Hoffmann Architects

Journal of architectural technology published by Hoffmann Architects, specialists in exterior rehabilitation

JOURNAL

First Issue 1992 Volume 10 Number 1

Repair and Maintenance of Historic Limestone and Marble Structures

Theodore F. Babbitt, AIA

Since antiquity, marble and limestone have been valued building materials, chosen for their inherent strength and durability. Yet, for all their aura of permanence, limestone and marble structures can — and do — succumb to the ravages of time and wear.

Detail of marble column showing deterioration of the capital. Note severe cracking in the volute.

With increasing urbanization and pollution, stone deterioration is occurring more rapidly than in the past. Dirt accumulation, cracked masonry, spalling, and loss of structural integrity are among the problems affecting these stone structures. Although some deterioration through natural causes is inevitable, there ***are*** ways to slow the process and head off serious damage.

The key? A thorough, ongoing maintenance and repair program that corrects minor problems before they become critical. Even surface damage, such as spalling and minor cracking, can signify underlying problems that demand immediate attention.

Start With a Thorough Exam

An in-depth survey of a building's existing condition is the first step in a successful rehabilitation and preventive maintenance program. This survey should include the following:

1. Classification of existing stone and structural conditions
2. Determination of causes and sources of surface deterioration through chemical and other testing methods
3. Determination of causes of stone displacement and joint failures
4. Evaluation of severity of conditions and potential safety issues
5. Plan of attack for repair, restoration, and prevention of further decay
6. Program for regular, preventive maintenance after restoration

Do It Right the First Time

"Do it right the first time" should be the guiding principle of any stone repair venture. Because most repair and preservation work requires highly skilled hand labor and extensive setup time, it is best to do all repair work at the same time. This approach prevents damage to newly repaired sections during subsequent construction and avoids additional setup costs. For example, a partial repointing job is not cost-effective if the remaining pointing has to be redone within a few years. It is usually safe to assume that, if one 3-foot area needs repointing, the adjacent mortar is probably on its last legs as well.

As Director of Architectural Services, Mr. Babbitt oversees stone, curtain wall, and roof rehabilitation services for Hoffmann Architects.

Pediment detail shows effects of stone displacement.

Typical Causes of Deterioration

There are two primary sources of stone deterioration: organic and mechanical. Organic damage occurs through natural aging and weathering, and the invasive action of plant growth, pollution, and dirt accumulation. Mechanical or physical deterioration can occur through over-stressed stone or stone movement due to water intrusion, faulty or broken anchors, or human error in design, engineering, and construction.

Because of their physical composition — carbonates formed from marine life skeletal remains, marble and limestone present several key maintenance and preservation problems:

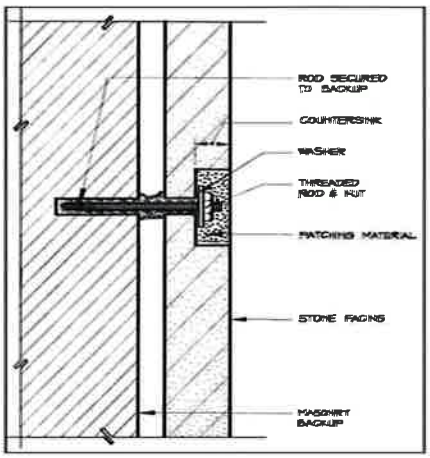
- Like all stone, marble is porous, although slightly less than limestone. In fact, water is the major cause of nearly all stone deterioration. Protecting the facade from water intrusion while still allowing evaporation of trapped moisture is vital.
- Unlike granite, marble's* carbonate base makes it highly sensitive to and soluble in acid. Even the natural acidity of rainfall, without the added effects of acid rain, automobile exhaust, and other airborne pollutants, causes marble to dissolve over time.
- Marble is a soft stone which can be easily scratched and marred. This "softness" means that chemical cleaners, sandblasting, and wind-driven grit all take their toll.

The chart on page 5 shows some common indicators and possible causes of damage. The underlying causes, as

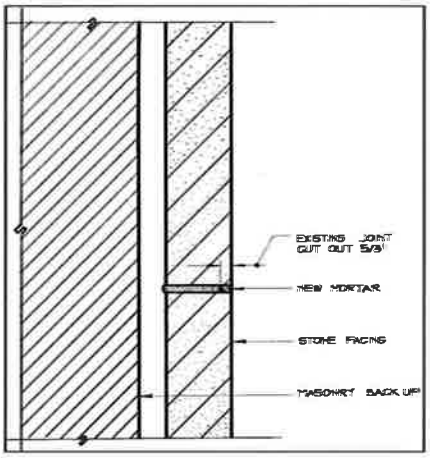
* *"Marble" is used for both marble and limestone throughout this article.*

