Historic door knobs and other hardware may be difficult to grip and turn. In recent years, lever-handles have been developed to replace door knobs. Other lever-handle devices can be added to existing hardware. If it is not possible or appropriate to retrofit existing door knobs, doors can be left open during operating hours (unless doing so would violate life safety codes), and power-assisted door openers can be installed. It may only be necessary to retrofit specific doorknobs to create an accessible path of travel and accessible restrooms.

Modifying Interior Stairs. Stairs are the primary barriers for many people with disabilities. However, there are some ways to modify stairs to assist people who are able to navigate them. It may be appropriate to add hand railings if none exist. Railings should be 1 ¼" (3.8 cm) in diameter and return to the wall so straps and bags do not catch. Color-contrasting, slip-resistant strips will help people with visual impairments. Finally, beveled or closed risers are recommended unless the stairs are highly significant, because open risers catch feet.

Building Amenities

Some amenities in historic buildings, such as restrooms, seating, telephones, drinking fountains, counters, may contribute to a building’s historic character. They will often require modification to improve their use by persons with disabilities. In many cases, supplementing existing amenities, rather than changing or removing them, will increase access and minimize changes to historic features and materials.

Upgrading Restrooms. Restrooms may have historic fixtures such as sinks, urinals, or
marble partitions that can be retained in the process of making modifications. For example, larger restrooms can sometimes be reconfigured by relocating or combining partitions to create an accessible toilet stall. Other changes to consider are adding grab bars around toilets, covering hot water pipes under sinks with insulation to prevent burns, and providing a sink, mirror, and paper dispenser at a height suitable for wheelchair users. A unisex restroom may be created if it is technically infeasible to create two fully accessible restrooms, or if doing so would threaten or destroy the significance of the building. It is important to remember that restroom fixtures, such as sinks, urinals, and partitions, may be historic, and therefore, should be preserved whenever possible.

**Modifying Other Amenities.** Other amenities inside historic buildings may require modification. Seating in a theater, for example, can be made accessible by removing some seats in several areas. New seating that is accessible can also be added at the end of existing rows, either with or without a level floor surface. Readily removable seats may be installed in wheelchair spaces when the spaces are not required to accommodate wheelchair users. Historic water fountains can be retained and new, two-tiered fountains installed if space permits. If public telephones are provided, it may be necessary to install at least a Text Telephone (TT), also known as a Telecommunication Device for the Deaf (TDD). Historic service counters commonly found in banks, theaters, and hotels generally should not be altered. It is preferable to add an accessible counter on the end of a historic counter if feasible. Modified or new counters should not exceed 36" (91.5 cm) in height.

**Making Historic Landscapes Accessible**

To successfully incorporate access into historic landscapes, the planning process is similar to that of other historic properties. Careful research and inventory should be undertaken to determine which materials and features convey the landscape's historical significance. As part of this evaluation, those features that are character-defining (topographical variation, vegetation, circulation, structures, furnishings, objects) should be identified. Historic finishes, details, and materials that also contribute to a landscape's significance should also be documented and evaluated prior to determining an approach to landscape accessibility. For example, aspects of the pedestrian circulation system that need to be understood include walk width, aggregate size, pavement pattern, texture, relief, and joint details. The context of the walk should be understood including its edges and surrounding area. Modifications to surface textures or widths of pathways can often be made with minimal effect on significant landscape features.

Additionally, areas of secondary importance such as altered paths should be identified—especially those where the accessibility modifications will not destroy a landscape's significance. By identifying those features that are contributing or non-contributing, a sympathetic circulation experience can then be developed.

After assessing a landscape's integrity, accessibility solutions can be considered. Full access throughout a historic landscape may not always be possible. Generally, it is easier to provide accessibility to larger, more open sites where there is a greater variety of public experiences. However, when a landscape is uniformly steep, it may only be possible to make discrete portions of a historic landscape accessible, and viewers may only be able to experience the landscape from selected vantage points along a prescribed pedestrian or vehicular access route. When defining such a route, the interpretive value of the user experience should be considered; in other words, does the route provide physical or visual access to those areas that are critical to understand the meaning of the landscape?

**Considering a New Addition as an Accessibility Solution**
Many new additions are constructed specifically to incorporate modern amenities such as elevators, restrooms, fire stairs, and new mechanical equipment. These new additions often create opportunities to incorporate access for people with disabilities. It may be possible, for example, to create an accessible entrance, path to public levels via a ramp, lift, or elevator. However, a new addition has the potential to change a historic property’s appearance and destroy significant building and landscape features. Thus, all new additions should be compatible with the size, scale, and proportions of historic features and materials that characterize a property.

New additions should be carefully located to minimize connection points with the historic building, such that if the addition were to be removed in the future, the essential form and integrity of the building would remain intact. On the other hand, new additions should also be conveniently located near parking that is connected to an accessible route for people with disabilities. As new additions are incorporated, care should be taken to protect significant landscape features and archeological resources. Finally, the design for any new addition should be differentiated from the historic design so that the property’s evolution over time is clear. New additions frequently make it possible to increase accessibility, while simultaneously reducing the level of change to historic features, materials, and spaces.

Federal Accessibility Laws

Today, few building owners are exempt from providing accessibility for people with disabilities. Before making any accessibility modification, it is imperative to determine which laws and codes are applicable. In addition to local and State accessibility codes, the following federal accessibility laws are currently in effect:

Architectural Barriers Act (1968)

The Architectural Barriers Act stipulates that all buildings designed, constructed, and altered by the Federal Government, or with federal assistance, must be accessible. Changes made to federal buildings must meet the Uniform Federal Accessibility Standards (UFAS). Special provisions are included in UFAS for historic buildings that would be threatened or destroyed by meeting full accessibility requirements.

Rehabilitation Act (1973)

The Rehabilitation Act requires recipients of federal financial assistance to make their programs and activities accessible to everyone. Recipients are allowed to make their properties accessible by altering their building, by moving programs and activities to accessible spaces, or by making other accommodations.

Americans with Disabilities Act (1990)

Historic properties are not exempt from the Americans with Disabilities Act (ADA) requirements. To the greatest extent possible, historic buildings must be as accessible as non-historic buildings. However, it may not be possible for some historic properties to meet the general accessibility requirements.
Under Title II of the ADA, State and local governments must remove accessibility barriers either by shifting services and programs to accessible buildings, or by making alterations to existing buildings. For instance, a licensing office may be moved from a second floor to an accessible first floor space, or if this is not feasible, a mail service might be provided. However, State and local government facilities that have historic preservation as their main purpose-State-owned historic museums, historic State capitols that offer tours-must give priority to physical accessibility.

Under Title III of the ADA, owners of "public accommodations" (theaters, restaurants, retail shops, private museums) must make "readily achievable" changes; that is, changes that can be easily accomplished without much expense. This might mean installing a ramp, creating accessible parking, adding grab bars in bathrooms, or modifying door hardware. The requirement to remove barriers when it is "readily achievable" is an ongoing responsibility. When alterations, including restoration and rehabilitation work, are made, specific accessibility requirements are triggered.

Recognizing the national interest in preserving historic properties, Congress established alternative requirements for properties that cannot be made accessible without "threatening or destroying" their significance. A consultation process is outlined in the ADA's Accessibility Guidelines for owners of historic properties who believe that making specific accessibility modifications would "threaten or destroy" the significance of their property. In these situations, after consulting with persons with disabilities and disability organizations, building owners should contact the State Historic Preservation Officer (SHPO) to determine if the special accessibility provisions for historic properties may be used. Further, if it is determined in consultation with the SHPO that compliance with the minimum requirements would also 'threaten or destroy' the significance of the property, alternative methods of access, such as home delivery and audio-visual programs, may be used.

**Conclusion**

Historic properties are irreplaceable and require special care to ensure their preservation for future generations. With the passage of the Americans with Disabilities Act, access to historic properties open to the public is a new civil right, and owners of historic properties must evaluate existing buildings and determine how they can be made more accessible. It is a challenge to evaluate properties thoroughly, to identify the applicable accessibility requirements, to explore alternatives and to implement solutions that provide independent access and are consistent with accepted historic preservation standards. Solutions for accessibility should not destroy a property's significant materials, features and spaces, but should increase accessibility as much as possible. Most historic buildings are not exempt from providing accessibility, and with careful planning, historic properties can be made more accessible, so that all citizens can enjoy our Nation's diverse heritage.

**Additional Reading**


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*Home page logo: Accessible historic building. Photo: NPS files.*

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"Stained glass" can mean colored, painted or enameled glass, or glass tinted with true glass "stains." In this Brief the term refers to both colored and painted glass. "Leaded glass" refers generically to all glass assemblies held in place by lead, copper, or zinc came. Because the construction, protection, and repair techniques of leaded glass units are similar, whether the glass itself is colored or clear, "stained glass" and "leaded glass" are used interchangeably throughout the text.

Glass is a highly versatile medium. In its molten state, it can be spun, blown, rolled, cast in any shape, and given any color. Once cooled, it can be polished, beveled, chipped, etched, engraved, or painted. Of all the decorative effects possible with glass, however, none is more impressive than "stained glass." Since the days of ancient Rome, stained glass in windows and other building elements has shaped and colored light in infinite ways.

Stained and leaded glass can be found throughout America in a dazzling variety of colors, patterns, and textures (Fig. 1). It appears in windows, doors, ceilings, fanlights, sidelights, light fixtures, and other glazed features found in historic buildings (Fig. 2). It appears in all building types and architectural styles—embellishing the light in a great cathedral, or adding a touch of decoration to the smallest rowhouse or bungalow. A number of notable churches, large mansions, civic buildings, and other prominent buildings boast windows or ceilings by LaFarge, Tiffany, Connick, or one of many other, lesser-known, American masters, but stained or leaded glass also appears as a prominent feature in great numbers of modest houses built between the Civil War and the Great Depression.

This Brief gives a short history of stained and leaded glass in America. It also surveys basic preservation and documentation issues facing owners of buildings with leaded glass. It addresses common causes of deterioration and presents repair, restoration, and protection options. It does not offer detailed advice on specific work treatments. Glass is one of the most durable, yet fragile building materials. While stained glass windows can last for centuries, as the great cathedrals of Europe attest, they can be instantly destroyed by vandals or by careless workmen. Extreme care must therefore be exercised, even in the most minor work. For this reason, virtually all repair or restoration work undertaken on stained and leaded glass must be done by professionals, whether the feature is a magnificent stained glass window or a clear, leaded glass storefront transom. Before undertaking any repair work, building owners or project managers should screen studios carefully, check references, inspect other projects, and require duplicate documentation of any work so that full records can be maintained. Consultants should be employed on major projects.

Figure 1. This door and transom suggest the richness of 19th century leaded glass. Photo: Jack E. Boucher, HABS.
**Historical Background**

Glassblowers were among the founders of Jamestown in 1607, and early glass manufacturing was also attempted in 17th-century Boston and Philadelphia. Dutch colonists in the New Netherlands enjoyed painted oval or circular medallions that bore the family's coat of arms or illustrated Dutch proverbs. German colonists in the mid-Atlantic region also began early glass ventures. Despite the availability of good natural ingredients, each of these early American glassmakers eventually failed due to production and managerial difficulties. As a result, colonists imported most of their glass from England throughout the 17th and 18th centuries.

Social values as well as high costs also restricted the use of stained and other ornamental glass. This was particularly true with regard to churches. The Puritans, who settled New England, rejected the religious imagery of the Church of England, and built simple, undecorated churches with clear glass windows. Less than 1% of the Nation's stained and leaded glass predates 1700. Considering the enormous loss of 17th-, 18th-, and early 19th-century buildings, any window glass surviving from these periods is very significant (Fig. 3). Every effort should be made to document and preserve it.

Despite many failed starts, the War of 1812, and British competition, American glass production increased steadily throughout the 19th century. Stained glass was available on a very limited basis in America during the first quarter of the 19th century, but American stained glass did not really emerge in its own right until the 1840s. The windows at St. Ann and the Holy Trinity Episcopal Church in Brooklyn, New York, made by John and William Jay Bolton between 1843 and 1848, are perhaps the most significant early American stained glass installation (Fig. 4). Other important early stained glass commissions were the glass ceilings produced by the J. & G. H. Gibson Company of Philadelphia for the House and Senate chambers of the United States Capitol in 1859.

America's glass industry boomed during the second half of the 19th century. (And although stained and leaded glass is found nationwide, the manufacturing was based in the Northeast and Midwest, where good natural ingredients for glass, and coal reserves...
for the kilns were available. Moreover, nearly all of
the nationally renowned studios were based in major
metropolitan areas of the central and northeastern
states—near the manufacturers that supplied their raw
materials.) In response to this growth, the industry
formed self-regulating associations that established
guidelines for business and production. In 1879
the Window Glass Association of America was
established, and in 1903 The National Ornamental Glass
Manufacturers' Association, precursor of the Stained
Glass Association in America, was formed.

The 60 years from about 1870 to 1930 were the high
point for stained glass in the U.S. In the early years,
American stylistic demands reflected those current
in Europe, including various historic revivals, and
aesthetic and geometric patterns. American patterns
prevailed thereafter; they tended to be more vivid,
brash, and bold (Fig. 5).

After the 1893 Columbia World's Exposition, the Art
Nouveau Style became the rage for windows. Sinuous
nymphs, leggy maidens, whiplashed curves, lilies, and
rambles became standard subjects until World War I.
Among the leading proponents of the Art Nouveau
Style were glassmakers John LaFarge and Louis Comfort
Tiffany. Both men experimented independently
throughout the 1870s to develop opalescent glass, which
LaFarge was first to incorporate into his windows.
Tiffany became the better-known, due in part to his
prolific output.

He attracted world-class artists and innovative
glassmakers to his studio. Today, "Tiffany" remains a
household name. His favorite and most popular scenes
were naturalistic images of flowers, colorful peacocks
and cockatiels, and landscapes at sunrise and sunset
(Fig. 6). LaFarge, while appreciated in his own day,
grADually slid into relative obscurity, from which he has
emerged in recent decades. Tiffany and LaFarge are the
greatest names in American stained glass.

In dramatic contrast to the American Art Nouveau style
was the Neo-Gothic movement that became so popular
for church and university architecture across the country.
Charles J. Connick was a leading designer of medieval-
style windows characteristic of the style (Fig. 7).

Advocates of the Prairie Style, of whom Frank Lloyd
Wright is the best known, rejected Tiffany's naturalistic
scenes and Connick's Gothic imitations. (Fig. 8).
Wright's rectilinear organic abstractions developed
simultaneously with the similar aesthetic of the various
European Secessionists. The creation of this style was
aided by the development of zinc and copper came
in 1893. These came — much stiffer than lead — made
it possible to carry out the linear designs of Prairie
School windows with fewer support bars. At first, these
windows had only an elitist following, but they were
soon widely accepted and proliferated during the early
20th century.

By 1900, stained and leaded glass was being mass-
produced and was available to almost everyone.
Leading home journals touted leaded glass windows for
domestic use, and a nationwide building boom created
an unprecedented demand for stained and leaded art
glass windows, door panels, and transoms. Mail order
catalogs from sash and blind companies appeared,
some offering over 100 low-cost, mass produced designs
(although the same catalogs assured buyers that their
leaded glass was “made to order”) (Fig. 9).

The fading popularity of the ornate Victorian styles,
combined with inferior materials used for mass
production, essentially eliminated the production
of quality leaded glass. The last mail order catalogs
featuring stained glass were published in the mid-1920s,
and tastes changed to the point that the 1926 House
Beautiful Building Annual declared: “the crude stained
glass windows in many of the Mansard-roof mansions
of the ‘eighties [1880s] prove how dreadful glass can be
when wrongly used.”

Some creative efforts expanded leaded glass media in new
directions. Lead-overlay or “silhouette” glass was one
novelty that climaxxed in the late 1920s and early 1930s.
Some designers sandwiched glass between layers of hand-
cut sheet lead, while others sandwiched the perforated
sheet lead between layers of glass. These windows
present a playful reversal from traditional stained glass;
in “silhouette” glass the lead metalwork, rather than the
glass, becomes the primary art form (Fig. 10). However,
such novelties failed to catch on during the Depression.
World War II delivered the final blow and ornamental
glass is seldom found in residential, commercial, and
secular architecture after circa 1940. The great age of
American stained glass was over. Fortunately, leaded
glass panels survived in uncounted numbers throughout
the country, and are now once again appreciated as
virtually irreplaceable features of historic buildings.
Dating and Documenting Historic Leaded Glass

Before deciding on any treatment for historic leaded glass, every effort should be made to understand—and to record—its history and composition. Documentation is strongly encouraged for significant windows. Assigning an accurate date, maker, and style to a stained glass window often requires extensive research and professional help. A documentation and recording project, however, is worth the effort and expense, as insurance against accidents, vandalism, fire and other disasters. The better the information available, the better the restoration can be. The following sources offer some guidelines for dating leaded windows.

Building Context. The history of the building can provide ready clues to the history of its leaded windows, doors, and other elements. The construction date, and dates of major additions and alterations, should be ascertained. Later building campaigns may have been a time for reglazing. This is especially the case with churches and temples. They were often built with openings glazed with simple or generic clear leaded glass. Stained glass was added later as finances allowed. Conversely, the windows may be earlier than the building. They may have been removed from one structure and installed in another (once again, this is more likely with religious structures). Bills, inventories, and other written documents often give clues to the date and composition of leaded glass. Religious congregations, fraternal lodges, historical societies and other preservation organizations may have written histories that can aid a researcher.

Inscriptions and Signatures. Many studios and artists affixed signature plates to their work—often at the lower right hand corner. In the case of Tiffany windows, the signature evolved through several distinct phases, and helps date the piece within a few years: Tiffany Glass Company (1886-1892), Tiffany Glass & Decorating Company (with address, 1892-1902), Tiffany Studios New York or Louis C. Tiffany (post 1902). (Tiffany Studios, like others, did not always sign pieces and the absence of an inscription cannot be used to rule out a particular studio or artist.) Windows may also feature dated plaques commemorating a donor. However, these do not always indicate the date of the window, since windows were often installed before a donor was found. Nevertheless, such marks help establish a reasonable date range.

Composition and Other Stylistic Elements. These elements are more subjective, and call for a fairly broad knowledge of architecture and art history. Do the windows fit the general style of the building? The style of the window may reflect a stylistic period (e.g., Arts & Crafts, Art Nouveau, Prairie School). The imagery or iconography of the windows may also reveal their overall historical context and establish a general time period.

Framing and Surround. Framing elements and the window surround can reveal information central to dating the window. Do moldings match other interior trim? Has the opening been altered? Is the window set in an iron frame (post-1850s), a steel frame (generally post-World War I), a cast stone or terra cotta frame (seen as early as the 1880s, but popular after 1900)?

Reinforcement and Leading Details. Does the window or other element have round bars or flat
Stained glass commissioned for a particular building was normally designed not only to reflect the shape of the opening but also to coordinate with other aspects of the overall setting such as the architectural style, adjacent materials, and interior decoration. The window opening, frame or sash colors, placement of the reinforcement, alignment with architectural elements, and orientation to natural light also establish the relationship between the stained glass and the building. The vibrant colors of opalescent glass, which can often be read from the exterior, and the linear designs of Prairie School windows, which often harmonize with both the interior and the exterior, are two examples that readily demonstrate the importance of architectural context to ornamental glass.

