Memorial Auditorium

Burlington, Vermont

Historic Preservation Report

Prepared for Burlington City Arts
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Historic Preservation Consulting Services

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Introduction

This historic preservation report for Memorial Auditorium in Burlington, Vermont was prepared by Emily E. Wadhams with the assistance of Scott Gurley for Burlington City Arts, City of Burlington. In consideration of Burlington City Arts' plans to raise funds to make improvements to the building and in light of the recent replacement of most of the original windows, this report was commissioned to serve as a guide for maintenance and rehabilitation plans for Memorial Auditorium in the future.

When Memorial Auditorium was constructed in 1927, it was a handsome civic building prominently located on the edge of Burlington's downtown business district. Although it retains many of its original features, incremental changes over the years have threatened the building's architectural integrity, especially on the exterior. The City of Burlington is continuing to use Memorial Auditorium as a multi-purpose facility. Additional improvements and changes are necessary to address life safety codes, handicapped accessibility, and energy, maintenance and programmatic needs. The challenge is to make these changes in ways that don't compromise the original design of the building. As the city considers maintenance and rehabilitation issues in the future, two historic preservation goals ought to be considered:

1) to protect the remaining original features that are architecturally significant, and
2) to restore as many of the lost architectural features as possible.

A Brief History and Building Description

Memorial Auditorium was constructed in 1927 when plans to include a 1000-seat auditorium in Burlington's City Hall were abandoned. Instead, the voters of Burlington chose to build a separate, larger auditorium and civic center to honor World War I veterans. Local builder and architect Frank Austin built the 16,650-square-foot building which can hold 2,600 people and is the state's largest indoor civic center. The building is managed by Burlington City Arts and is used for public performances, athletic events, exhibits, and as a rehearsal space, day care and teen center.

Memorial Auditorium lies on a steep slope and rises 3 1/2 stories at the front facade and 4 1/2 stories on the other three facades as a result of an exposed basement. The front facade faces east on to South Union Street and a side facade faces south on Main Street. The rectangular building is constructed of brick and cast-concrete, and features symmetrical fenestration. A parapet with segmental arches and concrete panels hides a flat roof. A concrete beltcourse caps the windows on the top story and continues around the entire building. A 3x3 bay section with pilasters is off-set from the main block at each corner. Vertical piers, a cubic form and detail along the roof line give Memorial Auditorium elements of the Art Deco style.

Many of the original metal windows are located at the corner towers of the building. These narrow, 'awning' style windows have opaque glass and two or three horizontal muntins. All of the windows on the building feature flat arches and concrete sills.

The interior of the building reflects its functionality. Exposed brick walls and steel truss frames indicate that the building was never an ornamental public space. The lobby features a terrazzo floor, plaster walls and two sets of wood pilasters that mark a threshold between the lobby and a pair of stair wells at the southeast and northeast corners of the building. Other original interior details include wood double-leaf doors and folding chairs in the balcony.

The building originally featured three marquees over the lobby entrances. A large marquee was located over the three doors at the front facade, while two smaller marquees marked the side entrances to the lobby on the south and north facades. Lamps formerly stood at the top of the steps and lit the area underneath the marquees. In addition, the original double-leaf doors to the building were wood, not metal. These doors featured panels on their lower half and multiple panes on their upper half. A similar multi-light transom was located above each set of doors.

Interior changes to the building include the addition of a tile floor in the basement over an original scored concrete surface, the replacement of an original stage curtain, and the removal of the folding chairs on the floor of the auditorium.

Historic Features

The following is a list of all exterior and interior character-defining features that contribute to the building's historic significance. Most of these elements may not be significant when considered individually, but are important collectively. Although the building does not contain a lot of detail or ornament, many original features remain intact. These features should be considered when any work is undertaken in order to avoid a continuation of the incremental change that is threatening the building's historic integrity. Note that the order of this list does not relate to the significance of these features.

Exterior

-All original brick with raked jointing (recessed mortar between bricks)
-All cast-concrete elements (including beltcourses, window sills, keystones, door moldings and panels at the parapets)
-Wide concrete steps to lobby and basement on south facade
-All remaining original metal windows
-Original cast-iron lanterns above doors at basement level (one on both the north and south facade)
-Wooden doors behind stage on west facade (second story)
-Transom lights above doors to lobby
-Cast-iron anchors for original marquees (located above doors to lobby)
-Cast-concrete blocks at foundation
-Original fenestration pattern on building
-All original door openings (photos indicate that the metal doors are not original)

Interior

Lobby
-Terrazzo floor
-Wood double-doors to auditorium (including hardware and glass)
-Transom lights above auditorium doors
-Plaster walls
-Openings framed with wood pilasters between lobby and stairwells
-Wooden phone booth
-Wooden ticket/concession windows
-Original configuration of room
-Bronze plaques
-Cast iron heat registers

Corner Stair Wells
-Wooden handrails
-Cast-iron balustrades
-Cast-iron stair frame or carriage

-Bathroom doors (bathrooms are not significant)
-Closet and wooden door at base of northeast stair well
-Exposed brick walls

Third Floor Loft
-Wood floor
-Exposed brick walls (including corbelling near ceiling)
-Exposed I-beams
-Wooden doors to utility rooms (including hardware)
-Concrete window sills
-Cast-iron registers
-Lights with green metal shades

Second Floor Loft
-Wood floor
-Exposed brick walls (including corbelling near ceiling)
-Double doors to auditorium (including hardware and glass)
-Transom lights above auditorium doors
-Elevated door to back of auditorium
-Wood molding around ticket booth/concession windows
-Lights with green metal shades

Auditorium and Balcony
-Wooden seats on balcony
-Tongue and grove wood paneling on face of balcony
-Wood floor
-Exposed brick walls
-Stage curtain (not original)
-Metal railings
-Cast-iron heat registers on walls
-Lights with green metal shades above balcony

Annex (Basement Level)
-Center two sets of doors between hall and main room (including hardware, glass and transom lights)
-Exposed ceiling
-Cast-iron columns
-Free-standing wooden ticket booths
-Brick walls

Condition of Existing Features and Treatment Recommendations

The following list gives the general physical condition of existing features and makes treatment recommendations for their repair or restoration. The recommendations will follow *The Secretary of the Interior's Standards for Rehabilitation* and will be general in nature. As a general rule, original features should be retained and repaired wherever possible.

Exterior

Roof
Condition: Poor to Fair. The built-up roof shows no obvious sign of deterioration from above, but leaks have developed in the southeast and southwest stair wells, and in the auditorium. There is also evidence that leaks are damaging the exterior walls of the buildings.
Treatment: Replace roof or determine as accurately as possible which areas are actively leaking and patch a large section of the roof above these areas. Patch flashing along parapet.

Brick
Condition: Good. Some efflorescence is visible at the upper corners of the front facade and on the piers of the north facade. These white stains are soluble salts deposited on the surface of the masonry. This is often an indication of water damage and a leaking roof may be the cause here. Several courses of brick on the west facade have been painted gray.
Treatment: Repair roof along parapet. Refrain from any attempt to remove paint on the west facade. It is very difficult to remove paint from a brick surface without damaging it. The area should be left undisturbed or repainted.

Brick Mortar
Condition: Good
Treatment: None. If repointing is needed in the future, the new mortar should match the original in color and jointing.

Concrete Features
Condition: Fair. Concrete has completely deteriorated at several corners along the beltcourse above the third story windows (specifically at the southeast corner of the southwest tower, at the southeast corner of the northeast tower, and at the northeast corner of the northwest tower). It appears that these areas were inappropriately repaired with a substitute material (see Figure 1). The northwest corner of the foundation is spalling. Some of the concrete blocks at the foundation of the stairs to the northeast lobby entrance may need to be reset due to settling (see Figure 2).
Treatment: A leaking roof may have been the original cause for deterioration at the upper beltcourse, but the leak may no longer be active. The preferable treatment for these areas is to remove the damaged sections and replace them

with similar concrete elements. It is possible to recast sections of the beltcourse in place, but due to the poor condition of the substrate, this repair may only last a few years.

The northwest corner of the foundation can be patched. All spalling concrete should be removed before a compatible patch material is used. It is important that the new concrete match the original as closely as possible so that the properties of the two materials, such as coefficient of thermal expansion and strength, are compatible enough to prevent future cracking. If the concrete contains rebars, rust should be removed from them with a wire brush before they are coated with an epoxy and patched. (See page 8 of Preservation Brief 15 for a detailed description).

Any masonry work on the building should be done by a mason who has experience working with historic structures.

Mortar around Concrete Features
Condition: Fair to poor. The mortar has failed around many concrete features (in particular, around the window sills, between the foundation blocks at the front facade and lobby steps, between the molding that surrounds the lobby doors, and along the beltcourses). Many of these areas have been patched inappropriately with caulking compound in an effort to prevent further damage (see Figure 3).
Treatment: Remove caulking compound and mortar to a depth approximately twice the width of the joint. Repoint with a mortar that matches the color of the original. This mortar should contain a binder that is composed of both lime and cement. The ratio for this composition should be approximately 1 part cement to 2 parts lime.

Steps to Lobby
Condition: Fair to poor. The steps leading to the north and south entrances to the lobby are in good condition, but those at the front entrance to the lobby are chipped and fractured in several areas (see Figure 4). A quarter-inch coat of painted concrete covers what appears to be the original concrete.
Treatment: Remove deteriorated concrete until the substrate is solid. If the bond between the first patch coat and original concrete is not strong, the first patch coat may have to be removed entirely. When a solid substrate is reached, the steps should be patched with a compatible material and repainted with a masonry sealant. Sand can be applied to the paint to increase traction on stairs. Measures should be taken in the future to protect steps when equipment is loaded and unloaded for performances.

Exterior Doors to Lobby
Condition: Good. Historic photos indicate that these metal doors replaced wood double leaf doors with panels at the lower half and multiple panes at the upper half. The transoms were probably also wood with multiple lights.
Treatment: Re-weather strip where needed.

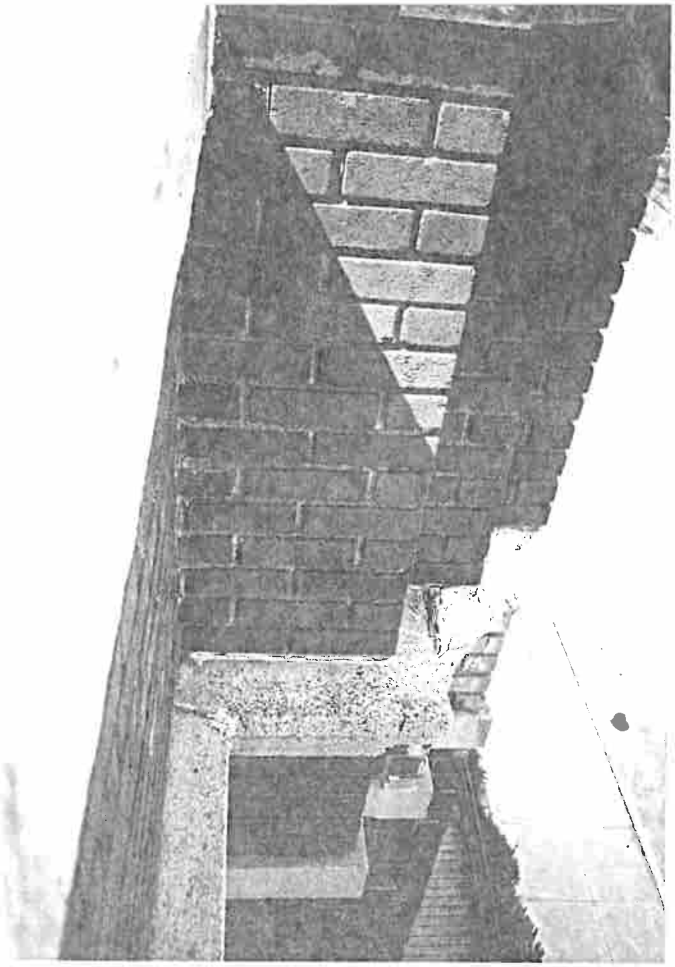


Figure 1 - View of concrete beltcourse taken from the roof.

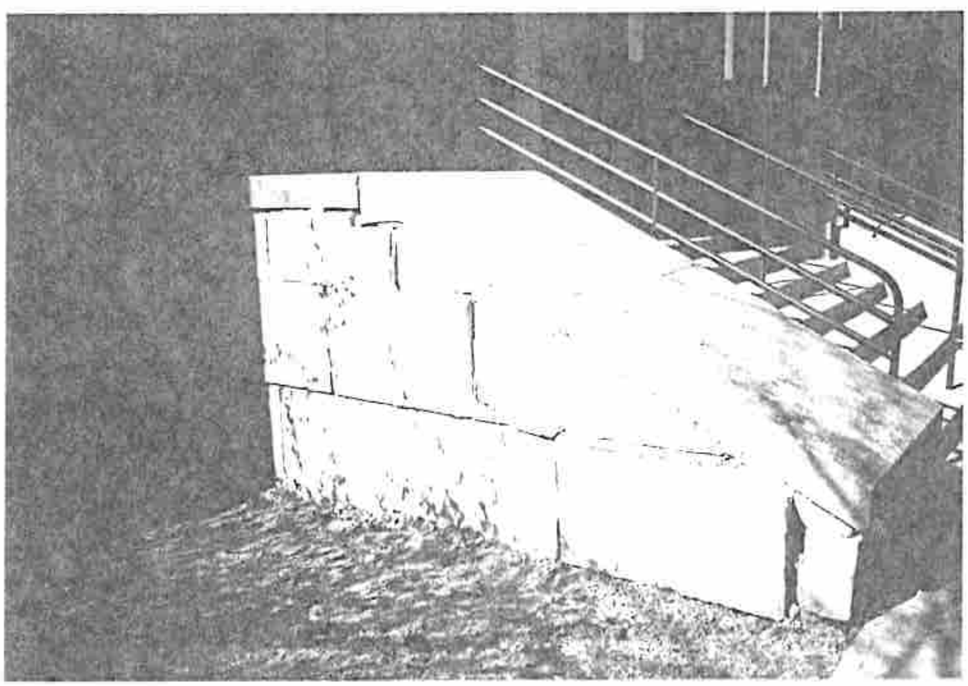


Figure 2 - View of the foundation blocks at the north lobby entrance.

Figure 3 - View of a concrete sill on the exterior of the building. Notice the caulking that was used to patch failed mortar around the sill.

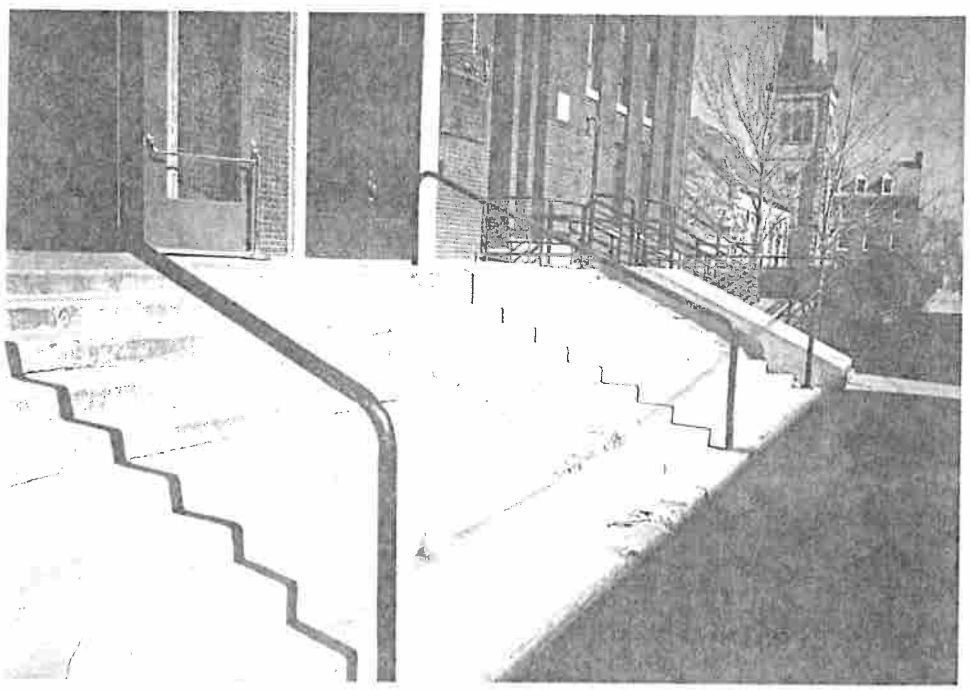


Figure 4 - View of the front steps to the lobby.

Replacement Windows
Condition: Good. Although these windows do not accurately replicate the historic ones they replaced, they are in fine condition. However, many have a space between their outer frame and the masonry that needs to be caulked (see Figure 5).
Treatment: Caulk masonry surrounds with a flexible caulk that is resistant to ultraviolet light and is intended for exterior use. Three effective compounds are polyurethane, vinyl acrylic, and butyl rubber. An appropriate color should be used. See the next section of this report for further discussion of these windows.

Historic Steel Windows
Condition: Poor to fair. Most windows have failing paint, loose glass, and rusted frames. Many latches and hinges are no longer functional.
Treatment: Scrape peeling paint and remove rust with a wire brush. Repaint frames using a rust-inhibiting primer on exposed metal. Replace existing glass with panes that have a similar opaque appearance. Use a thermal pane if frame is wide enough. Replace inoperable latches; glaze and weather strip new glass. Clean and lubricate hinges. See the next section for a discussion of replacement windows.

Interior

All Interior Doors
Condition: Good. Most of the interior doors appear to be original, but there are some replacements in the annex and in the dressing room area. The large, multi-pane, double doors that lead to the auditorium and balcony are the most significant doors in the building.
Treatment: None

Stairs
Condition: Good. There are four stair wells located at the corners of the building. The balustrades and railings are in good condition, but some of the treads are worn.
Treatment: Repaint worn treads with a masonry paint. The new paint should match the color of the existing paint or the entire surface should be repainted.

Walls
Condition: Fair to good. A leaking roof has resulted in water damage in the southeast and southwest stair wells and along the upper walls in the auditorium. There is also peeling paint at the foundation level of the southeast stair well. Efflorescence is visible at the basement level of the northeast stair well. The plaster walls in the lobby are in good condition.
Treatment: Repair roof, and repoint and repaint bricks along upper walls. Repoint foundation and monitor water damage at basement level of the building. If problems persist, a drainage pipe may need to be added below grade on the exterior to draw water away from the building.

Any attempt to remove paint from the interior walls may damage the brick substrate. However, if paint is removed, it should be done by the gentlest means possible. A *Peel-Away* product, which is applied in a paste, may be the most appropriate method for paint removal because it leaves no dust or fluids and is easy to contain. Any method however, should be tested in a small area before it is used over an entire wall surface. The paint should also be tested for lead before removal is considered. An experienced contractor should be hired.

Terrazzo Floor in Lobby
Condition: Fair to good. The floor has some large cracks, but is still functional.
Treatment: The cracks in the terrazzo indicate that the substrate may also be damaged. Although no immediate work is warranted, this area should be monitored closely. In order to determine if the cracks are still active, small areas can be patched with plaster or a similar material. If the plaster cracks, then the substrate is obviously still actively moving. To mitigate the visual effect of these 'tell tales' a colored pigment can be added to the plaster to more closely match the color of the floor.

Wood Floors
Condition: The wooden floors in the loft areas and in the auditorium are in good condition, but the floor in the balcony shows evidence of general wear.
Treatment: The balcony floor may need to be refinished in the near future.