Photo / Tom Zetterstrom

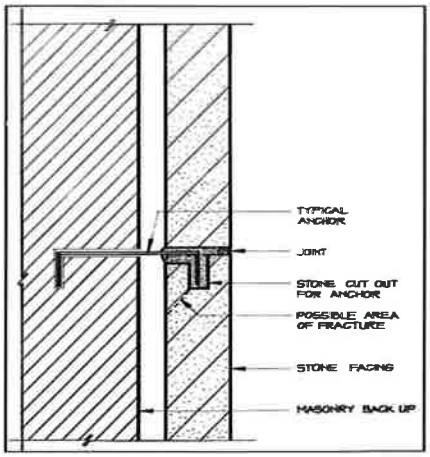
Restoration of limestone facade at Art Deco-style headquarters building.



Stone Pinning



Repointing



Typical Anchorage

well as the symptoms, should be thoroughly investigated before any work is performed. There is no point, for example, in patching cracked wall panels if the cause lies ***behind*** the stone and its anchoring system.

Common Repair Techniques

Typical repair methods include the following:

Patching is used to repair small areas of damaged stone with a matching cementitious material that is applied and built up in layers until it matches the original profile. For larger patches, anchor supports may be needed to secure the new material.

Sculpting, used most often to repair ornamentation, is the process of recarving badly eroded stone or re-accentuating indistinct detailing.

Resetting returns displaced stone to its original position.

Re-anchoring is usually required when the movement of the stone from its original position has broken existing anchors or fractured the back of the stone.

Repointing requires cutting out failed joint mortar and applying new mortar which is finished to replicate the original mortar style. Two caveats to observe when repointing:

- The new mortar should be of a weaker compressive strength than the surrounding masonry to avoid spalls at the joints.
- Joint sealant is ***not*** recommended, as it will prevent the migration of damaging moisture from within the wall system.

Stone replacement can be the most viable approach for restoring large areas of damage. A new anchoring system may be required.

Crack repair can be accomplished by injecting an adhesive material into the fissure to provide water impermeability and prevent further cracking. Minor cracks can often be successfully repaired by sawcutting the crack and filling with patching material.

New anchors for stonework are created by securing noncorrosive rods through the stone into the masonry backing. The ends of the rods are countersunk and the stone further secured with bolts.

Consolidation is a relatively new technique that chemically binds a new material (usually barium hydroxide) with the stone to strengthen it and arrest deterioration. Consolidation is recommended only as a last resort because of the difficulty in achieving full integration of new and old materials and in matching original appearances.

Water infiltration has caused stone section to shift from original position.

Ongoing Maintenance

Ongoing maintenance is essential to preserve the restored facade and prevent future deterioration. A good maintenance program includes routine inspections to catch early signs of stone damage and joint failure.

Severe cracking at base of marble column.

Heavy spalling and exfoliation on column shaft.

Spalling at joint between limestone panels.

Another preventive care technique is regular washing of the facade to remove accumulated dirt and pollutants. If done improperly, however, washing can exacerbate or precipitate stone deterioration. For that reason, the recommended approach is to use the mildest cleansing method available that will get the job done. Water washing is usually the best choice.

A purification system may be necessary to avoid the corrosive action of metallic impurities, particularly iron, in the water. The building facade should be watertight to avoid causing damage during washing. One rule of thumb: repair first, wash second.

Waterproof coatings should never be used on stone. Although these coatings prevent water infiltration, they also trap moisture within the stone and structural system. Even water repellent coatings will prevent the natural migration of water from the stone and should be used with caution, if at all. Their short lifespan (2 to 3 years) also makes water repellent coatings an expensive maintenance method.

Conclusion

A successful marble repair and preservation program includes:

- **Identification of the causes and long-term impact of existing deterioration problems.** All signs of damage should be thoroughly investigated — even a small crack can signal the start of a more serious problem. But not all damage requires repair, and the value of aesthetic repairs should be weighed against costs and overall building appearance.
- **Execution of all required repair work at the same time.** This will avoid additional setup costs later on and the risk of damage to newly repaired areas.
- **Initiation of a regular maintenance program.** This program should include cleaning, inspecting for and repairing minor damage, preservation of newly restored areas, and prevention of further deterioration.

Following these steps will help protect and preserve marble structures from decay and destruction by time, water, pollution, and other forces. ■

Stone has been removed to examine metal anchor, which has corroded and broken.

