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## **Historic Structure Assessment for Building 839, Carlisle Barracks**

Carlisle, Pennsylvania

Tom Vitanza, Mark Slater, and Caitlin Clinton-Selin

October 2017



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*Cover image of Building 839 at Carlisle Barracks was created by Dr. Andrew Hamblin, operating the Leica P40 ScanStation 3D laser scanner.*



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Carlisle, Pennsylvania

Tom Vitanza, Mark Slater, and Caitlin Clinton-Selin

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Final report

Approved for public release; distribution is unlimited.

Prepared for Directorate of Public Works  
U.S. Army Garrison Carlisle Barracks  
330 Engineer Avenue  
Carlisle Barracks, PA 17013

Under Project 461561, "Carlisle Barracks Farmhouse Analysis"

Monitored by Construction Engineering Research Laboratory  
U.S. Army Engineer Research and Development Center  
2902 Newmark Drive  
Champaign, IL 61822

## Abstract

Building 839 at Carlisle Barracks is a farmhouse that was likely constructed in the middle 1850s. It was utilized as a farmhouse by individual owners until the Carlisle Indian Industrial School acquired the farm in 1887. The school utilized the house as living quarters for its farmer and as classroom space for the farm unit of the school until 1918. After the War Department reacquired Carlisle Barracks in 1918, the farmhouse was used for officer housing. It was determined in a 2013 analysis and report to Carlisle Barracks that Building 839 should be included within the existing Carlisle Indian Industrial School National Historic Landmark District.

Architectural historians at the U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratory (ERDC-CERL), who conducted the previous analysis of Building 839, requested assistance from the Historic Preservation Training Center (HPTC) of the National Park Service to prepare an abbreviated Historic Structure Assessment Report (HSAR). Besides the HSAR reported herein, the work also includes government Class C cost estimates for five potential treatments for Building 839: restoration, rehabilitation, stabilization and mothballing, relocation, and demolition.

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## Foreword

After researchers at ERDC-CERL conducted a prior historic context, integrity analysis, and evaluation of Building 839 at Carlisle Barracks, Pennsylvania,\* follow-on assistance was requested by U.S. Army Garrison (USAG) Carlisle Barracks. ERDC-CERL researchers sought technical assistance on behalf of USAG Carlisle Barracks from the Historic Preservation Training Center (HPTC) of the National Park Service.

The HPTC provided a Historic Structure Assessment Report for Building 839, and that report is reproduced in its entirety as part of this ERDC-CERL Contract Report.

*Adam Smith, MArch*  
*Project Manager*

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\* Adam D. Smith, Susan I. Enscoe, and Megan W. Tooker, *Analysis of Building 839: Carlisle Barracks, Pennsylvania, ERDC/CERL SR-13-19*. (Champaign, IL: Engineer Research and Development Center-Construction Engineering Research Laboratory, 2013).

## Preface

This work was conducted by the Historic Preservation Training Center (HPTC) of the National Park Service under an Interagency Agreement #W81EWF70651256 with U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) for Project No. 461561, “Carlisle Barracks Farmhouse Analysis.” Funding for project monitoring was provided by Military Interdepartmental Purchase Request (MIPR) No. 10978224 from Carlisle Barracks to ERDC-CERL. Mr. Paul Herzer of Carlisle Barracks helped to provide technical monitoring.

The overall project was managed and monitored by the Land and Heritage Conservation Branch (CNC) of the Installations Division (CN) at ERDC-CERL (CEERD). At the time of publication, Dr. Michael Hargrave was Chief, CEERD-CNC; and Ms. Michelle J. Hanson was Chief, CEERD-CN. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti, and the Director was Dr. Ilker Adiguzel.

Assistance was provided to HPTC by two ERDC-CERL architects, Mr. Adam D. Smith, who was also Program Manager, and Ms. Megan W. Tooker.

The Commander of ERDC was COL Bryan S. Green, and the Director was Dr. David W. Pittman.

# Historic Structure Assessment Report



## **Building 839** **Carlisle Barracks** Carlisle, Pennsylvania

September 2017



National Park Service  
U.S. Department of the Interior

# Historic Structure Assessment Report

## **Building 839 Carlisle Barracks Carlisle, Pennsylvania**

September 2017

Prepared for:

US Army Corps of Engineers,  
Engineer Research and Development Center (ERDC),  
Construction Engineering Research Center (CERL)

Prepared by:



Historic Preservation Training Center  
4801A Urbana Pike  
Frederick, Maryland 21704



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## CHAPTER 1

### Overview

The National Park Service (NPS) Historic Preservation Training Center (HPTC) was engaged by the U.S. Army Corps of Engineers Construction Engineering Research Laboratory (CERL) to prepare an abbreviated Historic Structure Assessment Report (HSAR) for Building 839 at the Carlisle Barracks in Carlisle, Pennsylvania. Accompanying the abbreviated HSAR are government Class C cost estimates for five potential treatments for Building 839: restoration, rehabilitation, stabilization and mothballing, relocation, and demolition.

### Resource Information

<i>Structure Name</i>	<b>Building 839</b>
<i>Other Name(s)</i>	Farmhouse
<i>Location</i>	Patton Road Carlisle Barracks Cumberland County, Pennsylvania
<i>Date of Construction</i>	ca. 1859, with later alterations
<i>Total Gross Square Feet</i>	6850 SF
<i>National Register Status</i>	Not Listed – Deemed eligible as a contributing structure (Carlisle Indian Industrial School NHL District)
<i>National Register Date</i>	N/A
<i>National Historic Landmark?</i>	No.
<i>National Historic Landmark Date</i>	N/A
<i>Significance Level</i>	National
<i>NR Period of Significance</i>	1887-1918
<i>NR Criteria</i>	A: Association with the Carlisle Indian Industrial School, central to the agricultural vocational training of Native American students.
<i>Current Use</i>	Vacant
<i>Intended Use</i>	TBD
<i>Intended Treatment</i>	TBD (stabilization, restoration, rehabilitation, relocation, demolition)

## Scope and Objectives

This project consists of the preparation of an abbreviated Historic Structure Assessment Report (HSAR) as defined by the project agreement. The abbreviated HSAR includes the following chapters:

1. *Project Overview*: project purpose and administrative information;
2. *Resource Information*: building information and summary of findings;
3. *Standards and Definitions*: references for agency policies that guide the project;
4. *Condition Assessment Survey*: architectural fabric survey and assessment, summary of condition ratings, and maintenance deficiencies.

HPTC staff conducted an inspection and assessment during a series of field visits to the building. The historic structure assessment process includes establishing a Building Feature Master List. This list is derived from *Uniformat II*<sup>1</sup> as developed and widely adopted by the federal government for use in the asset management process. The list is modified specifically for Building 839 and is used as the guideline for the inspection and condition assessment, and for preparing recommended treatments.

Once identified, the building features are assigned a Qualitative Condition Rating of *Good, Fair, or Poor* and a Maintenance Deficiency Rating of *Critical, Serious, or Minor* which allow for development of immediate, short- and long-term treatment strategies. An approximate time period is selected in which the life-cycle assessment (service life) is assessed and on which the treatment recommendations are prioritized for planning purposes. In this project a three (3) to five (5) year time period was selected for long-term treatment cycle and a one (1) to three (3) year time period represents the short-term lifecycle assessment and treatment period. Those features with an immediate need should be addressed within one (1) year; this includes features requiring alterations for immediate mothballing/stabilization treatment.

Definitions of the previously listed terminology are derived from the NPS asset management process and adopted for use for this project. Definitions are provided in Chapter 2 and detailed more thoroughly in Appendix A.

Development of recommended treatments is based on the maintenance deficiencies and condition ratings of the features and their significance as character-defining features. All recommended treatments meet *The Secretary of the Interior's Standards for the Treatment of Historic Properties* and NPS-28 as it pertains to historic buildings. All treatments are intended for general execution by trained historic preservation professionals.

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<sup>1</sup> *Uniformat II Work Breakdown Structure (WBS) (Rev 02.13.08).*

## Methodology

HPTC conducted a feature inventory and condition assessment for Building 839 which included the following project tasks:

- Development of a Building Feature Master List adapted for the building;
- Field research of historical building records and architectural documentation;
- Documentation of existing conditions of the structure through field measurements, sketches, existing drawings, and photographs;
- Non-destructive, observation-based architectural fabric inspection and condition assessment;
- Development of an abbreviated HSAR which includes an illustrated narrative that depicts building conditions;
- Development of Class C cost estimates for five building treatment alternatives.

The following is a detailed description of the methodology involved in the development of the abbreviated HSAR.

### Field Research

HPTC worked collaboratively with Carlisle Barracks and the U.S. Army Corps of Engineers (CERL) to research, gather, and review existing available background documents, drawings, and photographs. Historic architectural drawings were provided by Carlisle Barracks and CERL provided a report titled *Analysis of Building 839*, dated September 2013, which presents a historic context, integrity analysis, and evaluation for the National Register of Historic Places.

### Inspection and Condition Assessment

The project team conducted a site visit to Building 839 in May 2017 to perform a condition assessment based on the Building Feature Master List (Appendix B). The list is adjusted to accommodate special or additional features of the building. Each building feature is inspected, assessed, and photographed. Maintenance deficiencies were determined using non-destructive investigation and evaluation techniques and visual observation.

### Historic Structure Assessment Report

Results of the feature inventory and condition assessment are compiled into this report. Maintenance deficiencies in the physical condition of the features, materials, and building systems are identified. This report also provides a written and illustrated narrative of the interior and exterior character-defining features of the building. However individual recommended treatments for each building feature are not provided in this abbreviated HSAR.