Annex Floor
Condition: Fair. Some tiles are missing and the floor is scuffed and scratched.
Treatment: Option 1: Replace missing tiles with new ones that match the existing tiles in color and material as closely as possible. Option 2: Remove all tiles and restore/replicate original scored concrete floor (see Figure 6). Option 3: Lay a new floor on top of existing tiles.

Wooden Chairs in Balcony
Condition: These free-standing, folding chairs are in fair condition. They are scuffed, stained and in need of refinishing. Some chairs are cracked, but most of the damage is cosmetic. Many of the slats are missing; some of the seats have been replaced with particle board. It is recommended that efforts be made to repair these chairs before replacement is considered. These are the only original chairs left in the building and they are a significant feature.
Treatment: Replace damaged parts in-kind and refinish.

Auditorium Ceiling
Condition: Fair. Many acoustical tiles show evidence of water damage.
Treatment: Repair roof and replace ceiling tiles.

Ceiling in Stair Wells

Condition: The wooden ceilings in the southwest and southeast stair wells are in poor condition due to a leaking roof.

Treatment: Repair roof and repaint wood. If wood has rotted, it should be replaced in-kind and primed before it is repainted.

Lighting

Condition: Good. Several of the hanging green metal light fixtures in the auditorium and the annex are original.

Treatment: These fixtures are not a very significant feature, but they should be retained if possible. If new lighting is installed, it should be discrete and compatible with the existing lights.

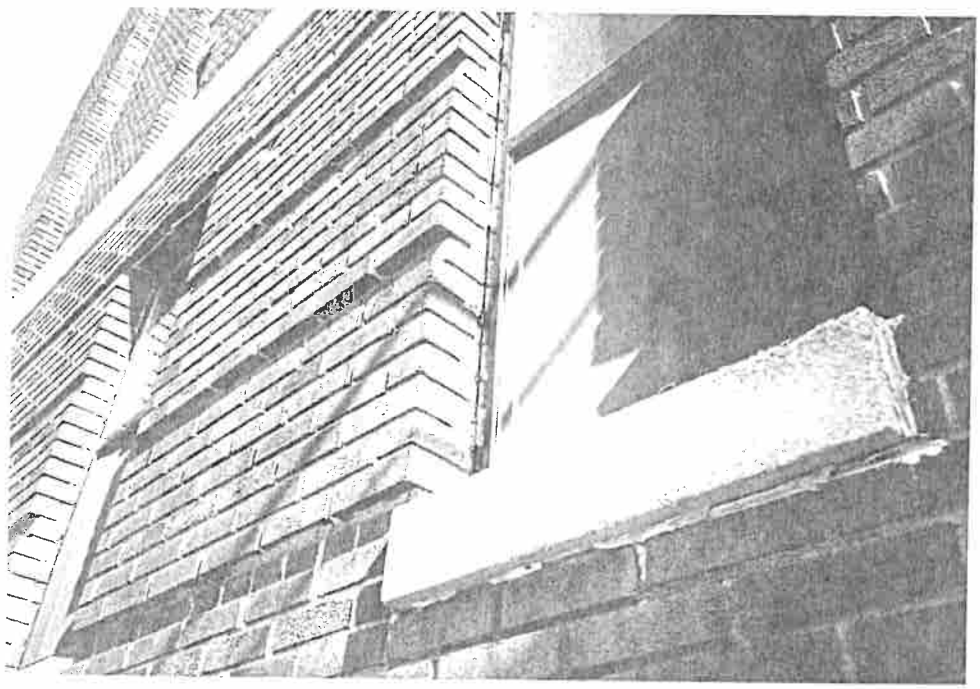
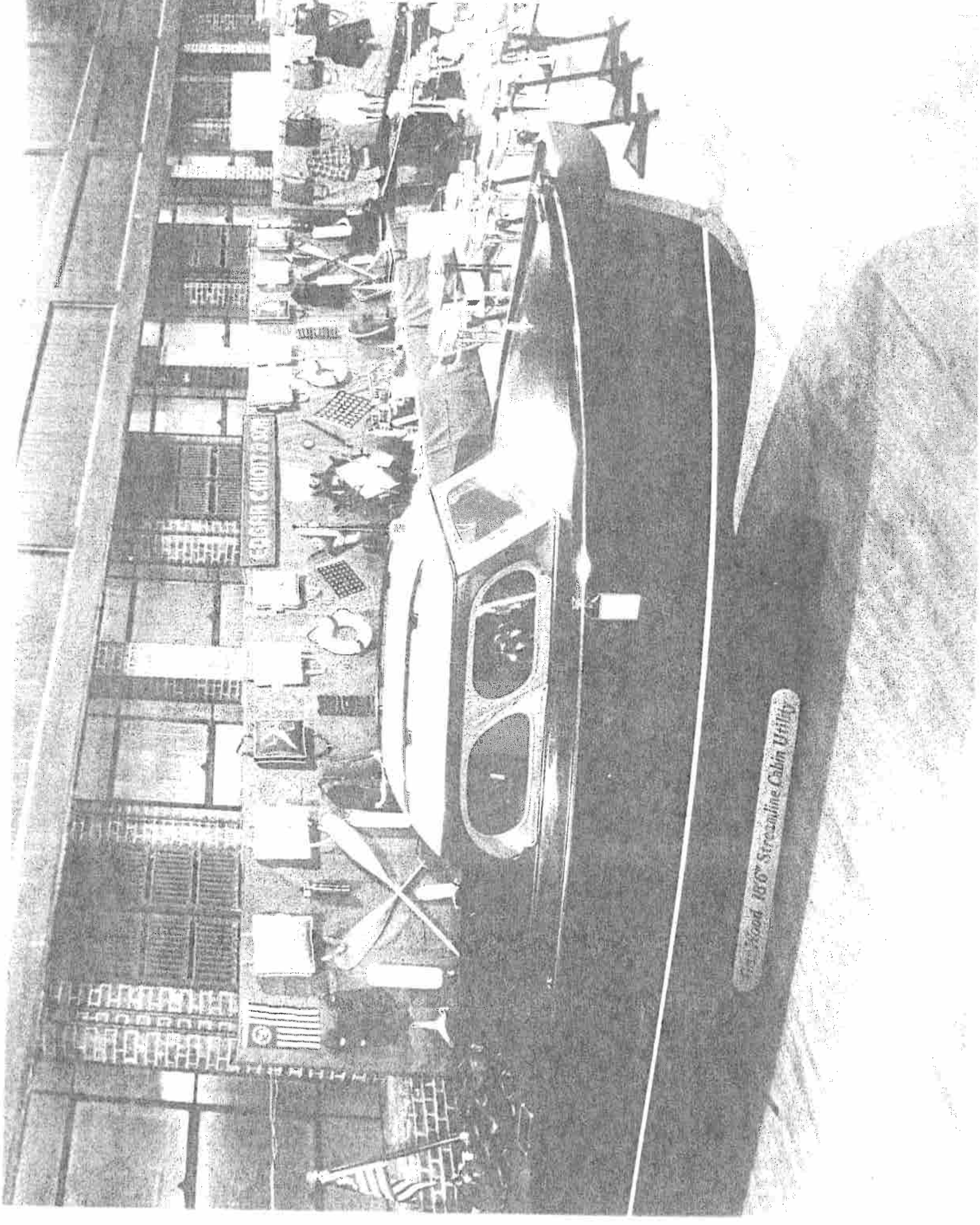
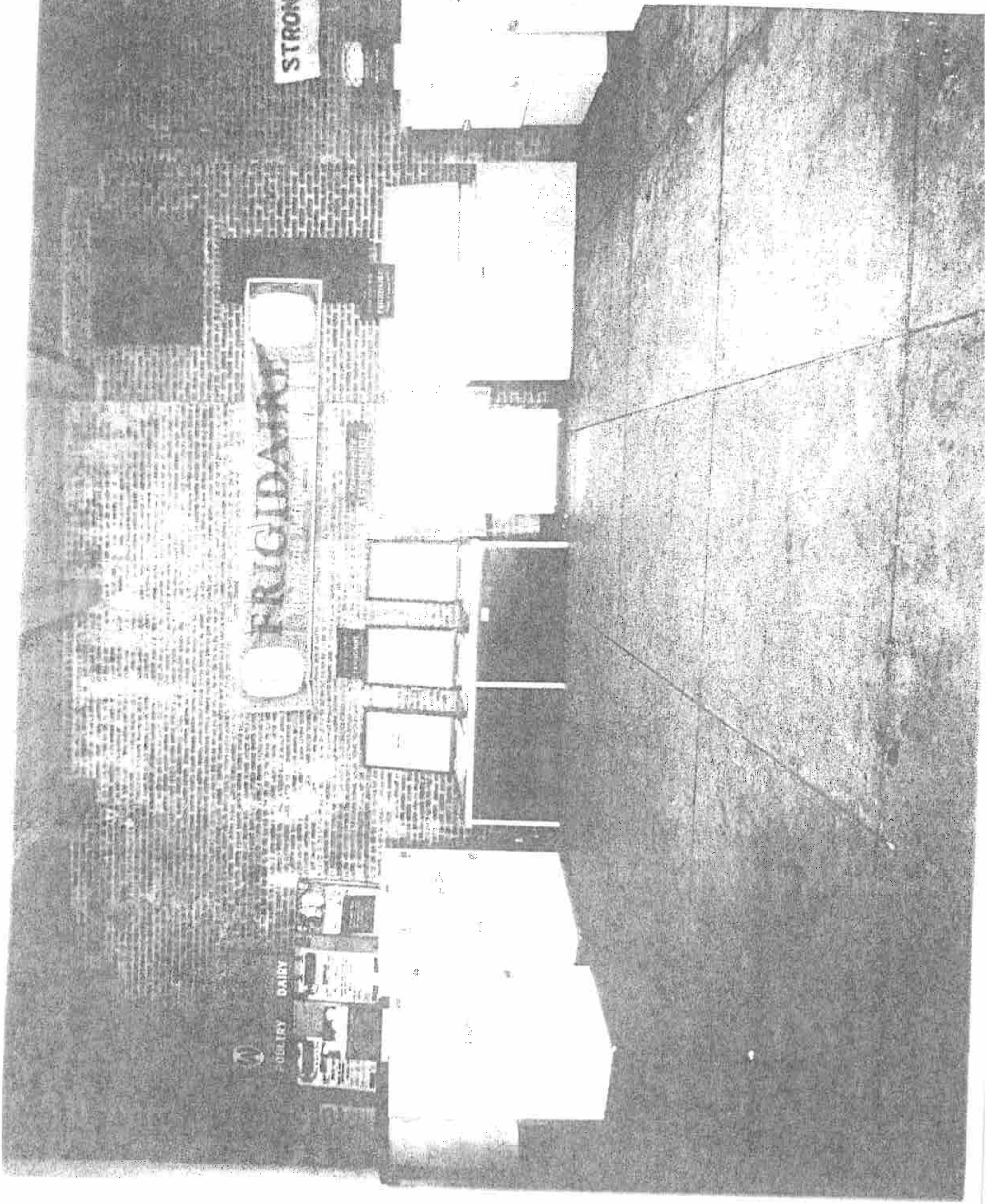


Figure 5 - This photo illustrates the need for caulking around some of the replacement windows.



... view of Memorial Auditorium basement showing scored concrete floor. (Photo: L.L. McAllister, UVM Special Collections)

Figure 7 - Circa 1950 view of auditorium. Note original steel 'awning' windows that were in the auditorium and basement.
(Photo: L.L. McAllister, UVM Special Collections)



Prioritization of Repairs and Restoration

Memorial Auditorium is generally in good condition, but several areas need to be addressed before minor problems worsen. This section prioritizes future work on the building and reiterates treatment recommendations from the previous section. The following general guidelines however, should be considered before any work on the building is undertaken:

Retain Historic Features
Memorial Auditorium was never meant to be an awe-inspiring public space, and consequently the building has little ornament or architectural detail. This does not mean however, that the building is not historically significant. The building retains a remarkable number of its original exterior and interior features. When considered collectively, these historic details are very important and should be retained wherever possible.

Retain Original Floor Plan
The original floor plan of the building should be preserved. If changes are made to the configuration of rooms, they should be done in a reversible manner. The addition of dropped ceilings should also be avoided.

Preserve East and South Facades
As a general rule, priority should be given to the east and south facades. These are the most public facades, and consequently the most important. Any future changes that need to be made to the building for accessibility should be made to the north or west facades. Conversely, any improvements to the building should be made to the east and south facades first.

Avoid Inappropriate Signage
Permanent signs on the exterior of the building should be carefully considered. New signs should be reversible, and of an appropriate size, scale and material.

The following list attempts to combine the general maintenance needs of the building with restoration and conservation work. Note that any work associated with conservation or restoration will have to be balanced with issues of handicap accessibility, energy efficiency, financial feasibility and the programmatic needs of the building.

1) Repair Roof
Water leaking from the roof is not only causing damage to the ceilings in the building, but may also be deteriorating the exterior walls. The roof and the flashing along the parapet should be patched or replaced immediately. Only a contractor with experience repairing or installing built-up roofs should be hired.

2) Fix or Replace Historic Steel Windows
Repair of the remaining steel windows should be examined before replacement is considered. Most of the steel frames appear to be in sound condition, therefore repair may be a viable option (see the appendix and previous section for treatment recommendations and more information). Adding thermal glass to the existing frames is a possibility that should be examined. Operable interior storm windows could also be added to increase energy efficiency. Exterior storm windows would be inappropriate and impractical.

If replacement is determined to be the most cost-effective solution, the new windows should replicate the originals as closely as possible. Window manufacturers can make windows to your required specifications. When reviewing replacement options, the following should be considered:

A. Material - Original windows were steel. If steel proves to be too expensive, aluminum could be considered as an alternative. Vinyl windows with clear glass should not be used as a replacement.

B. Style - Original windows were projecting or awning style. If insect screens are necessary, operable interior window screens could be installed. The muntin configuration of the screens should line up with the muntins on the windows.

C. Reflectivity - All of the original windows had opaque glass that was not highly reflective. Replacement glass should be opaque or frosted. It may be appropriate to have clear glass in some rooms, such as offices. However, the windows in the stairwells should be opaque, and if the windows in the auditorium and basement are replaced, they should be opaque as well.

D. Muntin Configuration - The muntin pattern should be duplicated.

E. Energy Efficiency - Replacement window can be thermal pane, providing increased energy efficiency.

3) Mitigation of Replacement Windows
The replacement windows used throughout the building do not match the originals in style, material, reflectivity and muntin configuration. The first option for mitigating the impact of these windows would be to remove and replace them with appropriate windows following the guidelines outlined above. However, these windows represent a considerable investment and therefore, this option is probably not practical or affordable at the present time. A second option would be to mitigate the impact of the existing vinyl windows. The replacement windows feature clear panes that change the overall appearance of the building due to their high reflectivity and allow more light to enter the building. In order to lessen the impact of these

changes, it is suggested that dark (black, dark green or charcoal) shades replace the existing curtains.

When funds are available to replace the vinyl windows with metal windows, the replacement windows should match the originals following the guidelines for replacement in the section above. The circa 1950s photograph included in this report (Figure 7) shows the configuration of the original auditorium and basement windows.

4) Repair and Repoint Concrete Features
The concrete elements on this building are a primary design feature. It is therefore both structurally and aesthetically important that they be repaired. Priority should be given to patching exterior steps and repointing the foundation, sills, and beltcourses. The upper beltcourse should be watched closely to determine if it is actively deteriorating. If it is determined that these areas are still spalling, replacement of the damaged blocks should be an additional priority. It is suggested that the spalling at the northwest corner of the foundation also be patched in the near future. A mason who has experience working on historic structures should be hired.

5) Address Potential Drainage Problems
The building's foundation is in fair condition, but some water damage is visible on the basement walls (particularly in the southeast stair well). This may be the result of poor drainage or a foundation that needs repointing. If the brick walls in the basement continue to show evidence of water damage after the foundation is repointed, a pipe may need to be installed below grade at the exterior of the foundation to drain water away from the building.

6) Replace Historic Marquees and Lamp Posts
Historic photos indicate that the building originally featured three marquees above the lobby entrances and lamp posts on the lobby steps. The marquees appear to have had pressed metal detail along their fascia boards. Anchors which held chains that supported these marquees are still located on the upper walls. There were six lamps (four at the east facade, and two each at the north and south facades) that were located along the top of the lobby steps. The lamps had bollard-like posts and globe lights. It is recommended that these details be replaced with similar historic reproductions. The historic photos should be studied in order to best determine the style and location of these elements (see the appendix for a list of potential suppliers).

7) Make Improvements for Accessibility
The existing ramp at the west facade that leads to the youth center may need to be widened and improved. The ramp at the front facade is in good condition, but an automatic door may need to be added. It would be preferable if both the ramp and the automatic door were located at the north lobby entrance, but it may not be practical to move the existing ramp. If a loading dock is needed, it should be added to the north facade, if possible.

8) Replace Lobby Doors and Transom Lights
Historic photos also indicate that the existing doors to the lobby are not original. The original doors were wood with multiple lights. The original transoms also probably had multiple lights and were of a similar style. If similar wood doors and transoms could be found, they could replace the existing metal doors and transoms. This should not be a priority however, because the existing doors are in good condition.

9) Lobby
The lobby area has very little ornament or detail and this is probably much the way it originally looked. Restoration work based on conjecture should be avoided in this room. In other words, architectural elements that were never a part of the room should not be added. Such elements should only be added if historic photos or drawings can document their existence. The walls should be painted a solid color if an historically accurate appearance is desired for the room. The existing configuration of the room should also be preserved.

10) Landscaping
The plantings at the southeast corner of the building and the tree that grows near the entrance to the day care center pose potential problems for the building's foundation. Removal of these plantings should be considered. Originally, the building had no landscaping except for the elm trees that lined the green belt on Main Street. The picket fence at the south facade should be removed if the day care center is relocated.

Appendix 1

Sources for Historic Lamp Posts

Classic Lamp Posts
3645 N.W. 67th Street
Miami, FL 33147
800-654-5852

Blake Industries
PO Box 155
Abington, MA 02351
617-337-8772

Herwig Lighting
PO Box 768
Russellville, Arkansas 72801
800-643-9523

Union Metal Corp.
PO Box 9920
Canton, OH 44711
216-456-7653

Spring City Electrical Manufacturing Company
610-948-4000

Sternberg Vintage Lighting
7401 Oak Park Ave.
Niles, IL 60714
847-588-3400

Sources for Exterior Pressed Metal Ornament

There are no known companies that specialize specifically in marquee reproduction, but the following suppliers produce exterior metal ornament and may have experience with marquees.

Passaic Metal Products
5 Central Ave.
Clifton, NJ 07015
201-546-9000

Copper Craft, Inc.
2143 Joe Field Rd., #100
Dallas, TX
800-486-2723

W.F. Norman Corp.
PO Box 323
Nevada, MO 64772
800-641-4038

Sources for Steel Windows

A & S Window Associates
88-19 76th Ave.
Glendale, NY 11385
718-275-7900
A & S makes a variety of steel frame windows. All are custom made.

Hope's
84 Hopkins Ave.
Jamestown, NY 14701
716-665-5124
High quality steel windows. All are custom made. May not be cost-effective or appropriate for Memorial Auditorium.

Bliss-Cashier Metal Products Inc.
617 W. Manlius St.
East Syracuse, NY 13057
315-437-3396

Sources for Aluminum Windows

A & S Window Associates
88-19 76th Ave.
Glendale, NY 11385
718-275-7900
A & S makes an 'awning' style window in steel and aluminum.

Hope's
84 Hopkins Ave.
Jamestown, NY 14701
716-665-5124
Hope's also makes an 'awning' style window in aluminum.