This important relationship between the glass and its setting, however, can be weakened or entirely lost over the years due to unsympathetic decorating schemes or building campaigns, damage, deterioration, inept repairs, or the mere accumulation of dirt.

Changes to the ornamentation and finish of the structural frame can have an especially pronounced effect on the overall appearance of a stained glass window or dome. In the Chicago Cultural Center dome the historic finishes of the ornamental cast iron frame have darkened considerably over the years, muting the dome's rich personality. In strong sunlight the glass is so dominant that the frame appears only as a silhouette. Restoring the vibrancy of the historic finish is necessary to recapture the equally important contribution of the frame to the original design intent of the dome. After careful investigation to document the historic appearance (right), a mock-up section of the frame was regilded with aluminum leaf (top). The dramatic effect of restoring the dome's overall context is readily apparent after only this small section of the frame was refinshed.

bars? Flat bars began to appear about 1890; round bars, used since the Middle Ages, remained in use until the 1920s, when flat bars supplanted them. Cames can also give dating clues. Zinc cames, for example, developed by Chicago Metallic in association with Frank Lloyd Wright, first appeared in 1893. In general, however, dating a window by the came alone is difficult unless it is disassembled to view the "heart" (center web) for millmarks. Over one hundred varieties of lead came were available in the early 20th century. Moreover, came was sometimes produced to look old. Henderson's Antique Leading from the 1920s was made "to resemble the old hand wrought lead" and also carried "easy-fix" clip-on Georgian-style ornaments.

Glass. The glass itself can help in dating a window. Opalescent glass, for instance, was patented by John LaFarge in 1879. Tiffany patented two variations on LaFarge's technique in the same year. (Opalescent glass is translucent, with variegated colors resulting from internally refracted light. It features milky colored streaks.) Pre-1880 glass is usually smooth translucent colored glass (painted or not); glass with bold, deep colors is typical of the 1880s and 1890s, along with jewels, drapery glass and rippled glass. But such flamboyance faded out with the rest of Victoriania by about 1910. However, stained glass styles of the late 19th century continued to appear in ecclesiastical buildings after they passed from general fashion. Leaded beveled plate glass was popular in residential architecture after 1890, and was used profusely until the 1920s.

The level of documentation warranted depends upon the significance of the window, but it is very important to document repair and restoration projects before, during, and after project work. Photographs will normally suffice for most windows. For highly significant windows, rubbings as well as written documentation are recommended. The leading patterns in such windows are complex, particularly in plated windows (which have several layers). Rubbings are therefore encouraged for each layer when restored; they are invaluable if a disaster occurs and reconstruction is required. Annotated rubbings of the leadwork should be done with a wax stone on acid-free vellum.

To document windows properly, inscriptions should be recorded word for word, including misspellings, peculiarities in type style, and other details. Names and inscriptions in or on windows can indicate ethnic heritage, particularly in churches or civic structures where windows often reflect styles and themes from the congregation or community's origins. Lastly, any conjectural information should be clearly noted as such.
Deterioration of Stained and Leaded Glass

Three elements of leaded glass units are prone to damage and deterioration: the glass itself; the decorative elements (mostly applied paint); and the structural system supporting the glass.

Glass Deterioration

Glass is virtually immune to natural deterioration. Most American glass is quite stable—due to changes in glass composition made in the mid-19th century, particularly the increased silica content and the use of soda lime instead of potash as a source of alkali. Rarely, however, glass impurities or poor processing can cause problems, such as minor discoloration or tiny internal fractures (particularly in opalescent glass). And all glass can be darkened by dirt; this can often be removed. However, while glass does not normally deteriorate, it is susceptible to scratching or etching by abrasion or chemicals, and to breakage.

The greatest cause of breakage or fracture is physical impact. Leaded glass in doors, sidelights, and low windows is particularly susceptible to breakage from accidents or vandalism. When set in operable doors or windows, leaded glass can crack or weaken from excessive force, vibration, and eventually even from normal use. Cracks can also result from improperly set nails or points that hold the window in the frame, or more rarely, by structural movement within the building. Leaded glass that is improperly annealed can crack on its own from internal stress. (Annealing is the process by which the heated glass is slowly cooled; the process is akin to tempering metal.) Glass can also disintegrate from chemical instability or the intense heat of a fire. Finally, windows assembled with long, narrow, angular pieces of glass are inherently prone to cracking. Often the cause of the cracks can be determined by the path they travel: cracks from impact typically radiate straight from the source. Stress cracks caused by heat or improper annealing will travel an irregular path and change direction sharply.

Deterioration of Painted Glass

Painted glass, typically associated with pictorial scenes and figures found in church windows, often presents serious preservation challenges. If fired improperly, or if poor quality mixtures were used, painted glass is especially vulnerable to weathering and condensation. Some studios were notorious for poorly fired paints (particularly those working with opalescent glass), while others had outstanding reputations for durable painted glass. Paints can be applied cold on the glass or fused in a kiln. Since they are produced from ground glass, enamels do not “fade,” as often suggested, but rather flake off in particles. Several steps in the painting process can produce fragile paint that is susceptible to flaking. If applied too thick, the paint may not fuse properly to the glass, leaving small bubbles on the surface. This condition, sometimes called “frying,” can also result from poor paint mixtures or retouching. Paint failure is more commonly caused by under firing (i.e., baking the glass either at too low a temperature or for too little time). Unfortunately, in American stained glass, the enamels used to simulate flesh tones were typically generated from several layers that were fired at too low a temperature. This means the most difficult features to replicate—faces, hands and feet—are often the first to flake away (Fig. 11).

Structural Deterioration

The greatest and the most common threat to leaded glass is deterioration of the skeletal structure that holds the glass. The structure consists of frame members, and lead or zinc (and occasionally brass or copper) came that secures individual pieces of glass. Frame members include wood sash and muntins that decay, steel t-bars and “saddle bars” that corrode, and terra cotta or stone tracery that can fracture and spall (Fig. 12). When frames fail, leaded glass sags and cracks due to insufficient bracing; it may even fall out from wind pressure or vibration.

Wood sash are nearly always used for residential windows and are common in many institutional windows as well. Left unprotected, wood and glazing compounds decay over time from moisture and exposure to sunlight—with or without protective storm glazing—allowing glass to fall out.
Steel frames and saddle bars (braces) corrode when not maintained, which accelerates the deterioration of the glazing compound and loosens the glass. Moreover, operable steel ventilators and windows are designed to tight tolerances. Neglect can lead to problems. Eventually, they either fail to close snugly or corrode completely shut. The leaded glass is then frequently reinstalled in aluminum window units, which require wider sections for equal strength and typically results in an inch or more of the glass border being trimmed. Instead of relocating glass in aluminum frames, historic steel frames should be repaired. Often the corrosion is superficial; frames in this condition need prepping, painting with a good zinc-enriched paint, and realigning in the frame.

Masonry frames typically last a long time with few problems, but removing leaded glass panels set in hardened putty or mortar can be nearly impossible; as a last resort, glass borders may have to be sacrificed to remove the window.

Occasionally, leaded glass was designed or fabricated with inadequate bracing; this results in bulging or bowing panels; leaded panels should generally not exceed 14 linear feet (4.25 m) around the perimeter without support. More often, the placement of bracing is adequate, but the tie-wires that attach the leaded panels to the primary frame may be broken or disconnected at the solder joints.

Lead and zinc camees are the two most common assembly materials used in stained and other "leaded" glass. The strength and durability of the leaded panel assembly depends upon the type of came, the quality of the craftsmanship, and the glazing concept or design, as well as on the metallic composition of the camees, their cross-section strength, how well they are joined and soldered, and the leading pattern within each panel. Came is prone to natural deterioration from weathering and from thermal expansion and contraction, which causes metal fatigue.

The inherent strength of the assembly system is also related to the cross-section, profile and internal construction of

**Came Types and Properties**

**Lead Came**

Lead is a soft malleable metal (it can be scratched with a fingernail). It naturally produces a protective dark bluish-gray patina. In the mid-19th century, improved smelting processes enabled manufacturers to extract valuable metal impurities from lead, thereby producing 100% pure lead came. The industry reasoned that 100% pure lead came was superior to the less pure variety. Although pure lead came is very workable and contributes to intricate designs, time has proven it to be less durable than medieval came, which contained trace elements of tin, copper, silver, and antimony. Unfortunately, the misconception that pure lead had greater longevity continued throughout the glory years of leaded glass use in America. Most glass conservators use a 100-year rule of thumb for the general life expectancy of 19th century came. In the 1970s, "restoration lead" (ASTM B29-84) was developed based on metallurgic analyses of medieval camees, some of which have lasted for centuries. Restoration lead should always be used when releading historic windows, unless the original integrity will be compromised.

**Zinc Came**

Zinc came is more vulnerable to atmospheric corrosion (particularly from sulfuric acids) than lead, but has proven to be durable in America because it weighs 40% less than lead and its coefficient of expansion is 7% lower. Thus, it is somewhat less susceptible to fatigue from expansion and contraction. Moreover, it is ten times harder than lead, and has three times the tensile strength. Zinc came is strong enough to be self-supporting and requires little bracing to interrupt the window's design. While zinc came is perfect for the geometric designs of Prairie School windows, it is usually too stiff to employ in curvilinear designs. Zinc can also take several finishes, including a copper or black finish. (As a result, zinc can be mistaken for copper or brass.)

**Other Came**

Other metals, primarily solid brass and copper, were also occasionally employed as came. They are generally found only in windows between ca. 1890 and ca. 1920. Frank Lloyd Wright started with zinc in 1893, was plating the zinc with copper by the late 1890s, and using solid copper by 1906.
the came (Fig. 13). Came can have a flat, rounded, or "colonial" profile, and aside from a few specialty and perimeter came (U-channel), is based on a variation of the letter "H" and ranges from 1/8" (3.2mm) wide to 1 1/2" (38mm) wide. The cross-section strength of came varies depending on the thickness of the heart and flanges. Occasionally, came with reinforced (double) hearts or a steel core was used for rigidity, usually in doors and sidelights. Such came added strength at the expense of flexibility and was typically used for rectilinear designs, or for strategically placed reinforcement within a curvilinear design.

How the came are joined in a leaded panel is crucial to their long-term performance. Poor craftsmanship leads to a weak assembly and premature failure, while panels fabricated with interlocking (weaving) came and lapped leads add strength. Soldered joints often reveal the skill level of the artisan who assembled the window, and can give evidence of past repairs. Solder joints should be neat and contact the heart of the came - wherein lies its greatest strength. Came joints should be examined closely; large globs of solder commonly conceal came that do not meet. (Lead came typically crack or break along the outside edge of the solder joint; stronger zinc came frequently break the solder itself where it bridges junctures.)

Leading patterns designed with inadequate support also contribute to structural failure. Panels with a series of adjacent parallel lines tend to hinge or "accordion," while lines radiating in concentric circles tend to telescope into a bulge. Stronger leading techniques, support bars, or specialty came are sometimes required to correct poor original design. Minor sagging and bulging is to be expected in an old window and may not require immediate action. However, when bulges exceed 1 1/2" (38mm) out of plane, they cross into a precarious realm; at that point, glass pieces can crack from severe sagging and pressure. If the bulged area moves when pressed gently, or if surrounding glass is breaking, it is time to address the problem before serious failure results.

**Figure 13. A wide variety of came has been used for ornamental glass in America: (a) flat lead came; (b) round lead came; (c) "Colonial" zinc came; (d) double-heart lead came with a steel core; (e) "Prairie School" zinc came.**

some cases, windows have bulged up to 4" (102mm) out of plane without harming the pieces of glass or risking collapse.

**Cleaning**

Perhaps the greatest virtue of stained glass is that its appearance is constantly transformed by the ever-changing light. But dirt, soot, and grime can build up on both sides of the glass from pollution, smoke, and oxidation. In churches the traditional burning of incense or candles can eventually deposit carbon layers. These deposits can substantially reduce the transmitted light and make an originally bright window muted and lifeless. Simply cleaning glass will remove harmful deposits, and restore much of its original beauty, while providing the opportunity to inspect its condition closely (Fig. 14). The type of cleaner to use depends on the glass. Water alone should be tried first (soft water is preferable); deionized water should be used for especially significant glass and museum quality restorations. If water alone is insufficient, the next step is to use a non-ionic detergent. Occasionally, windows are covered with a yellowed layer of shellac, lacquer, varnish, or very stubborn grime that requires alcohol, or solvents to remove. Most unpainted art glass can be treated with acetone, ethanol, isopropyl alcohol, or mineral spirits to remove these coatings if gentler methods have failed. All chemical residues must then be removed with a non-ionic detergent, and the glass rinsed with water. (All workers should take normal protective measures when working with toxic chemicals.)
**Painted glass** must never be cleaned before the stability of the paint is confirmed, and only then with great caution. If the paint is sound, it can be cleaned with soft sponges and cloth. If the paint was improperly fired or simply applied cold, paint can flake off during cleaning and special measures are required such as delicate cleaning with cotton swabs. Occasionally, paint is so fragile the owner must simply document and accept the windows in their current state rather than risk losing the original surface. Fragile paint typically calls for an experienced glass conservator and more costly restoration measures.

Acidic, caustic, or abrasive cleaners should never be used. They can damage glass. Most common household glass cleaners contain ammonia and should not be used either. Cleaning products should have a neutral pH.

**Repair**

As with all elements in older and historic buildings, maintenance of leaded glass units is necessary to prevent more serious problems. It is essential to keep the frame maintained regardless of the material. Often, this simply entails regular painting and caulking, and periodic replacement of the glazing compound. Wood frames should be kept painted and caulked; new sections should be spliced into deteriorated ones, and epoxy repairs made where necessary. Masonry frames must be kept well pointed and caulked to prevent moisture from corroding the steel armature and anchors within.

Windows that leak water, are draughty, or rattle in the wind (or when gently tapped) may indicate that the waterproofing cement ("waterproofing") and sealants have deteriorated and maintenance or restoration is needed. Waterproofing is a compound rubbed over the window—preferably while flat on a table—and pressed under the came flange to form a watertight bond between the leading and the glass. Traditionally, waterproofing was made of linseed oil and whiting, and a coloring agent. (Hardening agents should not be included in the mixture; solvent-based driers should be used sparingly.) The waterproofing allows leaded glass in a vertical position (e.g., in windows) to be used as a weatherproof barrier. It does not provide adequate protection for leaded glass in a horizontal or arched position; leaded glass ceilings and domes must always be protected by a secondary skylight or diffusing skylight.

Glazing and sealants (e.g., putties, caulks) are used to seal the leaded panel against the sash, and to seal any open joints around the window frame. Sealants improved dramatically in the mid-twentieth century. But these sealants are not without problems. Some release acetic acid as they cure. Acetic acid can harm lead, and should never be used on leaded glass. Instead, "neutral cure" sealants should be used. These high-performance construction sealants are not sold in consumer supply stores.

The appropriate type of sealant depends on the materials to be bonded and on the desired appearance and longevity. When windows are to be restored, the contractor should explain what types of waterproofing and sealants are to be used, and how long they are expected to last. On large projects, a letter from the product manufacturer should be obtained that approves and warranties the proposed application of their product. When in doubt, a traditional linseed-oil based glazing putty is often best.

Leaded panels will generally outlast several generations of waterproofing. When the waterproofing has failed, the window should be removed from the opening and waterproofed on a bench. Leaded glass cannot be adequately waterproofed in place. Removing the windows will provide an opportunity to perform maintenance on the window surround and to secure the reinforcement. This is far less expensive than totally releading the window, which is typically required if maintenance is deferred. When waterproofing or sealants break down, many building owners attempt to resolve the problem by installing protective glazing, when the window only needs maintenance. Protective glazing is not an alternative to maintenance; in fact, it impedes maintenance if not installed properly and can accelerate the deterioration of the stained glass.

A very common—but extremely harmful—practice in the American stained glass industry is performing major window repairs in place. The practice is routine among churches where the cost of restoring large windows can be prohibitive. However, undertaking major repairs in place provides only a quick fix. A window cannot be properly repaired or restored in place if it is bulging or sagging far out of plane, if over 5% of the glass is broken, or if solder joints are failing. Unscrupulous glazers can introduce a great deal of stress into the glass by forcibly flattening the window in place and soldering on additional bracing. At a comfortable distance the window may look fine, but upon close inspection the stress cracks in the glass and broken solder joints become obvious. Windows subjected to this treatment will deteriorate rapidly, and complete, much more costly restoration will likely be necessary within a few years (while a proper repair can easily last two generations or more).

![Figure 14. The external glass plate has been removed to clean the interlayer of this plated Tiffany Studios window.](image-url)  

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Major repairs to windows are sometimes part of a larger preservation project. In such cases, the risk of damaging the windows can be very great if their removal and reinstallation have not been carefully planned. When major building repairs are also to take place, the windows should be removed first to prevent damage during other work. Windows should be reinstalled as the next-to-last step in the larger project (followed by the painters or others working on the finishes surrounding the stained glass).

And glass should be protected whenever other work is undertaken on buildings—whether or not the windows are also to be repaired. External scaffolding, for example, erected for repointing or roofing projects, may offer vandals and thieves easy access to windows and, through them, to building interiors. Stained and leaded glass should always be well protected whenever chemical cleaners are used on the exterior of the building; some products, such as hydrofluoric-acid cleaners, will cause irreversible damage.

**Repairs to Glass**

Minor repairs, such as replacing a few isolated pieces of broken glass, can be performed in place. This work, typically called a “drop-in,” “stop-in,” or “open-lead” repair, entails cutting the came flange around the broken piece of glass at the solder joints, folding it back to repair or replace the old glass, and resoldering the joints. Repairing a zinc came window is not as easy. Zinc came is too stiff to open up easily, so they must be cut open with a small hack saw and dismantled until the broken area is reached. The glass is then repaired or replaced and the window is reassembled. New came can be patinated to harmonize with the originals—but only with difficulty. Repatination should never be attempted in place, since it is impossible to clean off harmful residues trapped under the came.

Original glass should be retained whenever possible, even though it may be damaged. Replacement glass that exactly or closely matches the original piece can be very difficult to find, and costly to make. An endless variety of glass colors and textures were produced, and given the delicate chemistry of glassmaking, even samples from the same run can be noticeably different. The traditional

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**Photographing Stained Glass**

Historic stained glass windows, laylights and domes should be documented to help ensure the best-quality restoration in the event of vandalism, fire or other loss. Photographic documentation is also important for insurance and investigation purposes when vandalism or theft is involved. Given the highly photogenic nature of stained glass, photographs can also serve as artwork for guidebooks or other interpretive or publicity purposes; quality photographs can be especially worthwhile in fundraising efforts.

Photographing stained glass is both challenging and rewarding. Windows and domes lit by daylight can seem to be ever changing in visual appearance. They can appear dramatically different in any given photograph depending not only on the photographic equipment and settings used, but also on the time of day, degree of cloud cover, the ambient interior light, and a multitude of other factors. Moreover, photographs may differ depending on the aspect to be captured. Painted flesh areas and highly translucent Prairie School windows often “burn out” if photographed in bright sunlight, while faceted jewels and very dense or plated opalescent glass often look best in direct sunlight.

Generally, exposures should be bracketed to capture the full range of the stained glass; the variation in images can permit different images to serve different purposes. Under most circumstances, interior lights should be turned off, and the stained glass should be photographed in both transmitted light (no flash) and reflected light utilizing a flash. The flash should ideally be positioned away from the camera to provide a raking light and to avoid reflected “hot spots.” Although photographing with a flash will neutralize the transmitted light and black out the glass, it reveals the location and condition of the lead cames, braces, tie-wires, and other structural elements.