Common Marble/Limestone Problems

Symptom	Indicators	Probable Causes
Open Joints	Loose, broken mortar.	Result of poor mortar bond, building movement, aging, and water intrusion.
Crumbling or Sanding	Brittle or broken stone	Typically caused by deterioration of the binder material or weakening of the stone through the intrusion of water or salts.
Efflorescence	Hazy white blotching on stone surface.	Caused by salt intrusion into the stone from lime mortar and other building materials or surface deposits from water- and airborne pollutants.
Erosion	Worn edges or surfaces.	Natural wearing away of the stone through weathering.
Cracking	Narrow fissures in stone surface.	Causes include building settling, stone movement from other causes, and improper mortar joints. Longer or wider cracks are evidence of serious structural flaws.
Spalling	Uneven peeling or chipping of stone layers.	Caused by trapped moisture or crystallized salts, freeze-thaw cycles, or joint mortars which do not compensate for natural expansion and contraction. May also indicate problems in the anchoring system.
Grime and Organic Growth	Dark patches, stains, discoloration.	Result of water- and airborne dirt and pollutants or lichen and algae. Some lichen excrete organic acids which eat away at the stone.
Structural System Flaws	Surface evidence of these "hidden", serious problems includes displaced stone, spalling, crumbling, and cracking.	Causes include improper installation, inappropriate mortars, and insufficient or incorrect anchoring systems.

Repointing Procedures

Most stone rehabilitation work involves repointing — removing deteriorated mortar and replacing it with new repointing mortar. While the task sounds simple, repointing requires expertise and skill and should be performed only by qualified masonry journeymen. Some technical guidelines are listed below:

Joint Preparation

- Joints should be cut out to a depth of at least 5/8" or deeper as required to remove all loose and unsound mortar or old sealant.
- Joints must be thoroughly cleaned with a brush to remove any remaining loose mortar and blown clean with air pressure to remove dust.
- Caution should be used when cutting out old mortar to avoid damaging stone edges.

Materials Selection

- A typical ratio for new mortar is 1 part portland cement, 1 part hydrated lime, and 6 parts sand. Under certain conditions, a higher lime content may be used to ensure flexibility of the mortar.
- The same brand and color of cement should be used consistently throughout the project.
- Non-staining cement, used with light colored stone, should contain no more than .06% water soluble alkali.
- Water for mixing mortar must be potable, clean, and free of deleterious amounts of acids, alkalis, and organic compounds.

Execution

- All areas prepared for repointing should be protected from the elements when not being worked on.
- No repointing should be done in temperatures below 40° Fahrenheit.
- Prior to beginning repointing, the work area should be thoroughly wetted with a sprayer pressurized with a hand pump to remove any remaining particles and to moisten the stone sufficiently to prevent hydration of the new mortar. Any standing water in the joints should be blown out with air pressure.
- Joints should be repointed to their full depth, using a jointing tool or tuckpointing trowel. The mortar must be evenly applied and forced into the joints with the jointing tool.
- Newly filled joints should then be dressed to a cove finish that is flush with the adjacent stone.
- Excess mortar, smears, and droppings must be removed before the mortar sets. Vigorous scrubbing action with burlap is recommended for the best results. ■

The Facility Manager's Bookshelf: Repairing Marble and Limestone

A. Indiana Limestone Institute
Stone City Bank Building, Suite 400
Bedford, IN 47421
(812) 275-4426

1. ***Indiana Limestone Handbook - 18th edition*** $ 15.00
2. ***Indiana Limestone Design and Procedure Aids*** $ 4.00
3. ***Repairing Damage to Indiana Limestone: A Basic Guide*** $ 3.00
4. ***The Patton Glossary of Building Stone and Masonry Terms*** $ 3.00

(Other publications also available.)

B. Marble Institute of America
33505 State Street
Farmington, MI 48024
(313) 476-5558

1. ***Dimensional Stone - Vol. 4 (4th edition)***, $89.00 plus shipping
2. ***Color Plates of Marbles of the World***, $195.00 plus shipping

(Other publications also available.)

C. Construction Specifications Institute
Specifier Reprints
601 Madison Street
Alexandria, VA 22314-1791
(703) 684-0300

1. Caroe, Martin. "Conserving Wells Cathedral's West Front." ***Construction Specifier***, July 1987, p. 52.
2. Doe, Bruce R. and Susan I. Sherwood. "Acid Rain and Dimension Stone: A Dangerous Combination?" ***Construction Specifier***, February 1985, p. 46.
3. Weiss, Norman R. "Restoring Architectural Stone." ***Construction Specifier***, July 1987, p. 60.

Cost: $4.00 each, $10.00 minimum. VA residents add 4.5% tax.

D. Superintendent of Documents
Government Printing Office
(202) 783-3238
(Credit card orders accepted)

1. Grimmer, Anne E. ***Keeping It Clean: Removing Dirt, Paint, Stains, and Graffiti from Exterior Masonry***. 45 pages. 35 illustrations. Bibliography. GPO Stock Number: 024-005-01035-1. $2.50 per copy.
2. Smith, Baird M. ***Moisture Problems in Historic Masonry Walls: Diagnosis and Treatment***. 48 pages. 32 illustrations. 1984. GPO Stock Number: 024-005-00872-1. $2.25 per copy.

