A Checklist for the Restoration of Architectural Cast Iron in the U.S.
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A Checklist for the Restoration of Architectural Cast Iron in the U.S.

RICHARD PIEPER

This article covers nine issues to consider when embarking on a cast-iron restoration.

It has been more than 160 years since the first building in the United States with a full cast-iron facade was erected in New York City. It is a bit surprising, then, that the first large-scale restorations of cast-iron building facades in the United States were undertaken less than 40 years ago. According to Robert Baird, principal of Historical Arts and Casting, one of the major architectural cast-iron-restoration firms in the U.S., the first significant restoration of a cast-iron facade in the United States was the 1973-1974 project at the Zions Cooperative Mercantile Institution (ZCMI) in Salt Lake City, Utah. While that is not to say that there were not earlier efforts to restore cast iron, this date is probably as good as any to designate the birth of the contemporary architectural cast-iron-restoration industry in the U.S.

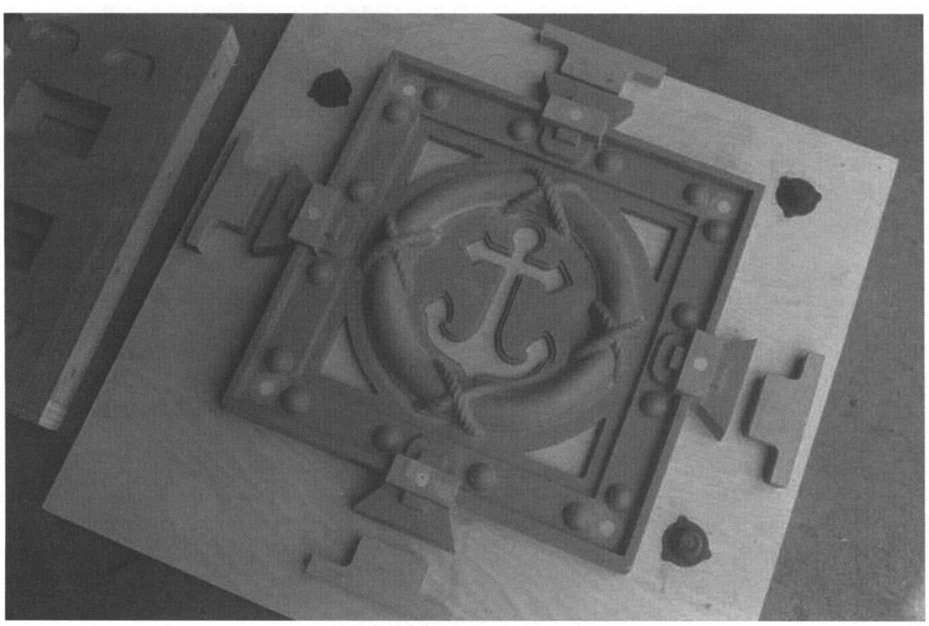


Fig. 1. The pattern for the anchor medallion of the loggia railing. Although a pattern was required for replacement of a few missing pieces, the medallions were considered so iconic to the building that all existing pieces were repaired for reuse. All photographs are of the Battery Maritime Building, New York, N.Y., courtesy of the author.

Historical Arts and Casting's next restoration project was work on the facade of the Grand Opera House in Wilmington, Delaware, about 1975 and the California State Capitol in 1976. The earliest significant cast-iron restoration efforts in New York City appear to have been the bridges of Central Park. Bow Bridge, Calvert Vaux's masterpiece, which was constructed from 1859 to 1862, was partially disassembled and restored in the mid- to late 1970s. In 1979 Historical Arts and Casting disassembled and restored Bridge 28 near the north end of the reservoir, below 96th Street. The other four cast-iron bridges in the park followed gradually. Robinson Iron made castings for the ceiling panels of Bethesda Terrace in 1982, but finances halted the ceiling restoration, and the panels were not installed until 2005. In recent years there has also been a significant amount of restoration done to cast-iron subway entrances in New York. This work was inaugurated by Prentice Chan Olhausen's replication of subway-entry kiosks for the Lexington Avenue line at Astor Place in 1985, a Robinson Iron project that was widely covered in the press.