A tripod should be employed for a sharp image whenever using long exposures and higher apertures. The subject should be shot at level as possible to minimize the distortion known as “parallax.” Occasionally, when shooting a group of windows, it is beneficial to develop a cardboard, Eucobord, Masonite or similar cutout material to mask the window being photographed. Adjacent windows or windows on the opposite side of the room may need to be shaded or blocked to avoid “front lighting” on the window from competing with the transmitted light. Windows should also be photographed from the outside if there is no protective glazing to interfere with the view. This is particularly important with opalescent glass, which often was intended to be read from the exterior as well as the interior.

Some glass projects warrant a visual representation of the stained glass window to be in place during restoration. After establishing the existing window dimensions, a photograph of the stained glass window can be enlarged to full scale and copied on adhesive-backed transparent film. In essence a decal, it can then be applied to acrylic or polycarbonate sheets and used as a temporary replacement to fill the opening (above). Such film decals are sensitive to light and will not last indefinitely. However, they are reasonably convincing from a distance and can last a year or longer while the actual window is being restored.
Figure 15. To permit repair of the cracked glass, the original lead overlay is first salvaged from this historic leaded panel of silhouette glass to retain as much of the original work as possible.

Figure 16. A valuable historic piece of original hand-painted glass is carefully edge-glued with epoxy.

secrecy that shrouds the glassmaking trade to this very day, as well as environmental bans of historically popular ingredients such as lead and cobalt for deep blues and greens, further hinders accurate reproductions. Therefore, it is nearly always better to use an imperfect original piece of glass than to replace it (Fig. 15). If the paint is failing on a prominent feature of a window, a coverplate of thin, clear glass can be painted and placed over the original. (The coverplates must be attached mechanically, rather than laminated, so that they can be removed later if necessary.) A reverse image of the fading feature should be painted on the backside of the coverplate in order to get the two painted images as close together as possible. With repetitive designs, stencils can be created to produce multiple duplicates.

Sometimes replacement is the only option. Fortunately, custom glass houses still exist, including the company that originally supplied much of the glass for Tiffany commissions. Stained and leaded glass has also experienced a resurgence in popularity, and American glassmakers have revived many types of historic glass.

When missing, shattered, or poorly matched glass from later repairs must be replaced, the new pieces should be scribed on the edge (under the same) with the date to prevent any confusion with original glass in the future.

Glass cracks will enlarge over time as the contacting edges grind against each other, whenever the window is subject to vibration, thermal expansion and contraction, and other forces such as building movement. Therefore, it is important to repair cracks across important features as soon as they are detected and while a clean break remains. Years ago, cracks were typically repaired with a "Dutchman" or "false lead" by simply splicing in a cover lead flange over a crack. Although this conceals the crack, it creates an even larger visual intrusion and provides no bond to the glass. Today, there are three primary options for repairing broken glass: copper foil, epoxy edge-gluing (Fig. 16), and silicone edge-gluing. These techniques differ in strength, reversibility, and visual effect, and the appropriate repair must be selected on a case-by-case basis by a restoration specialist.

Copper Foiling: Copper foil has the longest history and, unless the glass is unstable, is generally the best option when a piece of glass has only one or two cracks. Copper foil is a thin tape that is applied along each side of the break, trimmed to a minimal width on the faces, and soldered. A copper wire can be soldered on where additional strength is required. However, copper foil repairs should not be used on unstable glass, since heat is required that can cause further damage. Copper foil produces a strong repair, is totally reversible, and has a negligible aesthetic impact (a 1/16" [1.6mm] wide line).

Epoxy Edge-Gluing: This technique produces a nearly invisible line and is often used on painted glass, particularly focal points of a window such as a face, or a portion of sky intended to be one continuous piece. Epoxy can even be tinted to match the glass. It is also used for infusing shattered glass or microscopic cracks caused by intense heat from a fire. Epoxy produces a very strong repair, but will deteriorate in sunlight and requires secondary glazing to protect it from UV degradation. Epoxy is the least reversible of the three techniques, and usually the most expensive.

Silicone Edge-Gluing: This repair method has the lowest strength and should be used when a flexible joint is desirable—if, for instance, the window will be under continuous stress. Silicone repairs are easily reversible, and can be removed with a razor blade—when they are done correctly, that is. Silicone edge-gluing is not the same as smearing silicone all over the glass. This unfortunate practice, seen throughout the country, is useless as a repair technique, and usually causes more damage than if the glass were left alone. Silicone is almost clear, but it refracts light differently from glass and is, thus, easily detectable. Silicone is not affected by temperature, humidity or UV light. Silicone repairs are typically the least expensive repair option.
Repairs to Structural Support Systems

Windows may have detached from the saddle bars and begun to sag, bulge, and bow extensively. This point varies from window to window. Generally, however, a window sagging or bulging more than $1\frac{1}{2}$" (38mm) out of plane has reached the point where it should be removed from the opening to be flattened out. Under these conditions, it is essential to note if the support system or leading pattern has failed so it may be corrected before the window is reinstalled. The window must be allowed to flatten over a few weeks in a horizontal position. This will minimize stress on the solder joints and glass. A moderate weight and controlled heat will help coax the window back into its original plane. The process requires patience. Once the window has flattened, the original support system should be reattached and additional support added as necessary. It is crucial to consider the original design so the new support bars do not intrude on important window features. Sometimes small thin braces or “fins” can be manipulated to follow existing lead lines exactly. These give support, but are almost invisible. Flattening windows also provides a good opportunity to apply new waterproofing to help prevent further deterioration. Today, a wide variety of traditional and synthetic compounds are employed.

Windows should only be removed when they need to be flattened, waterproofed, reinforced, or resealed. Allow plenty of time for careful, thorough work. Large projects can take several months, especially if complete releading is necessary. Owners, consulting professionals, and construction managers must therefore ensure that vacant openings will be weather tight for an extended period—whether the openings are covered by plywood, acrylics, or polymer film. If desired, images of the window can be printed on adhesive film and applied to rigid plastic and installed in the openings as temporary facsimiles during studio restoration.

Rebuilding or releading a window is an expensive and involved process. The releading process requires that a window be disassembled before it can be reassembled (Fig. 17). The glass pieces must be removed from the cames, the old cement must be cleaned from each piece of glass, and all the pieces must be rejoined precisely. At every step the process involves the risk of damaging the glass. Furthermore, exceptional studios had unique leading techniques, and thus the cames should not be replaced casually. Total releading should only be undertaken when necessary to avoid or slow the loss of historic fabric. (It is essential to request a copy of all window rubbings if the windows are to be completely releded.)

Lead and zinc came, however, are intended to be a sacrificial element of a glass unit assembly, as mortar is to brick and paint is to wood; came will break down long before glass and must ultimately be replaced; came typically lasts 75 to 200 years depending on the window’s quality, design and environment. A common preservation conflict arises in releading historic windows: whether to retain historical accuracy by using the existing profile, or to use came with a stronger profile for greater longevity. The decision must be carefully weighed depending on the significance of the window, the contribution of the came profile to the overall design, and the severity of the deterioration caused by a thin or weak came. In most windows, the came profile is essentially lost in transmitted light, but occasionally shadow lines are important and should be reproduced. Furthermore, it is important to correct technical problems that arise from flimsy original came. Occasionally, a slightly heavier came may be the best solution to resolve weak panels that have not proven the test of time. Under these circumstances, the thicker lead came (even if only 1/64" [0.4mm]) will cause a re-leaded panel to swell slightly, and the frame or perimeter leads may have to be trimmed to fit the opening. (Trimming the glass should be the very last resort.) This would not be an appropriate solution in a museum-quality restoration or for a highly significant window.

Protective Glazing and Screens

The use of protective glazing (also known as secondary or storm glazing) is controversial. Potential benefits of protective glazing are that it can shield windows from wind pressure; increase energy savings; protect against environmental pollutants and UV light; provide vandalism and security protection, and reduce window maintenance. Potential drawbacks are that it can promote condensation; cause heat to build up in the air space and thereby increase the window’s expansion/contraction; eliminate natural ventilation; reduce access for maintenance; offer a poor energy payback for the cost, and significantly mar the building’s appearance. Protective glazing is often presented as a cheaper alternative to full-scale restoration. And all too often protective glazing is installed as a routine matter when there is little threat of damage from vandalism or other causes. Protective glazing, especially when improperly installed, may hasten deterioration of stained glass windows.

Figure 17. Total releading is very time consuming and costly and should only be undertaken when the original lead is exhausted beyond repair.
Domes and Ceilings

Stained glass domes and ceilings were very popular throughout the Victorian and Classical Revival periods. They are often principal interior features of churches, hotels, restaurants, railway stations, and civic buildings. The loss or unsympathetic alteration of leaded glass ceilings and domes is a widespread problem. Poorly planned rehabilitation projects sometimes cause the unnecessary removal or alteration of overhead leaded glass in order to comply with fire codes or to achieve perceived energy savings; occasionally, they are even concealed above suspended ceilings.

Moreover, stained glass in the horizontal position readily collects dust and dirt over the years and is relatively inaccessible for cleaning. It is also more likely to “creep” or slump when the reinforcement is inadequate. Most importantly, leaded glass cannot be sufficiently weatherproofed in a horizontal (or arched) position. It must always be protected by skylights or “diffusers”—rooftop features that diffuse the natural daylight into the attic or light shaft, and protect the leaded glass ceiling or dome from the elements (a).

Due to the inferior quality of glazing sealants of the late 19th and early 20th centuries, and to deferred maintenance, glass ceilings have frequently been removed or covered with roofing materials. Artificial lighting is then required to backlight the ceiling or dome, which robs the stained glass of its life—the vibrant effects created by ever-changing natural light. All types of artificial lighting can be found from floodlamps to fluorescent tubes. Outside sensors are even used to modulate the light level in an attempt to simulate changes in daylight. However, daylight is impossible to emulate. Moreover, it’s free. Artificial lighting requires maintenance, introduces an additional fire hazard in the attic, increases the building’s electrical load, and is supplied only at a financial and environmental cost.

Stained glass ceilings and domes that have been sealed off from natural light should be investigated for restoration. Once natural light is restored and the stained glass is cleaned, the lighting effect on an interior can be extraordinary. Improved skylight designs and major advances in glazing sealants since World War II (particularly silicones) encourage the restoration of skylights without the fear of inheriting a maintenance nightmare (b).

(a) Stained glass ceilings and domes are often principal interior features of churches, hotels, restaurants, railway stations, and civic buildings. This vaulted ceiling illuminates the Cypress Lawn Memorial Gardens mausoleum in Colma, California. The panel removed reveals the diffusing skylight above.

(b) Workers install a jeweled art glass oculus of a Healy & Millet dome. The diffusing skylight was restored overhead to reintroduce daylight to the historic 1897 dome after being roofed over since the 1940s.
Various types of metal grills or screens are also used. They add security and vandalism protection but also impair the appearance of the window (inside and out) by creating new shadows that telegraph on the stained glass or diffusing transmitted light. As a general rule, protective layers should not be added on historic buildings unless the glass setting was designed for storm glazing. In most cases the potential drawbacks outweigh the potential benefits.

Under some circumstances, however, protective glazing or screens may be necessary. (This applies to windows. Domes and ceilings present a special case. See “Domes and Ceilings”). A real vandalism or security threat warrants protective glazing, such as when the windows can be reached easily or are in an isolated location. Protective glazing is also warranted when employed historically on a particular window as original plating (Tiffany Studios, for example, often used plate glass to keep dirt and moisture out of their multi-plated windows). Unusual circumstances (such as when the windows are painted on the outside) may also dictate the use of protective glazing. Finally, protective glazing is warranted when a UV filter is needed to prevent epoxy glass repairs from breaking down.

A variety of protective glazing materials are available. They include polycarbonates, acrylics, laminated glass, plate glass, and tempered glass. The plastic products are very strong, lightweight, and relatively easy to install, but will scratch, haze, and yellow over time, despite UV inhibitors. They also have a high coefficient of expansion and contraction, so the frames must be designed to accommodate change induced by temperature fluctuations. Poor installations in restrictive frames cause distorted reflections from bowing panels often damaging the historic frame. Protective panels of glass are heavier and more difficult to install, making them more expensive than plastic. However, glass will not bow, scratch, or haze and is usually the best option in aesthetic terms; laminated glass provides additional impact resistance.

A common error in installing protective glazing is to create a new window configuration (Fig. 18). Insensitive installations that disregard the original tracery destroy the window’s aesthetics—and the building’s. When protective glazing is added, it should be ventilated. If a window is not ventilated, heat and condensation may build up in the air space between the ornamental glass and the protective glazing (creating a “greenhouse effect”).

When absolutely necessary, protective glazing should be installed in an independent frame between ⅜” (16mm) and 1” (25mm) from the leaded glass. This allows the protective panel to be removed for periodic maintenance of both the historic window and the new glazing. The conditions of the air space between the two layers should be monitored on a regular basis; condensation should never collect on the window.

No ideal formulas have been developed for venting the air space between the ornamental glass and the protective glazing, but it is typically vented to the outside (unless the building is air conditioned most of the year). Generally, a gap of several inches is left at the top and bottom when glass is used, or holes are drilled in the protective glazing at the top and bottom when polycarbonates and acrylics are used. Small screens or vents should be added to keep out insects. Finally, it is important to realize that most original plating was “rough plate” or “ribbed” and never had a modern polished reflection. Some glass tinted the transmitted light intentionally, as originally designed; in this case any new or replacement plating should simulate this effect to respect the artisan’s intention.

**Conclusion**

Much of the Nation’s stained glass and leaded glass has recently passed, or is quickly approaching, its 100th anniversary—yet much of this glass has not been cleaned or repaired since the day it was installed. With proper care, the stained and leaded windows, transoms, and other elements that add so much to historic buildings can easily last another century.
Selected Reading List


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Preservation Briefs

Applied Decoration for Historic Interiors
Preserving Composition
Ornament

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A NOTE TO OUR USERS: The web versions of the Preservation Briefs differ somewhat from the printed versions. Many illustrations are new, captions are simplified, illustrations are typically in color rather than black and white, and some complex charts have been omitted.

Anyone who has ever walked through historic houses and large public buildings, visited an art gallery, picked up a picture frame in an antique shop, or even ridden on an old carousel has been close to composition ornament, but has probably not known what it was or how it was made. This is not surprising, since composition or "compo" was conceived as a substitute for more laboriously produced ornamental plaster and carved wood and stone, so was intended to fool the eye of the viewer. The confusion has been heightened over time by makers who claimed to be the sole possessors of secret recipes and by the variety of names and misnomers associated with the material, including plaster, French stucco, and Swedish putty, to name a few.

Many natural or man-made materials can be made soft or "plastic" by the application of heat and are called "thermoplastics." Composition is a thermoplastic material used to create sculptural relief. It is soft and pliable when pressed into molds; becomes firm and flexible as it cools; and is hard and rigid when fully dry. Typically formulated with chalk, resins, glue, and linseed oil, this combination of materials gives compo its familiar light-to-dark brown color. It is the only one of the so-called thermoplastic materials to be used extensively in architectural decoration because of its low cost.

Generally adhered to wood, historic composition ornament is most often found decorating flat surfaces such as interior cornice and chair rail moldings, door and window surrounds, mantelpieces, wainscot paneling, and staircases—indeed, anywhere that building designers and owners wanted to delight and impress the visitor, but stay within a budget. While composition was cheaper than carved ornament, it was still meticulously hand made and applied; thus, it was more often used in "high style" interiors. But the types of structures historically decorated with composition ornament were more democratic, encompassing residential, commercial, and institutional buildings, and even including specialty applications such as the social saloon of a steamship.
With proper understanding of the material, historic composition ornament may be successfully cleaned, repaired, or replaced in sections. Unfortunately, because composition is often misidentified as plaster, stucco, or carved wood, the use of inappropriate methods for removing paint is a major cause of its loss. The purpose of this Brief is to assist historic property owners, managers, architects, craftsmen, and preservationists in identifying existing composition ornament, determining the extent of repair and replacement needed and, finally, selecting the most sensitive, non-destructive method of treating it.

De-Mystifying the Mix

While various types of moldable composition date to the Italian Renaissance, architectural use of composition did not begin to flourish until the last quarter of the 18th century. During this period, many composition ornament makers in Europe and America supplied the public with complex sculptural decoration. Also, the overly complicated and often intentionally mysterious earlier recipes were now reported to be comprised of a few basic ingredients: animal glue, oil (usually linseed), a hard resin (pine resin or pitch was cheapest), and a bulking or filling material, generally powdered chalk or whiting.

Compo: The Basic Ingredients

Chalk: Chalk is whiting in solid form. It is a type of white, soft limestone.

Glue: Before the invention of synthetic adhesives, glue meant animal or hide glue. This was made by boiling animal skins to extract a protein-collagen-in water, then condensing and drying the collagen until it was in solid form. A variety of types and grades were, and are still, available. Two are shown here.

Linseed oil: This is a yellowish drying oil obtained from flaxseed that is used in paint, varnish, printing ink, and linoleum; it is a key ingredient in composition ornament.

Resin: Resins are organic materials present in wood and exuded from various trees and shrubs. In unrefined form, they often consist of a mixture of solid natural polymers, oils, and volatile aromatic substances.

Compo mixes have been the subject of a good deal of variation and there has never been a set recipe, but the ornament manufacturers of the later 18th and early 19th centuries understood in general terms what their material was and what it could do. The advantages of the material were described by a prominent American maker, Robert Wellford, in his advertising broadside of 1801:

"A cheap substitute for wood carving has long been desirable for some situations, particularly enriched mouldings, etc., and various were the attempts to answer the purpose, the last and most successful is usually termed Composition Ornaments. It is a cement of solid and tenacious materials, which when properly incorporated and pressed
into moulds, receives a fine relievo; in drying it becomes hard as stone, strong, and durable, so as to answer most effectually the general purpose of Wood Carving, and not so liable to chip. This discovery was rudely conducted for some time, owing to Carvers declining every connection with it, till, from its low price, it encroached so much upon their employment, that several embarked in this work, and by their superior talents, greatly improved it."

In brief, compo is perhaps best understood as an early thermoplastic that allowed the rapid reproduction of complicated detail for popular use.

Making Composition Ornament: A Process Unchanged

Since the craft has essentially remained the same over time, a description of its historic manufacture is also applicable today.

In one container, chunks of amber colored pine rosin or the cheaper black pitch were heated in linseed oil until they melted together and combined completely. In another container (often a double-boiler), previously soaked chunks of animal glue derived from skins and hides were cooked and blended into a uniformly thick solution. The two liquid components were then stirred together. This "batter" was made into a pliable "dough" in a way familiar to any baker. It was poured into a cratered pile of whiting and first mixed with a spatula until it was thick enough to be kneaded by hand. Vigorous folding and kneading in of more whiting was done until the composition had a consistency like modeling clay and was completely uniform.

To mold a decoration, the compo was first warmed in a steamer, and the mold prepared with a thin coating of oil and a dusting with talcum powder. A piece was then kneaded and folded to produce a smooth and wrinkle-free surface on one side. The good side was placed down over the rigid mold, and pressed in loosely with the fingers, leaving excess above the surface of the mold. A damp board was placed over this and the "sandwich" placed in a screw press and squeezed so as to force the compo into the finest detail. It was then removed from the press and turned over so that the mold could be lifted straight up, leaving the compo stuck to the board. Upon cooling to room temperature, the compo gelled, becoming tough and rubbery (the gelling property is due to the glue component which is chemically identical to edible gelatin). At this stage, it was sliced off the board with a thin-bladed knife. The remaining mass of composition still adhered to the board could also be sliced off and reused.