Kawneer Company Inc.
PO Box 629
500 East 12th St.
Bloomsburg, PA 17815
717-784-8000
Makes an 'awning' style window with a thermal pane.

Sources for Steel Window Parts and Hardware

Blaine Window Hardware Inc.
17319 Blaine Dr.
Hagerstown, MD 21740
800-678-1919

Stry-Buc Industries
2006 Elmwood Ave.
Sharon Hill, PA 19079
800-352-0800

Appendix 2

Narrative Building Description

Memorial Auditorium lies on a steep slope and rises 3 1/2 stories at the front (east) facade and 4 1/2 stories on the other three facades as a result of an exposed basement. The rectangular building is constructed of brick and cast-concrete, and features symmetrical fenestration. A parapet with segmental arches and concrete panels hides a flat roof. A concrete beltcourse caps the windows on the top story and continues around the entire building. A 3x3 bay section with pilasters is off-set from the main block at each corner. Vertical piers, a cubic form and detail along the roof line give Memorial Auditorium elements of the Art Deco style.

The front facade of the building features three symmetrically-spaced double-doors which are approached by a flight of concrete steps. The glass metal doors have transom lights and are framed by concrete moldings. A large concrete-block foundation, which imitates stone, spans the front facade and continues at the corners of the south and north facades. Concrete panels ornament the parapets at the corners of the building and the center of the front facade. "Memorial Auditorium" is inscribed in the central panel of the parapet on the front facade.

Additional entries to the lobby area are located near the corners of the north and south facades. These secondary entrances also have glass metal doors, transom lights and concrete moldings.

The exposed basement at the north, south and west facades is characterized by several recessed courses of brick below a concrete beltcourse that articulates the first floor. Entries at the basement level on the south and north facades have flat arches with concrete keystones and corbelled brick. Two of these entries still contain original cast-iron lanterns above their keystones.

Many of the original metal windows are located at the corner towers of the building. These narrow, 'awning' style windows have opaque glass and two or three horizontal muntins. All of the windows on the building feature flat arches and concrete sills.

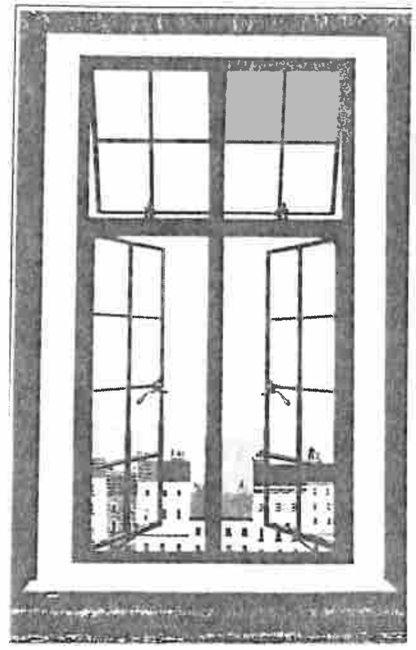
The interior of the building reflects its functionality. Exposed brick walls and steel truss frames indicate that the building was never an ornamental public space. The lobby features a terrazzo floor, plaster walls and two sets of wooden pilasters that mark a threshold between the lobby and a pair of stair wells at the southeast and northeast corners of the building.

Five sets of wooden double doors separate the lobby and front stair wells from the auditorium on the first floor. The auditorium has a wooden floor, wooden retractable bleachers, a stage and a balcony. The balcony, which is reached from a loft area that is directly above the lobby, also has wooden floors and original wooden chairs.

The basement of the building, or annex, can be reached from the two main stair wells. This large open area has a tile floor (probably asbestos), brick walls, cast-iron columns and several service entrances. The original configuration of the room has changed due to the addition of a day-care center at the south facade. A youth center is located at this level behind an original brick wall at the west end of the building.

An area behind the stage on the main floor contains locker/dressing rooms and additional stair wells at the northwest and southwest corners. These rooms were renovated approximately 20 years ago.

13 PRESERVATION BRIEFS



The Repair and Thermal Upgrading of Historic Steel Windows

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> The Secretary of the Interior's "Standards for Rehabilitation" require that where historic windows are individually significant features, or where they contribute to the character of significant facades, their distinguishing visual qualities must not be destroyed. Further, the rehabilitation guidelines recommend against changing the historic appearance of windows through the use of inappropriate designs, materials, finishes, or colors which radically change the sash, depth of reveal, and muntin configuration; the reflectivity and color of the glazing; or the appearance of the frame.

Windows are among the most vulnerable features of historic buildings undergoing rehabilitation. This is especially the case with rolled steel windows, which are often mistakenly not deemed worthy of preservation in the conversion of old buildings to new uses. The ease with which they can be replaced and the mistaken assumption that they cannot be made energy efficient except at great expense are factors that typically lead to the decision to remove them. In many cases, however, repair and retrofit of the historic windows are more economical than whole-sale replacement, and all too often, replacement units are unlike the originals in design and appearance. If the windows are important in establishing the historic character of the building (see fig. 1), insensitively designed replacement windows may diminish—or destroy—the building's historic character.

This *Brief* identifies various types of historic steel windows that dominated the metal window market from 1890-1950. It then gives criteria for evaluating deterioration and for determining appropriate treatment, ranging from routine maintenance and weatherization to extensive repairs, so that replacement may be avoided where possible.[1] This information applies to do-it-yourself jobs and to large rehabilitations where the volume of work warrants the removal of all window units for complete overhaul by professional contractors.

This *Brief* is not intended to promote the repair of ferrous metal windows in every case, but rather to insure that preservation is always the first consideration in a rehabilitation project. Some windows are not important elements in defining a building's historic character; others are highly significant, but so deteriorated that repair is infeasible. In such cases, the *Brief* offers guidance in evaluating appropriate replacement windows.

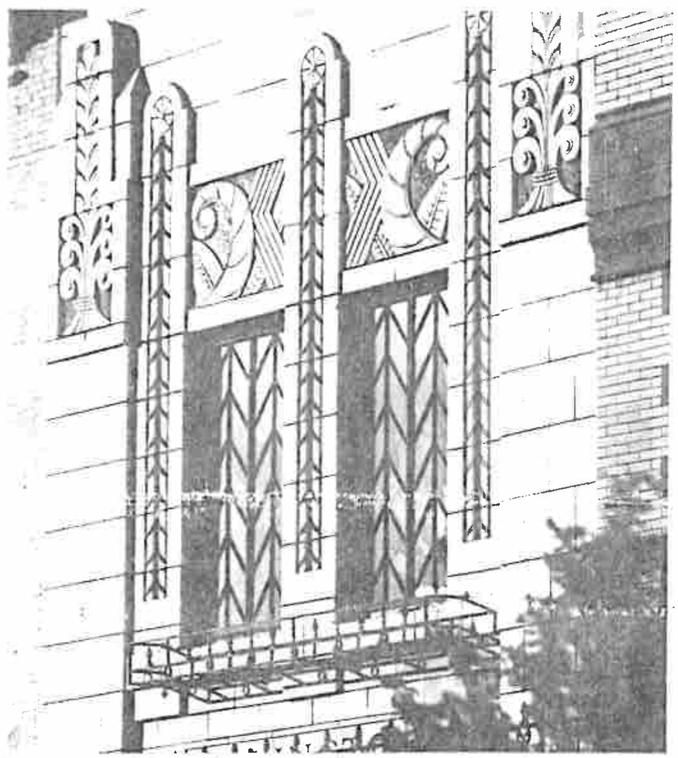


Fig. 1 Often highly distinctive in design and craftsmanship, rolled steel windows play an important role in defining the architectural character of many later nineteenth and early twentieth century buildings. Art Deco, Art Moderne, the International Style, and Post World War II Modernism depended on the slim profiles and streamlined appearance of metal windows for much of their impact. Photo: William G. Johnson.

[1] The technical information given in this brief is intended for most ferrous (or magnetic) metals, particularly rolled steel. While stainless steel is a ferrous metal, the cleaning and repair techniques outlined here must not be used on it as the finish will be damaged. For information on cleaning stainless steel and non-ferrous metals, such as bronze, Monel, or aluminum, refer to *Metals in America's Historic Buildings* (see bibliography).

Although metal windows were available as early as 1860 from catalogues published by architectural supply firms, they did not become popular until after 1890. Two factors combined to account for the shift from wooden to metal windows about that time. Technology borrowed from the rolling industry permitted the mass production of rolled steel windows. This technology made metal windows cost competitive with conventional wooden windows. In addition, a series of devastating urban fires in Boston, Baltimore, Philadelphia, and San Francisco led to the enactment of strict fire codes for industrial and multi-story commercial and office buildings.

As in the process of making rails for railroads, rolled steel windows were made by passing hot bars of steel through progressively smaller, shaped rollers until the appropriate angled configuration was achieved (see fig. 2). The rolled steel sections, generally 1/8'' thick and 1'' - 1 1/2'' wide, were used for all the components of the windows: sash, frame,and subframe (see fig. 3). With the addition of wire glass, a fire-resistant window resulted. These rolled steel windows are almost exclusively found in masonry or concrete buildings.

A byproduct of the fire-resistant window was the strong metal frame that permitted the installation of larger windows and windows in series. The ability to have expansive amounts of glass and increased ventilation dramatically changed the designs of late 19th and early 20th century industrial and commercial buildings.

The newly available, reasonably priced steel windows soon became popular for more than just their fire-resistant qualities. They were standardized, extremely durable, and easily transported. These qualities led to the use of steel windows in every type of construction, from simple industrial and institutional buildings to luxury commercial and apartment buildings. Casement, double-hung, pivot, projecting, austral, and continuous windows differed in operating and ventilating capacities. Figure 4 outlines the kinds and properties of metal windows available then and now. In addition, the thin profiles of metal windows contributed to the streamlined appearance of the Art Deco, Art Moderne, and International Styles, among others.

The extensive use of rolled steel metal windows continued until after World War II when cheaper, non-corroding aluminum windows became increasingly popular. While aluminum windows dominate the market today, steel windows are still fabricated. Should replacement of original windows become necessary, replacement windows may be available from the manufacturers of some of the earliest steel windows. Before an informed decision can be made whether to repair or replace metal windows, however, the significance of the windows must be determined and their physical condition assessed.

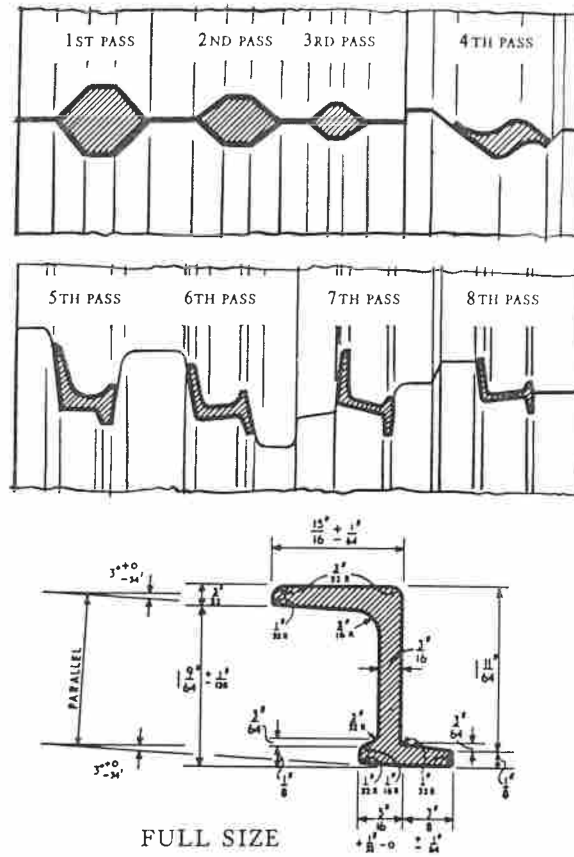


Fig. 2. The process of rolling a steel bar into an angled section is illustrated above. The shape and size of the rolled section will vary slightly depending on the overall strength needed for the window opening and the location of the section in the assembly: subframe, frame, or sash. The 1/8 '' thickness of the metal section is generally standard. Drawing: A Metal Window Dictionary. Used with permission.

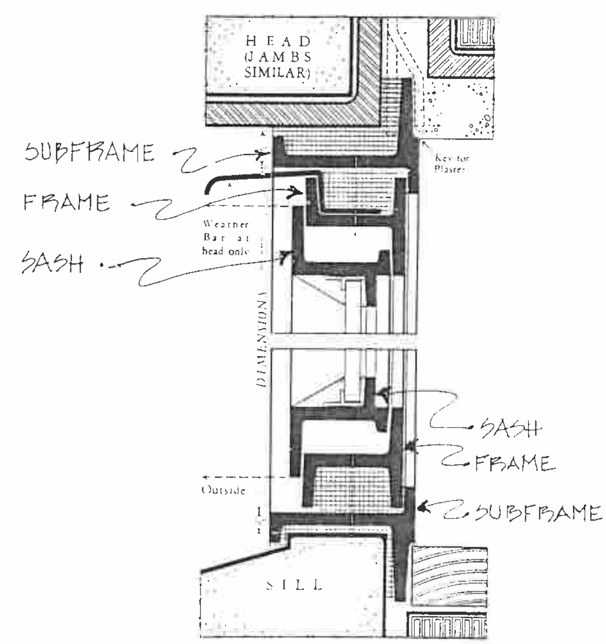


Fig. 3 A typical section through the top and bottom of a metal window shows the three component parts of the window assembly: subframe, frame, and sash. Drawings: Catalogue No. 15, January 1931; International Casement Co, Inc., presently Hope's Architectural Products, Inc., Jamestown, NY. Used with permission.

Cover illustration: from *Hope's Metal Windows and Casements: 1818-1926,* currently Hope's Architectural Products, Inc. Used with permission.

Historic and Architectural Considerations

An assessment of the significance of the windows should begin with a consideration of their function in relation to the building's historic use and its historic character. Windows that help define the building's historic character should be preserved even if the building is being converted to a new use. For example, projecting steel windows used to introduce light and an effect of spaciousness to a warehouse or industrial plant can be retained in the conversion of such a building to offices or residences.

Other elements in assessing the relative importance of the historic windows include the design of the windows and their relationship to the scale, proportion, detailing and architectural style of the building. While it may be easy to determine the aesthetic value of highly ornamented windows, or to recognize the importance of streamlined windows as an element of a style, less elaborate windows can also provide strong visual interest by their small panes or projecting planes when open, particularly in simple, unadorned industrial buildings (see fig. 5).

One test of the importance of windows to a building is to ask if the overall appearance of the building would be changed noticeably if the windows were to be removed or radically altered. If so, the windows are important in defining the building's historic character, and should be repaired if their physical condition permits.

Physical Evaluation

Steel window repair should begin with a careful evaluation of the physical condition of each unit. Either drawings or photographs, liberally annotated, may be used to record the location of each window, the type of operability, the condition of all three parts—sash, frame and subframe—and the repairs essential to its continued use.

Specifically, the evaluation should include: presence and degree of corrosion; condition of paint; deterioration of the metal sections, including bowing, misalignment of the sash, or bent sections; condition of the glass and glazing compound; presence and condition of all hardware, screws, bolts, and hinges; and condition of the masonry or concrete surrounds, including need for caulking or resetting of improperly sloped sills.

Corrosion, principally rusting in the case of steel windows, is the controlling factor in window repair; therefore, the evaluator should first test for its presence. Corrosion can be light, medium, or heavy, depending on how much the rust has penetrated the metal sections. If the rusting is merely a surface accumulation or flaking, then the corrosion is light. If the rusting has penetrated the metal (indicated by a bubbling texture), but has not caused any structural damage, then the corrosion is medium. If the rust has penetrated deep into the metal, the corrosion is heavy. Heavy corrosion generally results in some form of structural damage,through delamination, ed. A sharp probe or tool, such as an ice pick, can be used to determine the extent of corrosion in the metal. If the probe can penetrate the surface of the metal and brittle strands can be dug out, then a high degree of corrosive deterioration is present.

In addition to corrosion, the condition of the paint, the presence of bowing or misalignment of metal sections, the amount of glass needing replacement, and the condition of the masonry or concrete surrounds must be assessed in the evaluation process. These are key factors in determining whether or not the windows can be repaired in place. The more complete the inventory of existing conditions, the easier it will be to determine whether repair is feasible or whether replacement is warranted.

Rehabilitation Work Plan

Following inspection and analysis, a plan for the rehabilitation can be formulated. The actions necessary to return windows to an efficient and effective working condition will fall into one or more of the following categories: routine maintenance, repair, and weatherization. The routine maintenance and weatherization measures described here are generally within the range of do-it-yourselfers. Other repairs, both moderate and major, require a professional contractor. Major repairs normally require the removal of the window units to a workshop, but even in the case of moderate repairs, the number of windows involved might warrant the removal of all the deteriorated units to a workshop in order to realize a more economical repair price. Replacement of windows should be considered only as a last resort.

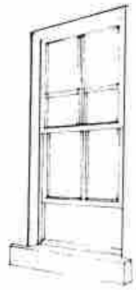
Since moisture is the primary cause of corrosion in steel windows, it is essential that excess moisture be eliminated and that the building be made as weathertight as possible before any other work is undertaken. Moisture can accumulate from cracks in the masonry, from spalling mortar, from leaking gutters, from air conditioning condensation runoff, and from poorly ventilated interior spaces.

Finally, before beginning any work, it is important to be aware of health and safety risks involved. Steel windows have historically been coated with lead paint. The removal of such paint by abrasive methods will produce toxic dust. Therefore, safety goggles, a toxic dust respirator, and protective clothing should be worn. Similar protective measures should be taken when acid compounds are used. Local codes may govern the methods of removing lead paints and proper disposal of toxic residue.

ROUTINE MAINTENANCE

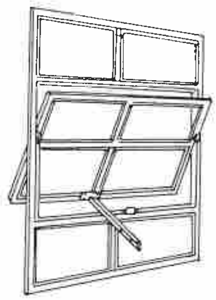
A preliminary step in the routine maintenance of steel windows is to remove surface dirt and grease in order to ascertain the degree of deterioration, if any. Such minor cleaning can be accomplished using a brush or vacuum followed by wiping with a cloth dampened with mineral spirits or denatured alcohol.

Double-hung industrial windows duplicated the look of traditional wooden windows. Metal double-hung windows were early examples of a building product adapted to meet stringent new fire code requirements for manufacturing and high-rise buildings in urban areas. Soon supplanted in industrial buildings by less expensive pivot windows, double-hung metal windows regained popularity in the 1940s for use in speculative suburban housing.

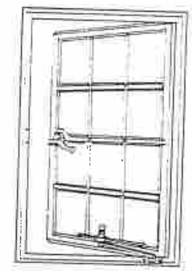


Austral windows were also a product of the 1920s. They combined the appearance of the double-hung window with the increased ventilation and ease of operation of the projected window. (When fully opened, they provided 70% ventilation as compared to 50% ventilation for double-hung windows.) Austral windows were often used in schools, libraries and other public buildings.

Pivot windows were an early type of industrial window that combined inexpensive first cost and low maintenance. Pivot windows became standard for warehouses and power plants where the lack of screens was not a problem. The window shown here is a horizontal pivot. Windows that turned about a vertical axis were also manufactured (often of iron). Such vertical pivots are rare today.



Casement windows adapted the English tradition of using wrought iron casements with leaded cames for residential use. Rolled steel casements (either single, as shown, or paired) were popular in the 1920s for cottage style residences and Gothic style campus architecture. More streamlined casements were popular in the 1930s for institutional and small industrial buildings.