### Class C Cost Estimates for Building Treatment Alternatives

For this report, Class C cost estimates were developed for various potential building treatment alternatives based on the existing conditions of the structure. The five estimated treatment alternatives include:

- A. Restoration (period of significance 1887 to 1918): convert building back to single family residence or duplex arrangement.
- B. Rehabilitation: Adaptive use of the building to include office space, restoration of character-defining features.
- C. Stabilization and Mothball: Estimates for 10 year and 20 year cycles.
- D. Relocation: Relocate building to another location (within 10 mile radius for the purpose of developing programmatic moving costs). The existing building foundation will be abandoned and a new masonry foundation will be constructed at the new location.
- E. Demolition of existing building. (Using Army standards for deconstruction and salvaging of historic materials.)

The overall objective of the project is to provide cost estimates for various treatments (other than demolition) that will improve the overall condition of the structure from *Poor* or *Fair* to *Good*. These treatment alternatives will enable Carlisle Barracks and the U.S. Army Corps of Engineers to determine an appropriate and feasible treatment plan for this National Register-eligible property.

### **Project Participants**

The following individuals contributed to the report or field investigation:

#### Historic Preservation Training Center (HPTC)

Tom Vitanza, Senior Historical Architect

Mark Slater, Project Historical Architect

Caitlin Clinton-Selin, Exhibits Specialist

#### Construction Engineering Research Laboratory (CERL)

Megan Tooker, Historic Landscape Architect

Dr. Andrew Hamblin, Research Ecologist, Tribal Liaison

Adam Smith, Architectural Historian

#### Carlisle Barracks

Paul Herzer, Chief Environmental Officer and Cultural Resources Manager



## References

### General References

ASTM – Standard Guide for Property Condition Assessments: Baseline Property Condition Assessment Process (ASTM: Designation E2018-01). American Society for Testing and Materials (ASTM), Conshocken, PA, 2002.

*Feasibility Assessment Manual for Reusing Historic Buildings*. Donovan D. Rypkema. A National Trust Publication, National Trust for Historic Preservation, Washington, D.C. 2007.

*A Field Guide to American Architecture*. Virginia McAlester. An imprint of Borzoi Books, Published by Alfred A. Knopf, Inc. New York. 1984.

*The Journal of Architectural Technology, Regular Inspections Are Key to Building Envelope Integrity*, Arthur L. Sanders, AIA, Volume 27 Number1, 1/2010 published by Hoffman Architects, Inc., Hamden, CT.

*National Window Preservation Standards*, 1<sup>st</sup> Edition Ver. 1.0, Window Preservation Standards Collaborative, July 2013.

*The Visual Dictionary of American Domestic Architecture*. Rachel Carley. An imprint of Owl Books, Henry Holt and Company, LLC. New York. 1994.

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Smith, Adam D., Susan I. Enscoe, and Megan W. Tooker. "Analysis of Building 839." U.S. Army Corps of Engineers, Engineer Research and Development Center. ERDC/CERL SR-13-19. September 2013.

Various architectural drawings. Carlisle Barracks archives.

### National Park Service Preservation Briefs (Appendix C)

Preservation Brief No. 2. "Repointing Mortar Joints in Historic Masonry Buildings." Robert C. Mack, FAIA, John P. Speweik. October 1998.

Preservation Brief No. 4, "Roofing for Historic Buildings." Lee H. Nelson, FAIA. February 1978.

Preservation Brief No. 6, "Dangers of Abrasive Cleaning to Historic Buildings." Anne E. Grimmer. June 1979.

Preservation Brief No. 9, "The Repair of Historic Wooden Windows." John H. Myers. 1981.

Preservation Brief No. 10, "Exterior Paint Problems on Historic Woodwork." Kay D. Weeks and David W. Look, AIA. September 1982.

Preservation Brief No. 16, "The Use of Substitute Materials on Historic Building Exteriors." Sharon C. Park, AIA. September 1988.

Preservation Brief No. 17, "Architectural Character: Identifying the Visual Aspects of Historic Character as an Aid to Preserving Their Character." Sarah M. Sweetser and Lee H. Nelson, FAIA. 1982.

Preservation Brief No. 18, "Rehabilitating Interiors in Historic Buildings." H. Ward Jandl. October 1988.

Preservation Brief No. 19, "The Repair and Replacement of Historic Wooden Shingle Roofs." Sharon C. Park, AIA. September 1989.

Preservation Brief No. 21, "Repairing Historic Flat Plaster – Walls and Ceilings." Marylee MacDonald. October 1989.

Preservation Brief No. 24, "Heating, Ventilating, and Cooling Historic Buildings: Problems and Recommended Approaches." Sharon C. Park, AIA. October 1991.

Preservation Brief No. 31, "Mothballing Historic Structures." Sharon C. Park, FAIA. September 1993.

Preservation Brief No. 35, "Understanding Old Buildings: The Process of Architectural Investigation." Travis. C. McDonald, Jr. September 1994.

Preservation Brief No. 37, "Appropriate Methods for Reducing Lead-Paint Hazards in Historic Housing." Sharon C. Park, FAIA, and Douglas C. Hicks. 2006.

Preservation Brief No. 39, "Holding the Line: Controlling Unwanted Moisture in Historic Buildings." Sharon C. Park, AIA. October 1996.

Preservation Brief No. 47, "Maintaining the Exterior of Small and Medium Size Historic Buildings." Sharon C. Park, FAIA, NPS Heritage Preservation Services, June 2007.

National Park Service Preservation Tech Notes (Appendix C)

- Windows Number 10, "Temporary Window Vents in Unoccupied Historic Buildings." Charles E. Fisher and Thomas A. Vitanza, U.S. Department of the Interior, National Park Service, Preservation Assistance Division, Washington, D.C., August 1985.

National Park Service Publications

*The Secretary of the Interior Standards for the Treatment of Historic Properties with Standards and Guidelines for Preserving, Rehabilitating, Restoring & Reconstructing Historic Buildings*, by Kay D. Weeks and Anne E. Grimmer, U.S. Department of the Interior, National Park Service, Cultural Resource Stewardships and Partnerships, Heritage Preservation Services, Washington, D.C., 1995—NPS, Heritage Preservation Services.

Unifomat II Work Breakdown Structure (WBS) (Rev 04.19.07) developed by the National Institute of Standards and Technology (NIST), the American Society of Testing Materials (ASTM) the American Institute of Architects (AIA), the General Services Administration (GSA), and the Construction Specification Institute (CSI). See NIST report *UNIFORMAT II Elemental Classification for Building Specifications, Cost Estimating, and Cost Analysis*.

End of Chapter 1

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## CHAPTER 2

### Secretary of the Interior's Standards for the Treatment of Historic Properties

Building 839 is considered eligible for listing in the National Register of Historic Places as a contributing resource to the Carlisle Indian Industrial School National Historic Landmark district<sup>1</sup>. As such, treatment philosophies should be based on the most appropriate treatment standards as defined by *The Secretary of the Interior's Standards for the Treatment of Historic Properties*.

The Standards offer four distinct approaches to the treatment of historic properties: *preservation, rehabilitation, restoration, and reconstruction* with Guidelines for each treatment.<sup>2</sup> Additional information is available in *Appendix A – Preservation Standards and Guidelines*.

Following are synopsized definitions of these standards:

**Preservation is appropriate** “when the property's distinctive materials, features, and spaces are essentially intact and thus convey the historic significance without extensive repair or replacement; when depiction at a particular period of time is not appropriate; and when a continuing or new use does not require additions or extensive alterations. Prior to undertaking work, a documentation plan for Preservation should be developed.”

**Rehabilitation is appropriate** “when repair and replacement of deteriorated features are necessary; when alterations or additions to the property are planned for a new or continued use; and when its depiction at a particular period of time is not appropriate. Prior to undertaking work, a documentation plan for Rehabilitation should be developed.”

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<sup>1</sup> Smith, Adam D., Susan I. Enscoe, and Megan W. Tooker. “Analysis of Building 839.” U.S. Army Corps of Engineers, Engineer Research and Development Center. ERDC/CERL SR-13-19. September 2013, p. 77.

<sup>2</sup> *The Secretary of the Interior Standards for the Treatment of Historic Properties with Standards and Guidelines for Preserving, Rehabilitating, Restoring & Reconstructing Historic Buildings*.

**Restoration is appropriate** *"when the property's design, architectural or historical significance during a particular period of time outweighs the potential loss of extant materials, features, spaces, and finishes that characterize other historical periods; when there is substantial physical and documentary evidence for the work; and when contemporary alterations and additions are not planned. Prior to undertaking work, a particular period of time (i.e. the restoration period) should be selected and justified, and a documentation plan for Restoration developed.*

**Reconstruction is appropriate** *"when a contemporary depiction is required to understand and interpret a property's historic value (including the re-creation of missing components in a historic district or site); when no other property with the same associative value has survived; and when sufficient historical documentation exists to ensure an accurate reproduction.*

## Stabilization

Another form of Preservation is **Stabilization**. While not one of the formally defined treatment standards, stabilization is a common management technique used to prevent the ultimate and untimely loss of a historic structure when treatment is not immediately possible. The following definition is presented as part of the *Guidelines for Preservation* in the *Secretary's Standards*.

"Deteriorated portions of a historic building may need to be protected thorough preliminary stabilization measures until additional work can be undertaken.

**Stabilizing** may include structural reinforcement, weatherization, or correcting unsafe conditions. Temporary stabilization should always be carried out in such a manner that it detracts as little as possible from the historic building's appearance. Although it may not be necessary in every preservation project, stabilization is nonetheless an integral part of the treatment Preservation; it is equally applicable to the other treatments if circumstances warrant."<sup>3</sup>

Further definition of the concept of stabilization is found in the National Park Service Cultural Resources Management Guidelines. As part of the overall definition of the preservation philosophy known as **preservation maintenance**, stabilization is defined along with other types of maintenance.

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<sup>3</sup> Ibid.