The industry has since become more widely employed, the practitioners more skilled, and the technology more sophisticated. Ambitious large projects in the New York City region have now become common. Jan Hird Pokorny Associates, for example, worked with Robert Silman Associates and Robinson Iron on the disassembly and reassembly of the New Jersey State House dome and rotunda in 1995 and more recently with Silman's office and three cast-iron-restoration firms (Robinson Iron, Historical Arts and Casting, and Allen Architectural Metals) on the exterior restoration of the 1908 Battery Maritime Building, a $56 million project that would have taxed the capacity of any one firm. The most celebrated recent cast-iron restoration in New York City is the Donald Judd studio and residence on Spring Street in SoHo. A rare reminder of SoHo's days as a sparsely populated haven for struggling artists and one of the few buildings in the neighborhood in which the ground floor has not been turned over to high-end retail, the Judd building is now completed and welcoming visitors. The restoration was designed by Walter B. Melvin Architects, in collaboration with Robert Silman Associates and Robinson Iron.

The cast-iron-restoration industry is now well established. There are experts to call who are familiar with the material and experienced with the work. New cast iron is readily available, and one is no longer beholden to aluminum foundries. Laser scanning, computer-numerical-control (CNC) milling, and 3D printing are transforming the art of patternmaking. While the resources are available to do the work, the range and extent of interventions that might reasonably be considered by a professional deciding on treatment for a cast-iron facade is enormous. To what extent should the facade be disassembled? How much of the cast iron is irreparably damaged and requires replacement? How much can be repaired? What method of surface preparation should be used to clean removed elements and those left in place? What treatments and paint systems should be used to provide maximum durability for the restored facade? What types of fasteners are optimal? Should sealants be used? Which failures warrant changes in design? What level of detail is required in construction documents to protect the owner, while not eliciting unreasonably high bids from the contractors? In some instances these questions are as difficult to answer today as they were 40 years ago.

In 1991 the New York Landmarks Conservancy organized a symposium on cast-iron restoration that was intended to take stock of an industry then in its infancy. It was an important meeting and one which broached many of the questions that architects and conservators face in caring for this material. Twenty years later another look at the field was warranted. The Historic Preservation Education Foundation and the Columbia University Graduate School of Architecture, Planning, and Preservation held a one-day symposium on the repair of historic cast and wrought iron in Avery Hall's Wood Auditorium on March 19, 2011.

This paper, which was part of that symposium, examines the technical questions that have been posed but not definitively answered in the last 40 years of restoration of architectural cast iron. It well may be that the answers to these questions are different for each building, but examining the technical decisions facing building owners, architects, and restoration professionals will serve to illuminate future efforts. What follows is a short list of the issues that confront the conservator or architect embarking on the restoration of a cast-iron facade today.

Repair or Replace?

Gray cast iron is brittle. During the planning for the restoration of the New Jersey State House in 1995, a very knowledgeable cast-iron restorer pointedly said that "The rule of thumb is, if it's cracked or broken, replace it." That approach is understandable when replacing posts of a damaged hand railing, especially if ductile cast iron is being used for safety reasons. Is this also understandable for replacement of ornate and truly iconic cast-iron elements? Ironically, the very same attribute that made cast iron so cheap to produce also makes it more difficult to retain original fabric when restoring it. That is, once you have made the pattern to replace even one piece, repairing damaged elements often becomes more expensive than replacing them.

Our office faced this problem with the 24 ornate medallions on the loggia railing of the Battery Maritime Building (Fig. 1). Three were missing, so a pattern was required. Many of the others had minor breaks on their mounting stubs but were otherwise intact. Because of their aesthetic and symbolic significance, the client was willing to pay a modest premium to retain and repair the original pieces.

Another example is the severely deteriorated cast-iron structure of the historically important Mount Morris fire watchtower in Harlem, the sole remaining witness to Manhattan's fire-watch days. This structure is now a vulnerable skeleton propped up with a supplementary structural frame. Eventually the tower will have to be disassembled and restored, and current plans call for replacement of perhaps 40 percent of original cast iron. At what point does a cast-iron restoration become a replication?