Projecting windows, sometimes called awning or hopper windows, were perfected in the 1920s for industrial and institutional buildings. They were often used in "combination" windows, in which upper panels opened out and lower panels opened in. Since each movable panel projected to one side of the frame only, unlike pivot windows, for example, screens could be introduced.

Continuous windows were almost exclusively used for industrial buildings requiring high overhead lighting. Long runs of clerestory windows operated by mechanical tension rod gears were typical. Long banks of continuous windows were possible because the frames for such windows were often structural elements of the building.

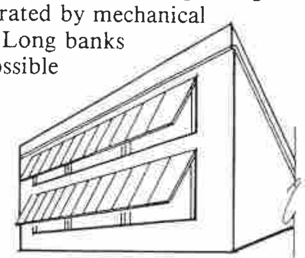


Fig. 4 Typical rolled steel windows available from 1890 to the present. The various operating and ventilating capacities in combination with the aesthetics of the window style were important considerations in the selection of one window type over another. Drawings: Sharon C. Park, AIA.

If it is determined that the windows are in basically sound condition, the following steps can be taken: 1) removal of light rust, flaking and excessive paint; 2) priming of exposed metal with a rust-inhibiting primer; 3) replacement of cracked or broken glass and glazing compound; 4) replacement of missing screws or fasteners; 5) cleaning and lubrication of hinges; 6) repainting of all steel sections with two coats of finish paint compatible with the primer; and 7) caulking the masonry surrounds with a high quality elastomeric caulk.

Recommended methods for removing light rust include manual and mechanical abrasion or the application of chemicals. Burning off rust with an oxy-acetylene or propane torch, or an inert gas welding gun, should never be attempted because the heat can distort the metal. In addition, such intense heat (often as high as 3800° F) vaporizes the lead in old paint, resulting in highly toxic fumes. Furthermore, such heat will likely result in broken glass. Rust can best be removed using a wire brush, an aluminum oxide sandpaper, or a variety of power tools

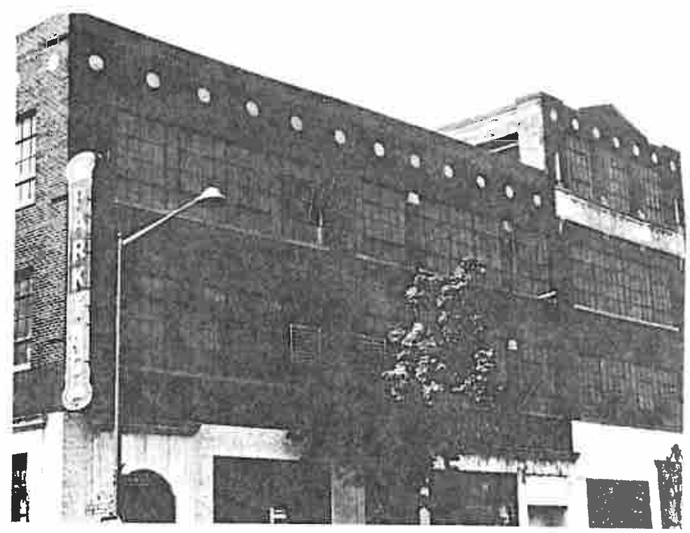


Fig. 5 Windows often provide a strong visual element to relatively simple or unadorned industrial or commercial buildings. This design element should be taken into consideration when evaluating the significance of the windows. Photo: Michael Auer.

adapted for abrasive cleaning such as an electric drill with a wire brush or a rotary whip attachment. Adjacent sills and window jambs may need protective shielding.

Rust can also be removed from ferrous metals by using a number of commercially prepared anti-corrosive acid compounds. Effective on light and medium corrosion, these compounds can be purchased either as liquids or gels. Several bases are available, including phosphoric acid, ammonium citrate, oxalic acid and hydrochloric acid. Hydrochloric acid is generally not recommended; it can leave chloride deposits, which cause future corrosion. Phosphoric acid-based compounds do not leave such deposits, and are therefore safer for steel windows. However, any chemical residue should be wiped off with damp cloths, then dried immediately. Industrial blow-dryers work well for thorough drying. The use of running water to remove chemical residue is never recommended because the water may spread the chemicals to adjacent surfaces, and drying of these surfaces may be more difficult. Acid cleaning compounds will stain masonry; therefore plastic sheets should be taped to the edge of the metal sections to protect the masonry surrounds. The same measure should be followed to protect the glazing from etching because of acid contact.

Measures that remove rust will ordinarily remove flaking paint as well. Remaining loose or flaking paint can be removed with a chemical paint remover or with a pneumatic needle scaler or gun, which comes with a series of chisel blades and has proven effective in removing flaking paint from metal windows. Well-bonded paint may serve to protect the metal further from corrosion, and need not be removed unless paint build-up prevents the window from closing tightly. The edges should be feathered by sanding to give a good surface for repainting.

Next, any *bare* metal should be wiped with a cleaning solvent such as denatured alcohol, and dried immediately in preparation for the application of an anti-corrosive primer. Since corrosion can recur very soon after metal has been exposed to the air, the metal should be primed immediately after cleaning. Spot priming may be required periodically as other repairs are undertaken. Anti-corrosive primers generally consist of oil-alkyd based paints rich in zinc or zinc chromate.[2] Red lead is no longer available because of its toxicity. All metal primers, however, are toxic to some degree and should be handled carefully. Two coats of primer are recommended. Manufacturer's recommendations should be followed concerning application of primers.

REPAIR

Repair in Place

The maintenance procedures described above will be insufficient when corrosion is extensive, or when metal window sections are misaligned. Medium to heavy corrosion that has not done any structural damage to the metal sections can be removed either by using the chemical cleaning process described under "Routine Maintenance" or by sandblasting. Since sandblasting can damage the masonry surrounds and crack or cloud the glass, metal or plywood shields should be used to protect these materials. The sandblasting pressure should be low, 80-100 pounds per square inch, and the grit size should be in the range of #10-#45. Glass peening beads (glass pellets) have also been successfully used in cleaning steel sections. While sandblasting equipment comes with various nozzle sizes, pencil-point blasters are most useful because they give the operator more effective control over the direction of the spray. The small aperture of the pencil-point blaster is also useful in removing dried putty from the metal sections that hold the glass. As with any cleaning technique, once the bare metal is exposed to air, it should be primed as soon as possible. This includes the inside rabbeted section of sash where glazing putty has been removed. To reduce the dust, some local codes allow only wet blasting. In this case, the metal must be dried immediately, generally with a blow-drier (a step that the owner should consider when calculating the time and expense involved). Either form of sandblasting metal covered with lead paints produces toxic dust. Proper precautionary measures should be taken against toxic dust and silica particles.

Bent or bowed metal sections may be the result of damage to the window through an impact or corrosive expansion. If the distortion is not too great, it is possible to realign the metal sections without removing the window to a metal fabricator's shop. The glazing is generally removed and pressure is applied to the bent or bowed section. In the case of a muntin, a protective 2 x 4 wooden bracing can be placed behind the bent portion and a wire cable with a winch can apply progressively more pressure over several days until the section is realigned. The 2 x 4 bracing is necessary to distribute the pressure evenly over the damaged section. Sometimes a section, such as the bottom of the frame, will bow out as a result of pressure exerted by corrosion and it is often necessary to cut the metal section to relieve this pressure prior to pressing the section back into shape and making a welded repair.

Once the metal sections have been cleaned of all corrosion and straightened, small holes and uneven areas resulting from rusting should be filled with a patching material and sanded smooth to eliminate pockets where water can accumulate. A patching material of steel fibers and an epoxy binder may be the easiest to apply. This steel-based epoxy is available for industrial steel repair; it can also be found in auto body patching compounds or in plumber's epoxy. As with any product, it is important to follow the manufacturer's instructions for proper use and best results. The traditional patching technique—melting steel welding rods to fill holes in the metal sections—may be difficult to apply in some situations; moreover, the window glass must be removed during the repair process, or it will crack from the expansion of the heated metal sections. After these repairs, glass replacement, hinge lubrication, painting, and other cosmetic repairs can be undertaken as necessary.

[2]Refer to Table IV. Types of Paint Used for Painting Metal in *Metals in America's Historic Buildings*, p. 139. (See bibliography).

cracked glass, deteriorated glazing compound, missing screws, and broken fasteners will have to be replaced; hinges cleaned and lubricated; the metal windows painted, and the masonry surrounds caulked. If the glazing must be replaced, all clips, glazing beads, and other fasteners that hold the glass to the sash should be retained, if possible, although replacements for these parts are still being fabricated. When bedding glass, use only glazing compound formulated for metal windows. To clean the hinges (generally brass or bronze), a cleaning solvent and fine bronze wool should be used. The hinges should then be lubricated with a non-greasy lubricant specially formulated for metals and with an anti-corrosive agent. These lubricants are available in a spray form and should be used periodically on frequently opened windows.

Final painting of the windows with a paint compatible with the anti-corrosive primer should proceed on a dry day. (Paint and primer from the same manufacturer should be used.) Two coats of finish paint are recommended if the sections have been cleaned to bare metal. The paint should overlap the glass slightly to insure weathertightness at that connection. Once the paint dries thoroughly, a flexible exterior caulk can be applied to eliminate air and moisture infiltration where the window and the surrounding masonry meet.

Caulking is generally undertaken after the windows have received at least one coat of finish paint. The perimeter of the masonry surround should be caulked with a flexible elastomeric compound that will adhere well to both metal and masonry. The caulking used should be a type intended for exterior application, have a high tolerance for material movement, be resistant to ultraviolet light, and have a minimum durability of 10 years. Three effective compounds (taking price and other factors into consideration) are polyurethane, vinyl acrylic, and butyl rubber. In selecting a caulking material for a window retrofit, it is important to remember that the caulking compound may be covering other materials in a substrate. In this case, some compounds, such as silicone, may not adhere well. Almost all modern caulking compounds can be painted after curing completely. Many come in a range of colors, which eliminates the need to paint. If colored caulking is used, the windows should have been given two coats of finish paint prior to caulking.

Repair in Workshop

Damage to windows may be so severe that the window sash and sometimes the frame must be removed for cleaning and extensive rust removal, straightening of bent sections, welding or splicing in of new sections, and reglazing. These major and expensive repairs are reserved for highly significant windows that cannot be replaced; the procedures involved should be carried out only by skilled workmen. (see fig. 6a—6f.)

dow should be numbered and the parts labelled. The operable metal sash should be dismantled by removing the hinges; the fixed sash and, if necessary, the frame can then be unbolted or unscrewed. (The subframe is usually left in place. Built into the masonry surrounds, it can only be cut out with a torch.) Hardware and hinges should be labelled and stored together.

The two major choices for removing flaking paint and corrosion from severely deteriorated windows are dipping in a chemical bath or sandblasting. Both treatments require removal of the glass. If the windows are to be dipped, a phosphoric acid solution is preferred, as mentioned earlier. While the dip tank method is good for fairly evenly distributed rust, deep set rust may remain after dipping. For that reason, sandblasting is more effective for heavy and uneven corrosion. Both methods leave the metal sections clean of residual paint. As already noted, after cleaning has exposed the metal to the air, it should be primed immediately after drying with an anti-corrosive primer to prevent rust from recurring.

Sections that are seriously bent or bowed must be straightened with heat and applied pressure in a workshop. Structurally weakened sections must be cut out, generally with an oxy-acetylene torch, and replaced with sections welded in place and the welds ground smooth. Finding replacement metal sections, however, may be difficult. While most rolling mills are producing modern sections suitable for total replacement, it may be difficult to find an exact profile match for a splicing repair. The best source of rolled metal sections is from salvaged windows, preferably from the same building. If no salvaged windows are available, two options remain. Either an ornamental metal fabricator can weld flat plates into a built-up section, or a steel plant can mill bar steel into the desired profile.

While the sash and frame are removed for repair, the subframe and masonry surrounds should be inspected. This is also the time to reset sills or to remove corrosion from the subframe, taking care to protect the masonry surrounds from damage.

Missing or broken hardware and hinges should be replaced on all windows that will be operable. Salvaged windows, again, are the best source of replacement parts. If matching parts cannot be found, it may be possible to adapt ready-made items. Such a substitution may require filling existing holes with steel epoxy or with plug welds and tapping in new screw holes. However, if the hardware is a highly significant element of the historic window, it may be worth having reproductions made.

Following are illustrations of the repair and thermal upgrading of the rolled steel windows in a National Historic Landmark (fig. 6). Many of the techniques described above were used during this extensive rehabilitation. The complete range of repair techniques is then summarized in the chart titled *Steps for Cleaning and Repairing Historic Steel Windows* (see fig. 7).

Fig. 6 a. View of the flanking wing of the State Capitol where the rolled steel casement windows are being removed for repair.

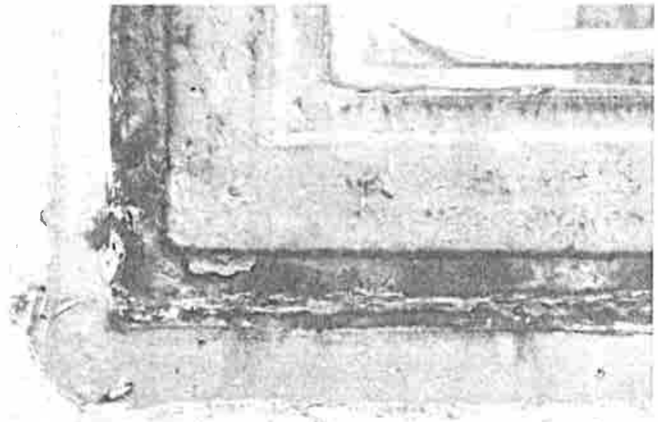


Fig. 6 b. View from the exterior showing the deteriorated condition of the lower corner of a window prior to repair. While the sash was in relatively good condition, the frame behind was rusted to the point of inhibiting operation.

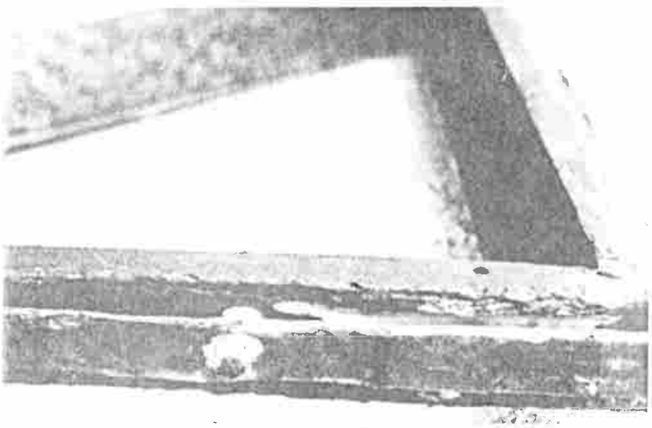


Fig. 6 c. View of the rusted frame which was unscrewed from the subframe and removed from the window opening and taken to a workshop for sandblasting. In some cases, severely deteriorated sections of the frame were replaced with new sections of milled bar steel.

Fig. 6 d. View looking down towards the sill. The subframes appeared very rusted, but were in good condition once debris was vacuumed and surface rust was removed, in place, with chemical compounds. Where necessary, epoxy and steel filler was used to patch depressions in order to make the subframe serviceable again.

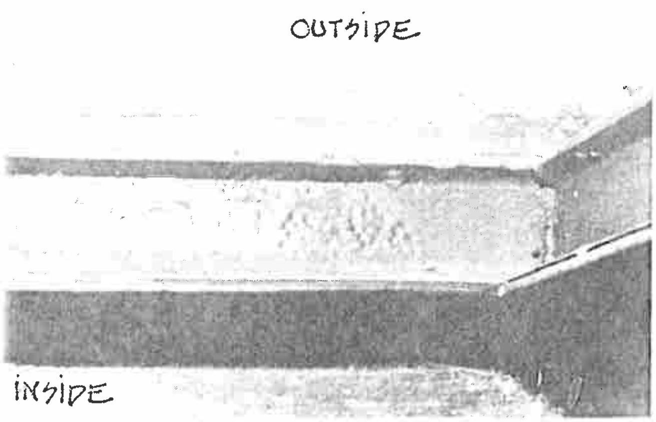


Fig. 6 e. View looking down towards the sill. The cleaned frame was reset in the window opening. The frame was screwed to the refurbished subframe at the jamb and the head only. The screw holes at the sill, which had been the cause of much of the earlier rusting, were infilled. Vinyl weatherstripping was added to the frame.

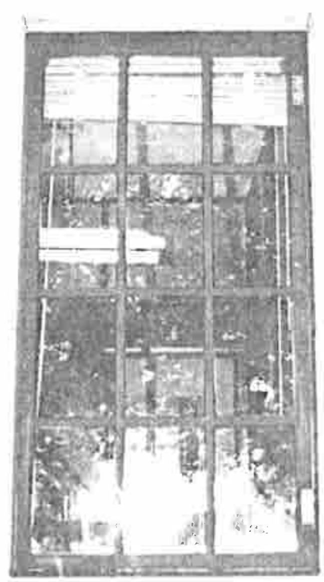


Fig. 6 f. View from the outside of the completely refurbished window. In addition to the steel repair and the installation of vinyl weatherstripping, the exterior was caulked with polyurethane and the single glass was replaced with individual lights of thermal glass. The repaired and upgraded windows have comparable energy efficiency ratings to new replacement units while retaining the historic steel sash, frames and subframes.

Fig. 6. The repair and thermal upgrading of the historic steel windows at the State Capitol, Lincoln, Nebraska. This early twentieth century building, designed by Bertram Goodhue, is a National Historic Landmark. Photos: All photos in this series were provided by the State Building Division.

STEPS FOR CLEANING AND REPAIRING HISTORIC STEEL WINDOWS

Work Item	Recommended Techniques	Tools, Products and Procedures	Notes
	*(Must be done in a workshop)		
1. Removing dirt and grease from metal	General maintenance and chemical cleaning	Vacuum and bristle brushes to remove dust and dirt; solvents (denatured alcohol, mineral spirits), and clean cloths to remove grease.	Solvents can cause eye and skin irritation. Operator should wear protective gear and work in ventilated area. Solvents should not contact masonry. Do not flush with water.
2. Removing Rust/ Corrosion			
Light	Manual and mechanical abrasion	Wire brushes, steel wool, rotary attachments to electric drill, sanding blocks and disks.	Handsanding will probably be necessary for corners. Safety goggles and masks should be worn.
	Chemical cleaning	Anti-corrosive jellies and liquids (phosphoric acid preferred); clean damp cloths.	Protect glass and metal with plastic sheets attached with tape. Do not flush with water. Work in ventilated area.
Medium	Sandblasting/abrasive cleaning	Low pressure (80-100 psi) and small grit (#10-#45); glass peening beads. Pencil blaster gives good control.	Removes both paint and rust. Codes should be checked for environmental compliance. Prime exposed metal promptly. Shield glass and masonry. Operator should wear safety gear.
Heavy	*Chemical dip tank	Metal sections dipped into chemical tank (phosphoric acid preferred) from several hours to 24 hours.	Glass and hardware should be removed. Protect operator. Deepset rust may remain, but paint will be removed.
	*Sandblasting/ abrasive cleaning	Low pressure (80-100 psi) and small grit (#10-#45).	Excellent for heavy rust. Remove or protect glass. Prime exposed metal promptly. Check codes for environmental compliance. Operator should wear safety gear.
3. Removing flaking paint.	Chemical method	Chemical paint strippers suitable for ferrous metals. Clean cloths.	Protect glass and masonry. Do not flush with water. Have good ventilation and protection for operator.
	Mechanical abrasion	Pneumatic needle gun chisels, sanding disks.	Protect operator; have good ventilation. Well-bonded paint need not be removed if window closes properly.
4. Aligning bent, bowed metal sections	Applied pressure	Wooden frame as a brace for cables and winch mechanism.	Remove glass in affected area. Realignment may take several days.
	*Heat and pressure	Remove to a workshop. Apply heat and pressure to bend back.	Care should be taken that heat does not deform slender sections.