**Preservation maintenance** is an action to mitigate wear and deterioration of a historic property without altering its historic character by protecting its condition, repairing when its condition warrants with the least degree of intervention including limited replacement in-kind, replacing an entire feature in-kind when the level of deterioration or damage of materials precludes repair, and stabilization to protect damaged materials or features from additional damage. Types of preservation maintenance are: <sup>4</sup>

- **Housekeeping:** the removal of undesirable deposits of soil in ways that minimize harm to the surfaces treated, repeated at short intervals so that the gentlest and least radical methods can be used.
- **Routine maintenance:** usually consists of service activities such as tightening, adjusting, oiling, pruning, etc.
- **Cyclic maintenance:** maintenance performed less frequently than annually; usually involves replacement or at least mending of material.
- **Stabilization:** action to render an unsafe, damaged, or deteriorated property stable while retaining its present form.

Another closely related form of stabilization is known as **mothballing**. The National Park Service's *Preservation Brief No. 31, Mothballing Historic Structures*, offers the following introduction:

*"When all means of finding a productive use for a historic building have been exhausted or when funds are not currently available to put a deteriorating structure into a useable condition (or good condition), it may be necessary to close-up the building temporarily to protect it from the weather as well as to secure it from vandalism.*

*This process, known as **mothballing**, can be a necessary and effective means of protecting the building while planning the property's future, or raising money for a preservation, rehabilitation or restoration project".*

The essential difference between stabilization and mothballing is that stabilization is used to stop deterioration and often includes structural repair. Mothballing is the preparation of a building for long-term inactivity. The two treatments are used in tandem to prepare a building for long-term inactivity especially if the building has structural deficiencies. When the long-term forecast for a building is to remain vacant and no imminent structural failures are evident, then mothballing is the preferred treatment option.

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<sup>4</sup> National Park Service Office of Policy: NPS-28, Cultural Resource Management Guideline, available at [https://www.nps.gov/parkhistory/online\\_books/nps28/28appena.htm](https://www.nps.gov/parkhistory/online_books/nps28/28appena.htm).

## **Condition Assessment Standard Definitions**

The following standard condition assessment definitions are based on those outlined by the National Park Service (NPS). NPS uses an industry-based condition assessment tool known as the Asset Management Process which has been adopted for use by HPTC for this project.

### **Qualitative Condition Ratings**

#### **Good**

This rating indicates that:

- Routine maintenance should be sufficient to maintain the current condition; and/or
- A cyclic maintenance or repair/rehabilitation project is not specifically required to maintain the current condition or correct deficiencies.

#### **Fair**

This rating indicates that:

- The feature generally provides an adequate level of service to operations, but
- The feature requires more than routine maintenance attention.

This rating also indicates that cyclic maintenance or repair/rehabilitation work may be required in the future.

#### **Poor**

This indicates that the feature is in need of immediate attention. This rating also indicates that:

- Routine maintenance is needed at a much higher level of effort to meet significant safety and legal requirements;
- Cyclic maintenance should be scheduled for the current year and/or
- A special repair/rehabilitation project should be requested consistent with the building owner's requirements, priorities, and long term management objectives.

**Maintenance Deficiency Priority Ratings (5-Year Rating Period)**

Listed as "Priority Ratings" on the *Feature Inventory Condition Assessment Tables*, these ratings are based on the condition rating of each feature and a priority rating was established. These priority ratings indicate either a critical, serious, or minor deficiency priority rating.

**Critical – (Emergency/Immediate)**

- This rating defines an advanced state of deterioration which has resulted in the failure of a feature or will result in the failure of a feature if not corrected within 1 year; or
- There is accelerated deterioration of adjacent or related materials or systems as a result of the feature's deficiencies if not corrected within 1 year; or
- There is an immediate threat to the health and/or safety of the user; or
- There is a failure to meet a legislated requirement.

**Serious – (Immediate/Short Term)**

- This rating defines a deteriorated condition that if not corrected within 1 to 3 years will result in the failure of the feature; or
- A threat to the health and/or safety of the user may occur within 1 to 3 years if the ongoing deterioration is not corrected; or
- There is ongoing deterioration of adjacent or related materials and/or features as a result of the feature's deficiency.

**Minor – (Short Term/Long Term)**

- This rating indicates standard preventative maintenance practices and preservation methods have not been followed; or
- There is reduced life expectancy of affected adjacent or related materials and/or systems within 3 to 5 years and beyond; or
- There is a condition with a long term impact within 3 to 5 years and beyond.

For the purposes of this report, these definitions were adhered to as a way to qualitatively assess the current condition of the Building 839.

End of Chapter 2

## CHAPTER 3

### Introduction

This chapter of the report describes the current condition (May 2017) of the interior and exterior architectural fabric of Building 839 at Carlisle Barracks and identifies maintenance deficiencies of the building features as described in the Building Feature Master List (Appendix B). Along with a written description of the observed conditions, a condition rating and deficiency rating are provided for each substantially separate building feature.

### Site Visit

An on-site condition assessment was conducted at Building 839 on May 2-5, 2017 by HPTC staff including a Historical Architect and Exhibits Specialist. Logistical assistance was provided by CERL and Carlisle Barracks. The weather during the assessment was cool with overcast conditions.

### Summary of the Findings

Building 839 receives an Overall Quality Condition Rating of **FAIR** and an overall Maintenance Deficiency Priority Rating categorized as **SERIOUS**.

The **Overall Quality Condition Rating** of **FAIR** indicates that the building provides an adequate level of service to operations, but more than cyclic maintenance is needed, i.e. capital improvement projects. This rating also indicated that cyclic maintenance or repair/rehabilitation work will be required in the future.

The **Maintenance Deficiency Priority Rating** of **SERIOUS** indicates that some building components are in a deteriorated condition and if not corrected within 1 to 5 years will result in the failure of the feature and possibly adjacent or related materials.

Building 839 has remained unoccupied since 2012 and has received minimal routine maintenance and repair. The building is structurally stable; however several components and finishes are in poor condition such as the exterior brick walls, windows, and wood siding and trim.

Most of the deficiencies can be addressed as part of a rehabilitation or preservation project and a cyclical maintenance program which will help to restore and maintain the historic appearance of the building.

The most critical maintenance deficiencies include:

- Failing paint finish on the exterior brick walls and wood siding
- Failing glazing putty and paint finish on the wood windows
- Deteriorated exterior wood trim
- Failing paint and torn screen on the west porch
- Weathered and deteriorated exterior wood deck
- Insufficient ventilation of the interior of the building
- Degraded interior wall and ceiling finishes
- Lack of a fire alarm and suppression system


### **Building Feature Master List**

The Building Feature Master List (Appendix B) is the overall outline used in the condition assessment of the structure. The category, topic, code, and sub-code nomenclature is derived from the format and structure of the *Uniformat* system which is used by many facility management industry leaders. Refer to Chapter 1 for a description of this methodology. The outline used for this project has been adapted to address the building features of Building 839.

### **Condition Assessment Reports**

Immediately following this section are the individual building feature condition assessment reports which are organized according to the Building Feature Master List as per Appendix B.



<b>A</b>	<b>SUBSTRUCTURE</b>	
	<b>A10</b>	<b>FOUNDATIONS</b>
		<b>A101001 Wall Foundations</b>
<p>The foundations supporting the main block and ell are composed of rough fieldstone approximately 1'-6" thick. Overall the stone foundation walls are in fair condition. The exposed exterior foundation wall on the north elevation has some patched areas and a failing paint finish. The interior of the foundation walls has a whitewashed finish with some loose mortar and efflorescence.</p>		
		
<p>The exposed stone foundation walls on the north elevation with a painted finish. (Photo: HPTC, 5/2/17)</p>		



The stone foundation wall on the west elevation of the main block is painted gray.  
(Photo: HPTC, 5/2/17)



The southwest corner of the ell foundation has concrete and brick patches and missing mortar joints.  
(Photo: HPTC, 5/2/17)



Whitewashed masonry main block foundation and triangular west elevation chimney foundation.  
(Photo: CERL, 5/2/17)



South stone foundation wall in the basement of Unit B (Room 003), with access door to crawlspace (Room 002).  
(Photo: CERL, 5/2/17)

### **A101001 Wall Foundations**

Qualitative Condition Rating

FAIR

Maintenance Deficiency Rating

MINOR

**A103001 Standard Slab On Grade**

The floors in the basement of the house consist of a concrete slab on grade. The slabs are in good shape with some minor cracking and spalls. The floor in the main block (Room 001) has a painted finish and some unfinished areas. The concrete floor in the ell is unfinished.




Unfinished concrete slab on grade in the basement of Unit B (Room 003).  
(Photo: CERL, 5/2/17)

**A103001 Standard Slab On Grade**

Qualitative Condition Rating	GOOD
Maintenance Deficiency Rating	MINOR

End of Chapter 3, Part A.