Composition ornament was often fixed to an already prepared wooden substrate at the factory while it was still fresh and flexible, but could be dried and shipped to the final user, who would make it flexible again by steaming on a cloth stretched over a container of boiling water. Instructions for doing this, as well as suitable brads for "fixing," were supplied by some manufacturers. Because of the glue component, steaming the backs of ornaments would make them soft and sticky enough to self-bond without additional glue. Soft ornaments were softened nailed through or pressed down on top of previously driven headless brads (also called sprigs). Strings and wires were often included in the mass.

http://www.nps.gov/history/hps/TPS/briefs/brief34.htm
during pressing to serve as internal armatures and reinforcements. These measures preserved the integrity of the ornaments even if they cracked.

Originally meant to copy other materials such as wood, plaster, and stone, composition had its own unique properties and advantages that were soon exploited in both technical and artistic terms. It has distinct characteristics in each of its three states: pliable, rubbery, and hard. When warm and pliable, it can be modeled by a skilled worker and it is capable of receiving the finest detail when squeezed into a mold. After it has chilled to room temperature and is gelled, it is rubbery, flexible, and tough. The detail is essentially set and cannot be easily damaged as the ornaments are manipulated.

Gelled composition ornaments can be easily bent over curved surfaces without cracking, and unlike a rigid cast material such as plaster, they can be stretched or compressed somewhat to fit a design without damaging the detail. An egg and dart motif, for example, could be made to come out evenly at the corners without making a partial egg or dart. The sculptural vocabulary from the maker’s mold collection could be re-arranged at will into larger decorative schemes. In fact, any smaller component of a decoration from a single mold could be sliced free and inserted into any location.

Composition could be carved to heighten detail, correct defects, or undercut ornaments that were, of necessity, straight-sided-so that they would release from the rigid molds. This could be done in the gelled state or, with more difficulty, after it had finally hardened to stone-like solidity.

Finally, when completely hard, it could be given a polished marble shine with nothing but a damp cloth. It could be stained, coated with any sort of paint, varnish, or oil gilded without any further preparation.

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**Molds and the Creation of Patterns**

A technical discussion of composition is not complete without an examination of the molds used to create the ornament. These were the ornament maker’s largest investment in time and expense, and were the key to the craft.

Composition molds were always made of rigid materials that would withstand the considerable pressure used in pressing the ornaments. All of these materials and methods have been used in sculptural crafts since the Renaissance. The comparative listing that follows helps explain their advantages and disadvantages.

*Wood* was carved in reverse to create a negative matrix. This was highly skilled work often performed by a specialist carver, and required a large initial investment in time, but wooden molds would essentially last indefinitely if properly maintained. A further design advantage of reverse carving is that fine incised lines will show up as fine raised lines in the final ornament. (Fine raised lines are notoriously difficult to carve or model in relief.) Molds carved from dense and close-grained fruit woods such as apple and pear seem to have been common in the 18th century. In the 19th century, the most intricate
molds were carved in boxwood, often encased or framed by larger and cheaper pieces of timber for ease of handling and to prevent splitting.

*Metal alloys* such as brass, bronze, and pewter made excellent molds capable of yielding the highest level of detail and were virtually indestructible in use. They were expensive due to the intrinsic value of the metal and because their production involved a variety of complex and skilled steps performed by modelers, pattern makers, and founders. Few historic metal molds have survived, possibly as a result of war-time scrap drives.

*Sulfur* melts into a clear fluid at about 115 C and could be poured over a positive clay model or another compo ornament. A sulfur mold resembles hard plastic, but is more fragile. Even when framed in wood and reinforced with iron fillings, as was common practice, it was especially vulnerable to breakage. A figural design, such as a frieze of *The Three Graces*, was much easier to model in relief than to carve in reverse, and sulfur was one of the few materials that could be used to make a hard mold from a clay model.

*Composition* itself could be squeezed over a hard relief pattern (such as another manufacturer's ornament) to make a mold. Composition shrinks as it hardens and so the mold was always smaller than the original. It is also fairly brittle when hard and, like sulfur molds, would tend to crack in the press. Composition "squeeze molds" were ideal for pirating another maker's patterns!

*Pitch* molds became popular during the late 19th and early 20th centuries. A warm and soft mixture composed primarily of pine pitch was poured into a recess in a wood block or frame. It was then turned over and squeezed down onto an oiled wooden pattern. Pitch molds might crack with age or in the press, but as long as the carved pattern was retained, they could be easily re-made.

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**Historical Survey**

**Early History and Renaissance.** Press-molded decoration has been used with various soft plastic materials for centuries. For example, it is known that medieval sculptors press-molded organic mixtures to decorate painted sculptures. But because mixtures based on organic binders such as glue, oil, resins, and waxes are prone to various sorts of degradation, actual survivors are rare.

The direct ancestors of the composition craft are most likely found in the Italian Renaissance; however, composition mixtures were not extensively used for architectural decoration during this period, probably due to building traditions as well as relative expense. It is worth nothing that this was an age of experimentation with materials and rediscovery of Greek and Roman designs. Press molded mixtures called *pastiglias* were used to decorate wooden boxes and picture frames as early as the 14th century. Moldable compositions were discussed by various Renaissance writers. The recipes are extremely varied and include, among their more common and understandable ingredients, gypsum, lead carbonate, wood and marble dust, eggs, pigments, sheep's wool, and various oils and resins.

**The 18th Century.** The first flowering of architectural composition in America took
place at the end of the 18th century when ornaments were both imported from England and produced by makers in every major eastern city. All of the conditions were right: molding technologies were well established (architectural papier mache, which, like composition, was produced in molds, had gained widespread acceptance during the middle decades of the century). The raw materials were produced or imported in volume, so the cost of the composition ingredients came down as the cost and availability of highly skilled labor went up. Economic and social conditions favored centralized "manufactories" in the production of various arts and crafts.

Design trends also fed into a favorable reception for composition. A more faithful reinterpretation of Greek and Roman design eventually termed "Neoclassical" had taken hold in Europe, championed in England by the architect, Robert Adam, after his return from study in Italy in 1758. Although Adam played no direct role in the "invention" of composition ornament, as has sometimes been said, he patronized English craftsmen who were making it and was generally receptive to new and innovative materials. One early maker, sometimes cited as the "inventor" of composition by his contemporaries, was John Jaques. His name appears in London advertising by 1785, but he was probably in business before then.

As a result of Adam's influence, designers of applied ornament in both Europe and America began to take advantage of a molding process that was ideally suited to producing the detailed, but repetitive, motifs of classical decoration—acanthus leaf, egg and dart, festoons, swags, and paterae—as well as classical themes depicting Greek and Roman gods and goddesses. And as the Neoclassical style became more popular, composition ornament makers increased in number.

The 19th Century. During the early decades of the nineteenth century, Neoclassical—encompassed in America by the terms Federal, Empire, and Greek Revival—was in the ascendancy. Composition makers continued to increase and also to find new uses for their material. Composition picture and mirror frames became common and some makers advertised the suitability of composition ornaments for casting iron firebacks and stoves. Composition ornament was explicitly advertised for exterior use as well, although very little has survived. The interiors of houses and public buildings in every prosperous American city were decorated with composition.

When the classically derived Federal and Empire styles gave way to the various revival styles—Rococo, Gothic, Renaissance, and Italianate—composition makers simply made new molds to accommodate them. (Although Rococo and Renaissance styles were not common for architecture in America, they were common for furnishings and interior decoration and, in consequence, for composition ornament.)

Along with a proliferation of styles in the mid-to-late decades of the century, there was a parallel growth in the number of moldable and castable materials that shared some features of the composition craft, such as carton pierre, gutta percha, fibrous plaster, shellac compositions and, eventually, celluloid and hard rubber. Composition continued to be the preferred material for detailed decoration on wood where the size of the ornament did not make its cost prohibitive. The publication of practical books by and for craftsmen, beginning in the 19th century, disseminated recipes and procedures to a broad audience and de-mystified the craft. Period composition ornaments called "imitation wood carvings" were widely advertised in manufacturers' catalogs. Balls of prepared compo became available from some art supply shops in large cities for use by small volume craftsmen.

http://www.nps.gov/history/hps/TPS/briefs/brief34.htm
During the later years of the century, the Arts and Crafts Movement—as preached by William Morris and his associates and followers—became increasingly important in design and philosophy. Morris stressed honesty to the material in design, exalted spirituality of hand work and rejected manufacturing, mass production and the distinction between "high" art and craft. These trends were to affect both technology and design in the 20th century. Composition ornament would have been anathema to Morris and his elite clients; most composition production during the last years of the century is best described as Victorian Eclectic.

**The 20th Century.** The Arts and Crafts and related styles, such as the more decorative Art Nouveau, were well rooted in America by the beginning of the century. Pitch molds made from relief-carved patterns had become common in America. The carving tool marks could be accentuated in these patterns in keeping with current vogue. Open-grained woods, such as mahogany, were often chosen so that the finished composition ornaments would have a wood-like grain that showed through stains and varnishes. A uniquely 20th century application of composition ornament was in the lavishly decorated movie palaces of the Depression era.

As interest in architectural embellishments declined, particularly as a result of the austere post-World War II styles, so did the composition trade. Many old firms went out of business and their molds were dispersed or destroyed. The few that remained concentrated on restoration projects or were sustained by diversification into other materials. By the 1950s and 60s, composition as a material and craft had been all but forgotten.

An upsurge in hand craft production that started in the late 60s and has continued to the present—as well as increasing interest in historic preservation—has led to the renewed study of old methods and materials, including composition. The few manufacturers that remain have seen a large increase in their business, and an increasing number of people recognize composition as a unique ornamental material and want to conserve, restore, or create it.

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**Compo Deterioration and Damage**

To some degree, the longevity of historic composition ornament is related to the ratio of ingredients in the original mix and to the skill of the craftsman in applying it. But it is far more dependent upon interior climatic conditions and the long-term effects of heat and dampness on both the compo and the wood substrate.

**Variables in mixing and application.** Dried compo is inherently hard and somewhat brittle; its increasing brittleness over time is primarily due to the oxidation and hardening of the linseed oil component. The drying oil, in turn, contributes to age cracking. Thus, during initial manufacture, if the oil content was low and the dry filler content (chalk) high, shrinking and cracking over time is less likely to occur. Originally, the compo was probably attached using small, headless brads (1/4") that penetrated the hardening compo as well as the wood substrate. They were used to keep the compo from shifting or warping after it was set in place. If an insufficient number of brads was used by the craftsman during the application process, the compo simply falls off as cracks develop.
**Interior environmental conditions.** Compo was conceived as a durable substitute for hand-carved wood or marble and decorative plaster; its potential for structural failure is generally due to substrate failure rather than to the compo mix itself. Theoretically, composition will move with atmospheric changes due to the moisture-sensitive glue component. Its breakdown typically occurs when the wood base expands and contracts at different rates than the compo during extreme temperature and humidity fluctuations. Especially when it is close to a source of heat, such as directly over a fireplace, compo develops fissures or shrinkage cracks. Contemporary heating systems in old buildings also contribute to the drying and cracking syndrome.

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**Planning for Treatment**

Simple stabilization and repairs to existing ornamentation can most likely proceed based solely on an analysis of existing conditions (see paragraphs on *Surface Cracking* and *Delamination*, below).

**Historical research.** For more complex work, a building owner, curator, or conservator should research the history of the building to find out when it was originally designed and constructed; who lived in it at various times; how the building was used; and which features were original and which were added later or removed. Some of this information may be found in the National Register of Historic Places.

Questions about the building's interior spaces and their decorative detailing also need to be asked, particularly when portions of the ornamentation will be replaced. Have the interior spaces evolved with successive occupancies or uses? In addition to compo, were other decorative materials used and are there differences in patterns that help date the work? For example, plaster and compo may have been used in the same room, but applied at different times. Receipts from workmen's bills may often be used to establish the dates of decorative detailing.

The historical research dealing with the original construction of the building and its use over time should, in turn, be linked to the scope of work that will take place.

Stabilization, conservation, and repair are maximized within the treatment, Preservation. Generally speaking, restoring decorative ornament to a specific earlier period is not recommended unless its historical significance outweighs the potential loss of extant ornament that characterizes other historical periods. But if a significant interior is missing original features and physical and documentary evidence are conclusive, replication may be appropriate in order to interpret a particular time.

**Existing conditions analysis.** After historical research is conducted, but before starting work, an analysis of the surface and substrate should be undertaken. These are some of the issues a conservator considers. First, if a surface is painted, the ornamentation material needs to be identified. Is it wood, plaster, composition ornament, or some other type of applied ornamental material? Usually, some of the ornamentation is chipped or broken. Close examination of the exposed material is the

first step. If it is white through the entire thickness of the ornament, then it could be plaster or stucco; if it is a darker brown material, it is more likely to be composition. After having identified the presence of composition ornament, its overall condition can be evaluated. Layers of paint may obscure fine detailing as well as deterioration problems. Degrees of damage and deterioration should be recorded. These are typical questions that need to be answered. Is the surface merely "crazed", requiring no action or limited repair, or are the cracks severe enough to require replacement? Are pieces missing? Are the attachment brads rusted or missing? The condition of the substrate is also important. Is the wood surface intact, or is it in need of repair? After answering key questions, the conservator will make random tests to differentiate original compo from later repairs, some of which may well have been done with plaster, rather than compo.

Deciding how to proceed depends upon the overall interpretive goals of treatment. For example, is the interior being restored to an earlier time? In this case, later repairs may be removed and the original appearance replicated. Or is the interior being preserved with limited replacement of lost or damaged historic materials? Not all conditions are foreseeable in conservation work and contingencies must be incorporated into the treatment plan to be considered realistic. As the project progresses, the conservator generally determines the work that needs to be done, and the order in which it should be undertaken.

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**Treating the Problem with Care**

The scope of work is generally based on several factors, including the historical significance of the building's interior, the degree of damage or deterioration of the compo, and the overall interpretive goals of project work. Several examples of repair and replacement follow in order to suggest a typical scope of work within preservation and restoration projects. Treatments are listed in hierarchical order, from the least intervention to the greatest.

*Paint removal.* Interior ornament is usually painted many times over during its lifetime and, as a result, the sharp surface detail of the original pattern is obscured. Before attempting to remove paint, it is always advisable to obtain professional advice on the ornamental material to be cleaned as well as the nature of the coatings that are covering it. And whatever the project work goal, at least one sample of intact, well-adhered paint layers on a feature should be preserved for future historical research. Based on the purpose of treatment, these are some of the questions a conservator routinely asks. How many layers of paint are there? Is it important to trace one layer to a particular occupancy of the building? If so, the
stratigraphy (or layering scheme) will be determined prior to paint removal. After the correct layer is identified, the color can be matched. Or, is the building being rehabilitated? If this is the case, period-typical paint colors may be appropriate.

For purposes of this Brief and the guidance paragraphs that follow, it is assumed that all layers of paint are being removed in order to reveal the fine detailing of the composition ornament.

The next step is to consider various methods of removing paint from the ornament without damaging it, or without being exposed to dangerous substances in the strippers or in the old paint itself! It should be noted from the standpoint of health and safety that most Federal and Empire period compo was meant to imitate marble; thus, the highly toxic white-lead paint was by far the most common original coating.

Caustic strippers based on lye should be avoided for two reasons. First, they will damage and dissolve compo both because they "chew up" the protein structure of the glue and, second, because they are water-based and compo remains soluble in water. If a stripper will damage the protein of your hands, it will do the same to compo!

A conservator will more often use organic solvents, such as methylene chloride, in conjunction with small implements such as a dental tool or toothbrush. (A small area is always tested first to establish the safety and effectiveness of any technique. Improper use of stripping tools can damage intricate surfaces beyond repair.) A solvent is applied according to manufacturer's recommendations, permitted to soak into and soften the paint, then re-applied as necessary, as the conservator gently removes paint from the intricate carved surfaces.

It should be emphasized that any amount of exposure to toxic chemicals without proper precautions can cause severe health problems. A hooded, air-fed, personal unit is desirable when using methylene chloride-based strippers if fume hoods or paint spray booths that exhaust effectively to the outside are not available. Organic vapor masks may not be as effective in protecting against methylene chloride exposure because the filters quickly become exhausted; however, a vapor mask with properly rated organic solvent cartridges can provide an acceptable level of safety when cartridges are regularly changed.

Some conservators have had excellent results heat-stripping excess paint layers using heat guns and dental tools. This is highly skilled work and its success depends upon the composition ornament being much older than the paint layers that lie on top, but has the capability of working as well or better than chemical methods in the hands of an expert. Precautions must be taken against lead fumes where removal of lead paint is involved.

Cleaning mixtures based on enzymes are also used by conservators. This is an effective method because enzyme mixtures can be formulated for very specific purposes (i.e., to dissolve only oil-based paints from protein-glue based compo). They dissolve paint without affecting the wood substrate. But, on the other hand, work can be very slow and the expense would only seem justified on small and rare or important museum objects. Enzymatic cleaners are dependent on a high level of skill, technical knowledge and professional training, but they are earning a solid place in the repertoire of professional conservators.

Increased concern about the environment may well render the toxic methylene chloride strippers obsolete in the near future. Manufacturers have already produced "safer" strippers based on dimethyl esters, and further research will probably yield other alternatives to chlorinated solvents. Slower acting solvent-type strippers may well be safer to the underlying composition ornament, but additional research and use are
needed before making definitive statements.

In summary, most damage to compo occurs during the removal of layers of paint; this is a critical process and should not be attempted without consulting a conservator and should not be undertaken by painting contractors unless they are highly skilled and have had extensive experience in this very delicate procedure.

Proper disposal of residual chemicals and debris must be undertaken to avoid contaminating the environment with solvents and lead, and such disposal is, in fact, now required by federal, state, and local ordinances. The company responsible for removing chemical waste should be licensed to dispose of it, otherwise the property owner may be held accountable if disposal laws are violated.

Refinishing compo ornament usually follows stripping. According to historic evidence uncovered and depending on the existing and desired appearance of the room, compo can be stained, painted, gilded, marbleized, or glazed. Paint types may include distemper, alkyd oil, or latex. A thin coating is recommended so the intricate surface detail is not clogged.

**Surface cracking.** Surface cracking indicates age and, thus, the history of the ornamentation itself. It does not necessarily mean that cracks have to be fixed. But if cracking interferes with the overall design pattern, then the conservator may elect to fill the cracks with suitable fill material. For example, "light weight" spackles bulked with microballoons are excellent because they are soft and compressible and will accommodate changes in the size of cracks due to moisture fluctuation. After stabilization, the surface is finished to match the existing area.

**Delamination.** Delamination or separation of the compo from the wood substrate is the simplest repair problem to remedy. The conservator begins by testing cracked areas with slight finger pressure to determine which parts of the design need consolidation. Compo sections that have separated from the substrate, but are otherwise intact, can be glued back in place using emulsion type adhesives such as "white" glues or a clear, solvent-release adhesive. For vertical surfaces, the glue is painted onto the back of the delaminated compo as well as the wood base and, when slightly tacky, re-attached, and held with clamps until dry.