Work Item	Recommended Techniques	Tools, Products and Procedures	Notes
	*(Must be done in a workshop)		
5. Patching depressions	Epoxy and steel filler	Epoxy fillers with high content of steel fibers; plumber's epoxy or autobody patching compound.	Epoxy patches generally are easy to apply, and can be sanded smooth. Patches should be primed.
	Welded patches	Weld in patches using steel rods and oxy-acetylene torch or arc welder.	Prime welded sections after grinding connections smooth.
6. Splicing in new metal sections	*Cut out decayed sections and weld in new or salvaged sections	Torch to cut out bad sections back to 45° joint. Weld in new pieces and grind smooth.	Prime welded sections after grinding connection smooth.
7. Priming metal sections	Brush or spray application	At least one coat of anti-corrosive primer on bare metal. Zinc-rich primers are generally recommended.	Metal should be primed as soon as it is exposed. If cleaned metal will be repaired another day, spot prime to protect exposed metal.
8. Replacing missing screws and bolts	Routine maintenance	Pliers to pull out or shear off rusted heads. Replace screws and bolts with similar ones, readily available.	If new holes have to be tapped into the metal sections, the rusted holes should be cleaned, filled and primed prior to redrilling.
9. Cleaning, lubricating or replacing hinges and other hardware	Routine maintenance, solvent cleaning	Most hinges and closure hardware are bronze. Use solvents (mineral spirits), bronze wool and clean cloths. Spray with non-greasy lubricant containing anti-corrosive agent.	Replacement hinges and fasteners may not match the original exactly. If new holes are necessary, old ones should be filled.
10. Replacing glass and glazing compound	Standard method for application	Pliers and chisels to remove old glass, scrape putty out of glazing rabbet, save all clips and beads for reuse. Use only glazing compound formulated for metal windows.	Heavy gloves and other protective gear needed for the operator. All parts saved should be cleaned prior to reinstallation.
11. Caulking masonry surrounds	Standard method for application	Good quality (10 year or better) elastomeric caulking compound suitable for metal.	The gap between the metal frame and the masonry opening should be caulked; keep weepholes in metal for condensation run-off clear of caulk.
12. Repainting metal windows	Spray or brush	At least 2 coats of paint compatible with the anti-corrosive primer. Paint should lap the glass about 1/8″ to form a seal over the glazing compound.	The final coats of paint and the primer should be from the same manufacturer to ensure compatibility. If spraying is used, the glass and masonry should be protected.

Fig. 7. STEPS FOR CLEANING AND REPAIRING HISTORIC STEEL WINDOWS. Compiled by Sharon C. Park, AIA.

Historic metal windows are generally not energy efficient; this has often led to their wholesale replacement. Metal windows can, however, be made more energy efficient in several ways, varying in complexity and cost. Caulking around the masonry openings and adding weatherstripping, for example, can be do-it-yourself projects and are important first steps in reducing air infiltration around the windows. They usually have a rapid payback period. Other treatments include applying fixed layers of glazing over the historic windows, adding operable storm windows, or installing thermal glass in place of the existing glass. In combination with caulking and weatherstripping, these treatments can produce energy ratings rivaling those achieved by new units.[3]

Weatherstripping

The first step in any weatherization program, caulking, has been discussed above under "Routine Maintenance." The second step is the installation of weatherstripping where the operable portion of the sash, often called the ventilator, and the fixed frame come together to reduce perimeter air infiltration (see fig. 8). Four types of weatherstripping appropriate for metal windows are spring-metal, vinyl strips, compressible foam tapes, and sealant beads. The spring-metal, with an integral friction fit mounting clip, is recommended for steel windows in good condition. The clip eliminates the need for an applied glue; the thinness of the material insures a tight closure. The weatherstripping is clipped to the inside channel of the rolled metal section of the fixed frame. To insure against galvanic corrosion between the weatherstripping (often bronze or brass), and the steel window, the window must be painted prior to the installation of the weatherstripping. This weatherstripping is usually applied to the entire perimeter of the window opening, but in some cases, such as casement windows, it may be best to avoid weatherstripping the hinge side. The natural wedging action of the weatherstripping on the three sides of the window often creates an adequate seal.

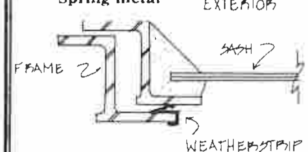
Vinyl weatherstripping can also be applied to metal windows. Folded into a "V" configuration, the material forms a barrier against the wind. Vinyl weatherstripping is usually glued to the frame, although some brands have an adhesive backing. As the vinyl material and the applied glue are relatively thick, this form of weatherstripping may not be appropriate for all situations.

Compressible foam tape weatherstripping is often best for large windows where there is a slight bending or distortion of the sash. In some very tall windows having closure hardware at the sash mid-point, the thin sections weatherstripping can normally fill the space. If the gap exceeds this, the window may need to be realigned to close more tightly. The foam weatherstripping comes either with an adhesive or plain back; the latter variety requires application with glue. Compressible foam requires more frequent replacement than either spring-metal or vinyl weatherstripping.

A fourth type of successful weatherstripping involves the use of a caulking or sealant bead and a polyethylene bond breaker tape. After the window frame has been thoroughly cleaned with solvent, permitted to dry, and primed, a neat bead of low modulus (firm setting) caulk, such as silicone, is applied. A bond breaker tape is then applied to the operable sash covering the metal section where contact will occur. The window is then closed until the sealant has set (2-7 days, depending on temperature and humidity). When the window is opened, the bead will have taken the shape of the air infiltration gap and the bond breaker tape can be removed. This weatherstripping method appears to be successful for all types of metal windows with varying degrees of air infiltration.

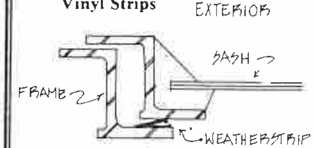
Since the several types of weatherstripping are appropriate for different circumstances, it may be necessary to use more than one type on any given building. Successful weatherstripping depends upon using the thinnest material adequate to fill the space through which air enters. Weatherstripping that is too thick can spring the hinges, thereby resulting in more gaps.

Spring-metal



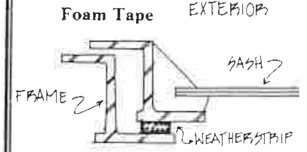
Spring-metal comes in bronze, brass or stainless steel with an integral friction-fit clip. The weatherstripping is applied after the repaired windows are painted to avoid galvanic corrosion. This type of thin weatherstripping is intended for windows in good condition.

Vinyl Strips



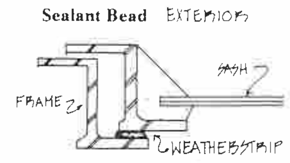
Vinyl strips are scored and fold into a "V" configuration. Applied adhesive is necessary which will increase the thickness of the weatherstripping, making it inappropriate for some situations. The weatherstripping is generally applied to the window after painting.

Foam Tape



Closed cell foam tape comes either with or without an adhesive backing. It is effective for windows with a gap of approximately 1/4" and is easy to install. However, this type of weatherstripping will need frequent replacement on windows in regular use. The metal section should be cleaned of all dirt and grease prior to its application.

Sealant Bead



This very effective type of weatherstripping involves the application of a clean bead of firm setting caulk on the primed frame with a polyetheiene bond breaker tape on the operable sash. The window is then closed until the bead has set and takes the form of the gap. The sash is then opened and the tape is removed leaving the set caulk as the weatherstripping.

Fig. 8 APPROPRIATE TYPES OF WEATHERSTRIPPING FOR METAL WINDOWS. Weatherstripping is an important part of upgrading the thermal efficiency of historic steel windows. The chart above shows the jamb section of the window with the weatherstripping in place. Drawings: Sharon C. Park, AIA.

[3]One measure of energy efficiency is the U-value (the number of BTUs per hour transferred through a square foot of material). The lower the U-value, the better the performance. According to *ASHRAE HANDBOOK-1977 Fundamentals*, the U-value of historic rolled steel sash with single glazing is 1.3. Adding storm windows to the existing units or reglazing with 5/8" insulating glass produces a U-value of .69. These methods of weatherizing historic steel windows compare favorably with rolled steel replacement alternatives: with factory installed 1" insulating glass (.67 U-value); with added thermal-break construction and factory finish coatings (.62 U-value).

The third weatherization treatment is to install an additional layer of glazing to improve the thermal efficiency of the existing window. The decision to pursue this treatment should proceed from careful analysis. Each of the most common techniques for adding a layer of glazing will effect approximately the same energy savings (approximately double the original insulating value of the windows); therefore, cost and aesthetic considerations usually determine the choice of method. Methods of adding a layer of glazing to improve thermal efficiency include adding a new layer of transparent material to the window; adding a separate storm window; and replacing the single layer of glass in the window with thermal glass.

The least expensive of these options is to install a clear material (usually rigid sheets of acrylic or glass) over the original window. The choice between acrylic and glass is generally based on cost, ability of the window to support the material, and long-term maintenance outlook. If the material is placed over the entire window and secured to the frame, the sash will be inoperable. If the continued use of the window is important (for ventilation or for fire exits), separate panels should be affixed to the sash without obstructing operability (see fig. 9). Glass or acrylic panels set in frames can be attached using magnetized gaskets, interlocking material strips, screws or adhesives. Acrylic panels can be screwed directly to the metal windows, but the holes in the acrylic panels should allow for the expansion and contraction of this material. A compressible gasket between the prime sash and the storm panel can be very effective in establishing a thermal cavity between glazing layers. To avoid condensation, 1/8" cuts in a top corner and diagonally opposite bottom corner of the gasket will provide a vapor bleed, through which moisture can evaporate. (Such cuts, however, reduce thermal performance slightly.) If condensation does occur, however, the panels should be easily removable in order to wipe away moisture before it causes corrosion.

The second method of adding a layer of glazing is to have independent storm windows fabricated. (Pivot and austral windows, however, which project on either side of the window frame when open, cannot easily be fitted with storm windows and remain operational.) The storm window should be compatible with the original sash configuration. For example, in paired casement windows, either specially fabricated storm casement windows or sliding units in which the vertical meeting rail of the slider reflects the configuration of the original window should be installed. The decision to place storm windows on the inside or outside of the window depends on whether the historic window opens in or out, and on the visual impact the addition of storm windows will have on the building. Exterior storm windows, however, can serve another purpose besides saving energy: they add a layer of protection against air pollutants and vandals, although they will partially obscure the prime window. For highly ornamental windows this protection can determine the choice of exterior rather then interior storm windows.

The third method of installing an added layer of glazing is to replace the original single glazing with thermal glass. Except in rare instances in which the original glass is of special interest (as with stained or figured glass), the glass can be replaced if the hinges can tolerate the weight of the additional glass. The rolled metal sections for steel windows are generally from 1" - 1 1/2" thick. Sash of this thickness can normally tolerate thermal glass, which ranges from 3/8" - 5/8". (Metal glazing beads, readily available, are used to reinforce the muntins, which hold the glass.) This treatment leaves the window fully operational while preserving the historic appearance. It is, however, the most expensive of the treatments discussed here. (See fig. 6f).

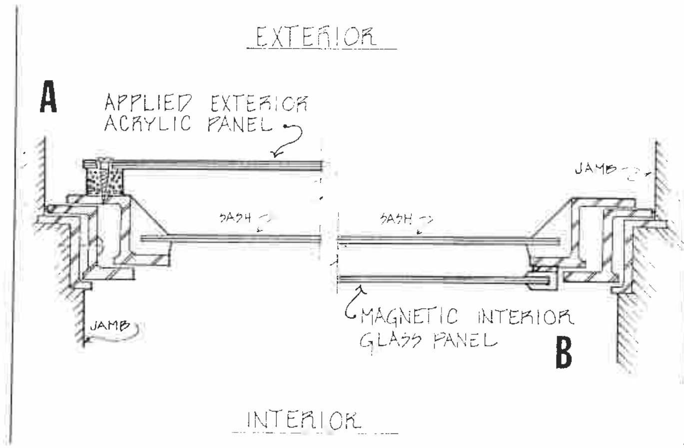


Fig. 9 Two examples of adding a second layer of glazing in order to improve the thermal performance of historic steel windows. Scheme A (showing jamb detail) is of a ¼" acrylic panel with a closed cell foam gasket attached with self-tapping stainless steel screws directly to the exterior of the outwardly opening sash. Scheme B (showing jamb detail) is of a glass panel in a magnetized frame affixed directly to the interior of the historic steel sash. The choice of using glass or acrylic mounted on the inside or outside will depend on the ability of the window to tolerate additional weight, the location and size of the window, the cost, and the long-term maintenance outlook. Drawing: Sharon C. Park, AIA.

WINDOW REPLACEMENT

Repair of historic windows is always preferred within a rehabilitation project. Replacement should be considered only as a last resort. However, when the extent of deterioration or the unavailability of replacement sections renders repair impossible, replacement of the entire window may be justified. In the case of significant windows, replacement in kind is essential in order to maintain the historic character of the building. However, for less significant windows, replacement with compatible new windows may be acceptable. In selecting compatible replacement windows, the material, configuration, color, operability, number and size of panes, profile and proportion of metal sections, and reflective quality of the original glass should be duplicated as closely as possible.

A number of metal window manufacturing companies produce rolled steel windows. While stock modern window designs do not share the multi-pane configuration of reproduce the historic configuration if requested, and the cost is not excessive for large orders (see figs. 10a and 10b). Some manufacturers still carry the standard pre-World War II multi-light windows using the traditional 12" x 18" or 14" x 20" glass sizes in industrial, commercial, security, and residential configurations. In addition, many of the modern steel windows have integral weatherstripping, thermal break construction, durable vinyl coatings, insulating glass, and other desirable features.

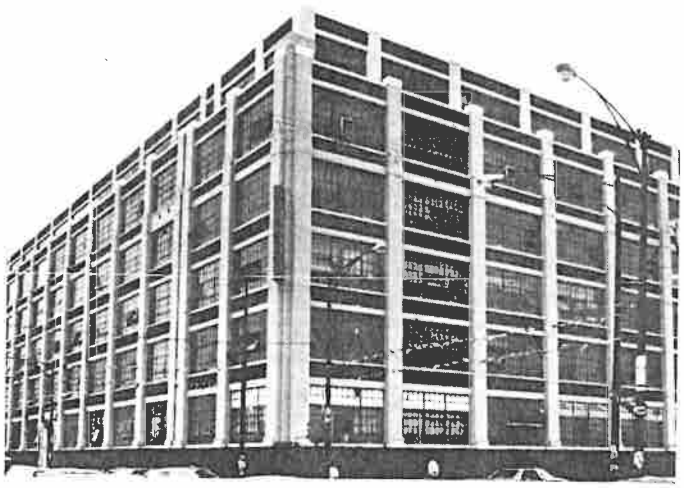


Fig. 10 a. A six-story concrete manufacturing building prior to the replacement of the steel pivot windows. Photo: Charles Parrott.

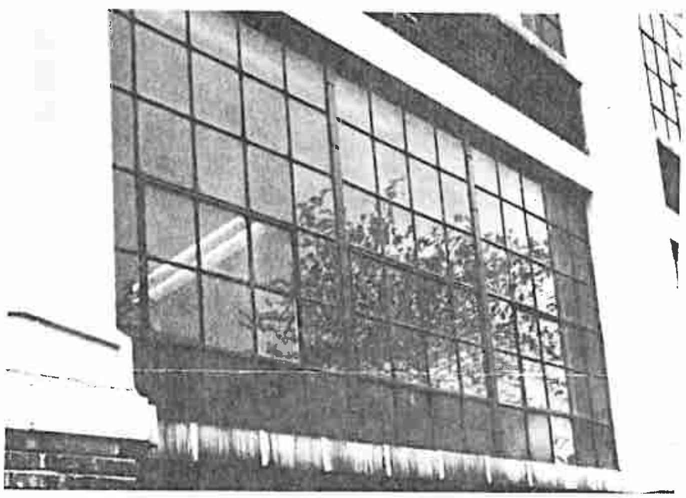


Fig. 10 b. Close-up view of the new replacement steel windows which matched the multi-lighted originals exactly. Photo: Charles Parrott.

Windows manufactured from other materials generally cannot match the thin profiles of the rolled steel sections. Aluminum, for example, is three times weaker than steel and must be extruded into a box-like configuration that does not reflect the thin historic profiles of most steel windows. Wooden and vinyl replacement windows generally are not fabricated in the industrial style, nor can they reproduce the thin profiles of the rolled steel sections, and consequently are generally not acceptable replacements.

For product information on replacement windows, the owner, architect, or contractor should consult manufacturers' catalogues, building trade journals, or the Steel Window Institute, 1230 Keith Building, Cleveland, Ohio 44115.

SUMMARY

The National Park Service recommends the retention of significant historic metal windows whenever possible. Such windows, which can be a character-defining feature of a historic building, are too often replaced with inappropriate units that impair rather than complement the overall historic appearance. The repair and thermal upgrading of historic steel windows is more practicable than most people realize. Repaired and properly maintained metal windows have greatly extended service lives. They can be made energy efficient while maintaining their contribution to the historic character of the building.

BIBLIOGRAPHY

ASHRAE Handbook - 1977 Fundamentals. New York: American Society of Heating, Refrigerating and Airconditioning Engineers, 1978.

Crittal, W. F. *A Metal Window Dictionary.* London:Curwen Press, 1926. Reprinted by B.T. Batsford, Ltd., 1953.

Gayle, Margot; David W. Look, AIA; John G. Waite.*Metals in America's Historic Buildings: Uses and Preservation Treatments.* Technical Preservation Services, U.S. Department of the Interior. Washington,D.C.: U.S.Government Printing Office, 1980.

Gillet, William. "Steel Windows." *Windows and Glass in the Exterior of Buildings.* National Academy of Sciences Publication 478. Washington, D.C.: 1957,75-78.

Sarton, R. H. "Selecting and Specifying an Appropriate Type of Steel Window." *Metalcraft.* Vol 6, No. 1 (January, 1931): 43-48, 64-65.

Sweet's Architectural Catalogue. 13th Edition, New York, Sweets Catalogue Service, Inc., 1918.

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This publication has been prepared pursuant to the Economic Recovery Tax Act of 1981, which directs the Secretary of the Interior to certify rehabilitations of historic buildings that are consistent with their historic character; the guidance provided in this brief will assist property owners in complying with the requirements of this law.

Preservation Briefs: 13 has been developed under the technical editorship of Lee H. Nelson, AIA, Chief, Preservation Assistance Division, National Park Service, U.S. Department of the Interior, Washington, D.C. 20240. Comments on the usefulness of this information are welcomed and can be sent to Mr. Nelson at the above address.

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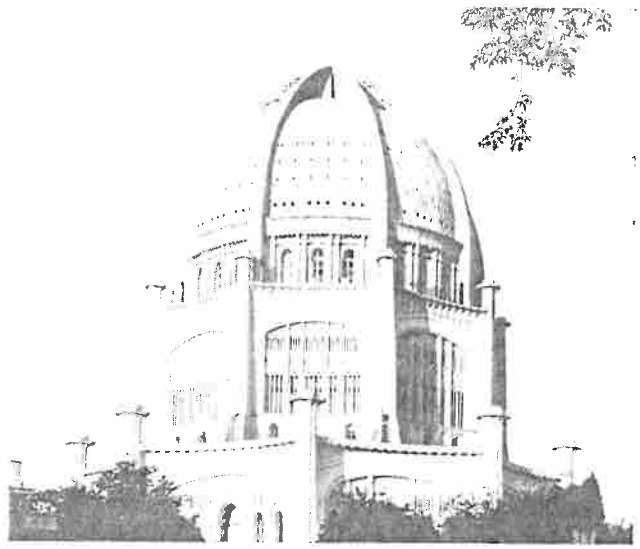

Preservation of Historic Concrete: Problems and General Approaches

William B. Coney, A.I.A.