<b>B</b>	<b>SHELL</b>
<b>B10</b>	<b>SUPERSTRUCTURE</b>
	<b>B1010 Floor Construction</b>
<p>The structural floor frame on the first floor of the main block (Unit A) is composed of 4" x 9" hewn joists spaced at 18" on-center supported by a 9" x 11" summer beam. Joists run east-west.</p> <p>The first-floor structural floor frame in the ell addition (Unit B) above the basement crawlspace (Room 002) is composed of 2½" x 8" joists spaced at 16" on-center running east-west. A 6' x 6" wood beam running north-south is supported by three 6" x 6" wood posts on stone piers.</p> <p>The first-floor structural floor frame in the ell addition (Unit B) above Room 003 is composed of random-sized joists spaced at approximately 16" on-center with cross bracing. The joists are supported by a 6" x 6¾" bolted steel U-channels running.</p> <p>The floor frame is in good condition with some insect damage on select joists in the main block. The second- and third-floor structural floor frames in the main block and ell were not accessible but appear to be in good condition with no evidence of deflection in the floors.</p> <p>The south entry porch has a modern concrete floor in good condition, which likely replaced a wood-framed floor. The west porch has a wood frame floor in fair condition.</p>	
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>First-floor structural floor frame of the main block (Unit A) above Room 001. (Photo: CERL, 5/2/17)</p> </div> <div style="text-align: center;">  <p>First-floor structural floor frame of the ell addition (Unit B) above Room 003. Bolted U-channels (arrow) support the joists. (Photo: CERL, 5/2/17)</p> </div> </div>	

<b>B1010 Floor Construction</b>	
Qualitative Condition Rating	GOOD
Maintenance Deficiency Rating	MINOR

<b>B1020 Roof Construction</b>
<p>The structural roof frame of the main block is comprised of 2¾" x 3¾" rafters spaced at 24" on-center. The ell addition has 3" x 4½" rafters at 24" on-center. The 1" x 10" collar ties appear to have been added at a later time. Several collar ties are inscribed with "1914", which may be the year they were added to the roof frame. The main block and ell addition structural roof frames are in good condition.</p> <p>The west porch roof frame is in fair to poor condition, with deteriorated post bases and rafters and roof boards in poor condition. The south porch roof frame is non-historic but is in fair condition.</p>




Structural roof framing in the main block, visible in Room 302.  
(Photo: CERL, 5/2/17)



Structural roof framing in the ell addition, visible in Room 305.  
(Photo: CERL, 5/2/17)

**B1020 Roof Construction**

Qualitative Condition Rating	GOOD
Maintenance Deficiency Rating	MINOR

<b>B20</b>	<b>EXTERIOR ENCLOSURE</b>
	<b>B2010 Exterior Walls</b>
	<b>B201001 Exterior Skin</b>
The exterior skin of the main block and ell addition consist of painted brick masonry in fair condition. The walls have extensive paint failure; however the bricks and mortar joints are solid.	
	
<p>Typical brick masonry wall with failing paint. (Photo: HPTC, 5/2/17)</p>	



The exterior walls on the north and east elevations of the ell addition consists of painted wood novelty siding with painted wood trim. The siding is in poor condition with extensive paint failure and some deteriorated boards.



East elevation of the ell addition with painted wood novelty siding.  
(Photo: HPTC, 5/2/17)



Paint failure and deterioration at the northeast corner of ell addition.  
(Photo: HPTC, 5/2/17)

#### **B201001 Exterior Skin**

Qualitative Condition Rating

POOR

Maintenance Deficiency Rating

SERIOUS

#### **B201008 Exterior Soffits (Cornice)**

The cornice on the main block has wood molding and brackets. The front (south) gable has decorative bargeboard.

The ell addition has plain, painted wood soffit and fascia with no brackets. The north gable end has serrated rake boards and cornice returns with carved fascia boards. A wooden balustrade is located on the second floor porch of the ell addition.

Generally the exterior wood trim is in poor condition with some missing components, deterioration, and extensive paint failure. The ell addition balcony railing has extensive paint failure and related deterioration.





Wood cornice and brackets on the main block.  
(Photo: HPTC, 5/2/17)



Fascia and cornice returns on the north elevation of the ell addition.  
(Photo: HPTC, 5/2/17)



The second-floor balcony railing on the east elevation of the ell addition has damaged wood components and significant paint failure.  
(Photo: HPTC, 5/2/17)

#### **B201008 Exterior Soffits (Cornice)**

Qualitative Condition Rating

POOR

Maintenance Deficiency Rating

SERIOUS

**B201099 Masonry Chimneys**

The main block has an interior brick on the west gable end and an exterior brick chimney on the east gable end. The ell addition has an exterior brick chimney on the north elevation. Each chimney has a capstone and side openings. The main block chimneys have screening over the openings.

Generally the chimneys are in fair condition with some loose or missing mortar, moderate staining, and loose flashing.



East chimney on the main block.  
(Photo: HPTC, 5/2/17)



The step flashing on the north chimney on the ell addition has become loose. (Photo: HPTC, 5/2/17)



Interior chimney on the west gable end of the main block. (Photo: HPTC, 5/2/17)

#### **B201099 Masonry Chimneys**

Qualitative Condition Rating	FAIR
Maintenance Deficiency Rating	MINOR

#### **B2020 Exterior Windows**

The house has several window types, both historic and non-historic. First- and second-floor windows in Unit A and Unit B are wood 6-over-6 double-hung sash. All of the windows are screwed shut and most openings have modern exterior storm window units. The south elevation window openings have decorative hoods.

The third-floor windows in the main block include an oculus window with Plexiglas in the south elevation and two pentagonal openings in each gable end. The pentagonal openings have casement sashes and decorative wood hoods. Two of the casement sashes have been removed and replaced with a plywood panel. The ell addition has a pentagonal window in the north gable end on the third floor and is covered with plywood on the interior side.

The windows are in poor condition overall, with significant glazing failure, several cracked lights and broken/missing storms, and paint failure on sash, jambs, and sills. Several openings have been modified to accept air conditioning units. None of the openings has ventilation louvers or screens in order to provide cross ventilation within the building.





An oculus window with Plexiglas lite on the south elevation. (Photo: HPTC, 5/2/17)



Typical historic wood 6-over-6 double-hung window on the south elevation with a decorative hood and an exterior storm unit. (Photo: HPTC, 5/2/17)



Typical windows on the west elevation of the main block with plain wood lintels and sills. (Photo: HPTC, 5/2/17)



Typical pentagonal window in the gable ends of the main block. (Photo: HPTC, 5/2/17)



A variant of the pentagonal window in the gable end on the south elevation of the ell addition. (Photo: HPTC, 5/2/17)

### **B2020 Exterior Windows**

Qualitative Condition Rating

POOR

Maintenance Deficiency Rating

SERIOUS

### **B2030 Exterior Doors**

The exterior doors are historic wood doors of various types: 4-panel, 4-lite/2-panel, 9-lite/1-panel, and vertical board. Most doors have modern storm doors. Metal Bilco doors are used to access one of the basement entries. Overall, the exterior doors are operational and in fair condition.





Front door (D101) on the south elevation.  
(Photo: HPTC, 5/2/17)



Front door (D102) on the south elevation.  
(Photo: HPTC, 5/2/17)



West porch door (D106) on the west elevation.  
(Photo: HPTC, 5/2/17)



One of two identical doors (D103, D104) on the east elevation. (Photo: HPTC, 5/2/17)





Steel basement access doors on the east elevation.  
(Photo: HPTC, 5/2/17)



Basement door (D002) on the north elevation.  
(Photo: HPTC, 5/2/17)

<b>B2020 Exterior Windows</b>	
Qualitative Condition Rating	FAIR
Maintenance Deficiency Rating	MINOR

	<b>B30</b>	<b>ROOFING</b>
		<b>B3010 Roof Coverings</b>
		<b>B301001 Roof Finishes</b>
<p>The finish on the roofs of the main block, ell addition, and west elevation porch is standing seam metal roofing. The south porch and east elevation entrance roofs are flat seam metal. Sheathing consists of 3/4" x 9 3/4" boards in the main block and a combination of 3 1/4" tongue-and-groove and 10" standard boards in the ell addition.</p> <p>Overall, the roofing systems are in good condition, with one damaged area on the south porch roof.</p>		
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Typical standing seam metal roof. (Photo: HPTC, 5/2/17)</p> </div> <div style="text-align: center;">  <p>Flat seam metal roof on the south porch. (Photo: HPTC, 5/2/17)</p> </div> </div>		
		<b>B301001 Roof Finishes</b>
	Qualitative Condition Rating	GOOD
	Maintenance Deficiency Rating	MINOR

	<b>B301004 Flashing and Trim</b>
<p>The roofs and chimneys of the main block and ell addition are flashed. Overall, flashings are in fair condition, with some failure/loose components on the south elevation porch roof and the north elevation chimney.</p>	





Valley flashing between the ell addition and main block roofs. (Photo: HPTC, 5/2/17)



The step flashing has separated from the south chimney on the ell addition. (Photo: HPTC, 5/2/17)

#### **B301004 Flashing and Trim**

Qualitative Condition Rating

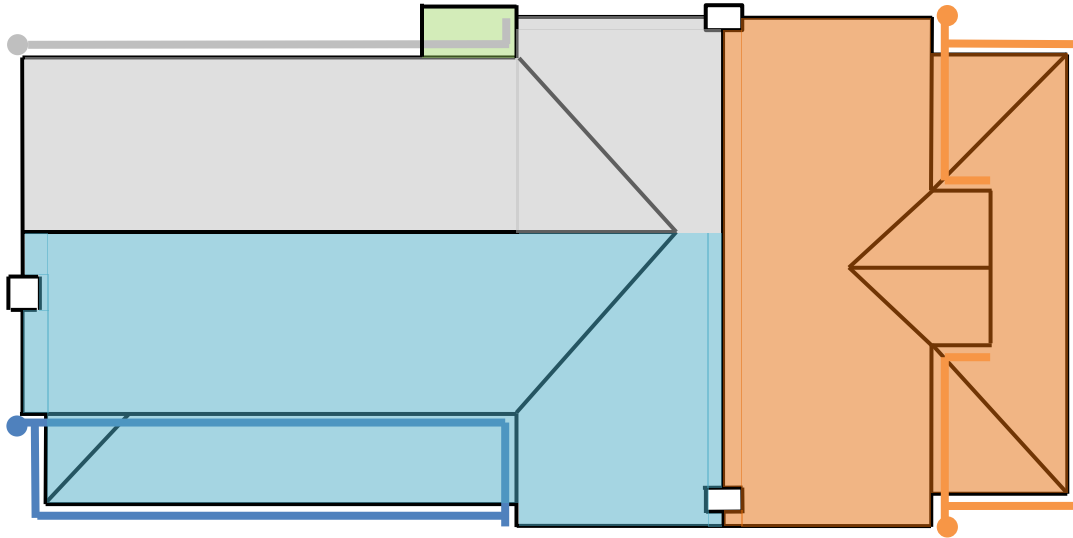
FAIR

Maintenance Deficiency Rating

MINOR

### B301005 Gutters and Downspouts

Gutters are corrugated half round on most of the building, with box gutters on the main block. The downspouts are 5" round fluted. One downspout is connected to an underdrain and the other downspouts outlet to splash pads. Overall, the gutter and downspout system is in fair condition.