Professional conservators often formulate their own adhesives based on stable synthetic polymers (plastics) dissolved in solvent that will be more reversible, should the need arise, and also offer better long-term stability than many commercial adhesives.

**Repairs to broken or damaged compo.** When some original compo has been lost, additional work is required to make a repair. One particularly easy and inexpensive method of repairing broken ornamentation is to use non-hardening clay ("plastilina") or polymer-based modeling materials as an impression material to make a mold. After a mold is made from existing ornament, missing or deteriorated portions of the historic design can be duplicated with a durable gypsum plaster. Especially in cases where economic considerations dictate procedure, use of this substitute material may be helpful because it is cheaper. Alternatively, an existing studio mold may sometimes be used to make small replacement pieces in a repair project.

In another scenario, a repetitive design on a mantelpiece may be damaged or portions missing. Especially if the compo design is complex and several portions of ornament need to be replaced, rigid polymer molds with traditional compo are recommended for the repair work. The mold is created using a section of the original ornament as a model. After replacement pieces are fabricated, they are attached using brads, or finish nails. The pointed end of the nail is clipped blunt with snips to avoid possible splitting of the wood substrate. The nail is first hammered into the surface, then countersunk, and
the resulting hole filled with gesso putty or additional compo.

Finally, a ready-made replacement piece can be ordered from the catalog of a compo manufacturer, but it is unlikely to be a perfect match to an extant historic decoration.

**Replacement of missing compo ornamentation.** Once-attractive compo may become damaged to such a degree that the remaining fragments are removed by an owner and the entire surface painted over. Thus, if there is some existing composition ornament in a room, such as an overdoor or chair railing, the conservator would most likely look for evidence of other ornament that is now missing.

For example, a mantel may appear as a flat, unornamented surface to the untrained eye, but after many layers of paint are removed by the conservator, shadow images are revealed. These images or "ghost marks" are left by the hide glue component of the original mix. Although the glue is water soluble, it will not be completely removed by an organic stripper such as methylene chloride. (But if earlier inappropriate paint removal methods were used, such as water-based strippers, caustic strippers, or mechanical sanding, ghost marks from the glue would be destroyed.)

When the paint stripper dries, a ghost mark left by composition ornament appears slightly darker than the surrounding area where no compo had been attached. In addition, small, square-headed, ¼" brads used to reinforce the original compo may be embedded in the wood.

In summary, detailed physical evidence, as well as written and pictorial documentation, can provide a valid framework for replacement at a particular site. With careful detective work, missing historic ornamentation may be successfully identified and replaced with matching ornament.

**Restoration of a "period" interior.** When ornamentation is extensively deteriorated and missing, owners often want to re-create the historic appearance through restoration. Physical evidence and other documentation may be used as a basis for the restoration; it should be remembered, however, that as the amount of surviving material diminishes, the greater the chance for inaccuracy when attempting to depict the historic appearance. Choosing restoration as a treatment thus requires exacting documentation prior to work and meticulous attention to detail in the work itself.

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**Conclusion**

Despite its popularity and widespread use as a decorative material, the history of composition ornament has yet to be thoroughly studied. Individual craftsmen have acquired fragmentary knowledge about some designs and historic methods; historians and students of interior decorative design have accumulated knowledge about patterns, artisans, and methods of manufacture and distribution; and curators of historic collections that include compo are knowledgeable about the objects under their care. The combined knowledge of these individuals, together with examples and images of compo ornament from a variety of sources, needs to be synthesized to address the complex issues involving compo repair and preservation. The future of the study of composition ornament, as well as many other facets of architectural, decorative, and
fine art history, lies in this sort of cooperative effort.

Further Reading


Organizations

http://www.nps.gov/history/hps/TPS/briefs/brief34.htm
For information on conservators, contact the following organizations:

**Association for Preservation Technology**
4513 Lincoln Ave., Suite 213,
Lisle, IL 60532-1290

**Heritage Preservation**
3299 K St., NW, Ste. 403
Washington, D.C. 20007

**American Institute for the Conservation of Historic & Artistic Works**
1400 16th St.
Washington, D.C. 20036

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Home page logo: Making compo dough. Photo: Lenna Tyler Kast.

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This publication has been prepared pursuant to the National Historic Preservation Act of 1966, as amended, which directs the Secretary of the Interior to develop and make available information concerning historic properties. Technical Preservation Services (TPS), Heritage Preservation Services Division, National Park Service prepares standards, guidelines, and other educational materials on responsible historic preservation treatments for a broad public.
Preserving Historic Ceramic Tile Floors

Anne E. Grimmer and Kimberly A. Konrad

»The Tile-Making Process
»Ceramic Floor Tile Types
»Laying Historic Tile Floors
»Preservation and Maintenance
»Damage and Deterioration Problems
»Repair and Replacement
»Summary
»Selected Reading
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A NOTE TO OUR USERS: The web versions of the Preservation Briefs differ somewhat from the printed versions. Many illustrations are new, captions are simplified, illustrations are typically in color rather than black and white, and some complex charts have been omitted.

With a tradition that dates to ancient civilizations, ceramic tile flooring can be found in a variety of settings in diverse cultures and structures, including residential buildings ranging from large apartment buildings to small private houses, institutional buildings such as government offices and schools, and religious buildings such as cathedrals and mosques. Historically, its widespread use may be attributed to the fact that a readily available natural material—clay—could be converted by a relatively simple manufacturing process—baking or firing—into a very durable, long-lasting and attractive floor tile that is easy to maintain. Ceramic floor tiles exhibit a versatility of colored glazes and decoration, and they range from the plainest terra cotta tiles to highly decorated individual ceramic tiles and elaborately patterned tile floors. Their modularity, as standardized units, make them easy to fit into different sized spaces which also explains much of the popularity of ceramic floor tiles throughout history.

*Ceramic: Any product manufactured from a nonmetallic mineral (such as clay), by firing at high temperatures.

This Brief begins with an overview of ceramic tiles as a traditional flooring material. It includes an explanation of the various kinds of historic floor tiles used in the United States and how they were made. General guidance is given on preservation treatments, focusing on maintenance, and, when necessary, selective replacement of damaged floor tiles. The Brief is intended to provide owners and managers of historic properties with an understanding of the significance and historical background of ceramic floor tiles, and a basic awareness of maintenance techniques and various deterioration problems to which tile floors are especially prone. In the case of significant historic ceramic tile floors, a professional conservator of ceramics should be consulted to advise in matters of repair, restoration or conservation. Historically, ceramic tiles were used on walls as wainscoting, on fireplace hearths and fireplace surrounds, and even on furniture, as well as for flooring. However, because floor tiles are subject to greater damage and deterioration, they are the primary emphasis of this Brief. Highlights include: a short

The Tile-Making Process

Clay is an earthen material, moldable or plastic when wet, non-plastic when dry, and permanently hard when baked or fired. It is widely distributed geographically, and often found mixed with sand in soils of a loam type—a mixture of clay, silt and sand. Relatively pure clay is not usually a surface deposit, although, in some cases, it may be exposed by erosion. Clay types vary throughout the world, and even within a region. Each type of clay possesses a unique combination of special properties such as plasticity, hardness and lightness, as well as color and texture, which makes some clays better suited for one kind of ceramic than another. The correct clay mixture needed for a particular purpose can be created by blending clays and adding other materials, but using the wrong type of clay can result in expensive production problems such as crazing (the formation of tiny cracks in a tile glaze) or warping of the tile itself. Traditionally, chalky clays have been preferred for many kinds of ceramic tiles, in part because they produce, when fired, a white body which is desirable for decorating. Other materials can be added, including grog (or ground-up fired clay) that helps aerate the clay and prevents warping, speeds firing and reduces shrinking, or calcined flint, to harden it.

There are several methods used for making ceramic tiles: extrusion; compaction or dust-pressing; cutting from a sheet of clay; or molded in a wooden or metal frame. Quarry tiles are extruded, but most ceramic floor tiles, including traditional encaustic, geometric and ceramic "mosaic" tiles are made from refined and blended ceramic powders using the compaction method, known as dust-pressing. Encaustic tiles, which were made by dust-pressing, are unique in that their designs are literally "inlaid" into the tile body, rather than surface-applied. Once formed, tiles are dried slowly and evenly to avoid warpage, then fired in a special kiln that controls high, even heat at temperatures up to 1200°C (or approximately 2500°F) for 30-40 hours. Higher temperatures produce denser tiles with harder glazes. Most ceramic tiles require only one firing to achieve low porosity and become vitrified or grass-like, but some, especially highly decorated tiles, are fired more than once. Non-vitreous and semi-vitreous tiles are fired at lower temperatures and are much more porous.

Historical Background

Historically, the use of ceramic floor tiles goes back to the fourth millennium B.C. in the Near and Far East. The Romans introduced tile-making in Western Europe as they occupied territories. However, that art was eventually forgotten in Europe for centuries until the 12th century when Cistercian monks developed a method of making encaustic floor tiles with inlaid patterns for cathedral and church floors. But, this skill was again lost in the 16th century following the Reformation. Except for finely decorated wall tiles made in Turkey and the Middle East, and Delft tiles made in Holland in the 17th century, ceramic floor tiles were not made again in Europe until almost the mid-19th century.
The modern tile industry was advanced by Herbert Minton in 1843 when he revived the lost art of encaustic tile-making in England. The industry was further revolutionized in the 1840s by the "dust-pressing" method which consisted of compressing nearly dry clay between two metal dies. Dust-pressing replaced tile-making by hand with wet clay, and facilitated mechanization of the tile-making industry. Throughout the rest of the 19th century, dust-pressing enabled faster and cheaper production of better quality floor tiles in a greater range of colors and designs. In the 1850s encaustic tiles were selected for such important structures as the new Palace at Westminster in London, and Queen Victoria's Royal Residence on the Isle of Wight. By the latter part of the 19th century, despite the fact that encaustic tiles were still quite expensive, they had become a common flooring material in many kinds of buildings.

**Development of the Tile Industry in America.**
Although plain, undecorated ceramic tiles were traditionally a common flooring material in many parts of the Americas, especially in Latin and South America, ceramic floor and roof tiles were probably not made in the North American Colonies until the late-16th or early-17th century. It was, however, in the Victorian era that ceramic tile flooring first became so prevalent in the United States. The production of decorative tiles in America began about 1870 and flourished until about 1930.

Like so many architectural fashions of the day, the popularity of ceramic tile floors in America was greatly influenced by the noted architect and critic, Andrew Jackson Downing. In his book *The Architecture of Country Houses*, published in 1850, Downing recommended encaustic floor tiles for residential use because of their practicality, especially in vestibules and entrance halls.

The 1876 Philadelphia Centennial Exposition, with its European and even a few American exhibits of decorative floor tile, was a major factor in popularizing ceramic tile floors in the U.S. Initially, most ceramic tiles-other than purely utilitarian floor tiles-were imported from England, and their relatively high cost meant that only wealthy Americans could afford them. However, when English tile companies realized the potential for profitable export, they soon established agents in major U.S. cities to handle their American business. The English near monopoly actually stimulated the growth of the U.S. tile industry in the 1870s resulting in sharply decreased English imports by 1890.

The location of potteries and ceramic tile factories is dependent upon the ready availability of suitable ball clay (clay that balled or held together), kaolin (a white clay used as a filler or extender), and feldspar (a crystalline mineral), and an accessible market. Since the cost of shipping the manufactured products tended to restrict profitable sales to limited areas, this usually determined whether a factory would succeed. Although the United States Pottery in Bennington, Vermont, is known to have made encaustic tiles as early as 1853, the Pittsburgh Encaustic Tile Company (later the Star Encaustic Tiling Company), was the first successful American tile company, and is generally considered the first to manufacture ceramic tile in the U.S. on a commercial basis beginning in 1876.

At least 25 ceramic tile companies were founded in the United States between 1876 and 1894. In the East, several notable tile firms that were established in this period flourished in the Boston area, such as the Chelsea Keramic Art Works, the Low Art Tile Works, and the Grueby Faience Company. Other East Coast companies organized in the late-19th and early-20th century included the International Tile & Trim Company, in Brooklyn, New York; the Trent Tile Company, Providential Tile Company, Mueller Mosaic

http://www.nps.gov/history/hps/TPS/briefs/brief40.htm
Tile Company, and the Maywood Tile Company, all in New Jersey; and the Moravian Pottery and Tile Works in Doylestown, Pennsylvania.

Many factories were also established in the Midwest—Indiana, Michigan, and, especially, in Ohio. In the last quarter of the 19th century, the town of Zanesville, Ohio, was the largest center for pottery and tile-making in the world. Some of the factories in Zanesville included: Ohio Encaustic Tile Company; Mosaic Tile Company; Zanesville Majolica Company; and J.B. Owens Pottery, later to become the Empire Floor and Wall Tile Company. The American Encaustic Tiling Company, established in 1876, was one of the first, and most successful manufacturers in Zanesville. In the early 1930s it was the largest tile company in the world, producing large quantities of floor tile, plain and ornamental wall tile, and art tile until it closed about 1935, as a result of the Depression. The United States Encaustic Tile Company, Indianapolis, Indiana; Rookwood Pottery, Cincinnati, Ohio; Cambridge Art Tile Works, Covington, Kentucky; and Pewabic Pottery, Detroit, Michigan, were some of the other well-known potteries in the Midwest.

Around the turn of the century, the industry began to expand as tilemakers moved West and established potteries there. Joseph Kirkham started the ceramic tile industry on the West Coast in 1900 when he set up the Pacific Art Tile Company in Tropico, California, after his company in Ohio was destroyed by fire. In 1904 the company became the Western Art Tile Company, surviving for five years until it went out of business in 1909. During the early-20th century, other companies were founded in Southern California, in and around Los Angeles. Batchelder & Brown, in particular, of Pasadena (later Batchelder-Wilson in Los Angeles), was well-known for its Arts and Crafts-style tiles in the teens and 1920s. By the early 1940s California had become one of the leading producers of tile, especially faience, in the U.S.

Ceramic engineers, potters and artists not only moved frequently from one pottery to another, but often struck out on their own and established new factories when dissatisfied with a former employer. Also, it was not uncommon for one company to reuse a defunct factory or purchase another pottery business, change the name and increase the product line. As a result, many of the companies in existence today are descendants of the early pioneering firms.

**Changes in the Tile Industry.** The majority of ceramic floor tile made in the U.S. before 1890 was encaustic, but various factories gradually began to develop and produce other kinds of tiles. The Trent Tile Company, among others, started to manufacture both white and colored ceramic mosaic tiles by the mid-1890s. White vitreous wall tile became available, as well as more decorative tiles with colored glazes, such as the variegated faience glazes intended to give a more hand-crafted appearance that were originated by the Grueby Faience and Tile Company in 1894, and soon adopted by other potteries.

In the 19th and early-20th century, many ceramic tile firms had their own engraving departments, while some used commercial designs supplied by professional printers. Well-known designers were often commissioned to work on specific product lines for a particular firm. These designers worked for one firm after another which resulted in similar designs being produced by different companies. (Historic ceramic floor tiles were usually identified by a manufacturer's or designer's mark on the back, if they were marked at all.) By the latter part of the 19th century ready-mixed glazes and colors were also available. This was a great advantage for potters who, prior to this, had to mix their own colors and glazes.

During the 20th century, the floor tile industry continued to evolve as much as it had in the previous century. Modern methods of production employed sophisticated machinery, new
Ceramic mosaic tiles are a practical floor covering in the entryway of this early 20th century school building. Photo: NPS files.

materials and decorating techniques. In the years following World War II, there were many advances in the industry. Commercially manufactured dust-pressed tiles, which had previously required more than 70 hours just in the kiln, could be made in less than two hours from the raw material stage to finished tiles, boxed and ready to ship. Dried, unglazed tiles were sprayed with colored glaze evenly and automatically as conveyors carried the tiles into the tunnel kilns, and the extrusion process ensured that the tiles were cut to a uniform thickness and size. The changes and developments in the production of floor tile brought forth a wide range of shapes and sizes, along with new colors, glazes and decorating techniques.

After the turn of the century, fewer encaustic floor tiles were used, particularly in residential architecture. The introduction of ceramic mosaic floor tiles was a factor in their decline. The development of rubber interlocking floor tiles in 1894, along with other, more resilient, flooring materials, was instrumental in the decreased popularity not only of encaustic tiles, but also other ceramic tile flooring. These new materials were not only cheaper, they were not as fragile; they were also lighter and thinner, and easier to install.

Ceramic mosaic tiles remained in common use through the 1930s in part because an innovative development had made laying such small tiles easier. The tiles were pre-mounted in decorative patterns on 12" x 12" sheets of paper, and sold ready to lay in cement. This greatly simplified the tile setter's work, and no doubt was a significant factor in the increased popularity of ceramic mosaic tiles. Sophisticated mosaic floor designs became common in entrance foyers of public and private buildings. Small, white, unglazed tiles in round, square, octagonal or hexagonal shapes were promoted for their sanitary qualities, particularly for bathroom floors, while larger, rectangular, white, glazed tiles were used for bathroom walls or wainscoting. Colored tiles were also popular, especially for bathrooms, and even kitchens. Quarry tile, which was larger and thicker than other ceramic floor tile of this period, was often used in public buildings, as well as for entrance halls, small studies, libraries, dining rooms and even living rooms in private homes. But, by the 1930s, the fashion for art tile had diminished to the point where floor tiles were, for the most part, generally regarded as primarily utilitarian, as opposed to important decorative elements.

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**Ceramic Floor Tile Types**

The thickness of historic ceramic floor tiles varied considerably according to their intended use and when they were made. Floor tiles were thicker and harder than wall or ceiling tiles. Stove tiles, meant to retain the heat of the stove, were sometimes as much as several inches thick. Medieval floor tiles were usually one inch thick; encaustic tiles of the Victorian era tended to be slightly thinner. Modern, 20th-century tiles, with the exception of some art pottery tiles, are the thinnest, as a result of modern manufacturing methods. The backs of most, but not all, ceramic floor tiles are covered with raised (or sometimes recessed) ridges, circles or squares which help to increase the bonding capability of the tile.

**Unglazed and Glazed Tiles**

Ceramic floor tiles can generally be divided into two types: **unglazed** and **glazed**.
Unglazed tiles include: quarry tiles; encaustic and geometric tiles; and ceramic mosaic tiles, which can be either glazed or unglazed. Most other ceramic floor tiles are glazed.

**Unglazed Tiles**

Quarry tiles are the most basic type of historic ceramic floor tile. Originally made from quarried stone, they are machine-made using the extrusion process. Quarry tiles are unglazed, semi-vitreous or vitreous, and essentially are square or rectangular slabs of clay baked in a kiln. The colors of quarry tiles are natural earthen shades of gray, red and brown determined by the clay and, to some extent, the temperature and duration of firing. Quarry tiles, which range from ¼" to ½" in thickness, are available in square and rectangular shapes in sizes that include 3", 4-1/4", 6" (one of the most common sizes), 9" and 12" squares; 6" x 12", 6" x 9", 4-1/4" x 9", 3" x 6", and 3" x 9" rectangles; and 4" x 8" hexagon shapes. (Pavers or paver tiles are a simpler, and tend to be somewhat cruder, version of quarry tiles. Like quarry tiles, they are usually unglazed, but slightly thicker. Machine-made pavers are either semi-vitreous or vitreous, and generally formed by dust-pressing, although sometimes are extruded. Hand-made pavers which are common in Mexico and southern Europe are non-vitreous.)