Traditionally, cracked cast iron has been repaired by grinding out and brazing the cracks with brass or nickel-alloy rod. The brazing itself can introduce stresses in the repaired piece, however, and many restorers will braze only if they are able to supplement the "weld" with a mechanically fastened plate beneath it. This approach cannot be used at flanges or other locations where the cast iron is lapped. In many cases inappropriate old repairs are themselves the problem. Rusting mild-steel plates or improper welds may further damage cast-iron elements and complicate new work.

Where the cast iron is thick enough to be cut, tapped, and bolted, mechanical repairs can be quite successful, but this seldom applies to the vast majority of cladding applications. In the UK a method called "cold-stitching," which utilizes a series of drilled holes across a crack to create a mechanical join, has often been used to repair cracked pieces of cast iron, especially machinery components where the cost of disassembly or downtime is onerous. This technique has been applied infrequently in the U.S., where a craft approach predominates for architectural projects. Cold stitching has been used recently for repairs on the dome of the U.S. Capitol, however, where castings were under stress but could not be removed or accessed from the back. It is hardly a panacea, and it is expensive, but it is certainly useful where disassembly is impractical. It is unclear whether it will find wide acceptance in the United States.

Extent of Disassembly

Cast iron is relatively resistant to rust. The high carbon content (about 4 percent) of cast iron (which in gray cast

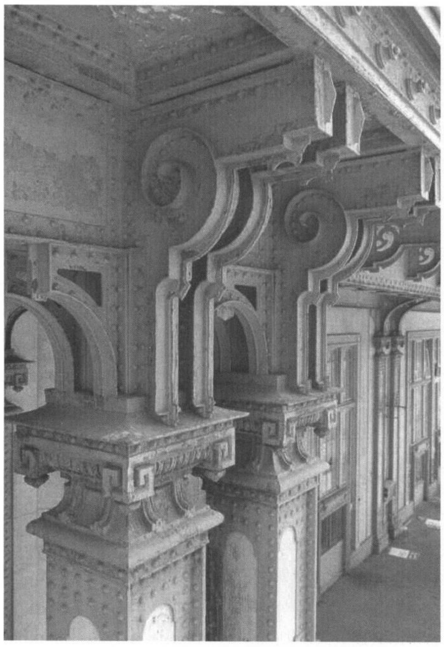


Fig. 2. Entablature on the street facade before restoration, c. 2003. Establishing a rationale for the extent of disassembly is extremely important to the success of a cast-iron restoration. The entire entablature and cornice pictured here were disassembled. Identical pilaster capitals in the background, sheltered from the weather, exhibited much less rust on lapped surfaces and were left in place.

iron occurs as flakes of graphite in an iron matrix) allows it to rust superficially but, in most environments, not to great depth. Cast iron is not prone to the dramatic expansive pack rusting of steel; it does rust, however, and the rust can exert enough expansive force to crack masonry. By its nature architectural cast iron is an assembly of lapped or applied pieces. Unless a piece of cast iron is removed from the piece it is attached to, there is some portion of it that cannot be cleaned and treated. The extent of disassembly depends upon a number of factors: the client's budget, the occupancy of the building, the nature of the fastening system, and the sanctity of interior finishes. Ultimately, however, the durability depends upon the extent of disassembly (Fig. 2). Restorers need to realize, as well, that their work is part of a repetitive process, not a unique event. The ZCMI building is being taken apart again, and the Bow Bridge, which was partially disassembled in the mid-1970s, was again partially disassembled in 1998 (and is likely to be partially disassembled once more to accommodate deck repairs in the not-too-distant future). Our responsibility as preservation architects, conservators, and restorers is to complete a restoration thoroughly enough that the process need be repeated as infrequently as possible.

Surface Preparation

Most preservationists are familiar with the standards of the SSPC (formerly the Steel Structures Painting Council, now the Society for Protective Coatings) and their wonderful, photographically illustrated field-standard books. The book for air-abrasive cleaning of steel, for example (SSPC-VIS 1 *Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning*, SSPC Publication 02-12), classifies rust into seven different types and then illustrates what each condition looks like when prepared to different standards of cleaning (Fig. 3). The SSPC books were written to guide the surface preparation of steel, not cast iron, but the standards are often applied to cast iron. Standard air-abrasive cleaning, which is verboten for many architectural materials, such as brick and bronze, has long been the gold standard for the preparation of iron and steel. There are many different air-abrasive techniques, however. Which ones are best? And if air-abrasive cleaning is not feasible, what are the issues with other forms of surface preparation? How should conservators view the conflict between proper surface preparation for repainting and the loss of historic finishes?