U.S. Department of the Interior, National Park Service
Rocky Mountain Regional Office, Division of Cultural Resources

> The Secretary of the Interior's "Standards for Rehabilitation" require that deteriorated architectural features shall be repaired rather than replaced. When the severity of deterioration requires removal of historic material, its replacement should match the material being replaced in composition, design, color, texture, and other visual qualities.

"Concrete" is a name applied to any of a number of compositions consisting of sand, gravel, crushed stone, or other coarse material, bound together with various kinds of cementitious materials, such as lime or cements. When water is added, the mix undergoes a chemical reaction and hardens. An extraordinarily versatile building material, concrete is used for the utilitarian, the ornamental, and the monumental. While early proponents of modern concrete considered it to be permanent, it is, like all materials, subject to deterioration. This Brief surveys the principal problems posed by concrete deterioration, their likely causes, and approaches to their remedies. In almost every instance, remedial work should only be undertaken by qualified professionals. Faulty concrete repair can worsen structural problems and lead to further damage or safety hazards. Concrete repairs are not the province of do-it-yourselfers. Consequently, the corrective measures discussed here are included for general information purposes only; they do not provide "how to" advice.

HISTORICAL OVERVIEW

The Romans found that the mixture of lime putty with pozzolana, a fine volcanic ash, would harden under water. The result was possibly the first hydraulic cement. It became a major feature of Roman building practice, and was used in many buildings and engineering projects such as bridges and aqueducts. Concrete technology was kept alive during the Middle Ages in Spain and Africa, with the Spanish introducing a form of concrete to the New World in the first decades of the 16th century. It was used by both the Spanish and English in coastal areas stretching from Florida to South Carolina. Called "tapia," or "tabby," the substance was a creamy white, monolithic masonry material composed of lime, sand, and an aggregate of shells, gravel, or stone mixed with water. This mass of material was placed between wooden forms, tamped, and allowed to dry, the building arising in layers, about one foot at a time.

Despite its early use, concrete was slow in achieving widespread acceptance as a building material in the United States. In 1853, the second edition of Orson S. Fowler's *A Home for All* publicized the advantages of "gravel wall" construction to a wide audience, and poured gravel wall buildings appeared across the United States (see fig. 1). Seguin, Texas, 35 miles east

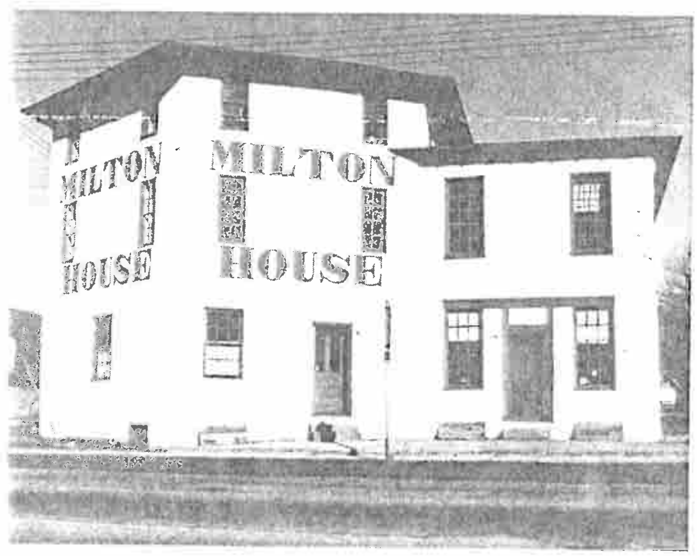

Fig. 1. Milton House, Milton, Wisconsin (1844). An early example of gravel wall construction with 12- to 15-inch thick monolithic concrete walls coated on the exterior with stucco. Photo: William B. Coney.

of San Antonio, came to be called "The Mother of Concrete Cities" for some 90 concrete buildings made from local "lime water" and gravel (see fig. 2). Impressed by the economic advantages of poured gravel wall or "lime-grout" construction, the Quartermaster General's Office of the War Department embarked on a campaign to improve the quality of building for frontier military posts. As a result, lime-grout structures were built at several western posts, such as the buildings that were constructed with 12- or 18-inch-thick walls at Fort Laramie, Wyoming between 1872 and 1885. By the 1880s sufficient experience had been gained with unreinforced concrete to permit construction of much larger buildings. The Ponce de Leon Hotel in St. Augustine, Florida, is a notable example from this period (see fig. 3).

Reinforced concrete in the United States dates from 1860, when S.T. Fowler obtained a patent for a reinforced concrete wall. In the early 1870s William E. Ward built his own house in Port Chester, New York, using concrete reinforced with iron rods for all structural elements. Despite these developments, such construction remained a novelty until after 1880, when innovations introduced by Ernest L. Ransome made reinforced concrete more practicable. The invention of the horizontal rotary kiln allowed production of a cheaper, more uniform and reliable cement, and led to the greatly increased acceptance of concrete after 1900.

During the early 20th century Ransome in Beverly, Massachusetts, Albert Kahn in Detroit, and Richard E. Schmidt in Chicago promoted concrete for utilitarian buildings with their "factory style," featuring an exposed concrete skeleton filled with expanses of glass. Thomas Edison's cast-in-place reinforced concrete homes in Union Township, New Jersey, proclaimed a similarly functional emphasis in residential construction (see fig. 4). From the 1920s onward, concrete began to be used with spectacular design results: in James J. Earley and Louis Bourgeois' exuberant, graceful Baha'i Temple in Wilmette, Illinois (see cover); and in Frank Lloyd Wright's masterpiece "Fallingwater" near Mill Run, Pennsylvania (see fig. 5). Eero Saarinen's soaring Terminal Building at Dulles International Airport outside Washington, D.C., exemplifies the masterful use of concrete achieved in the Modern era.

Fig. 2. Sebastopol House, Seguin, Texas (1856). This Greek Revival dwelling is one of the few remaining poured-in-place concrete structures in this Texas town noted for its construction of over 90 concrete buildings in the mid-nineteenth century. The high parapets surrounding the flat roof were lined and served as a water reservoir to cool the house. Photo: Texas Historical Commission.

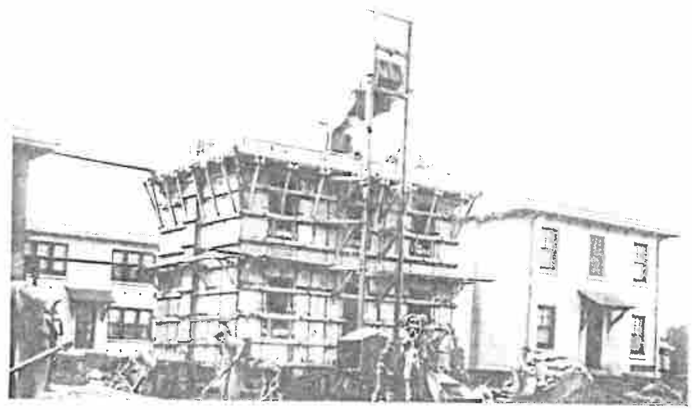

Fig. 4. Thomas A. Edison's Cast-in-Place Houses, Union Township, New Jersey (1909). This construction photo shows the formwork for the cast-in-place reinforced concrete houses built as low-cost housing using a standard 25- by 30-foot module. Photo: Edison National Historical Site.

Fig. 3. Ponce de Leon Hotel, St. Augustine, Florida (1885-87). An example of unreinforced concrete used on a grand scale, this Spanish Colonial Revival hotel was designed by Carrere and Hastings and commissioned by railroad magnate Henry Flagler. The building now serves as the main campus hall for Flagler College. Photo: Flagler College.

Fig. 5. "Fallingwater," near Mill Run, Pennsylvania (1936-37). This dramatic reinforced concrete residence by Frank Lloyd Wright is anchored into bedrock on the hillside and cantilevered over the stream. The great tensile strength of reinforced concrete made this type of construction possible. Photo: Paul Mayen.

Types of Concrete

Unreinforced concrete is a composite material containing aggregates (sand, gravel, crushed shell, or rock) held together by a cement combined with water to form a paste, and gets its name from the fact that it does not have any iron or steel reinforcing bars. It was the earliest form of concrete. The ingredients become a plastic mass that hardens as the concrete hydrates, or "cures." Unreinforced concrete, however, is relatively weak, and since the turn of the century has largely been replaced by reinforced concrete. *Reinforced concrete* is conrete strengthened by the inclusion of metal bars, which increase the tensile strength of concrete. Both unreinforced and reinforced concrete can be either cast in place or precast. *Cast-in-place* concrete is poured on-site into a previously erected formwork that is removed after the concrete has set. *Precast concrete* is molded off-site into building components. More recent developments in concrete technology include *post-tensioned concrete* and *pre-stressed concrete,* which feature greater strength and reduced cracking in reinforced structural elements.

CAUSES OF CONCRETE DETERIORATION

Deterioration in concrete can be caused by environmental factors, inferior materials, poor workmanship, inherent structural design defects, and inadequate maintenance (see figs. 6, 7, and 8).

Environmental factors are a principal source of concrete deterioration. Concrete absorbs moisture readily, and this is particularly troublesome in regions of recurrent freeze-thaw cycles. Freezing water produces expansive pressure in the cement paste or in nondurable aggregates. Carbon dioxide, another atmospheric component, can cause the concrete to deteriorate by reacting with the cement paste at the surface.

Materials and workmanship in the construction of early concrete buildings are potential sources of problems. For example, aggregates used in early concrete, such as cinders from burned coal and certain crushed brick, absorb water and produce a weak and porous concrete. Alkali-aggregate reactions within the concrete can result in cracking and white surface staining. Aggregates were not always properly graded by size to ensure an even distribution of elements from small to large. The use of aggregates with similarly sized particles normally produced a poorly consolidated and therefore weaker concrete.

Fig. 6. Battery Fortifications, Ft. Washington, Maryland (1891-97). This unreinforced concrete fortification exhibits several kinds of deterioration: the diagonal structural crack due to uneven settlement, the long horizontal crack at the cold joint, the spalling of the concrete surface coating, and vegetative growth. Photo: Sharon C. Park, AIA.

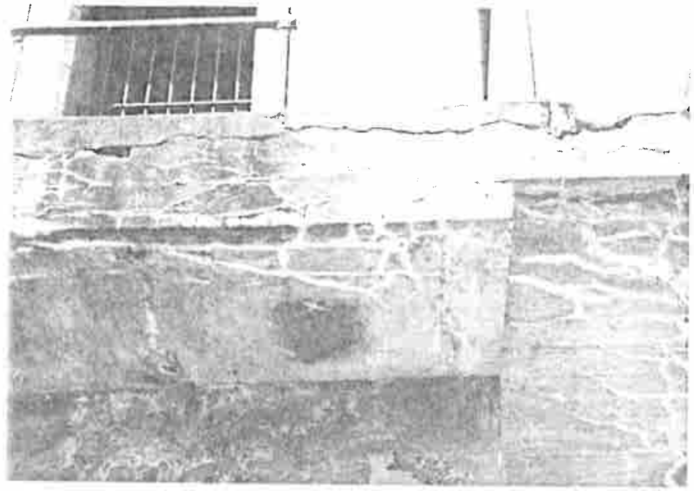

Fig. 7. Battery Commander's Station, Ft. Washington, Maryland (1904). This reinforced concrete tower with a cantilevered balcony is showing serious deterioration. Water has penetrated the slab, causing freeze-thaw spalling around the posts and corrosion of the reinforcing bars. This internal corrosion is causing expansion inside the slab and creating major horizontal cracks in the concrete. Under the balcony can be seen the network of hardened white calcified deposits, which have exuded through cracks in the concrete as a result of alkali-aggregate reaction. Photo: Lee H. Nelson, FAIA.

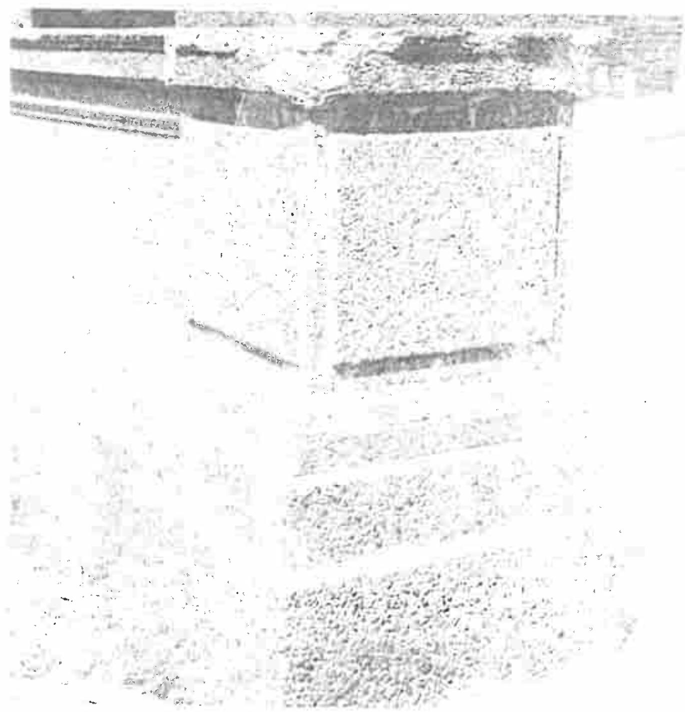

Fig. 8. Meridian Hill, Washington, D.C. (1934). This reinforced concrete pier has lost much of its projecting molding partly from accidental impact and partly from spalling induced by freeze-thaw action. Evidence of moisture leaching out from the interior through cracks is seen as white deposits on the surface of this exposed aggregate concrete. Photo: Lee H. Nelson, FAIA.

inadvertently compromised concrete by using seawater or beach sand in the mix or by using calcium chloride or a similar salt as an additive to make the concrete more "fireproof." A common practice, until recently, was to add salt to strengthen concrete or to lower the freezing point during cold-weather construction. These practices cause problems over the long term.

In addition, early concrete was not vibrated when poured into forms as it is today. More often it was tamped or rodded to consolidate it, and on floor slabs it was often rolled with increasingly heavier rollers filled with water. These practices tended to leave voids (areas of no concrete) at congested areas, such as at reinforcing bars at column heads and other critical structural locations. Areas of connecting voids seen when concrete forms are removed are known as "honeycombs" and can reduce the protective cover over the reinforcing bars.

Other problems caused by poor workmanship are not unknown today. If the first layer of concrete is allowed to harden before the next one is poured next to or on top of it, joints can form at the interface of the layers. In some cases, these "cold joints" visibly detract from the architecture, but are otherwise harmless. In other cases, "cold joints" can permit water to infiltrate, and subsequent free-thaw action can cause the joints to move. Dirt packed in the joints allows weeds to grow, further opening paths for water to enter. Inadequate curing can also lead to problems. If moisture leaves newly poured concrete too rapidly because of low humidity, excessive exposure to sun or wind, or use of too porous a substrate, the concrete will develop shrinkage cracks and will not reach its full potential strength.

Structural Design Defects in historic concrete structures can be an important cause of deterioration. For example, the amount of protective concrete cover around reinforcing bars was often insufficient. Another design problem in early concrete buildings is related to the absence of standards for expansion-contraction joints to prevent stresses caused by thermal movements, which may result in cracking.

Improper Maintenance of historic buildings can cause long-term deterioration of concrete. Water is a principal source of damage to historic concrete (as to almost every other material) and prolonged exposure to it can cause serious problems. Unrepaired roof and plumbing leaks, leaks through exterior cladding, and unchecked absorption of water from damp earth are potential sources of building problems. Deferred repair of cracks allowing water penetration and freeze-thaw attacks can even cause a structure to collapse. In some cases the application of waterproof surface coatings can aggravate moisture-related problems by trapping water vapor within the underlying material.

MAJOR SIGNS OF CONCRETE DETERIORATION

Cracking occurs over time in virtually all concrete. Cracks vary in depth, width, direction, pattern, location, and cause. Cracks can be either active or dormant (inactive). Active cracks widen, deepen, or migrate through the concrete. Dormant cracks remain unchanged. Some dormant cracks, such as those caused by shrinkage during the curing process, pose no danger, but if left unrepaired, they can provide convenient channels for moisture penetration, which normally causes further damage.

Structural cracks can result from temporary or continued overloads, uneven foundation settling, or original design inadequacies. Structural cracks are active if the overload is continued or if settlement is ongoing; they are dormant if the temporary overloads have been removed, or if differential settlement has stabilized. Thermally-induced cracks result from stresses produced by temperature changes. They frequently occur at the ends or corners of older concrete structures built without expansion joints capable of relieving such stresses. Random surface cracks (also called "map" cracks due to their resemblance to the lines on a road map) that deepen over time and exude a white gel that hardens on the surface are caused by an adverse reaction between the alkalis in a cement and some aggregates.

Since superficial repairs that do not eliminate underlying causes will only tend to aggravate problems, professional consultation is recommended in almost every instance where noticable cracking occurs.

Spalling is the loss of surface material in patches of varying size. It occurs when reinforcing bars corrode, thus creating high stresses within the concrete. As a result, chunks of concrete pop off from the surface. Similar damage can occur when water absorbed by porous aggregates freezes. Vapor-proof paints or sealants, which trap moisture beneath the surface of the impermeable barrier, also can cause spalling. Spalling may also result from the improper consolidation of concrete during construction. In this case, water-rich cement paste rises to the surface (a condition known as laitance). The surface weakness encourages scaling, which is spalling in thin layers.

Deflection is the bending or sagging of concrete beams, columns, joists, or slabs, and can seriously affect both the strength and structural soundness of concrete. It can be produced by overloading, by corrosion, by inadequate construction techniques (use of low-strength concrete or undersized reinforcing bars, for example), or by concrete creep (long-term shrinkage). Corrosion may cause deflection by weakening and ultimately destroying the bond between the rebar and the concrete, and finally by destroying the reinforcing bars themselves. Deflection of this type is preceded by significant cracking at the bottom of the beams or at column supports. Deflection in a structure without widespread cracking, spalling, or corrosion is frequently due to concrete creep.

Stains can be produced by alkali-aggregate reaction, which forms a white gel exuding through cracks and hardening as a white stain on the surface. Efflorescence is a white, powdery stain produced by the leaching of lime from Portland cement, or by the pre-World War II practice of adding lime to whiten the concrete. Discoloration can also result from metals inserted into the concrete, or from corrosion products dripping onto the surface.

Erosion is the weathering of the concrete surface by wind, rain, snow, and salt air or spray. Erosion can also be caused by the mechanical action of water channeled over concrete, by the lack of drip grooves in beltcourses and sills, and by inadequate drainage.

Corrosion, the rusting of reinforcing bars in concrete, can be a most serious problem. Normally, embedded reinforcing bars are protected against corrosion by being buried within the mass of the concrete and by the high alkalinity of the concrete itself. This protection, however, can be destroyed in two ways. First, by carbonation, which occurs when carbon dioxide in the air reacts chemically with cement paste at the surface and reduces the alkalinity of the concrete. Second, chloride ions from salts combine with moisture to produce an electrolyte that effectively corrodes the reinforcing bars. Chlorides may come from seawater additives in the original mix, or from prolonged contact with salt spray or de-icing salts. Regardless of the cause, corrosion of reinforcing bars produces rust, which occupies significantly more space than the original metal, and causes expansive forces within the concrete. Cracking and spalling are frequent results. In addition, the load-carrying capacity of the structure can be diminished by the loss of concrete, by the loss of bond between reinforcing bars and concrete, and by the decrease in thickness of the reinforcing bars themselves. Rust stains on the surface of the concrete are an indication that internal corrosion is taking place.