Encaustic tiles are a type of traditional unglazed-yet decorative-floor tile, manufactured by the dust-pressed method. Whereas most ceramic tiles are surface-decorated or decorated with impressed or embossed designs created by a mold, encaustic tiles are unique in that their decorative designs are not on the surface, but are inlaid patterns created as part of the manufacturing process. First, a thin, approximately ¼" layer of fine, almost powder-dry, clay was pressed into a mold with a relief design at the bottom which formed a depression in the face of the tile. A second, thicker layer of coarser clay was laid over the first layer, then covered with another layer of fine clay. This "sandwich" helped prevent warping and ensured that the body of the tile was strong and had a fine, smooth surface. The layers of clay "dust" were compacted by presses, after which the mold was inverted and the die removed, thus producing a tile with an indented or intaglio pattern on top. After the tile dried, colored slip (liquid white clay colored with dyes), was poured to fill in the intaglio pattern. Each color had to dry before another color of slip was added. The recessed area was overfilled to allow for shrinkage, and after drying for several days, and before firing, the excess slip was scraped off the surface by a rotating cutter that created a flat, although not completely smooth, face. Problems might arise during the firing. Due to the dissimilar rates of contraction of the different clays, the inlaid clay could shrink too much and fall out of the tile recesses; or, the tile could be stained by the different pigments used for the design if impure or unstable.

By the 1840s, encaustic tiles were made entirely with almost-dry clay using the dust-pressed method. This served to eliminate the possibility of staining the body of the tile with other colors and permitted the use of more colors on a single tile. Thus, an encaustic tile can sometimes be dated according to the complexity and the number of colors in its pattern. Red tiles with white figurative patterns were generally the earliest, followed by brown and buff colored tiles. In the 1860s, blue tiles with yellow or buff patterns were popular, succeeded by more subtle color schemes featuring a "chocolate" red with a soft grey. By 1860, up to six colors were used in a single tile to form a pattern. Toward the end of the century, white encaustic tiles with a black or gold design were common, as well as tiles with complicated color patterns of white, black, gold, pink, green and blue. Encaustic tiles were decorated with traditional as well as original...
designs. Some, particularly intricate, designs were painted on the surface of the tile with opaque colored glazes, instead of being inlaid. Most major tile manufacturers sold many of the same pre-formed encaustic floor tile patterns through catalogues. Encaustic tiles were produced in a variety of sizes, mostly square or octagonal in shape, and almost any design could be custom-made for a special purpose or to fit a particular space. Historic, 19th-century encaustic tiles were generally slightly less than 1" thick, about 15/16." Cheaper tiles of lesser quality were also made of clay or cement. These designs resembled those commonly found on encaustic tiles but applied as a transfer printed pattern, or using a multi-color lithographic or silkscreen process. These are still manufactured and popular in many parts of the world.

Smaller, single-colored versions of encaustic tiles that, when assembled together form a geometric pattern, are called geometric tiles in England. However, in the United States they are generally not differentiated from encaustic tiles. Based on the geometric segments of a six-inch square, they were typically rectangular, square, triangular or hexagonal in shape, and about the same thickness as patterned encaustic tiles. Geometric tiles were especially well suited for decorative borders, and a wide variety of floor designs could be created with their many shapes, sizes and colors—either alone or combined with patterned encaustic tiles. The cost of producing geometric tiles was much less than of encaustic tiles because each tile involved only one type of clay and one color. By the end of the 19th century, over 60 different shapes and sizes of geometric tiles were available in up to ten colors, including buff, beige or tan, salmon, light grey, dark grey, red, chocolate, blue, white and black.

Ceramic mosaic tiles are essentially smaller versions of geometric tiles (usually no larger than 2-1/4", and no thicker than 1/4") ranging in size from ½" to 2 3/16", in square, rectangular or oblong, hexagonal, pentagonal and trapezoidal shapes. Both vitreous and semi-vitreous mosaic tiles were available, unglazed in solid or variegated colors with a matte finish, or glazed in unlimited colors. Single, one-piece tiles were also fabricated to give the appearance of multiple mosaic pieces. This was achieved with a mold, which gave the appearance of recessed mortar joints separating individual "mosaics".

**Glazed Tiles**

With the exception of quarry tiles, encaustic tiles, and some mosaic tiles, most ceramic floor tiles are decorated with a glaze. While unglazed tiles derive their color solely from the clay, or from oxides, dyes or pigments added to the clay, the color of glazed tiles is provided by the glaze, either shiny or matte. Some potteries specialized in certain kinds of glazes and were famous for them. The earliest and most common method of clay tile decoration made use of tin-glazes which were essentially transparent lead glazes. Tiles were either dipped into the glaze or the glaze was brushed on the tile surface. Glazes were generally made with white lead, flint, or china clays ground up and mixed with finely ground metallic oxides that provided the color. Colored glazes were commonly known as "enamels". Colors included blue derived from cobalt, green from copper, purple from manganese, yellow from antimony and lead, and reds and browns from iron. An opaque glaze was created by adding tin oxide.

**Laying Ceramic Tile Floors**

http://www.nps.gov/history/hps/TPS/briefs/brief40.htm

6/25/2009
19th Century Techniques. Aside from the use of improved tools and modern materials, installation methods have changed little since the mid-19th century. M. Digby Wyatt, an architect for one of the major 19th century encaustic tile manufacturers in Britain, Maw & Co., described this procedure for laying encaustic and geometric tiles in 1857:

First, either an even layer of bricks, a 2-1/2" bed of concrete of quicklime and gravel, or a mixture of Portland cement and clean sharp sand was laid to prepare a solid foundation for the tiles. If the tiles were to be laid over an existing wooden floor, the floor boards had to be pulled up, sawn into short lengths and fitted between the joists. Concrete filled in the spaces and made the base flush with the upper face of the joists, and created a level surface finished within 1" of the finished floor line. A layer of cement mortar was then laid on top. This allowed the tiles to fit in the same amount of space as the floorboards they replaced.*Before laying the tiles, skirting boards or shoe moldings were to be removed, and replaced after the tiles were laid. This eliminated having to cut the outer tiles to fit exactly, and resulted in a neater appearance.

Next, the floor design was marked off with mason's string or chalk lines which divided the space into equal quadrants. The first section to be laid out was defined by two parallel strips of wood, or guide pieces, about 4" wide. A level thickness of cement was spread between these strips. The tiles, thoroughly soaked in water, were laid in the cement and leveled with a straight-edge. The foundation had to be kept wet while the tiles were being laid. Small strips of wood temporarily placed at right angles to the guide pieces helped keep elaborate patterns straight.

When the bed was hard, the joints were filled with pure cement mortar-sometimes colored with lamp black, red ochre or other natural pigments-mixed to the consistency of cream. Excess mortar was wiped off the tiles with a piece of flannel or sponge.

A newly-laid tile floor could not be walked on for 4-6 days until the cement hardened properly. Occasional washing would remove the saline scum that often appeared on the surface right after the tiles were laid.

20th Century Techniques. Almost 50 years later, in 1904, the Tile Manufacturers of the United States of America published Suggestions for Setting Tile with the intent of bringing tile-laying up to a uniform standard. This guidance was very similar to that given by Wyatt. But, there were some differences, such as using hollow clay tile as a foundation material and heavy tar paper when laying tile over a wooden floor to protect the floor boards from the moisture of the mortar mix. Emphasis was placed on using the best quality cement, sand, and purest water to obtain a durable tile floor. Soaking the tiles before setting was no longer necessary, but using stiffer mortar was suggested to prevent it from rising up between the tiles.

Tile-laying methods changed somewhat more later in the 20th century, mostly due to the availability of new materials and techniques. By the 1920s small ceramic mosaic tiles were manufactured as 12" square sheets held together by a face-mounted paper "skin." This made it possible to lay the 12" square of tiles as a unit rather than each of the small tiles individually. Mounting the tiles directly in the cement resulted in a very strong bond. But the face-mounted paper obscured the tiles from view making it difficult for the tile-setter to see if the tiles were being laid straight. The fact that the paper was not removed until after the tiles were firmly set in the cement bond coat further complicated realignment of crocked tiles. This paper "skin" was eventually replaced with a fabric mesh backing. This permitted the tiles to be aligned as soon as the moisture from the bond coat loosened the mesh from the back of the tile; it also allowed a single tile to be cut away from the mesh and repositioned immediately. Although the fabric mesh made tile setting faster, sometimes it also resulted in a weaker bond by reducing the contact area between the backs of the tiles and the bond coat.

http://www.nps.gov/history/hps/TPS/briefs/brief40.htm
Following World War II, different methods of preparing a foundation for a ceramic tile floor were developed to be more compatible with new materials, such as reinforced concrete, expanded wire mesh, polyethylene and waterproof plywood. New adhesives and grouts also facilitated tile installation, and an increased variety of epoxy and cement mortars allowed for different setting bed thicknesses. But today, after half a century of practical application, some of these "new" materials, such as plywood, particle board, oriented strand boards and other wood panels, are no longer recommended for use with ceramic tile.

Mortar beds are lighter, more flexible, and much thinner than they were previously, having shrunk from several inches to as thin as 3/32". A greater variety of materials are used for setting ceramic floor tiles, including bonding agents and waterproof membranes. Basic installation methods have not changed significantly, but they vary according to the type of subfloor on which the tile is to be laid. While the same concerns for level underlayment and strong adhesion exist, advancement has occurred mostly in the increased speed and ease of laying the tiles.

*The traditional practice of sawing the original floor boards and fitting them between the joists, still used today to maintain a low finished floor profile, has resulted in numerous cracked tiles and other failures. Instead, a better approach is to leave the existing floor boards, if they are in good shape, and install a cementitious backer board (CBU) available in thicknesses ranging from ¼" to 5/8" as the setting bed for the tiles.

Historic Ceramic Floor Tile: Preservation and Maintenance

Before undertaking any work more complicated than regular maintenance or a very simple repair on a significant historic ceramic tile floor, or on any historic tile floor where serious damage has occurred, it is recommended that a professional conservator of ceramics, an historical architect, an architectural historian, or a chemist with particular knowledge and experience in this field be consulted. This will ensure that all future work, whether it be regularly-scheduled maintenance or more technical and specialized repair and restoration, is done in accordance with the Secretary of the Interior’s Standards for the Treatment of Historic Properties.

Cleaning Methods. Ceramic tiles are essentially a practical, low-maintenance flooring material. Yet, even glazed tiles are somewhat porous, and can get dirty and stained, especially in heavy traffic areas or where oil, fat, and grass stains are likely to occur. Although heavily soiled areas may be difficult or impossible to clean completely, in most instances, cleaning ceramic tile floors is relatively easy. Cleaning should always begin with the gentlest means possible, which may be as simple as warm water. Regular maintenance should include sweeping, or preferably dry or damp mopping or vacuuming to reduce grit. Tiles can usually be cleaned with a non-soap-based household floor cleaner, such as one of the commercial products intended for cleaning ceramic tile floors available on the market.

All cleaning and stain-removal products should always be tested on a small, inconspicuous area before using. Abrasive cleaners (including powdered cleansers and even "mildly" abrasive creams) and mechanical equipment can damage and wear away the protective surface, as well as the decorative design on the tiles, and should not be

This tiled Presidential seal was laid in the floor of the Pension Building in 1901 at President McKinley's 2nd inauguration. Photo: NPS files.
used on ceramic tile floors. Generally, acid-based cleaning solutions should also not be used on ceramic tile floors because they can damage the complex silicates in a glaze. However, there are some acid-based cleaners specially formulated for cleaning and removing coatings from ceramic tile floors that may be acceptable, but even these must be used with caution. Sometimes an acid-based cleaner may, in fact, be needed to remove discoloration or staining caused by lime or cement mortar. But, it should be tested first, used with caution, and applied only to a thoroughly wetted tile floor from which excess water has been removed. Pre-wetting a ceramic tile floor before cleaning is a good policy to observe with all cleaners. The water saturates the porous tile and prevents chemicals or other cleaning agents from penetrating into the tile body. Floor tiles should be always rinsed thoroughly after cleaning.

Plastic pot-scrubbers may be effective in loosening and removing superficial dirt without abrading the glazed or vitrified surface of the tiles. Stubborn asphalt or oil stains, scuff marks, or soiling can sometimes be removed with ammonia or one of the household spray products intended for cleaning kitchen or bathroom tiles. If necessary, a solvent may be applied carefully to pre-wetted tiles, but it should not be left on the surface for an extended amount of time as it may cause discoloration. If possible, a stain should always be identified first in order to select the material best-suited to remove it.

Organic growth, such as mold or mildew, can be eliminated with a dilute solution of household bleach and a neutral household detergent, or a dilute (5-10%) solution of trisodium phosphate (TSP). After applying either of these solutions, it may be necessary to scrub the floor with a natural bristle or nylon brush, and then rinse with clear water. Even a dilute bleach solution should not be left on a ceramic tile floor for more than a few minutes, since the alkali in the bleach can lead to the formation of a white efflorescent deposit. Efflorescence (a whitish haze of water-soluble salts) may stain and streak the tile, or may even cause minor spalling around the joints.

Regular maintenance of a ceramic tile floor should always begin with vacuuming to remove loose dirt and grit. Then, a mild cleaning solution may be applied and left on the floor for 10-15 minutes, without letting it dry on the tiles. Heavily soiled areas may be scrubbed with a natural bristle or nylon brush to loosen dirt from the tile surface. Finally, the floor should be thoroughly rinsed with clean, clear water, preferably twice, and dried with terry cloth towels, if necessary. Any proprietary cleaning product should always be used in accordance with the manufacturer's directions.

**Protective Coatings.** In most instances, traditional ceramic tile floors probably would not have been treated or given a protective coating other than wax. In the 19th century, some encaustic tile floors were treated with linseed oil, but this is not a practice recommended today because linseed oil tends to attract dirt and discolors as it ages. Most historic ceramic tile floors simply acquired a natural "polish" or sheen through use. Because the surface of ceramic tiles is already protected with a fired skin or a glaze, an additional protective coating should generally not be needed.

Opinions differ concerning the use of protective coatings, penetrating sealers, or waxes on ceramic tile floors, and, especially, on historic ceramic tile floors. If properly applied and regularly cleaned, a coating can sometimes be an effective maintenance treatment, but only on interior floors. However, if not adequately or properly maintained, rather than facilitating maintenance of ceramic tile floors in high traffic areas, such coatings may tend to emphasize traffic patterns as they wear away or become scratched. Some coatings may also peel in spots, or cause tile to appear hazy or cloudy if the coating is not applied in accordance with the manufacturer's specifications, or if the tiles are not perfectly clean when the coating is applied. Furthermore, applying such a coating may actually increase maintenance costs, since a coating requires periodic removal and renewal. The frequent removal of a coating can also damage a ceramic tile floor if it is carried out with harsh chemicals or abrasive mechanical equipment. If any coating is considered, a traditional coating, such as floor wax, may be the most suitable. Wax is
easy to remove when it becomes worn, and does not impart a high, potentially inappropriate, gloss to the surface.

On the other hand, a penetrating sealer, or impregnator, may be worth considering to protect patterned encaustic tiles, or painted or printed tiles featuring a design that might be worn off, particularly in public buildings with a high volume of foot traffic. For example, some manufacturers of new, reproduction encaustic tiles recommend applying a penetrating sealer to the replacement tiles, as well as to the historic tiles. Impregnators do not change the color of the tile surface and, unlike some penetrating sealers, are completely invisible after they have been applied. They can reduce the porosity or water absorption of the tile surface, and provide some protection for the tile (and the grout) against staining. This may be particularly useful on light-colored floors. Whether to apply an impregnator to an historic ceramic tile floor, and what type or product to use, are decisions that should generally made in consultation with a conservator or ceramic tile specialist. It may also be necessary to comply with certain safety standards and friction requirements of the ADA (Americans with Disabilities Act). The ADA Guidelines recommend "a static coefficient of friction" of 0.6 for level surfaces and 0.8 for ramps. This may require the application of a non-slip sealer or wax to historic ceramic tile floors in some public buildings.

Despite the non-traditional shiny finish they may impart to a floor surface, two-part, acrylic-based coating systems are commonly used today on historic ceramic tile floors in many public buildings, primarily because they facilitate easy maintenance. If it is decided that a sealer is to be used, a product with a matte or dull finish may be preferable, or more appropriate, for a historic ceramic tile floor than one with a high-gloss.

In some cases, temporary protection may be the best approach until a better solution is found. Non-permanent protection for an historic ceramic tile floor may be as simple as using floor mats at doors or in heavy traffic areas.

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**Historic Ceramic Floor Tile: Damage and Deterioration Problems**

**Loss of Tile Surface and Pattern.** Ceramic tiles are among the most durable of historic flooring materials, but natural wear and a certain amount of deterioration or damage is inevitable. Some tiles, such as dense, close-textured quarry tiles and ceramic mosaic tiles, resist abrasion and stain absorption very well. But many others, especially patterned encaustic and geometric tiles, are extremely susceptible to abrasion. Heavy traffic can also result in uneven wear, or even cupping, in certain areas of tile floors that get more use than others, such as doorway entrances. The particular clay mix, or the dye or pigment used to color the clay, can also affect the hardness and durability of individual tiles or an entire ceramic tile floor.

**Tile Glaze Failure.** Occasionally some glazes can become pitted or powdery as they age. Lead glazes used in the 19th century, which were fired at low temperatures, deteriorated relatively quickly. Glazes have different physical properties from the fired clay tile body itself, and as a result may sometimes crack or craze. Unless the crazing visibly extends into the porous clay of the tile body beneath, this is not generally a
serious material failure; however, dirt entering these cracks cannot be removed, and will discolor the tile. If the crazing penetrates through the glaze, it may increase the water absorption of the tile.

**Tile Breakage.** Ceramic floor tiles are very susceptible to damage and breakage caused when something heavy is dropped. Repeated passage of heavy objects, or carts, over a floor can also crack and break ceramic tiles, as well as heavy vibration from outside traffic.

**Moisture Damage to Tile.** Ceramic tile floors have been traditionally viewed as highly waterproof systems that do not require protection from moisture. In reality, however, this is not true. Water-related problems are one of the most common causes for the deterioration and failure of historic tile floors, particularly in bathrooms and other rooms where there is a lot of moisture. Water that is allowed to sit in areas around shower stalls and bathtubs can eventually damage grout and mortar, and loosen tiles. Some of the more porous kinds of tiles that are not as hard-fired may actually begin to powder or spall if subjected to constant moisture.

**Loose, Cracked, Broken or Unbonded Tile due to Mortar Failure.** The durability of ceramic tile floors depends to a great extent on a sound mortar bed and sound mortar joints. The wrong mortar type or mortar that is inadequately mixed can also spell trouble for a ceramic tile floor. Failure of a tile floor system laid over a subfloor is often the result of weakened or deteriorated grout or mortar which allows the tiles to become loose. Mortar may also be weakened or loosened by cleaning solutions that are too strong.

Proper tile-laying technique includes the use of a material that will allow for some movement of the tiles. Traditionally, a layer of asphalt (replaced by a layer of plastic or building paper in more modern construction) was inserted to separate the base and the bedding underneath. This prevents bonding between the base and the bed, and allows for some "relative" movement. It is intended to prevent the ceramic tile floor from arching or ridging, a condition in which single or entire rows of tiles can pop up to relieve tension and separate completely from the bed. When this happens, the condition will probably require taking up and relaying many or all of the tiles.