Roof plan of the various drainage zones:

**Grey** includes the east slope of the ell addition and the east half of the north slope of the main block. There are two sections of gutter, one at the lower edge of each slope. A shared downspout that drains to grade is located at the north end of the ell addition.

**Orange** includes the south slope of the main block roof and the south entry porch roof. Gutters are located at the lower edge of the main block roof and the lower edges of the south entry porch roof. A shared downspout at the southwest corner of the south elevation drains to an underdrain and a shared downspout at the southeast corner of the main block drains to grade.

**Blue** includes the west end of the north slope of the main block roof, the west slope of the ell addition roof, and the west entry porch roof. These areas share a downspout at the northwest corner of the ell addition roof.

**Green** includes the shed roof of the east elevation entry porch. This roof has no gutter and drains from the eave to the porch below.



Downspout with splash pad, northwest corner of ell addition. (Photo: HPTC, 5/2/17)



Half-round gutter on the ell addition and box gutter on the main block. (Photo: HPTC, 5/2/17)

### **B301005 Gutters and Downspouts**



Qualitative Condition Rating

FAIR

Maintenance Deficiency Rating

MINOR

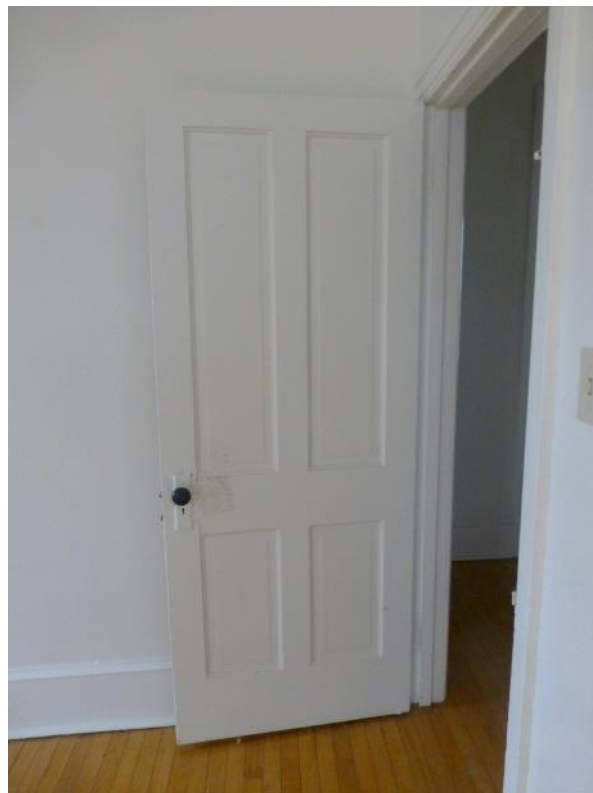
End of Chapter 3, Part B.

<b>C</b>	<b>INTERIORS</b>	
	<b>C10</b>	<b>Interior Construction</b>
		<b>C1010 Partitions</b>
		<b>C101001 Fixed Partitions</b>
<p>The interior fixed partitions (non-loadbearing) walls are wood frame construction and are in overall fair condition. Several modern framed partition walls in the third floor of Unit A have been vandalized and are in poor condition.</p>		
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Partition wall, Room 109, Unit B, first floor. (Photo: CERL, 5/2/17)</p> </div> <div style="text-align: center;">  <p>Damaged partition walls in Room 304 on the third floor in Unit A. (Photo: CERL, 5/2/17)</p> </div> </div>		
<b>C101001 Fixed Partitions</b>		
Qualitative Condition Rating		FAIR
Maintenance Deficiency Rating		MINOR

	<b>C1020 Interior Doors</b>
	<b>C102001 Standard Interior Doors</b>
<p>The interior doors are painted wood with two panels and four panels and most doors are through-tenoned. All doors are original historic doors except one modern bi-fold door in the second-floor hall (Room 204) in Unit B. The historic hardware is present on most doors.</p> <p>Jamb mortises are present in several first-floor door openings where doors have been removed. Some historic doors have been stored in the attic in Unit B. Overall, the interior doors are in fair condition.</p>	



Closet doors, Room 202, Unit A. Most of the closet doors in Unit A are through-tenoned. Note that one door retains its historic hardware and one does not. (Photo: CERL, 5/2/17)



Door D204, Room 205, Unit B.  
(Photo: CERL, 5/2/17)

#### **C102001 Standard Interior Doors**

Qualitative Condition Rating	FAIR
Maintenance Deficiency Rating	MINOR

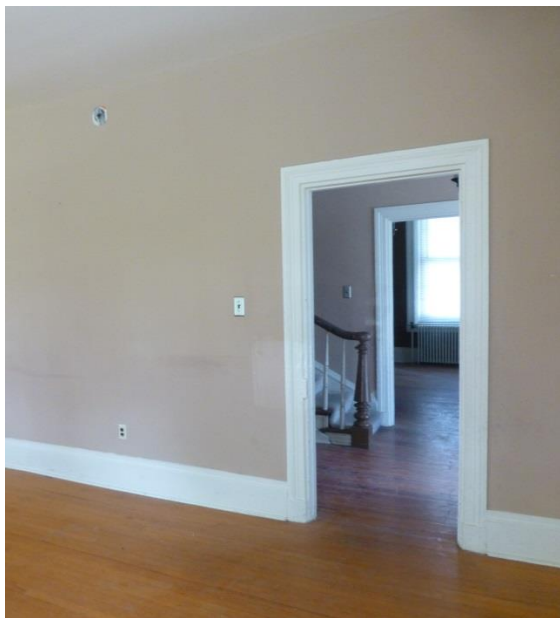
#### **C1030 Fittings (Trim, Cabinets, Counters)**

The trim on the interior of the house is mostly painted wood. Trim includes window surrounds, door surrounds, and baseboards in assorted rooms as well as the stair balustrades and newel posts.

The interior trim is largely historic, with several exceptions. The first-floor mantel in Unit A is non-historic, as are most fittings in the kitchens and bathrooms. Baseboards throughout Unit A are also non-historic, likely having been replaced when drywall was installed over the historic plaster in Unit A. A small segment of historic baseboard is located between Doors D212 and D213 in Unit A. Modern vinyl baseboards are present in the bathrooms.

Overall, the fittings are in good condition.

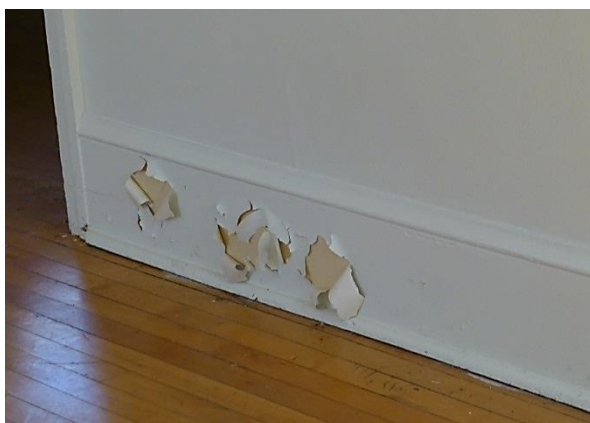




Non-historic baseboards and historic door surround in Room 112, Unit A.  
(Photo: CERL, 5/2/17)



The only extant historic baseboard in Unit A is located between Doors D212 and D213.  
(Photo: HPTC, 5/5/17)



Historic baseboard, Room 205, Unit B.  
(Photo: CERL, 5/2/17)

*Right:* Historic window surround, Room 112, Unit A. Non-historic strips have been added to the perimeter of window surrounds throughout the first floor of Unit A to accommodate the installation of drywall. (Photo: CERL, 5/2/17)





Historic newel post and balustrade on the main stairs in Unit A. (Photo: CERL, 5/2/17)



Non-historic mantel, Room 112, Unit A. (Photo: CERL, 5/2/17)



Non-historic cabinets in the kitchen (Room 103) in Unit A. (Photo: CERL, 5/2/17)



Sink and toilet in the third-floor bathroom (Room 301). The sink is the only extant historic plumbing fixture in the building, but does not date to the period of significance. Note also non-historic baseboards. (Photo: CERL, 5/2/17)