PLANNING FOR CONCRETE PRESERVATION

Whatever the causes of deterioration, careful analysis, supplemented by testing, is vital to the success of any historic concrete repair project. Undertaken by experienced engineers or architects, the basic steps in a program of testing and analysis are document review, field survey, testing, and analysis.

Document Review. While plans and specifications for older concrete buildings are rarely extant, they can be an invaluable aid, and every attempt should be made to find them. They may provide information on the intended composition of the concrete mix, or on the type and location of reinforcing bars. Old photographs, records of previous repairs, documents for buildings of the same basic construction or age, and news reports may also document original construction or changes over time.

Field Survey. A thorough visual examination can assist in locating and recording the type, extent, and severity of stress, deterioration, and damage.

Testing. Two types of testing, on-site and laboratory, can supplement the field condition survey as necessary. On-site, nondestructive testing may include use of a calibrated metal detector or sonic tests to locate the position, depth, and direction of reinforcing bars (see fig. 9). Voids can frequently be detected by "sounding" with a metal hammer. Chains about 30 inches long attached to a 2-foot-long crossbar, dragged over the slabs while listening for hollow reverberations, can locate areas of slabs that have delaminated. In order to find areas of walls that allow moisture to penetrate to the building interior, areas may be tested from the outside by spraying water at the walls and then inspecting the interior for water. If leaks are not readily apparent, sophisticated equipment is available to measure the water permeability of concrete walls.

If more detailed examinations are required, nondestructive instruments are available that can assist in determining the presence of voids or internal cracks, the location and size of rebars, and the strength of the concrete. Laboratory testing can be invaluable in determining the composition and characteristics of historic concrete and in formulating a compatible design mix

Fig. 9. Nondestructive sonic tests are one way of determining the location and soundness of internal reinforcing bars and the hardness of the concrete. There are a variety of other nondestructive tests provided by professional consultants that will help in the evaluation of the structural integrity of concrete prior to major repair work. Photo: Feld, Kaminetzky and Cohen and American Concrete Institute.

for repair materials (see fig. 10). These tests, however, are expensive. A well-equipped concrete laboratory can analyze concrete samples for strength, alkalinity, carbonation, porosity, alkali-aggregate reaction, presence of chlorides, and past compostion.

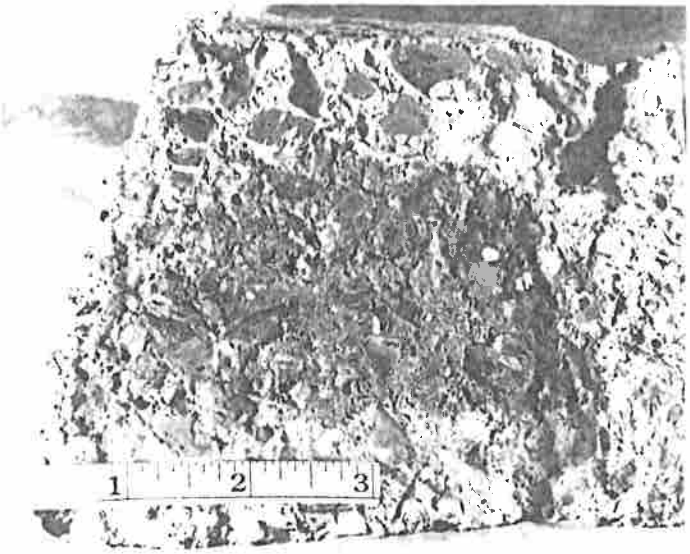

Fig. 10. Testing of actual samples of concrete in the lab may be necessary to determine the strength and condition of the concrete. In this sample, the surface, which is lighter than the sound concrete core, shows that carbonation has taken place. Carbonation reduces the alkalinity in concrete and may hasten corrosion of reinforcing bars close to the surface. Photo: Stella L. Marusin.

Analysis. Analysis is probably the most important step in the process of evaluation. As survey and test results are revised in conjunction with available documentation, the analysis should focus on determining the nature and causes of the concrete problems, on assessing both the short-term and long-term effects of the deterioration, and on formulating proper remedial measures.

CONCRETE REPAIR

Repairs should be undertaken only after the planning measures outlined above have been followed. Repair of historic concrete may consist of either patching the historic material or filling in with new material worked to match the historic material. If replacement is necessary, duplication of historic materials and detailing should be as exact as possible to assure a repair that is functionally and aesthetically acceptable (see fig. 11). The correction and elimination of concrete problems can be difficult, time-consuming, and costly. Yet the temptation to resort to temporary solutions should be avoided, since their failure can expose a building to further and more serious deterioration, and in some cases can mask underlying structural problems that could lead to serious safety hazards (see fig. 12).

Principal concrete repair treatments are discussed below. While they are presented separately here, in practice, preservation projects typically incorporate multiple treatments (see figs. 13a-i).

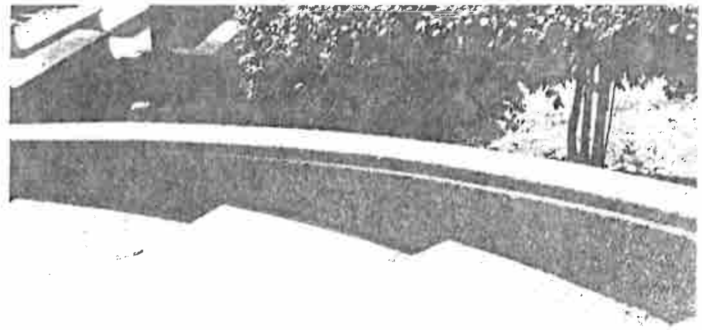

Fig. 11. Meridian Hill, Washington, D.C. (1934). It is important to match the visual qualities, such as color and texture, when repairs or replacement sections are undertaken. In this case, the new replacement step, located second from the left, matches the original pebble-finish surface of the adjacent historic steps. Photo: Sharon C. Park, AIA.

Fig. 12. Without proper preparation and correction of a pre-existing problem, repairs will fail. Insufficient concrete at the surface caused this patch around a reinforcing bar to fail within a year. In this case, a structural engineer should have assessed the need for this rod so close to the surface. Redundant rods are often cut out prior to patching. Photo: Alonzo White.

Fig. 13a. Buckling concrete under a painted surface indicates underlying deterioration. It is often difficult to assess the amount of deterioration until the area has been cleaned and examined closely.

Fig. 13c. Narrow cracks often need to be widened to receive concrete patches. Here a pneumatic chisel is being used.

Fig. 13e. A spalled area of concrete has been cleaned back to a sound surface, and is being coated with a bonding agent to increase adherence of the new concrete patch.

Fig. 13g. A soft brush is used to smooth the patch and to blend it with the adjacent historic concrete.

Fig. 13a-i. Virginia Heating Plant, Arlington, Virginia (1941). This reinforced concrete building exhibits several serious problems, including cracking, spalling, and corrosion of reinforcing bars. As a result of careful planning and close supervision, successful repairs have been carried out. Photos: Alonzo White and Sharon C. Park, AIA.

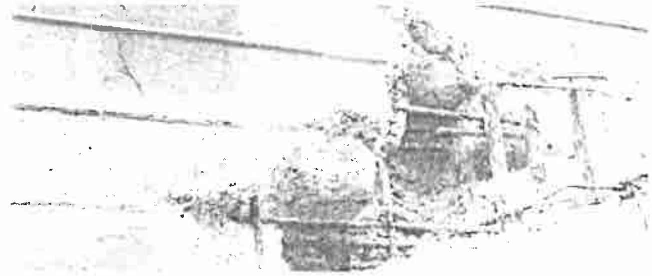

Fig. 13b. Upon removal of the deteriorated surface, a pocket of poorly mixed concrete (mostly sand and gravel) was easily chiseled out. The reinforcing rods were in good condition.

Fig. 13d. Deteriorated or redundant reinforcing bars are removed after evaluation by a structural engineer. An acetylene torch is being used to cut out the bars.

Fig. 13f. Workmen are applying patching concrete and using a trowel to form ridges to match the appearance of the historic concrete ridges that were originally created by the form boards.

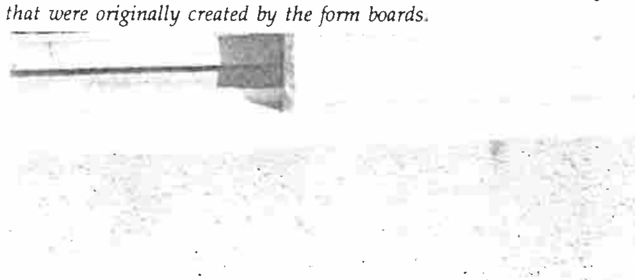

Fig. 13h. This active crack at a window sill and in the foundation wall has been filled with a flexible sealant. This area was subsequently painted with a masonry paint compatible with the sealant.

Fig. 13i. Upon completion of all repairs, the building was painted. The finished repair of the deterioration seen in 13a and b is shown in this photograph. The patch matches the texture and detailing of the historic concrete.

Repair of Cracking. Hairline, nonstructural cracks that show no sign of worsening normally need not be repaired. Cracks larger than hairline cracks, but less than approximately one-sixteenth of an inch, can be repaired with a mix of cement and water. If the crack is wider than one-sixteenth of an inch, fine sand should be added to the mix to allow for greater compactibility, and to reduce shrinkage during drying. Field trials will determine whether the crack should be routed (widened and deepened) minimally before patching to allow sufficient penetration of the patching material. To ensure a long-term repair, the patching materials should be carefully selected to be compatible with the existing concrete as well as with subsequent surface treatments such as paint or stucco.

When it is desirable to reestablish the structural integrity of a concrete structure involving dormant cracks, epoxy injection repair should be considered. An epoxy injection repair is made by sealing the crack on both sides of a wall or a structural member with an epoxy mortar, leaving small holes, or "ports" to receive the epoxy resin. After the surface mortar has hardened, epoxy is pumped into the ports. Once the epoxy in the crack has hardened, the surface mortar can be ground off, but the repair may be visually noticeable. (It is possible to inject epoxy without leaving noticeable patches, but the procedure is much more complex.)

Other cracks are active, changing their width and length. Active structural cracks will move as loads are added or removed. Thermal cracks will move as temperatures fluctuate. Thus, expansion-contraction joints may have to be introduced before repair is undertaken. Active cracks should be filled with sealants that will adhere to the sides of the cracks and will compress or expand during crack movement. The design, detailing, and execution of sealant-filled cracks require considerable attention, or else they will detract from the appearance of the historic building.

Random (map) cracks throughout a structure are difficult to correct, and may be unrepairable. Repair, if undertaken, requires removing the cracked concrete. A compatible concrete patch to replace the removed concrete is then installed. For some buildings without significant historic finishes, an effective and economical repair material is probably a sprayed concrete coating, troweled or brushed smooth. Because the original concrete will ultimately contaminate new concrete, buildings with map cracks will present continuing maintenance problems.

Repair of Spalling. Repair of spalling entails removing the loose, deteriorated concrete and installing a compatible patch that dovetails into the existing sound concrete. In order to prevent future crack development after the spall has been patched and to ensure that the patch matches the historic concrete, great attention must be paid to the treatment of rebars, the preparation of the existing concrete substrate, the selection of compatible patch material, the development of good contact between patch and substrate, and the curing of the patch.

Once the deteriorated concrete in a spalled area has been removed, rust on the exposed rebars must be removed by wire brush or sandblasting. An epoxy coating applied immediately over the cleaned rebars will diminish the possiblity of further corrosion. As a general rule, if the rebars are so corroded that a structural engineer determines they should be replaced, new supplemental reinforcing bars will normally be required, assuming that the rebar is important to the strength of the concrete. If not, it is possible to cut away the rebar.

Proper preparation of the substrate will ensure a good bond between the patch and the existing concrete. If a large, clean break or other smooth surface is to be patched, the contact area should be roughened with a hammer and chisel. In all cases, the substrate should be kept moist with wet rags, sponges, or running water for at least an hour before placement of the patch. Bonding between the patch and substrate can be encouraged by scrubbing the substrate with cement paste, or by applying a liquid bonding agent to the surface of the substrate. Admixtures such as epoxy resins, latexes, and acrylics in the patch may also be used to increase bonding, but this may cause problems with color matching if the surfaces are to be left unpainted.

Compatible matching of patch material to the existing concrete is critical for both appearance and durability. In general, repair material should match the composition of the original material (as revealed by laboratory analysis) as closely as possible so that the properties of the two materials, such as coefficient of thermal expansion and strength, are compatible. Matching the color and texture of the existing concrete requires special care. Several test batches of patching material should be mixed by adding carefully selected mineral pigments that vary slightly in color. After the samples have cured, they can be compared to the historic concrete and the closest match selected.

Contact between the patch and the existing concrete can be enhanced through the use of anchors, preferably stainless-steel hooked pins, placed in holes drilled into the structure and secured in place with epoxy. Good compaction of the patch material will encourage the contact. Compaction is difficult when the patch is "laid-up" with a trowel without the use of forms; however, by building up thin layers of concrete, each layer can be worked with a trowel to achieve compaction. Board forms will be necessary for large patches. In cases where the existing concrete has a significant finish, care must be taken to pin the form to the existing concrete without marring the surface. The patch in the form can be consolidated by rodding or vibration.

surfaces normally develop a sheen that does not match the surface texture of most historic concrete, the forms must be removed before the patch has fully set. The surface of the patch must then be finished to match the historic concrete. A brush or wet sponge is particularly useful in achieving matching textures. It may be difficult to match historic concrete surfaces that were textured, as a result of exposed aggregate for example, but it is important that these visual qualities be matched. Once the forms are removed, holes from the bolts must also be patched and finished to match adjacent surfaces.

Regardless of size, a patch containing cement binder (especially Portland cement) will tend to shrink during drying. Adequate curing of the patch may be achieved by keeping it wet for several days with damp burlap bags. It should be noted that although greater amounts of sand will reduce overall shrinkage, patches with a high sand content normally will not bond well to the substrate.

Repair of Deflection. Deflection can indicate significant structural problems and often requires the strengthening or replacement of structural members. Because deflection can lead to structural failure and serious safety hazards, its repair should be left to engineering professionals.

Repair of Erosion. Repair of eroded concrete will normally require replacing lost surface material with a compatible patching material (as outlined above) and then applying an appropriate finish to match the historic appearance. The elimination of water coursing over concrete surfaces should be accomplished to prevent further erosion. If necessary, drip grooves at the underside of overhanging edges of sills, beltcourses, cornices, and projecting slabs should be installed.

SUMMARY

Many early concrete buildings in the United States are threatened by deterioration. Effective protection and maintenance are the keys to the durability of concrete. Even when historic concrete structures are deteriorated, however, many can be saved through preservation projects involving sensitive repair (see figs. 14a-c), or replacement of deteriorated concrete with carefully selected matching material (see figs. 15a-c). Successful restoration of many historic concrete structures in America demonstrates that techniques and materials now available can extend the life of such structures for an indefinite period, thus preserving significant cultural resources.

Fig. 14a. Spalled concrete was most noticeable at locations of concentrated rebars. Deteriorated concrete, the 1960s stucco finish, and corrosion were removed by grit-blasting. Photo: Robert Bell.

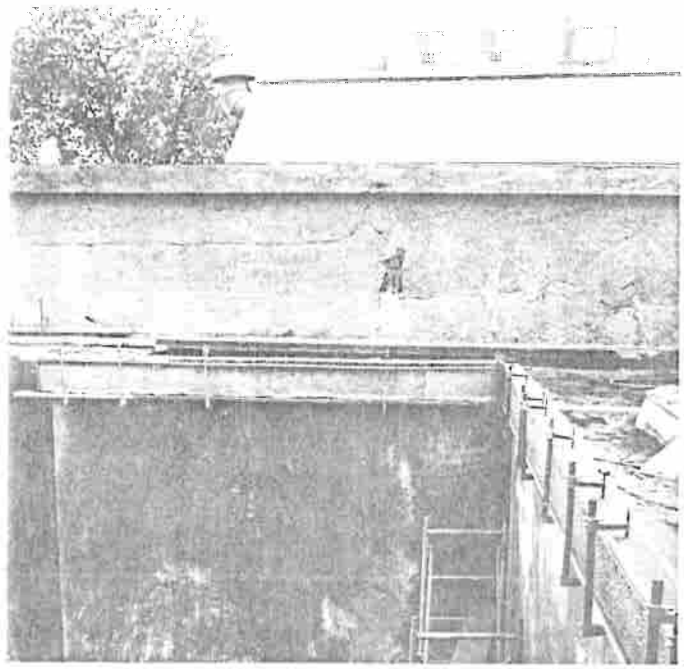

Fig. 14b. Board screeds were attached to the building to recreate the sharp edges of the original detail. Photo: Robert Bell.

Fig. 14c. Once the repair work was complete, the entire building was sprayed with a concrete mixture consisting of pea-gravel, cement, and sand, which was then hand-troweled. Finally, the building was lightly grit-blasted to remove the cement paste and reproduce the exposed agregate finish. Photo: Harry J. Hunderman.

Fig. 14a-c. Unity Temple, Oak Park, Illinois (1906). Architect Frank Lloyd Wright used cast-in-place concrete with an exposed aggregate finish. However, reinforcing bars placed too close to the surface resulted in corrosion, cracking, and spalling. A superficial repair in the 1960s coated the surface with a concrete mix and Portland cement paint which produced a stucco-like finish and accelerated deterioration. Repair work was undertaken in 1971.

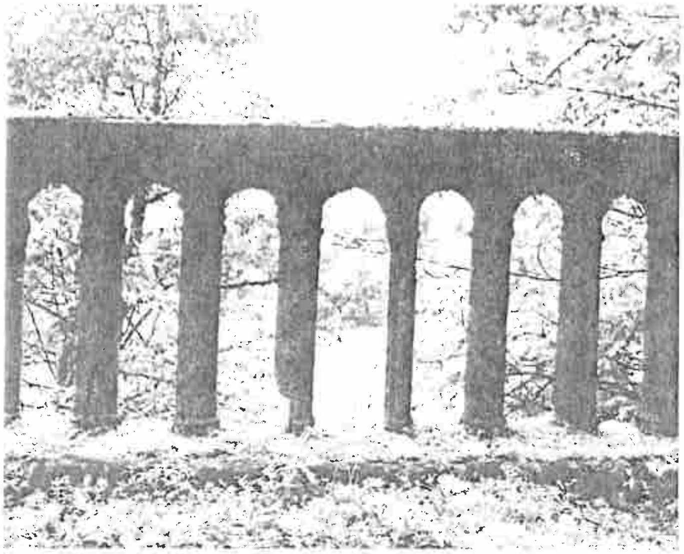

Fig. 15a. The spindle-type railings were deteriorated beyond repair. The concrete was cracked or broken and the center reinforcing rods were exposed and badly rusted.