**Tile Damage or Loss caused by Systems Update.** The installation of new plumbing, electrical and HVAC systems, or the attachment of new fixtures and furnishings, may be one of the most common sources of damage to an historic ceramic tile floor. Earlier remodeling projects to remove old pipes or to replace "out-dated" bathroom fixtures may have resulted in the loss of floor tiles. Different shapes and sizes of new fixtures, equipment or pipes may have exposed previously untiled areas that have been inappropriately patched with cement. Careless workers and insensitive installations can also result in damage, breakage or removal of historic floor tiles. All of these conditions will require matching replacement tile.

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**Historic Ceramic Floor Tile: Repair and Replacement**

*The Secretary of the Interior's Standards for the Treatment of Historic Properties* emphasize the retention and preservation of historic building material. Preservation and repair treatments are always preferable to replacement.

**Mortar Joint Repair.** Deteriorated mortar joints and loose mortar or grout can generally be repaired. First, the entire floor should be checked for loose tiles that need to be regrouted. Damaged mortar should be carefully removed by hand and the joints wetted or a bonding agent applied in preparation for regrouting. When making mortar
repairs, it is important to use grout that matches the old in color and consistency as closely as possible.

**Tile Repair.** Trying to remove one tile can endanger surrounding tiles. Thus, it may be better to preserve and retain an original historic tile that is only slightly damaged, rather than replace it. Sometimes cracks may be repaired, or a corner or piece of tile that has broken off may be re-attached, using an epoxy glue, or grout. If a tile is chipped or a small corner or edge is missing, a carefully executed patch of epoxy-mixed with colored enamel, or mortar tinted to blend with the tile, may be less conspicuous than trying to replace every tile that has even the slightest damage. And, it is a better preservation treatment.

In limited instances, glaze failure or surface powdering of ceramic floor tiles may sometimes be treated successfully by a conservator with a specially formulated, solvent-based, mineral densifying agent (such as silicic acid), followed by a siloxane sub-surface repellent, applied 24 hours later. Under the right circumstances, such a treatment can harden and bind the surface, and lower the absorbency of the tile, and still maintain the vapor transmission. But this is a highly complex undertaking and should only be attempted by a conservator after appropriate testing. Not only are these chemicals highly toxic and dangerous to handle, but if used improperly, they can cause greater damage to the tile!

**Tile Replacement.** When an individual tile or a larger portion of an historic ceramic tile floor is missing or so severely damaged that it cannot be repaired, or if it has become a safety hazard, then it should be replaced. When a ceramic tile floor has deteriorated as a result of long term wear and abrasion, or from settlement or vibration damage to the setting bed, there are a number of factors that need to be considered before choosing a preservation treatment. If damage to tiles is the result of more than normal wear and tear, the source of the problem needs to be identified, and the problem corrected before replacing the damaged tiles.

Successful replacement not only depends on the availability of matching tiles, but on the condition of the substrate on which the tiles are laid. Before installing the replacement tiles, any problems, such as settlement or vibration, will have to be addressed, and the height of the new setting bed may have to be adjusted for the thickness of the new tiles.

**Selective Replacement of Individual Tiles.** This cautious approach, typically an attempt to replace only the most seriously damaged tiles, is often taken or considered when only a small number of tiles are involved. Unless old, matching tiles can be found and reused, replacement often requires specially fabricated reproduction tiles. In some instances, individual historic tiles that are damaged may be replaced with matching tiles salvaged from other, less prominent areas of the floor or from other buildings. This is most feasible if the tiles to be replaced are either plain, and easy to match, or decorated with a common historic floor tile pattern.

In order to replace damaged tiles, it can be helpful to identify the manufacturer and the approximate date of the tiles, if possible. However, many mass-produced tiles are not marked and give little or no information as to their origin, although stylistic similarities with other marked tiles may sometimes provide a clue as to the manufacturer. Some decorating firms seldom signed their work, while many firms made bisque tiles (plain, unglazed, once-fired tiles) for other companies, as well as their own use. Identifying
marks will generally be found on the back of the tile. A mark impressed or molded into the back of the tile may give the name or initials of the company which made the tile or the bisque; sometimes a printed or painted mark indicates if it was decorated by a different company, or artist. Historic building records and construction documents may provide information about the tile company or supplier. Catalogues of the period may also be useful in identifying the tile manufacturer of unmarked tiles.

Replacing a single damaged tile is based on the ability to remove only the deteriorated tile without harming surrounding tiles. Attempts to remove one or several damaged tiles often fail because a hammer and chisel are used. The shock of the blows to the tile being removed travels through the grout into surrounding tiles and cracks them. To avoid damaging good tiles, all the grout around the tile must be removed. This is best accomplished by an experienced tile installer using a hand tool called a grout saw or, for grout joints wider than 3/8", a dry-cutting diamond blade, mounted in an angle grinder or circular saw.

Other difficulties may be encountered when selectively replacing damaged tiles with reproduction tiles. New tiles, especially encaustic tiles, may be different in thickness and, sometimes, despite the attention to detail of the reproduction process, slightly different in color and design from historic tiles. This can cause both visual and physical problems, especially if the replacements are being laid in a piecemeal fashion.

If the setting bed does not have enough mortar to grip and hold the tile, one new tile laid among the originals will eventually come loose. If the new and old tiles are different thicknesses, the setting bed in which the new tiles are laid must be at a different height to create a level finished surface. In addition, the two levels of setting beds may be of different composition; one may be harder, stronger and less flexible than the other. This may also lead to problems, since the setting bed foundation should act and respond as a unit to the load and stresses placed upon it.

**Sectional Replacement of Tiles.** In some instances, the best approach may be to remove a complete section of damaged original tiles and replace that section of floor in its entirety with new reproduction tiles. Advantages of this method include the ability to lay a level setting bed, as well as achieving a finished product that is uniform in color and pattern match. Although this approach may involve replacing more original tiles with reproduction tiles than may be absolutely necessary, original tiles that remain in good condition can be saved to be reused in other sections where only a few tiles are damaged. This technique is generally most appropriate either when the section being replaced is the most damaged portion of the floor, or is in a relatively inconspicuous location and the tiles that are removed will supply enough salvaged pieces to permit in-kind repair of a more visually prominent area.

When laying a section of reproduction tiles, it may be a good idea to use contemporary materials and installation methods such as expansion joints or flexible expansion material. One of the major causes of ceramic floor tile installation failure and cracked, broken or disbonded tiles is the lack of expansion joints. Expansion joints were sometimes used in laying historic ceramic tile floors, and these are frequently the ones that have survived in the best condition. Many preservation contractors hesitate to use conventional expansion joint filler materials because of their limited range of colors. However, there are new flexible sealants in a wide range of colors that are available in either sanded or unsanded textures to match the surrounding grout joints. As a result, the expansion joints are almost invisible. A bonding agent may also be considered-if recommended by the tile manufacturer—and any drawings provided by the manufacturer should be used to guide the installation.

Each preservation technique has advantages and disadvantages that the historic property owner or manager should take into consideration before deciding which one is
best suited to the particular flooring problem. For example, slight differences in the shape, size, color and the pattern between the old and the new tiles are frequently encountered. If replacing an entire section, the slightest difference in size and dimension between the original tiles and the reproduction tiles, even if it is as small as 1/8" or 1/16", can mean that the new section of tile will not fit inside an existing border. Even though drawings and photos are provided to the manufacturer, there may be some variation in the design and pattern size on the new tiles. Thus, they may not align perfectly with the original tiles, and as a result the section of the floor that has been replaced may be quite conspicuous.

Summary

Historic ceramic tiles are a common flooring material in many different kinds of small, as well as large, private and public, structures throughout the United States. Whether plain, or decoratively patterned, traditional ceramic floor tiles are important in defining the character of historic buildings. Although ceramic floor tiles are a practical material, they are also fragile, and can be easily damaged by improper installation techniques, insensitive remodeling, harsh cleaning methods, and even regular daily use. Preserving them requires careful day-to-day maintenance. This should begin with using gentle, non-abrasive methods and materials to clean them, and, in some instances, using an appropriate coating or impregnator to protect them.

Some historic ceramic tile floors, due to their manufacturer, their unique design, or their location in a certain room or within a particular building, may have greater significance than those that are purely utilitarian. Such floors should be accorded special care, and a ceramics conservator or preservation specialist should always be consulted to prepare responsible maintenance plans and to provide guidance concerning repair treatments and replacement techniques for them.

Unless an historic ceramic tile floor is extensively damaged with many missing and broken tiles and, therefore, potentially hazardous, it may be preferable to leave it alone. An unevenly worn floor surface, worn colors or patterns on the tiles, or slight cracks, chips, or scratches in the tiles themselves does not necessarily mean that the tiles should be replaced. Such relatively minor imperfections seldom detract from the character of an historic ceramic tile floor. They may, in fact, impart character, and be less noticeable or obtrusive than replacement of a single tile or a larger section with new tiles that do not match the originals exactly. Each situation should be evaluated on its own basis before selecting the preservation approach best suited to the project.

Selected Reading


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Some Sources for Replacement Tiles

There are a number of companies that offer standard lines of reproduction tiles, while others focus on custom work. Some new lines of reproduction tile attempt to be exact replicas of original tiles from the late-19th and early-20th century, while others are modern interpretations or adaptations of traditional designs, and may not be appropriate as replacement tiles in a preservation or restoration project. For additional sources see: "Traditional Building's Ceramic Tile SourceList," Traditional Building, Vol. 9, No. 4 (July/August 1996), pp. 92-93.
Designs in Tile  
P.O. Box 358  
Mt. Shasta, CA 96067  
Custom-made reproduction art tile.

Fulper Tile  
P.O. Box 373  
Yardley, PA 19067  
Reopened factory reproduces historic  
tiles using original Arts and Crafts-period glazes.

H&H Johnson Tiles Ltd.  
Head Office: Highgate Tile Works  
Tunstall, Stoke-on-Trent  
England ST6 4JX  
U.S. Office: Johnson USA Inc.  
P.O. Box 2335  
Farmingdale, NJ 07727  
Stock and custom reproductions  
of Minton Hollins encaustic and geometric tiles.

L’Esperance Tile Works  
237 Sheridan Avenue  
Albany, NY 12210  
Custom-made encaustic,  
geometric, mosaic and other traditional ceramic tiles.

Moravian Pottery and Tile Works  
Swamp Road  
doylestown, PA 18901  
Reproduction tiles based on  
Henry Chapman Mercer’s original designs.

Motawi Tileworks  
33 North Staebler Road, Suite 2  
Ann Arbor, MI 48103  
Reproduction tiles in Arts and Crafts,  
Art Nouveau and other styles.

Native Tile and Ceramics  
4230 Glencoe Avenue  
Marina Del Rey, CA 90292  
Reproduction decorative tiles in  
Southern California tradition of Craftsman,  
Mission, Art Deco and other styles.

Original Style  
Stovax Ltd.  
Falcon Road  
Sowton Industrial Estate  
Exeter, Devon  
England EX2 7LF  
Reproduction ceramic tiles from 1750-1902.

Pewabic Pottery, Inc.  
10125 East Jefferson Avenue  
Detroit, MI 48214
Reopened factory reproduces original tile designs and glazes.

**Terra Designs Tileworks**
241 East Blackwell Street
Dover, NJ 07801
*Mosaic tesserae experts, and reproduction of historic ceramic tiles.*

**Tile Guild**
2840 East 11th Street
Los Angeles, CA 90023
*Reproduction of traditional Spanish, Portuguese, Dutch, Italian and English tiles.*

**Tile Restoration Center, Inc.**
3511 Interlake N.
Seattle, WA 98103
*Reproduction of Arts and Crafts-period tiles.*

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**Helpful Organizations**

**The American Institute for Conservation of Historic and Artistic Works (AIC)**
1717 K Street, N.W., Suite 301
Washington, DC 20006

**Ceramic Tile Institute of America, Inc.**
12061 Jefferson Boulevard
Culver City, CA 90030-6212

**Friends of Terra Cotta, Inc.**
771 West End Avenue, 10E
New York, NY 10025

**Tile Council of America**
P.O. Box 1787
Clemson, SC 29633

**Tile Heritage Foundation**
P. O. Box 1850
Healdsburg, CA 95448

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**Acknowledgements**

Anne E. Grimmer is Senior Architectural Historian, Technical Preservation Services Branch, Heritage Preservation Services Program, National Park Service, Washington, D.C. Kimberly A. Konrad is a Preservation Planner, Boston Landmarks Commission, The Environment Department, City of Boston, MA. The authors wish to thank the following individuals for providing technical review and other assistance in the development of this publication: Marc Tartaro, AIA, and William Allen, Office of the Architect of the Capitol, Washington, DC; Mary Catherine Bluder, Bucks County Historical Society, Doylestown, PA; Michael F. Byrne, Ceramic Tile Education Foundation, Clemson, SC; Milford Wayne Donaldson, FAIA, Los Angeles, CA; Gray LaFortune, CTC, Ceramic Tile Institute of America, Inc., Culver City, CA; Joseph Taylor, Tile Heritage Foundation, Healdsburg, CA; Susan Tunick, Friends of Terra Cotta, Inc., New York, NY; Anne Weber, Ford Foreword Mills and Gatsch, Architects, Princeton, NJ; Glenn Wharton, Wharton & Griswold

http://www.nps.gov/history/hps/TPS/briefs/brief40.htm

6/25/2009
Washington, D.C. October, 1996

Home page logo: This Minton encaustic floor tile was installed in the U.S. Capitol in the 1850s. Photo: NPS files.

This publication has been prepared pursuant to the National Historic Preservation Act of 1966, as amended, which directs the Secretary of the Interior to develop and make available information concerning historic properties. Technical Preservation Services (TPS), Heritage Preservation Services Division, National Park Service prepares standards, guidelines, and other educational materials on responsible historic preservation treatments for a broad public.
E  Room Data Sheet Template
**ROOM DATA SHEET & SURVEY**

**Massachusetts State House**

**Date:**

**Report By:**

**Department:**

**Room No.:**

**Room Name:**

**Significance Level:**

**USER INFO**

**Occupancy / Function Type:**

**Typical Hours of Occupancy:**

**Typical Number of Occupants:**

**Typical Access:**

- Staff
- Public
- Press
- Facilities
- Security

**Identify any unique user information:**

---

**ARCHITECTURAL**

*See Design Guidelines Kit of Parts for () component diagrams and descriptions*

**Existing Conditions**

<table>
<thead>
<tr>
<th>Major existing building elements?</th>
<th>Dimensions / Room Width:</th>
<th>Room Length:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Exterior Windows Yes _ No _</td>
<td>RoomDiagram / Locate major critical room elements.</td>
<td></td>
</tr>
<tr>
<td>2. Exterior Doors Yes _ No _</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Corridor Doors Yes _ No _</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Emergency Exit Doors Yes _ No _</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Structure or Columns Yes _ No _</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Mechanical Chases Yes _ No _</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Floor level changes Yes _ No _</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Partition Type**

- _ Full Solid Panel (A) __
- _ Solid Panel + Transom (B) _
- _ Wainscot Panel + Glass (C) _
- _ Full Glass Panel (D) _
- _ Glass Wainscot + Panel (E) _
- _ Glass Multi Panel (F) _
- _ Multi Glass Panels (G) _
- _ Historic (H) _

**Flooring Type**

- _ Carpet _
- _ Hardwoods _
- _ Laminate _
- _ Vinyl Composition Tile _
- _ Ceramic / Porcelain Tile _
- _ Terrazzo _
- _ Stone _
- _ Concrete _

**Ceiling Type**

- _ Gypsum Wall Board _
- _ Acoustical Tile 2x2 _
- _ Acoustical Tile 2x4 _
- _ Acoustical Tile Other _
- _ Wood Panel _
- _ Plaster _
- _ Historic Plaster _

**Door Type**

- _ Wood (D1) _
- _ Wood + Transom (D2) _
- _ Wood Lite (D3) _
- _ Wood Lite+Transom (D4) _
- _ Glass (D5) _
- _ Glass + Transom (D6) _
- _ Hollow Core Metal (D7) _
- _ Historic Door (DH) _

**Architectural Features * **

- _ Base Board _
- _ Chair Rails _
- _ Wainscot Paneling _
- _ Crown Molding _
- _ Ceiling Moldings _
- _ Ceiling Medallions _
- _ Fireplace Mantles _
- _ Pilasters / Columns _

**Lighting**

- _ Ceiling Flush Mounted _
- _ Pendant Direct _
- _ Pendant Indirect _
- _ Pendant Direct/Indirect _
- _ Desk Task Lighting _
- _ Decorative Lamps _
- _ Utility Grade _
- _ Historical Fixtures _

**Window Treatments**

- _ Wood Blinds _
- _ Vinyl Blinds _
- _ Sun Shades _
- _ Blackout Shades _
- _ Fabric Drapes-Office _
- _ Fabric Drapes-Executive _
- _ Historical Fixtures _

**Acoustical Separation**

- _ Full Privacy / Confidential _
- _ Full Privacy _
- _ Semi-Private _
- _ Not Required _

**Interior Window Types**

- _ Translucent Full Vision _
- _ Transparent / Frosted _
- _ Transaction Windows _

* See Design Guidelines Historic Material Treatment for identification
FURNITURE, STORAGE & EQUIPMENT
See Design Guidelines Kit of Parts for ( ) component diagrams and descriptions

Workstations
☐ Exec. Desk (WS1)
☐ Exec. Workstation (WS2)
☐ Office Workstation (WS3)
☐ Staff Workstation (WS4)
☐ Staff Workstation (WS5)
☐ Office Desk (WS6)
☐ Office Desk (WS7)
☐ Reception A (WS8)
☐ Reception B (WS9)

Tables
☐ Executive Conference (T1)
☐ Office Conference (T2)
☐ Meeting Table (T3)
☐ Break Table (T4)
☐ Training Table (T5)
☐ Break/Cafe Table (T6)
☐ Multipurpose Table (T7)
☐ Occasional Table (T8)
☐ Folding Table (T9)

Common Files
☐ Pedestal Stationary (F1)
☐ Pedestal Mobile (F2)
☐ Vertical - Two High (F3)
☐ Vertical - Four High (F4)
☐ Lateral - 2 High (F5)
☐ Lateral - 4 High (F6)
☐ Legal - 2 High (F7)
☐ Legal - 4 High (F8)

Chairs
☐ Executive Ergonomic (C1)
☐ Office Ergonomic (C2)
☐ Guest Chair (C3)
☐ Conference Executive (C4)
☐ Conference Office (C5)
☐ Folding Chair (C6)

Storage
☐ Low Standard (S1)
☐ Low Bookcase (S2)
☐ High Standard (S3)
☐ High Bookcase (S4)
☐ High Wardrobe (S5)

Equipment Storage
☐ Printer Cart / Stand (E1)
☐ Fax Cart / Stand (E2)
☐ AV Cabinet Small (E3)
☐ AV Cabinet Large (E4)
☐ Mobile Cart (E5)

Accessories
☐ Trash Can
☐ Clock
☐ Coat Hook Rack
☐ Planters

SYSTEMS (Mechanical, Electrical, Telecom, Plumbing & Security)
See Design Guidelines Building Systems for related issues

Mechanical
Temperature (Typical):
Humidity (Typical):
Identify unique HVAC concerns:

Electrical
Qt. Duplex outlets:
Electrical for Equipment:
Identify unique Electrical needs:

Security
Identify any security/alarm requirements:

Plumbing
Sinks (i.e. Break area):
Water supply: Hot____ Cold____ Filtered____
Identify unique Plumbing needs:

Telecommunications
Qt. Phone lines:
Qt. Data lines:
Identify unique Audio-visual needs:

HISTORIC PRESERVATION
Reference the Master Plan Significance Levels and Design Guidelines Preservation Standards
Identify additional details of historic elements within space
(i.e. architectural moldings, paneling, doors etc.):

ADDITIONAL COMMENTS
Identify any additional critical needs or criteria:
# F Acoustic Condition Data

Massachusetts State House  
Background Sound Level Recordings  
Acentech Project No. 620511  
Measured October 30, 2009

<table>
<thead>
<tr>
<th>Location</th>
<th>Sound level (NC)</th>
<th>Sound level (dBA)</th>
<th>Condition during measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>13, open office</td>
<td>NC-42</td>
<td>47 dBA</td>
<td>AHU on</td>
</tr>
<tr>
<td>74, open office</td>
<td>NC-39</td>
<td>44 dBA</td>
<td>FCU on, traffic</td>
</tr>
<tr>
<td>257, open office</td>
<td>NC-37</td>
<td>43 dBA</td>
<td>FCU on</td>
</tr>
<tr>
<td>13, private office</td>
<td>NC-38</td>
<td>43 dBA</td>
<td>AHU on</td>
</tr>
<tr>
<td>16, private office</td>
<td>NC-40</td>
<td>42 dBA</td>
<td>FCU off</td>
</tr>
<tr>
<td>16, private office</td>
<td>NC-45</td>
<td>50 dBA</td>
<td>FCU on</td>
</tr>
<tr>
<td>74, private office</td>
<td>NC-38</td>
<td>42 dBA</td>
<td>FCU on</td>
</tr>
<tr>
<td>115, private office</td>
<td>NC-37</td>
<td>42 dBA</td>
<td>FCU on</td>
</tr>
<tr>
<td>114, private office</td>
<td>NC-38</td>
<td>44 dBA</td>
<td>FCU on</td>
</tr>
<tr>
<td>256, private office</td>
<td>NC-36</td>
<td>42 dBA</td>
<td>FCU on</td>
</tr>
<tr>
<td>443, private office</td>
<td>NC-31</td>
<td>36 dBA</td>
<td>FCU off</td>
</tr>
<tr>
<td>443, private office</td>
<td>NC-38</td>
<td>43 dBA</td>
<td>FCU on</td>
</tr>
<tr>
<td>445, private office</td>
<td>NC-35</td>
<td>40 dBA</td>
<td>Fridge on</td>
</tr>
<tr>
<td>445, private office</td>
<td>NC-25</td>
<td>32 dBA</td>
<td>Fridge and FCU off</td>
</tr>
<tr>
<td>445, private office</td>
<td>NC-43</td>
<td>47 dBA</td>
<td>FCU on</td>
</tr>
<tr>
<td>13, conference room</td>
<td>NC-38</td>
<td>43 dBA</td>
<td>AHU on</td>
</tr>
<tr>
<td>109, conference room</td>
<td>NC-40</td>
<td>45 dBA</td>
<td>FCU on</td>
</tr>
<tr>
<td>109, conference room</td>
<td>NC-30</td>
<td>37 dBA</td>
<td>FCU off</td>
</tr>
<tr>
<td>251, conference room</td>
<td>NC-41</td>
<td>46 dBA</td>
<td>FCUs on</td>
</tr>
<tr>
<td>251, conference room</td>
<td>NC-25</td>
<td>31 dBA</td>
<td>FCUs off</td>
</tr>
<tr>
<td>Hearing Room A1</td>
<td>NC-36</td>
<td>43 dBA</td>
<td>AHU on</td>
</tr>
<tr>
<td>Great Hall</td>
<td>NC-43</td>
<td>48 dBA</td>
<td>HVAC, contractors</td>
</tr>
<tr>
<td>State Library</td>
<td>NC-34</td>
<td>40 dBA</td>
<td>AHU on</td>
</tr>
<tr>
<td>House chamber</td>
<td>NC-30</td>
<td>36 dBA</td>
<td>AHU on</td>
</tr>
</tbody>
</table>
G  Sustainable Design Criteria

Massachusetts Executive Order 484 (signed 2007) is the standard for state-owned building performance and sustainability. The Executive Order requires all new construction and significant renovation projects over 20,000 square feet to meet the Massachusetts LEED + Criteria.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Requirement</th>
<th>LEED reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Certification</td>
<td>LEED for all projects over 20,000 square feet</td>
<td></td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>20% better than Massachusetts Energy Code</td>
<td></td>
</tr>
<tr>
<td>Commissioning</td>
<td>Independent 3rd Party</td>
<td></td>
</tr>
<tr>
<td>Water Consumption</td>
<td>Reduce outdoor water consumption by 50% relative to standard baseline projections</td>
<td>Water Efficiency, Credit 1.1</td>
</tr>
<tr>
<td></td>
<td>Reduce indoor water consumption by 20% relative to standard baseline projections</td>
<td>Water Efficiency, Credit 3.1</td>
</tr>
<tr>
<td>Smart Growth</td>
<td>Construct or renovate on a previously developed site, in a community with a minimum density of 60,000 square feet per acre, or within one-half mile of ten basic services and a residential zone or neighborhood with an average density of ten units per acre; and with pedestrian access between buildings and services.</td>
<td>Sustainable Sites, Credit 2</td>
</tr>
<tr>
<td></td>
<td>Construct or renovate on a site with public transportation (train or bus) within one-half miles</td>
<td>Sustainable Sites, Credit 4.1</td>
</tr>
<tr>
<td></td>
<td>Maintain 75% of existing building structure and envelope</td>
<td>Materials and Resources, Credit 1.1</td>
</tr>
</tbody>
</table>
For projects smaller than 20,000 square feet, all executive agencies shall design and construct new buildings and major renovation projects to meet at least one of the following:

- Adhere to the Massachusetts LEED + Criteria, or
- Surpass the Massachusetts Energy Code requirements by at least 20 percent, or
- Follow the prescriptive approach of the New Buildings Institute's Advanced Buildings Benchmark Tool (www.advancedbuildings.net)

Overview of LEED 2009

The LEED (Leadership in Energy and Environmental Design) rating system is a voluntary process to evaluate the environmental performance of buildings according to their design, construction, and operation. The rating system was developed by the private non-profit U.S. Green Building Council (USGBC).

Historic buildings from the period of the State House, are readily adaptable to many conditions of LEED certification. Buildings constructed before the advent of widespread energy reliance contain many architectural features in conformance with current sustainable design principles. Table 2 lists both historic features and potential improvements to the State House and matches them to relevant points from the LEED system.
### Table 2: Rehabilitative Strategies related to LEED Credits

<table>
<thead>
<tr>
<th>LEED 2009</th>
<th>Inherent Credit</th>
<th>LEED +</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEED building certification</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Sustainable Sites</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Existing urban site</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Rail and Bus Station Proximity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Provide bicycle storage and changing rooms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Vehicular parking moratorium; reserved spaces for car and vanpools</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water Efficiency</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Decrease baseline water usage by 30% or more</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Energy &amp; Atmosphere</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Standard or Enhanced Commissioning Process activities for building systems</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Comply with state energy code for commercial buildings</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Zero use of CFC-based refrigerants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Lighting power density 15% or more below standards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Install daylight and occupancy sensor controls for lighting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Install high-efficiency HVAC systems with separate zoning and controls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 70% of all eligible equipment is Energy Star</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Install continuous monitoring equipment for end uses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Purchase electricity from renewable sources</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Materials &amp; Resources</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Tenant commitment minimum 10 years</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Retention of 60% existing non-shell, nonstructural components</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Institute program for storage and collection of Recyclables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Salvage or recycle 50% or more construction and demolition debris (measured by weight or volume)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Use 5% or more salvaged construction materials (measured by value)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Use 30% or more salvaged furniture/furnishings (measured by value)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Use 10% or more recycled content in construction materials, furniture/furnishings (measured by weight)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Use 20% or more regional materials (measured by value)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Use 5% or more rapidly renewable materials (measured by value)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Use 50% or more certified wood (measured by value)</td>
<td></td>
<td></td>
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<td><strong>Indoor Environmental Quality</strong></td>
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<tr>
<td>• Comply with Ventilation for Acceptable Indoor Air Quality (ASHRAE Standard 62.1-2007) and/or increase outdoor air ventilation rates by 30% or more</td>
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<tr>
<td>• Monitor CO2 concentrations</td>
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<tr>
<td>• Use all low-emitting materials, according to product type</td>
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<tr>
<td>• Institute indoor air quality controls during construction</td>
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<tr>
<td>• Install source controls for indoor chemicals and pollutants</td>
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<tr>
<td>• Individual lighting controls for 90% of occupants</td>
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<tr>
<td>• Individual thermal controls for 50% of occupants</td>
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<tr>
<td>• Design HVAC system according to ASHRAE Standard 55-2004</td>
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<tr>
<td>• Perform Thermal Comfort surveys</td>
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“Kit of Part” Specifications
Partition Specifications & References

Green Products

All products should be evaluated for their environmental impact. Partitions should be composed of materials:
- containing 0% Urea Formaldehyde content,
- certified by the Forest Stewardship Council,
- achieving Greenguard Certification or equivalent, and
- containing high percentages of recycled content.

See Sustainable Design Criteria in Section 4 of the Design Guidelines for additional information.

Gypsum Wallboard (GWB)

Solid panel partitions of GWB should be minimally constructed of 5/8" gypsum wallboard on metal wall studs with a seamless veneer finish coat of plaster and 3 coats (1 prime and 2 finish coats) of a non-VOC eggshell finish paint. A profiled painted or stained wood baseboard of minimum 4" in height should be included. Crown molding at the ceiling or additional wall moldings are optional. Typically these partitions are custom constructed on site and are not pre-manufactured products.

Glass & Interior Aluminum Framing Systems

Glass & metal partition systems should be minimally constructed of aluminum meeting requirements of ASTM B221, 6063T5 alloy, and as otherwise required to assure compliance with dimensional tolerances and maintain color uniformity. Aluminum finish should be a clear anodized or powder coated factory finish. Additional manufacturers of glass and aluminum systems can be found in the Demountable Partitions section.
Wood Veneer Panels & Partitions

Partitions of wood veneers should be minimally constructed of formaldehyde free MDF board with paper-backed wood veneers. Panels should meet all standards for the Architectural Woodwork Institute. “Premium Grade” materials and workmanship. All finished hardwoods and veneers to be AWI Lumber Grade 1 and AWI Grade A veneers. All woodwork called out as having a satin transparent finish should be of AWI Premium Grade TR-6 catalyzed polyurethane, with UV protective coatings.

Demountable Partitions

Demountable partitions are pre-engineered, pre-manufactured movable wall systems that provide a flexible option with potential long-term benefits. Considered a benefit particularly for renovation projects and where flexibility, consistent style, user friendly and environmental issues are at the forefront of the discussion. These partitions are aluminum-framed systems available in an increasingly wide variety of cladding options including wood veneer, laminates, fabric-wrapped tackable, painted MDF, glass or whiteboard materials. A significant environmental benefit is that the partitions are pre-manufactured, resulting in little on-site construction waste and a better-planned use of the raw materials during manufacturing. Installation of pre-manufactured product is a faster and cleaner process, resulting in more precise and streamlined project schedules and expedited occupancy.

Architectural Woodwork
www.awinet.org

Columbia Forest Products
www.columbiaforestproducts.com

SJ Morse Company
www.sjmore.com

Treefrog Veneer
www.treefrogveneer.com

Clestra Hauserman
www.clestra.com

Teknion / Altos & Optos
www.teknion.com

DIRTT / Combination Walls
www.dirtt.net

Steelcase / Privacy Wall
www.steelcase.com
Doors Specifications & References

Wood
Minimally constructed as 1-¾” thick solid wood or solid core wood veneer doors.

VT Industries
www.vtindustries.com
Jeld-Wen Inc.
www.jeld-wen.com
Simpson Door Co.
www.simpsondoor.com

Glass
For use as a frameless glass door or as a glass lite within a wood or metal door. Glass lites should be minimally 3/16” thick transparent, tempered safety glass. Glass used in a frameless full glass door should be minimally constructed of transparent 1/4” thick tempered safety glass.

Oldcastle Glass
www.oldcastleglass.com
C.R. Laurence Co.
www.crlaurence.com
EPCO USA
www.epcocorp.com

Hollow Metal
Hollow metal doors should be minimally manufactured of 20-gauge commercial quality cold rolled steel and constructed 1-¾” thick. They should meet ANSI 115 and Steel Door Institute ANSI/SDI-100.

Ceco Door
www.cecodoor.com
Republic Doors & Frames
www.republicdoors.com
Curries Co.
www.curries.com

Door Finish Hardware
All door hardware, including pulls, hinges and closers to fully comply with ADA Standards for Accessible Design.

Schlage
www.commercial.schlage.com
Yale Security Inc.
www.yalecommercial.com
Corbin Russwin Inc.
www.corbinrusswin.com
Furniture Specifications & References

Wood Veneered Workstations & Freestanding Furniture
Components should be minimally constructed of lock-miter case and mortise and tenon pedestal construction with additional steel angle brackets and wood glue blocks. All exposed surfaces are number one (1) select matched wood veneers sets consistent in grain patterns. All work surfaces are minimum 1-1/4” thick multi-ply construction and profiled on all sides. All drawers are box case construction and have full extension ball bearing glides. All case interiors are sanded and finished. Keyed locking devices shall be provided on all storage. Final finish is a urethane clearcoat. Drawer and door pulls shall be integral or provided.

Laminate Workstations & Freestanding Furniture
Components should be minimally constructed of lock-miter case and mortise and tenon pedestal construction with additional steel angle brackets and wood glue blocks. All exposed vertical and horizontal work surfaces are minimum 1 1/4” thick multi-ply construction with high pressure laminates (HPL). All drawers are box case construction and have full extension ball bearing glides. All case interiors are melamine. Keyed locking devices shall be provided on all storage. Drawer and door pulls integral or provided. Drawer and door pulls shall be integral or provided.
Seating
Framing should be of durable construction according to federal standards for wood, steel, or plastics. All moving parts shall operate smoothly and quietly. Chair upholstery and filling shall be symmetrical. Synthetic and natural fabrics to have appropriate thickness, color fastness, abrasion resistance, and tear strength according to their specific material. All upholstery, cover materials, seat decking, welts, interior fabrics, fillings, paddings and foam shall meet applicable flammability requirements.

Storage
All storage and filing cabinets should be of full steel construction. Cases should be of U-style construction from a single sheet of 22-gauge steel with no joints. All drawers and drawer fronts to be 22-gauge steel. Drawers to roll smoothly on precision steel ball-bearing glides. Drawers to be equipped with an anti rebound feature to prevent rebound during operation. Drawers to be tested at .023 pounds per cubic inch proof load; .017 pounds per cubic inch functional load. File drawers should have full height sides and extend fully beyond the case for access to the complete drawer. Box drawer slides to be rated at 70 pounds per set. File drawer glides to be rated to 100 pounds per set. Mobile pedestals to include four durable nylon, non-locking casters. Casters are to be rated minimally at 40 pounds each (160 pounds total). Mobile pedestal to come standard with factory installed 35-pound counterweight to improve stability.
Acoustic Materials/Equipment Specifications & References

Suspended ceilings

Suspended ceiling systems are available in familiar lay-in grid systems, with panels of various sizes; 2'-by-2' and 2'-by-4' are most common, and larger sizes are available as well. Generally, suspended ceiling systems should be chosen to achieve NRC 0.70 or greater and CAC 30 or greater.

Suspended ceilings are also available in "cloud" formats. These are installed over specific areas within a larger space and are open at the perimeter. Cloud ceilings are often appropriate for reception areas, information stations, or other transaction areas within larger spaces. Cloud ceiling systems should be selected to achieve NRC 0.80 or greater; the CAC rating does not apply to these systems.

Direct-applied ceiling and wall finishes

Wide-span direct-applied systems generally employ a perimeter framework that is mounted to the existing ceiling, sound-absorbing fiberglass core material, and a continuous sound-transparent membrane that is stretched tight over the core material and held in place by the framework. The result is a smooth, continuous surface that is acoustically absorptive. The choice of membrane is an aesthetic choice; all of the above offer excellent acoustical performance. In general, these systems can span up to 16 feet in one dimension and indefinitely in the other dimension. They protrude approximately 1 inch from the existing ceiling.

Direct-applied products also include panelized products, such as fabric-wrapped fiberglass panels or

Armstrong “Ultima”
www.oldcastleglass.com

U.S. Gypsum
www.usg.com

Certainteed
www.certainteed.com

Sound Concepts
www.soundconcepts.com

Newmat
www.newmatusa.com

Wall Technology “Eurospan”
www.walltechnology.com

Snap-tex
www.snapshot.com

Clipso
www.clipso.com

Newmat
www.newmatusa.com

Decoustics
www.decoustics.com

Sound Concepts “Claro”
www.soundconcepts.com

CMA “Quiet Coordinates”
www.cmainc.net

Wall Technology “New Dimensions”
www.walltechnology.com
specially-finished panels. These panels come pre-fabricated and ready to mount to existing ceilings, generally in sizes up to 4' by 8', and thickness of approximately 1 inch.

Direct-applied systems cannot be used to conceal ductwork.

_Spray-applied ceiling materials_

In tall spaces, where the ceiling is at a significant distance from the occupants, it may be appropriate to consider spray-applied acoustically absorptive ceiling products. These products are made of cellulose or cementitious compounds. They typically have a visible texture, but the highest-quality choices appear relatively smooth when viewed from a distance.

**Plaster-like Finishes**

Baswaphon is a multi-layer finish that provides a very smooth monolithic finish and good acoustical performance. It requires a hard substrate such as an existing plaster or drywall ceiling, and it reduces the ceiling height by approximately 2 inches. It can accommodate lighting fixtures and other features as a drywall ceiling would, while maintaining its appearance. It is a relatively fragile finish, and is appropriate only for ceilings or high walls that are not within reach of occupants. Baswaphon is the most expensive and time-consuming of all the recommended finishes, and it is appropriate for the most aesthetically demanding spaces where a monolithic plaster-like finish appearance is required.
Cleanable ceiling and wall materials

Acoustically absorptive panels and direct-applied perforated stretch-vinyl systems, that meet various standards for cleanability appropriate intense cleaning with fluids (kitchens and serveries), or less (dining areas). Panels are available for use in a suspended lay-in grid ceiling system, or as direct-applied panels for ceilings or walls. Panels meet standards for cleanability (better than preferable to gypsum board or plaster) and range in NRC from 0.80 to 0.55.

Sound Masking Systems

A direct field masking system incorporates small loudspeakers within a suspended ceiling, similarly to lighting fixtures, sprinkler heads, and other features. The loudspeakers emit sound directly to the occupants of the space, hence the name direct field. We are aware of one such system; manufactured by Cambridge Sound Management (Acentech has a proprietary interest in Cambridge Sound Management). This system may also be suitable for spaces without suspended ceilings.

An above-ceiling masking system utilizes loudspeakers above a suspended ceiling and adjusts the sound spectrum to achieve the desired spectrum in the occupied space below the ceiling. These systems may also be suitable for spaces without suspended ceilings. An advantage of these systems is that the loudspeakers are not visible in the occupied space. A disadvantage is that there is less control over the sound spectrum that reaches the occupied space. These systems may also be suitable for spaces without suspended ceilings.