### **C1030 Fittings (Trim, Cabinets, Counters)**


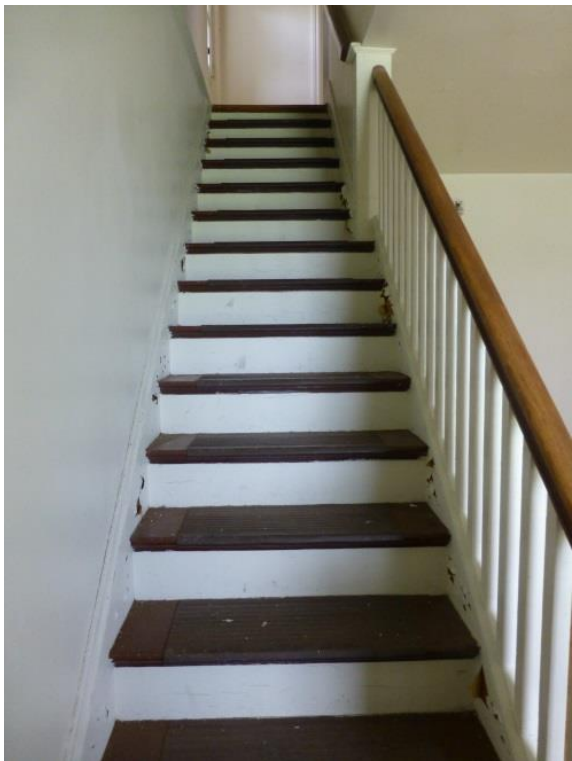
Qualitative Condition Rating

GOOD

Maintenance Deficiency Rating

MINOR



	<b>C20</b>	<b>STAIRS</b>
		<b>C2010 Stair Construction</b>
		<b>C201001 Interior Stair Structure</b>
<p>Each unit has an interior basement stair and an interior main stair. The main stair extends from the first floor to the third floor in Unit A and from the first floor to the second floor in Unit B. A fold-down stair is used to access the attic in Unit B.</p> <p>Both main stairs are in good structural condition. Each is supported by a structural wall. The Unit A main stair has metal supports on the balustrade side of the staircase, likely added after the period of significance.</p> <p>Both sets of interior basement stairs are non-historic, but are in good structural condition.</p>		
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Main stair, Unit A. Note metal supports. (Photo: CERL, 5/2/17)</p> </div> <div style="text-align: center;">  <p>Main stair, Unit B. (Photo: CERL, 5/2/17)</p> </div> </div>		



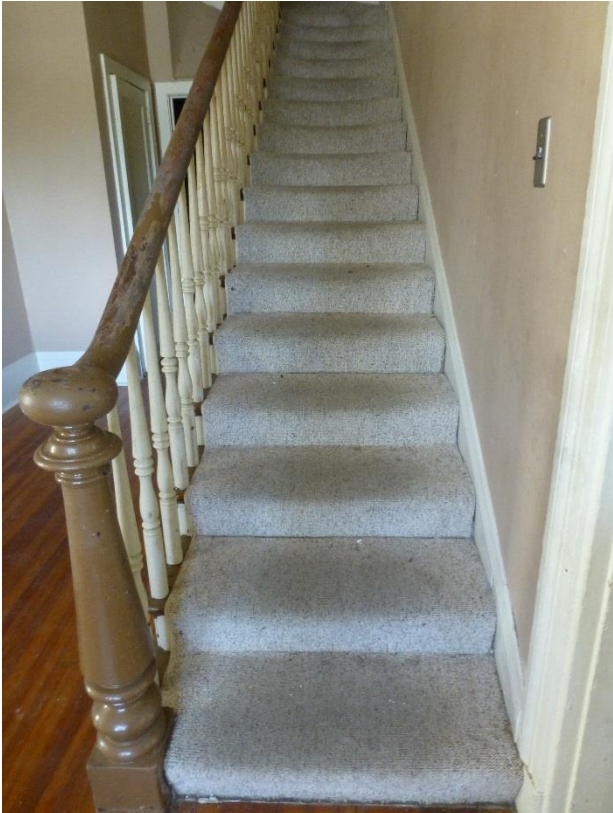

Non-historic interior basement stair, Unit B.  
(Photo: CERL, 5/2/17)



Attic access stair in Unit B (Room 204). The  
bottom tread is missing. (Photo: CERL, 5/2/17)

### **C201001 Interior Stair Structure**

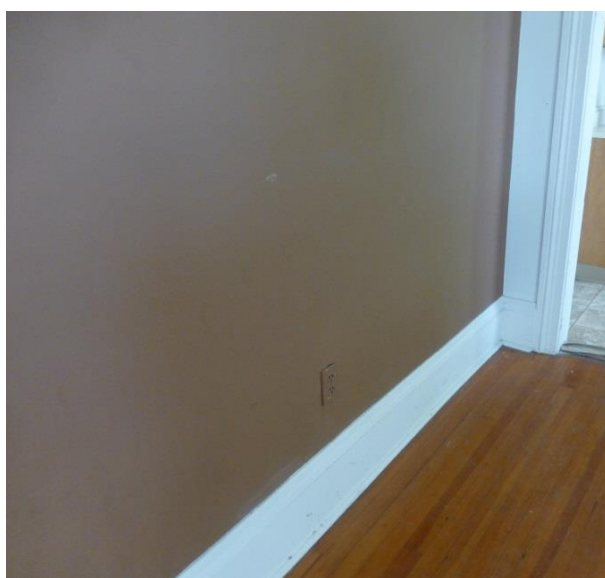
Qualitative Condition Rating	GOOD
Maintenance Deficiency Rating	MINOR

<b>C2020 Stair Finishes</b>	
<p>The main stair and the basement stair in Unit A are carpeted and in poor condition. The main stair in Unit B has rubber treads affixed to the top of each wooden tread. The treads are in fair condition. The basement stairs in Unit B have unfinished wood treads in fair condition.</p>	
 <p>Main stair, Unit A. Note metal supports. (Photo: CERL, 5/2/17)</p>	 <p>Main stair, Unit B. (Photo: CERL, 5/2/17)</p>
<b>C2020 Stair Finishes</b>	
Qualitative Condition Rating	FAIR
Maintenance Deficiency Rating	MINOR

<b>C30</b>	<b>Interior Finishes</b>
	<b>C3010 Wall Finishes</b>
<p>The majority of wall finishes in Unit A are drywall over historic plaster. A small amount of painted beaded board wall finish is present in the enclosed east porch (Room 104). Modern tiles are present in the second floor bathroom (Room 201). Third floor walls consist of drywall over modern framing and brick. The interior walls in Room 302 in the attic are unfinished.</p>	

Historic plaster is the predominant wall finish in Unit B. Modern drywall is present in the kitchen in Unit B (Room 111). Painted and varnished beaded board wall finishes are present in the enclosed first and second story east elevation porches (Rooms 105, 211). The west wall in the enclosed east first-floor porch (Room 105) is brick and was formerly an exterior wall. Modern tiles are present on second-floor bathroom walls (Room 206).

Overall, the wall finishes are in fair condition. However, both units have extensive paint failure throughout and some localized damage in locations where previous invasive materials testing was conducted. The wall damage in Rooms 304 and 305 was caused by vandalism.



Most wall finishes in Unit A are drywall over historic plaster. (Photo: CERL, 5/2/17)



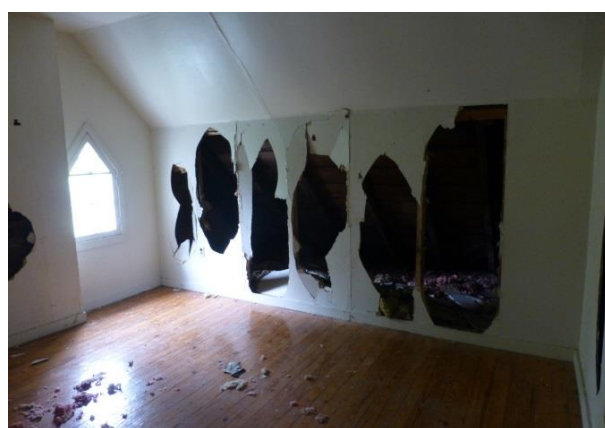
Most wall finishes in Unit B are historic plaster. Note paint failure. (Photo: CERL, 5/2/17)





Beaded board wall finish damaged by invasive materials testing in Room 106.  
(Photo: CERL, 5/2/17)

*Left:* Painted brick and beaded board wall finishes in Room 107. (Photo: CERL, 5/2/17)



Damaged drywall walls in Room 304 in Unit A.  
(Photo: CERL, 5/2/17)

*Left:* Drywall over plaster wall finish damaged by invasive materials testing (Room 112).  
(Photo: CERL, 5/2/17)

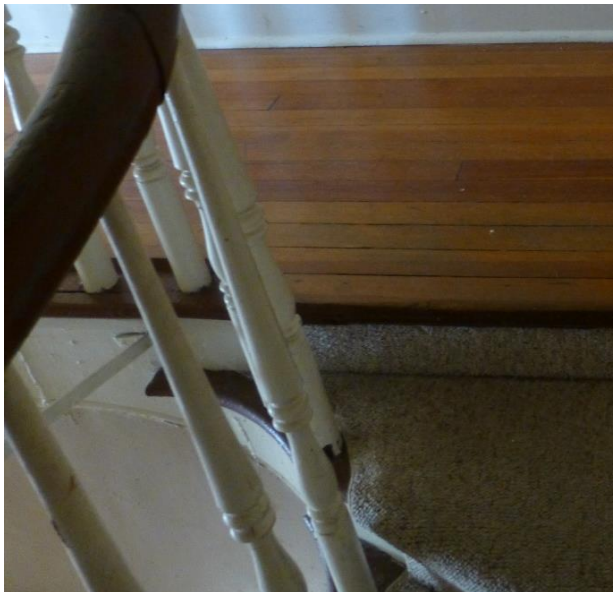
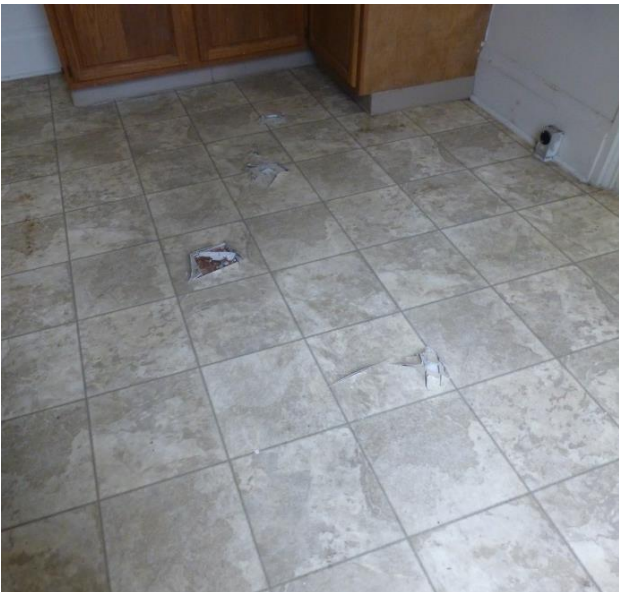
### **C3010 Wall Finishes**