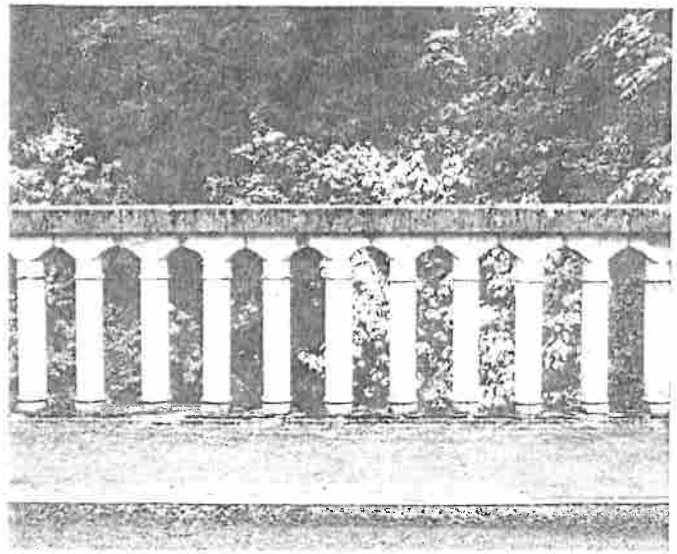

Fig. 15b. Deteriorated spindles were removed. The original 1914 molds were still available and used in casting new concrete spindles, but had they not been available, new molds could have been made to match the originals.

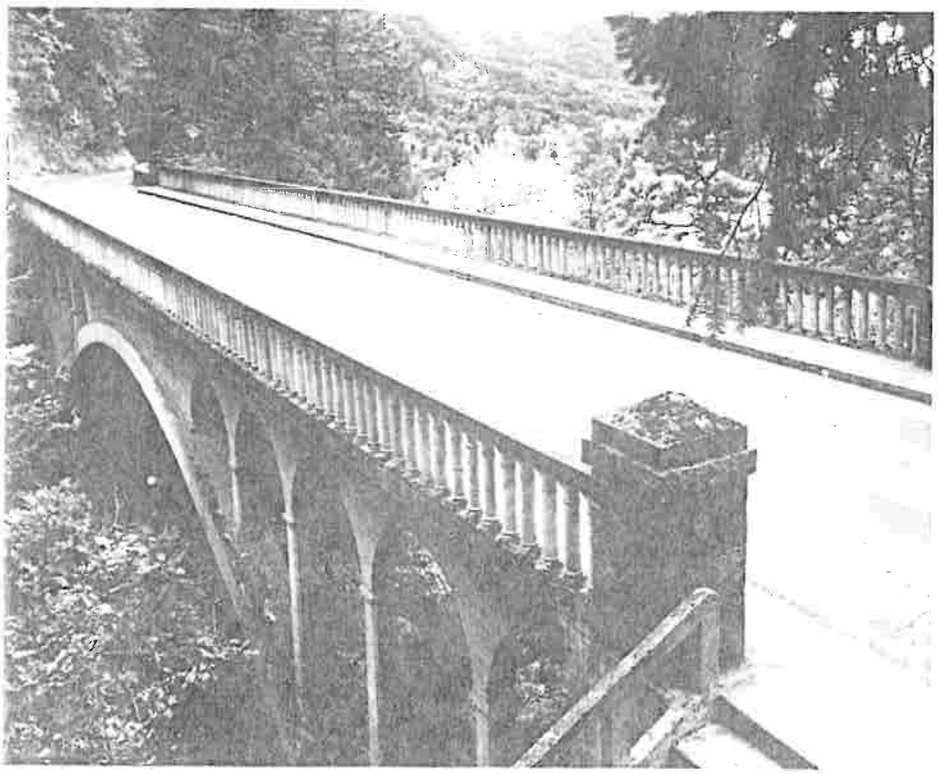

Fig.15c. The new concrete spindles have been installed. This sensitive renovation reused the historic concrete cap railing and stone piers, as they were still in sound condition.

Fig. 15a-c. Columbia River Highway, Oregon. This historic highway overlooking the Columbia River Gorge was constructed from 1913 to 1922 and contains a number of significant concrete bridges. These photos illustrate the sensitive replacement of the concrete spindle-type balusters on the Young Creek (Shepperd's Dell) Bridge of 1914. Photos: James Norman, Oregon Department of Transportation.

Concrete Repair and Restoration. ACI Compilation No. 5. Detroit: American Concrete Institute, 1980. Reprint of *Concrete International: Design & Construction.* Vol. 2, No. 9 (September 1980).

Condit, Carl W. *American Building: Materials and Techniques from the First Colonial Settlements to the Present.* Chicago: University of Chicago Press, 1968.

Hime, W.G. "Multitechnique Approach Solves Construction Materials Failure Problems." *American Chemical Society.* Vol. 46, No. 14 (1974).

Huxtable, Ada Louise. "Concrete Technology in U.S.A." *Progressive Architecture.* (October 1960).

Onderdonk, Francis S. *The Ferro-Concrete Style.* New York: Architectural Book Publishing Company, Inc., 1928.

Perenchio, W.F., and Marusin, S.L. "Short-Term Chloride Penetration into Relatively Impermeable Concretes." *Concrete International.* Vol. 5, No. 4 (April 1983), pp. 34-41.

Pfiefer, D.W., Perenchio, W.F., and Marusin, S.L. "Research on Sealers, Coatings and Specialty Concretes for Barrier Films and Layers on Concrete Structures." *Proceedings of the RILEM Seminar on the Durability of Concrete Structures Under Normal Outdoor Exposure,* Hanover, Federal Republic of Germany, March 26-29, 1984.

Pfiefer, D.W. "Steel Corrosion Damage on Vertical Concrete, Parts I & II." *Concrete Construction.* (February 1981).

Prudon, Theodore. "Confronting Concrete Realities." *Progressive Architecture.* (November 1981), pp. 131-137.

Ropke, John C. *Concrete Problems, Causes & Cures.* New York: McGraw-Hill, 1982.

Sabnis, Gajanan, ed. *Rehabilitation, Renovation and Preservation of Concrete and Masonry Structures.* ACI-SP-85. Detroit: American Concrete Institute, 1985.

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Cover: Baha'i Temple, Wilmette, Illinois (1933). Photo: William B. Coney.

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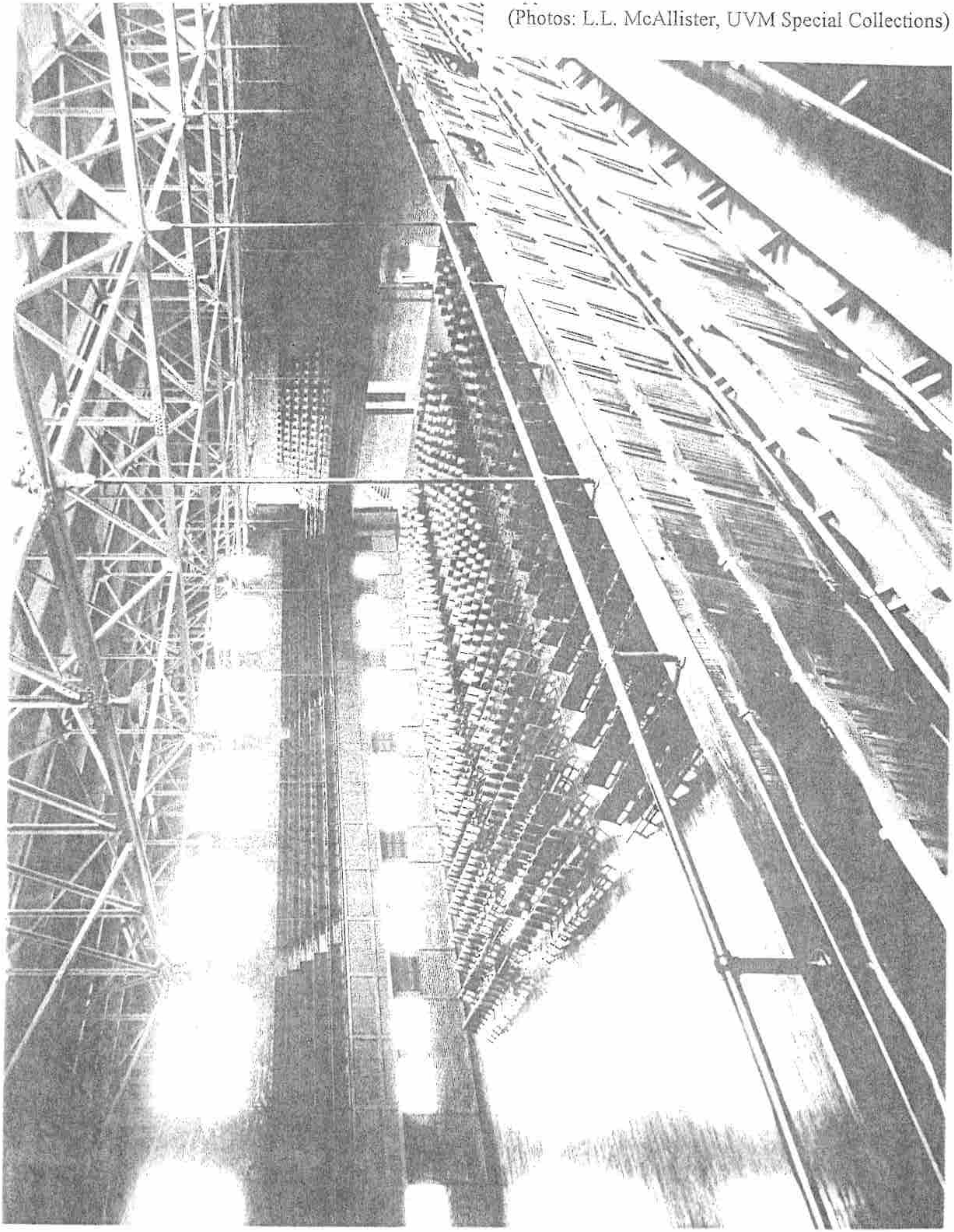
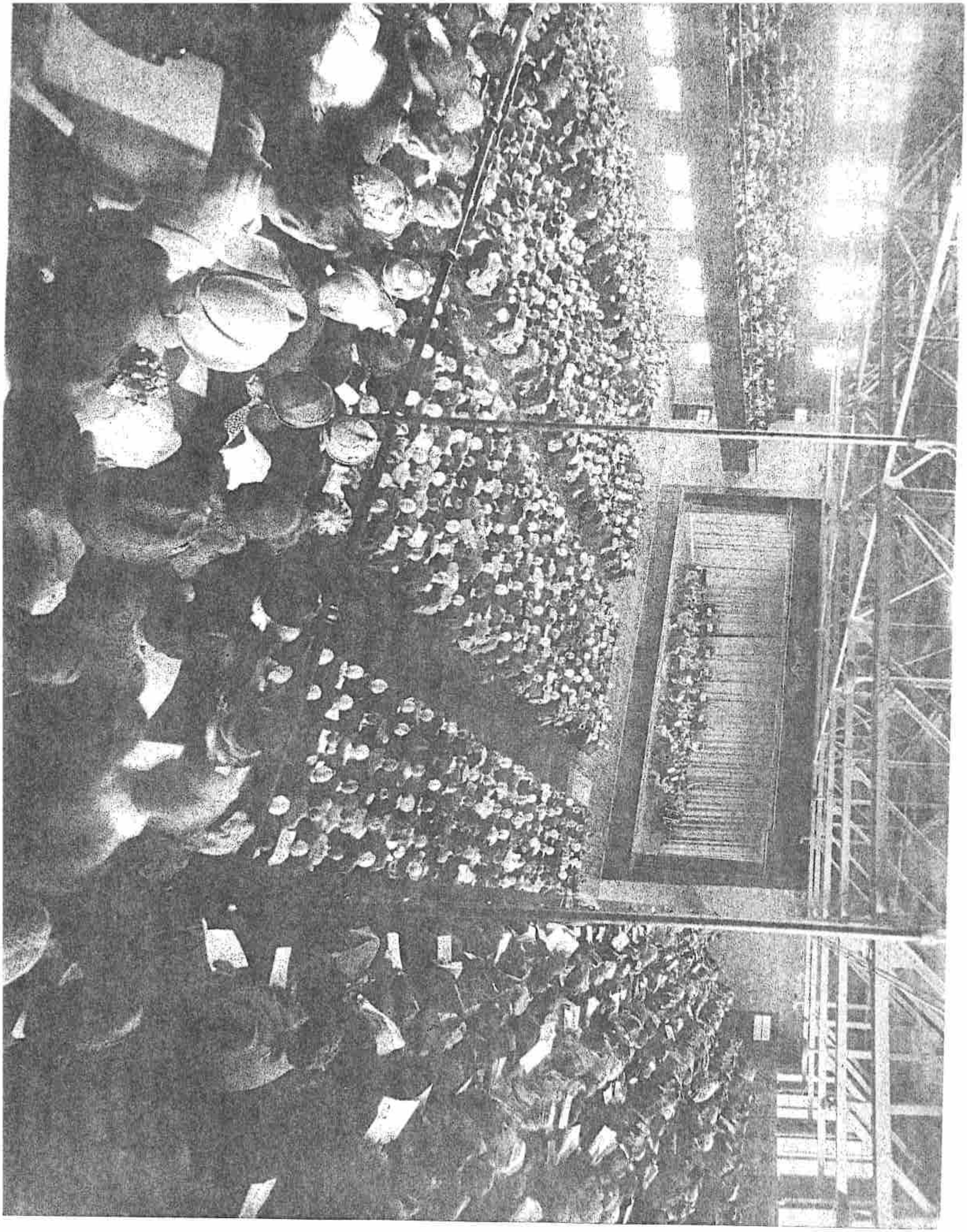
(Photos: L.L. McAllister, UVM Special Collections)





Appendix 6

Burlington Free Press
March 30, 1928

NEW AUDITORIUM DATES BACK TO 1925

High Points In Construction of Fine Building That Was Dedicated Wednesday Evening Are Presented In Chronological Order

March 30 1928

Many interesting events have happened in the course of the more than two years since the proposition to build a new City Hall and Auditorium in Burlington was taken up officially. The events leading up to the construction of public buildings almost always form an interesting chapter in the history of any city. It is the purpose here to chronicle briefly the high points of the chapter which deals with the building of the Memorial Auditorium, dedicated Wednesday evening.

1925

October 14—Citizens of Burlington voted to bond for $750,000 to build new City Hall and Auditorium, under one roof.

1926

January 15—Advisory Board discussed plans submitted by McKim, Mead & White for City Hall with auditorium seating 1,000 people, to occupy north end of building. Suggestion made for a separate auditorium.

January 22—Advisory Board recommended by vote of 7 to 3 to build an auditorium separate from the City Hall. It was thought that the separate auditorium could be built for the $175,000 available from original bond issue.

January 29—Board of Aldermen held public hearing on proposed building program at which Former Mayor James E. Burke raised only opposition and was answered by Mayor C. H. Beecher.

February 8—Petition circulated to ask Mayor Beecher to submit to voters the question of building separate auditorium, transferring $150,000 of City Hall bonds for that purpose.

February 22—Plans prepared by Frank L. Austin for a separate auditorium placed on exhibition at various places in city.

February 26—Mayor Beecher called special meeting for March 9 to allow voters to decide upon question of building separate auditorium in memory of citizens of Burlington who were in the military or naval service.

March 9—Citizens voted by majority of 1401 in most largely attended meeting in history of city to erect Memorial Auditorium costing $150,000 and seating 3,000 people.

March 11—Aldermen voted to cancel $150,000 worth of City Hall bonds and re-issue $150,000 worth of bonds for Memorial Auditorium and to employ Frank L. Austin as architect for the proposed building.

March 24—Aldermen voted to buy Dr. G. M. Sabin's property at cost of $14,000 as part of site for auditorium.

November 18—Aldermen voted to call for bids on several different plans submitted for auditorium.

December 6—Bids received by Aldermen on auditorium. Discovered that a transfer of funds probably would be necessary to carry out the project.

December 8—Discovered that an error in figuring makes difference of $25,875 in lowest bid for auditorium, so that Alexander Terrien's bid was that much more than first stated. After discussion, it was voted that Architect Frank L. Austin furnish the Aldermen with revised plans, eliminating the exhibition hall.

December 13—Revised plans presented to Aldermen reducing auditorium to one-story structure and James E. Cashman presented revised bids based on the new plans. Other bids rejected.

December 14—Mayor Beecher called special city meeting to vote on question of transferring $30,000 from the unexpended balance of the City Hall funds to the Memorial Auditorium account.

December 22—Voters authorized $30,000 transfer referred to above, the voice of Former Mayor James E. Burke being practically the only one raised in opposition.

1927

January 7—Aldermen voted to award contract for Memorial Auditorium to James E. Cashman, with a number of specified deductions from the original plans, the contract price to be $171,426. However, the situation was left that deductions made in order to get the cost of the building within the funds available could be replaced in the contract when, and if, more funds were secured later.

January 10—Architect F. L. Austin estimated total cost of auditorium, if built according to plans, to be $233,185. Contract signed with James E. Cashman, with deductions from plans, bringing cost down to $171,426. But statement was made that anticipated additional tax revenue of $75,000 could be used to supplement the above sum, so as to carry out the complete plans.

March 31—With all estimates in, Aldermen decided that $80,000 to $100,000 would be needed to build the auditorium, with exhibition hall included, public opinion having developed along that line. Architect Austin's revised figure for building, to include exhibition hall, was announced as $250,988. Aldermen recalled and rescinded award of contract to J. E. Cashman.

April 5—Mayor Beecher called special city meeting to vote on question of bonding for an additional $100,000 for construction of the auditorium.

April 15—Voters authorized further bond issue of $100,000 for auditorium.

April 18—J. E. Cashman again awarded contract for memorial auditorium for general contract price of $204,629. Aldermen also accepted bid of Burlington Light and Power Company for lighting and fixtures, to cost for heating and plumbing, to cost $11,630; and the bid of H. C. Wheelock $16,816. It was estimated that the cost for architect's fees and hardware would bring the total up to just about $250,000.

April 21—Ground was broken for the construction of the Memorial Auditorium.

1928

March 28—Memorial Auditorium dedicated.

Appendix 7

The Secretary of the Interior's Standards for Rehabilitation

REHABILITATION is defined as the act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values.

The Standards for Rehabilitation pertain to historic buildings of all materials, construction types, sizes and occupancy and encompass the exterior and the interior of historic buildings. The Standards also encompass related landscape features and the building's site and environment as well as attached, adjacent or related new construction.

The Standards are to be applied to specific rehabilitation projects in a reasonable manner, taking into consideration economic and technical feasibility.

STANDARDS FOR REHABILITATION

1. A property shall be used as it was historically or be given a new use that requires minimal change to its distinctive materials, features, spaces, and spatial relationships.

2. The historic character of a property shall be retained and preserved. The removal of distinctive materials or alteration of features, spaces, and spatial relationships that characterize a property shall be avoided.

3. Each property shall be recognized as a physical record of its time, place, and use. Changes that create a false sense of historical development, such as adding conjectural features or elements from other historical properties, shall not be undertaken.

4. Changes to a property that have acquired historic significance in their own right shall be retained and preserved.

5. Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize a property shall be preserved.

6. Deteriorated historic features shall be repaired than replaced. Where the severity of deterioration requires replacement of distinctive feature, the new feature shall match the old in design, color, texture, and, where possible, materials. Replacement of missing features shall be substantiated by documentary and physical evidence.

7. Chemical or physical treatments, if appropriate, shall be undertaken using the gentlest means possible. Treatments that cause damage to historic materials shall not be used.

8. Archeological resources shall be protected and preserved in place. If such resources must be disturbed, mitigation measures shall be undertaken.

9. New additions, exterior alternations, or related new construction shall not destroy historic materials, features, and spatial relationships that characterize the property. The new work shall be differentiated from the old and shall be compatible with the historic materials, features, size, scale and proportion, and massing to protect the integrity of the property and its environment.

10. New additions and adjacent or related new construction shall be undertaken in such a manner that, if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.