Finishes

More than any other construction material (wood notwithstanding), iron requires a protective coating (Fig. 4). While tremendous advances have been made in the paint industry over the past 40 years, realists do not expect an applied coating on iron to survive more than a quarter of a century. If the goal is to avoid taking these buildings apart, how should the cast iron (or, as importantly, any wrought-iron, cast-iron, or steel structure that is hidden behind and supporting the cast-iron cladding) be treated so that the standard service life of an optimum paint job does not require disassembly every 25 years? Should the metal simply be painted? Should a layer of zinc be applied before painting? And given that chemical conversion layers, stable oxides, have long been applied to steel in everything from handguns to automobile bodies to prepare them for paint, is there any other system that might work as well?

On a building from the last decade of the nineteenth century or first decade of the twentieth where cast-iron cladding is often combined with large sections of exposed riveted steel plate, the steel (if it can be removed) can be treated with hot-dip galvanizing (Fig. 5). While cast iron should not be hot-dipped (it can warp), it is possible to apply a zinc or zinc-aluminum thermal spray, a "metallizing" technique that leaves between 3 and 15 mils of zinc on the surface and provides a great tooth for the primer. For the most part this process can be completed only in an enclosed booth in a workshop environment. This technique was first used by our office in 1991 on the heavily rusted wrought-iron elements of the Century Association at West 43rd Street in Manhattan. The steel was brush blasted to remove paint, "pickled" in an acid bath to remove rust, and then metallized; 20 years later it is still free of rust. Thermal spray was used in a similar fashion to treat cast iron at the base of the Battery Maritime Building, where it would be most exposed to the harsh maritime environment. The crevices in highly ornate cast iron can be difficult to clean with air-abrasive techniques, however, and there have been recent efforts to apply dip-treatment conversion layers to cast iron,

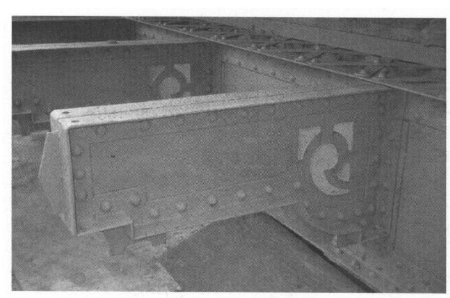


Fig. 3. In-situ air-abrasive cleaning of steel and cast iron. Air-abrasive cleaning according to SSPC SP#6 guidelines is desirable for paint preparation. Where zinc-aluminum thermal spray is required, disassembly for shop preparation to SSPC SP#10 standards is generally required.

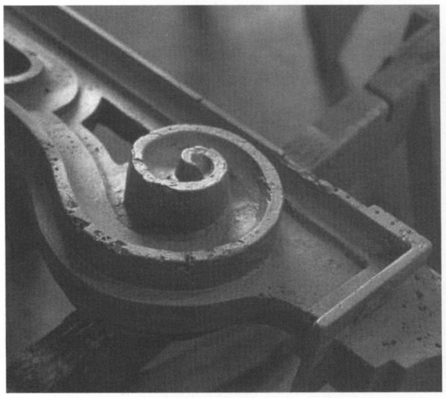


Fig. 4. Air bubbles on the surface of a historic cast-iron railing bracket. When blasted to bare metal, many historic castings will reveal original casting defects that must be filled.