Qualitative Condition Rating

FAIR

Maintenance Deficiency Rating

MINOR

<b>C3020 Floor Finishes</b>	
<p>The floor finishes in Unit A are predominantly wood strip flooring installed over older wood flooring. The wood strip floor finishes are in fair to good condition. The linoleum sheet flooring in Rooms 101, 102, 112, 201, 301, and 303, likely installed over historic wood floors, is in poor condition. The non-historic carpeting on basement and main stairs is in poor condition.</p> <p>Wood strip flooring is also the predominant flooring in Unit B, and is in fair condition. Modern linoleum sheet flooring is present in Unit B in Rooms 107, 111, and 206 and is in fair to poor condition. Painted tongue-and-groove flooring located in the enclosed former porch (Rooms 105 and 106) is in fair condition.</p>	
 <p>Wood strip flooring in Room 210 and carpeting on the main stair in Unit A. Note two layers of wood flooring, evident at base of balusters. (Photo: CERL, 5/2/17)</p>	 <p>Sheet linoleum flooring in Room 103 is not historic. (Photo: CERL, 5/2/17)</p>
<b>C3020 Floor Finishes</b>	
Qualitative Condition Rating	FAIR
Maintenance Deficiency Rating	MINOR

<b>C3030 Ceiling Finishes</b>	
<p>The ceilings in Unit A have various finishes. Rooms 102, 103, 112, and 113 have painted drywall ceilings in good condition except for some minor water damage to the ceiling in Room 113. Room 101 has a plaster ceiling with cracking and paint failure and Room 104 has a painted tongue-and-groove beaded board ceiling with evidence of water damage. Second-floor rooms have painted drywall ceilings in good condition.</p>	

The plaster ceiling in Room 210 has some minor cracking. Third-floor ceilings are unfinished or drywall in fair to poor condition.

The ceilings in Rooms 108, 109, 110, 203, 204, 205, and 207 in Unit B are painted plaster in fair condition with some paint failure and minor cracking. An approximately 2'-0" x 3'-0" area of plaster has been removed from the Room 110 ceiling. Rooms 111 and 206 have painted drywall ceilings in good condition. Rooms 107 and 109 have painted beaded board ceiling finishes in fair to poor condition, with water damage at the exterior wall. Room 108 has a painted beaded board ceiling in fair condition. The exterior second-floor storage space on the east balcony has an unpainted beaded board ceiling finish in fair condition.



Painted plaster ceiling in Room 101.  
(Photo: CERL, 5/2/17)



Exposed lath in the ceiling of Room 110.  
(Photo: CERL, 5/2/17)

### **C3030 Ceiling Finishes**

Qualitative Condition Rating

FAIR

Maintenance Deficiency Rating

MINOR

End of Chapter 3, Part C.



**NOTE:** The Services (Plumbing System, HVAC, Fire Protection Specialties, and Electrical System) for Building 839 were not inspected for code compliance as part of this assessment. However, a cursory visual inspection of the Services was conducted to provide general observations.

D	SERVICES	
	D20	PLUMBING
Plumbing System observations: <ul style="list-style-type: none"><li>• The water supply to the building is turned off and the supply line in the northwest corner of the Unit B basement is cut below the valve.</li><li>• A 130 gal water heater (ca. 2005) is located in the basement of Unit B.</li><li>• The condition of the plumbing system and the sewer system is unknown.</li><li>• A natural gas meter is located on the exterior at the northeast corner of the building. The gas supply is turned off.</li></ul>		
Qualitative Condition Rating		Not Rated
Maintenance Deficiency Rating		MINOR

	D30	HVAC
HVAC System observations: <ul style="list-style-type: none"><li>The boiler in the basement of Unit A appears to be in good condition and reusable.</li><li>The condition of the radiators throughout the building is unknown.</li><li>The building does not have central air conditioning.</li></ul>		
Qualitative Condition Rating		Not Rated
Maintenance Deficiency Rating		MINOR

	<b>D40</b>	<b>FIRE PROTECTION SYSTEMS</b>
Fire Protection System observations: <ul style="list-style-type: none"><li>• No fire detection or suppression system is installed in the building.</li><li>• No fire extinguishers are located in the building.</li><li>• Several of the existing battery-operated smoke detectors are non-working.</li></ul>		
Qualitative Condition Rating		POOR
Maintenance Deficiency Rating		CRITICAL

	<b>D50</b>	<b>ELECTRICAL</b>
Electrical System observations: <ul style="list-style-type: none"><li>• The power is on in the building.</li><li>• Breaker panels are located in both basements.</li><li>• The condition of the wiring, devices, and fixtures throughout the building is unknown.</li><li>• The building does not have a security system installed.</li></ul>		
Qualitative Condition Rating		Not Rated
Maintenance Deficiency Rating		SERIOUS

End of Chapter 3, Part D.

**NOTE:** A cursory visual inspection of the Building Sitework was conducted to provide general observations.

<b>G</b>	<b>BUILDING SITEWORK</b>	
	<b>G20</b>	<b>SITE IMPROVEMENTS</b>
Site Improvements observations: <ul style="list-style-type: none"> <li>• The asphalt parking lot is in good condition.</li> <li>• All pedestrian paving around the building is in good condition.</li> <li>• All landscaping is maintained and in good condition.</li> <li>• The overall building site drainage is functional and in good condition.</li> </ul>		
Qualitative Condition Rating		GOOD
Maintenance Deficiency Rating		MINOR

End of Chapter 3, Part G.

<b>Carlisle Barracks Building 839 - Summary of Condition Assessment Ratings</b>				
UNIFORMAT II Outline Data			Condition Rating	Deficiency Rating
<b>A</b>	<b>SUBSTRUCTURE</b>			
A10	FOUNDATIONS			
A1010	Standard Foundations			
A101001	Wall Foundations	Fair	Minor	
A1030	Slab On Grade			
A103001	Standard Slab On Grade	Good	Minor	
<b>B</b>	<b>SHELL</b>			
B10	SUPERSTRUCTURE			
B1010	Floor Construction			
B101001	Structural Frame	Good	Minor	
B1020	Roof Construction			
B102001	Structural Frame	Good	Minor	
B20	EXTERIOR ENCLOSURE			
B2010	Exterior Walls			
B201001	Exterior Skin			
B201001-1	Brick	Poor	Serious	
B201001-2	Wood Siding	Poor	Serious	
B201008	Exterior Soffits (Cornice)	Poor	Serious	
B201099	Masonry Chimneys	Fair	Minor	
B2020	Exterior Windows			
B2020-1	Basement Windows	Poor	Serious	
B2020-2	1 <sup>st</sup> Floor Windows	Poor	Serious	
B2020-3	2 <sup>nd</sup> Floor Windows	Poor	Serious	
B2020-4	Attic Windows	Poor	Serious	
B2030	Exterior Doors			
B2030-1	Basement Doors	Fair	Minor	
B2030-2	1 <sup>st</sup> Floor Doors	Good	Minor	
B30	ROOFING			
B3010	Roof Coverings			
B301001	Roof Finishes	Good	Minor	
B301004	Flashings & Trim	Fair	Minor	
B301005	Gutters & Downspouts	Fair	Minor	
<b>C</b>	<b>INTERIORS</b>			
C10	INTERIOR CONSTRUCTION			
C1010	Partitions			
C101001	Fixed Partitions	Fair	Minor	
C1020	Interior Doors			
C102001	Standard Interior Doors	Fair	Minor	
C1030	Fittings	Good	Minor	
C20	STAIRS			
C2010	Stair Construction			
C201001	Interior Stair Structure	Good	Minor	
C2020	Stair Finishes	Fair	Minor	

C30	INTERIOR FINISHES			
	C3010	Wall Finishes	Fair	Minor
	C3020	Floor Finishes	Fair	Minor
	C3030	Ceiling Finishes	Fair	Minor
<b>D</b>	<b>SERVICES</b>			
	D20	PLUMBING	Not Rated	Minor
	D30	HVAC	Not Rated	Minor
	D40	FIRE PROTECTION SYSTEMS		
		D4030	Fire Protection Specialties	
		D403001	Fire Extinguishing Devices	Poor Critical
		D4090	Other Fire Protection Systems	
		D409099	Smoke/Heat Detectors	Not Rated Critical
	D50	ELECTRICAL		
		D5010	Electrical Service & Distribution	Not Rated Minor
		D5020	Lighting & Branch Wiring	Not Rated Minor
		D5030	Communications & Security	
		D503001	Fire Alarm System	N/A Critical
		D503003	Telecommunications System	Not Rated Minor
		D503008	Security System	N/A Serious
<b>G</b>	<b>BUILDING SITEWORK</b>			
	G20	SITE IMPROVEMENTS		
		G2020	Parking Lots	Good Minor
		G2030	Pedestrian Paving	Good Minor
		G2050	Landscaping	Good Minor
	G90	OTHER SITE WORK		
		G9087	Overall Building Site Drainage	Good Minor
<i>End of Table</i>				



## CHAPTER 4

### Class C Cost Estimate for Building 839

#### Class C (Conceptual) Construction Cost Estimating

Class C Construction Cost Estimates are referred to as *conceptual* estimates by the Federal government and are generally prepared without a fully-defined scope of work. These estimates are general in nature, representative of a broad-based vision rather than focused on specific details and require a great deal of interpretation and assumptions on the part of the estimator to fill in the blanks between programmed elements. Class C estimates are generally used for: feasibility studies, development of project scope and program, establishing preliminary budgets, and selecting from among alternative design types.