E. Miscellaneous Articles

1. Anger, Natalie. "Debate on Buildings: To Scrub or Not." ***New York Times***, 14 January 1992, p. C1.
2. "Preservation Resource: The National Park Service Offers Advice in Restoring Historic Structures." (Includes bibliography). ***Architecture***, November 1991, pp. 125 - 128 (Vol. 80 No. 11).

F. The Aberdeen Group
1-800-323-3550, Ext. 6
(Credit card orders accepted)

Ashurst, John and Nicola Ashurst. ***Practical Building Conservation, Volume 1; Stone Masonry***. 100 pages, hard cover. Item Number: 573. $36.95.

Compiled by Alan Eddy, Technical Librarian ■

REPRESENTATIVE PROJECTS

Limestone and Marble Rehabilitation

As stone rehabilitation specialists, Hoffmann Architects' primary objective is to diagnose and treat the underlying causes as well as the symptoms of deterioration.

The firm's architects and engineers begin with an exhaustive analysis of factors contributing to stone damage, e.g., water intrusion, weathering, pollution, and failure of the stone and its anchoring system. A comprehensive repair program is then formulated, costs and benefits analyzed, and a preventive maintenance plan developed.

Repair solutions range from simple cleaning, repointing, and minor repairs to replacement of stone sections and anchoring systems.

The firm's services include survey and analysis of existing conditions, preparation of construction documents, and contract administration.

Hoffmann Architects has provided marble and limestone rehabilitation services for numerous corporate and institutional facilities including:

Radio City Music Hall
New York, New York
(Rockefeller Center Management Corporation)

Hartford Insurance Headquarters
Hartford, Connecticut
(Hartford Fire Insurance Company)

Clio Hall
Princeton, New Jersey
(Princeton University)

International Building
New York, New York
(Rockefeller Center Management Corporation)

23 Wall Street Complex
New York, New York
(Morgan Guaranty Trust Company)

Executive Building
Washington, District of Columbia
(Prudential Insurance Company of America)

SNET Headquarters Building
New Haven, Connecticut
(Southern New England Telephone)

1270 Avenue of the Americas
New York, New York
(Rockefeller Center Management Corporation)

New Rochelle Towers
New Rochelle, New York
(Chase Manhattan Bank, N.A.)

310 Orange Street
New Haven, Connecticut
(Southern New England Telephone)

Exxon Building
New York, New York
(Rockefeller Center Management Corporation)

Laboratory of Epidemiology and Public Health
New Haven, Connecticut
(Yale University) ■

Carved stone panels at entrance to GE Building (RCA Building), Rockefeller Center, New York City.

North facade of Whig Hall, Princeton University, New Jersey.

American Institute of Architects Honors Firm's Founder

John J. Hoffmann, FAIA, founder and principal of Hoffmann Architects, has been elected to the College of Fellows of the American Institute of Architects. Elevation to Fellowship recognizes an architect's achievements as an individual and as a contributor to the profession of architecture and to society.

Mr. Hoffmann was selected for this prestigious award by a jury of professional peers for outstanding achievements in promoting "the aesthetic, scientific, and practical efficiency of the profession." In nominating Mr. Hoffmann, J.P. Chadwick Floyd, FAIA of Centerbrook Architects cited his "innovative use of design technology in the preservation and protection of our national landmarks."

"In a series of extraordinary historic preservation projects, John Hoffmann has developed ways to reverse the effects of time with sensitivity and grace," Mr. Floyd said. "His continuing research into construction technology and refusal to accept conventional wisdom at face value give him a fresh outlook toward design and make him a leader in the profession."

The American Institute of Architects will honor Mr. Hoffmann this June at the AIA National Convention in Boston. ■

John J. Hoffmann, FAIA

JOURNAL is a publication of Hoffmann Architects, specialists in investigative and rehabilitative architecture/engineering, including the analysis and solution of problems within roofs, exterior walls, glazing and structural systems of existing buildings, plazas and parking garages.

Please send news, technical information, address changes, or requests for free subscriptions to Ann Prokop, Editor, Hoffmann Architects/*JOURNAL* at 432 Washington Avenue, North Haven, Connecticut 06473.

For answers to specific questions or for information on the services we offer, please call Brian Schafer at (203) 239-6660.

Hoffmann Architects
432 Washington Avenue
North Haven, Connecticut 06473
(203) 239-6660

Editor: Ann M. Prokop *Editorial Services:* Jonelle Lawhorn Hobbs Communications