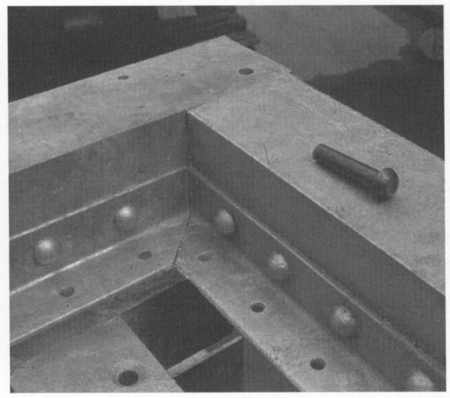


Fig. 5. Hot-dip galvanized-steel cornice assembly.

as they have been done to steel. It will be interesting to see how the applied durability of these treatments compares to zinc thermal spray.

Fasteners

When cast iron is being disassembled, the fasteners become visible on the exterior face. A standard technique is to remove the head of the fastener with an oxyacetylene torch. This work must be done carefully to avoid blowing out the countersink on the cast iron. In early cast iron, however, the fasteners may not be visible. Photographs documenting the 1971 disassembly of the 1849 Edgar Laing Stores, then the oldest building in New York City with a full cast-iron facade, show that the bolts are generally inside the castings. To disassemble the cast iron, the interior finishes must be removed. How does one approach this in an occupied building?

Two other questions about fasteners are their material and appearance. Since much of the damage to cast iron is caused by rusting wrought-iron or steel fasteners, the use of stainless-steel or coated fasteners for reassembly is imperative. (Given the great volume of cast-iron cladding and the small amount of stainless steel, the likelihood of damage from galvanic action is small.) However, to replicate the elaborate fastener patterns and appearance on many buildings in stainless steel, it may be necessary to fabricate a significant number of custom fasteners at no small expense. The custom-turned, stainless-steel rivet-head bolts used at the Battery Maritime Building cost seven dollars each.

Sealants

Cast-iron buildings were not detailed with contemporary waterproofing standards in mind. Horizontal joints were usually lapped to prevent water penetration, but vertical joints were often just butted. Generally the ends of cast-iron elements at vertical joints are bolted to small interior plates (usually also made of cast iron) so that the pieces align, but the plates are often discontinuous, with openings at the joint above and below their locations and no potential for installing foam rod or other backing for a proper sealant joint. There is often a very generous interstitial space between the cast-iron exterior "skin" and the building's interior finishes, so exterior leaks may not always cause failure of the interior finishes. Leakage frequently becomes a problem when cast-iron cladding covers an occupied space, such as at a dome. At the New Jersey State House our office used a redundant approach: membrane-lined "bathtubs" were provided beneath horizontal cladding where leakage seemed likely, and a paintable membrane was applied to a large, low-slope surface above a finished space. At the Battery Maritime Building none of the cladding abutted finished space; all supporting structural steel was hot-dip galvanized, but the design provided for virtually no sealant whatsoever. A one-size-fits-all approach to sealants is not likely to be developed for cast-iron facades.

Design Changes

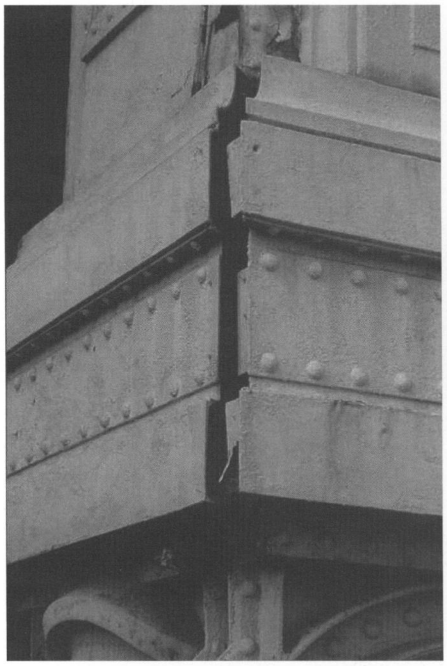
It is tempting to assume that the original builders knew much, much more about cast-iron design than today's practitioners do. On occasion, however, they did make design errors. Cast iron performs beautifully under compressive loads but has poor tensile strength. It is prone to failure if heavy loads are imposed on thin cladding pieces where they step in or out from the plane of the facade. Pieces at the bases of the massive piers between the ferry slips of the Battery Maritime Building had shattered from eccentric loading. New structural steel was inserted to take the load of the vertical cladding, and the base pieces were hung from the new supports.

One other common error, especially in early-twentieth-century cast-iron buildings, was to pour concrete behind base assemblies to carry heavy loads from above. The thermal coefficient of expansion for concrete is greater than that for gray cast iron, which may cause cracks and crack propagation in areas subject to significant temperature changes. Water infiltration through open joints can allow ice to form between the cast iron and the concrete fill, cracking the cladding. An appropriate design solution is to remove the concrete and provide a new steel frame to carry any superposed load.

Construction Documentation

The format for construction documents should communicate adequate information without intimidating or overwhelming the bidders (Fig. 6). The format used for a set of documents for the restoration of an 800-piece facade is not likely to be appropriate for a large ferry terminal with nearly 9,000 pieces. The documents prepared for the restoration of the Battery Maritime Building were so overwhelming to bidders that the project was ultimately divided into two different bid packages (Fig. 7).

One aspect of cast-iron buildings must be considered while preparing documents: while duplicate castings may start out much the same, once they have been filed and ground and fitted into larger assemblies they are no longer completely interchangeable. Whatever system is used for construction documentation should provide a basis for a



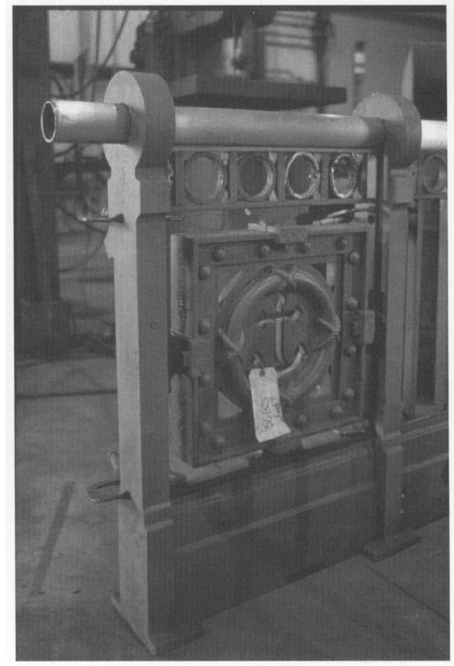


Fig. 6. Castings mimicking riveted-steel assemblies at the base of the street facade. Identification of each cladding element is important for construction documentation. Castings frequently mimic more complex assemblies.

Fig. 7. Cornice brackets. The bracket in the foreground is fabricated of riveted-steel plate and angle. The similar bracket behind it is one large casting.

Fig. 8. Mockup of the loggia railing. While pieces may appear identical, once they have been fitted, they are not interchangeable. Shop preassembly and fitting of components is necessary for complex assemblies, especially if individual pieces have been replaced.

method of identification that allows each individual piece to be tracked through abatement, cleaning, finishing, and reassembly (Fig. 8).

Logistics and Teamwork

The distance between the restoration site and the iron foundries can also pose special problems. When the New Jersey State House dome was disassembled, the cast-iron pieces were individually wrapped in plastic, stacked on the back of a flatbed truck, and trucked to Alabama for abating, cleaning, repair, and reassembly. Parts of the Battery Maritime Building went to Salt Lake City for treatment. When these pieces came back to New York City partially reassembled, they generally had to be assembled off-site into larger units for installation in the field. For the Battery Maritime Building this was done at a steel firm's yard in the Bronx. Depending upon the size of the project and the exigencies of the site, several teams and several work sites may need to collaborate in order to reinstall a building's cast iron. For some projects, the shortage of experienced local craftspeople, combined with the need to work on hundreds of pieces at different repair venues, may jeopardize the schedule and the budget.

Conclusion

This article presents a rough checklist of the issues that may arise when embarking upon the restoration of a cast-iron facade. The materials and craftspeople are now generally readily available, and the technology of finishes and assembly are much better than when the buildings were erected originally. On the other hand, not all of the technical questions have been answered (for example, the issue of energy use in buildings with metal facades and unsealed joints). The budget, building occupancy, or schedule will almost inevitably compromise the execution of some of the work and techniques. Still, the field of cast-iron restoration is progressing; the papers in this volume serve as a reminder of past work and suggest a vision of where the field is going.

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