The Class C Construction Cost Estimates is a *conceptual* cost estimate based on a combination of detailed installation analysis, typical assembly costs, and some lump sum or square footage costs derived from similar projects.

#### Class C Construction Cost Estimating Accuracy

Class C Construction Estimates are generally prepared with little, if any, formal design documents and often without a fully defined scope of work. This lack of detail requires that a high level of skill and careful estimating judgment is employed during the development of conceptual costs.

The generally accepted industry accuracy range of Class C Construction Cost Estimates is -30% to +50%. For example, with this as the accepted accuracy, a \$1,000,000 Class C Construction Cost Estimate would have an accepted range of \$700,000 to \$1,500,000.

#### Class C Construction Cost Estimate Mark-ups and Design Contingencies

The cost information used to prepare Conceptual Class C Cost Estimates may be a combination of local costs obtained through detailed research, and/or be derived from sources other than park- and/or project-specific cost data. Complete design details are likely not available to precisely define every aspect of the work and some design elements may still change or be eliminated, while others may need to be added. Some additional elements may include location adjustments, design contingency, and general conditions including conditions that relate to the use of historic buildings.

### Historic Preservation Factor

If a project involves additions or repairs to historic structures, or is in close proximity to historical or cultural sites, a Historic Preservation Factor may need to be included to account for unknown or unidentified costs associated with protecting and/or matching the historical fabric of the resource.

At the Class C Construction Cost Estimate level, few of these impacts are typically quantified for most projects; therefore a mark-up should be applied to the estimate to allow for the associated costs. A range of 0-10% is not uncommon.

For many new construction and other non-historical projects it is common for this mark-up factor to be zero (0). For solely historical preservation/restoration projects, all of the additional associated costs should be included in the direct cost items.

### **NPS Cost Estimating Requirements Handbook**

The *NPS Cost Estimating Requirements Handbook* offers a clear overview of the background and purpose of the NPS cost estimating system.

Chapter 1 of the *Handbook* addresses Background, Purpose, Application, and Cost Management Policies. Technical and administrative requirements are presented for the development, preparation, documentation, and submittal of construction cost estimates during the project life cycle of a NPS construction project's pre-planning/pre-design, schematic design, design development, and construction document preparation phases.

NOTE: After a review of these requirements, the information provided for this project is considered to pre-planning/pre-design information for the purposes of cost estimating.

### **Building Treatment Options**

The U.S. Army Corps of Engineers Construction Engineering Research Center (CERL) is considering five potential treatments and uses for Building 839 at the Carlisle Barracks. These include:

1. **Restoration:** to period of significance (1887-1918). Convert building back to use as residence(s).
2. **Rehabilitation:** adaptive use of the building for office use while restoring character-defining features.
3. **Stabilization/Mothballing:** 10 and 20 year cycles.
4. **Relocation:** relocate building to another location.
5. **Demolition**

**Option 1: Restoration to 1887-1918 for Use as Residence(s)**

This treatment consists of restoration of the interior and exterior of the Building 839 with retention and preservation of character-defining features. This treatment also includes removing modern additions (e.g. screened-in porch), and reproducing lost CDFs to the building (e.g. paint colors and front porch trim details). The building interior would be upgraded for use as a single residence or duplex.

Restoration tasks include:

- Conduct a historic paint study/analysis to determine historic paint colors
- Foundations: spot repointing, paint stripping, and cleaning
- Treatment for wood-boring insects
- Repairs to the west porch roof structural system (posts, rafters, and roof boards)
- Exterior Brick Walls: paint stripping and repainting to match historic colors
- Exterior Siding: replacement of deteriorated boards, prep, and repainting to match historic colors
- Trim & Porches: wood repair/replacement, where needed, removal of screen-in porch components, restoration of the lost trim components at front porch, prep and repaint to match historic colors
- Chimneys: add screening to cap openings, where missing, and repoint, as needed
- Exterior Windows: complete preservation of windows and openings, removal of unsympathetic storm windows, installation of new interior storm windows, and removal of window air condition units
- Exterior Doors: minor preservation of wood exterior doors, replacement of exterior storm doors with compatible new units
- Repair of flashing at south elevation porch and north elevation chimney
- Repair of third-floor partition walls
- Interior Doors: minor repairs, prep, and repainting
- Interior Trim: minor repairs, prep, and repainting; complete replacement of non-historic mantel in Unit A, Room 112
- Cabinets & Counters: Replace kitchen cabinets, restore bathrooms to historic appearance
- Stairs: remove carpet and rubberized treads, prep and repaint, new Unit B attic access stair
- Walls: remove drywall and modern bathroom tiles, restore underlying plaster, prep, and paint
- Floors: remove linoleum, install more historically-sensitive material
- Ceilings: remove drywall, restore underlying plaster, prep, and paint

NOTE: Utilities and mechanical, electrical, plumbing (MEP) systems are not addressed in tasks needed, as these systems were not assessed by the HPTC assessment team.

<b>Cost Range<sup>1</sup></b>	<b>Average Cost/SF<sup>2</sup></b>	<b>Building 839 SF (1<sup>st</sup> 2<sup>nd</sup> 3<sup>rd</sup> Floors)</b>	<b>Restoration Cost</b>
<i>Low</i>	\$210/SF	5,420 SF	<i>\$1,138,200</i>
<i>Medium</i>	\$300/SF	5,420 SF	<i>\$1,626,000</i>
<i>High</i>	\$450/SF	5,420 SF	<i>\$2,439,000</i>
<i>Average</i>	\$320/SF	5,420 SF	<i><u>\$1,734,400</u></i>

The generally accepted industry accuracy range of Class C Construction Cost Estimates is -30% to +50%.

Restoration: Class C Cost Estimate Range based on average cost of \$1,734,400.

Accepted industry accuracy range:

-30% [-\$520,320] to + 50% [+\$867,200] = *\$1,214,080 to \$2,601,600*

Mean cost equals approximately **\$1,907,840** in FY17 dollars, or **\$352/SF**.

NOTE: Allowances for inflation are required in future out-year estimates.

<sup>1</sup> Derived from RS Means Square Foot Costs, 2017. These represent construction costs only and do not include traditional contractor's overhead and profit or the architectural design fees.

<sup>2</sup> Derived from RS Means Quick Estimating Tool for metro Washington, D.C.

## Option 2: Rehabilitation for Use as Offices

This treatment consists of the general rehabilitation of the interior and exterior of Building 839 with retention and preservation of character-defining features. The interior spaces would be upgraded for use as administrative offices or other compatible uses (e.g. meeting space, gallery space, exhibition space, interpretive display (non-archival) space, public information display space, or an education center) which would to allow visitors to access to the building.

Rehabilitations tasks include:

- Foundations: spot repointing, paint stripping, and cleaning
- Treatment for wood-boring insects
- Repairs to the west porch roof structural system (posts, rafters, and roof boards)
- Exterior Brick Walls: paint stripping and repaint
- Exterior Siding: replacement of deteriorated boards, prep, and repaint
- Trim & Porches: wood repair/replacement, where needed, prep and repaint
- Chimneys: add screening to cap openings, where missing, and repoint, as needed
- Exterior Windows: complete preservation of windows and openings, repair of storm windows, installation of new exterior storm windows where missing, and removal of window air condition units
- Exterior Doors: minor preservation of wood exterior doors, repair of exterior storm doors
- Repair of flashing at south elevation porch and north elevation chimney
- Repair of third-floor partition walls
- Interior Doors: minor repairs, prep, and repaint
- Interior Trim: minor repairs, prep, and repaint
- Stairs: remove carpet and rubberized treads, prep and repaint, new Unit B attic access stair
- Walls: repair drywall/plaster, prep, and paint
- Floors: replace damaged linoleum
- Ceilings: repair drywall/plaster, prep, and paint
- Accessibility: provide accessible route from the exterior, accessible entrance, and accessible space on at least one floor.

NOTE: Utilities and mechanical, electrical, plumbing (MEP) systems are not addressed in tasks needed, as these systems were not assessed by the HPTC assessment team



<b>Cost Range<sup>3</sup></b>	<b>Average Cost/SF<sup>4</sup></b>	<b>Building 839 SF (1<sup>st</sup> 2<sup>nd</sup> 3<sup>rd</sup> Floors)</b>	<b>Rehabilitation Cost</b>
<i>Low</i>	\$140/SF	5,420 SF	<i>\$758,800</i>
<i>Medium</i>	\$200/SF	5,420 SF	<i>\$1,084,000</i>
<i>High</i>	\$300/SF	5,420 SF	<i>\$1,626,000</i>
<i>Average</i>	\$213/SF	5,420 SF	<i><u>\$1,154,460</u></i>

The generally accepted industry accuracy range of Class C Construction Cost Estimates is -30% to +50%.

Rehabilitation: Class C Cost Estimate Range based on average cost of \$1,154,460.

Accepted industry accuracy range:

-30% [-\$346,338] to + 50% [+\$577,230] = \$808,122 to \$1,731,690

Mean cost equals approximately **\$1,269,906** in FY17 dollars, or **\$234/SF**.

NOTE: Allowances for inflation are required in future out-year estimates.

<sup>3</sup> Derived from RS Means Square Foot Costs, 2017. These represent construction costs only and do not include traditional contractor's overhead and profit or the architectural design fees.

<sup>4</sup> Derived from RS Means Quick Estimating Tool for metro Washington, D.C.

### Option 3: Stabilization/Mothballing

This treatment consists of the stabilization of the exterior and mothballing of the interior of Building 839 with retention and preservation of character-defining features. This treatment accommodates vacancy of the building for an interim period of 10 to 20 years.

Stabilization/mothballing tasks include:

- Foundations: spot repointing, scrape paint
- Treatment for wood-boring insects
- Repairs to the west porch roof structural system (posts, rafters, and roof boards)
- Exterior Brick Walls: scrape paint
- Exterior Siding: replacement of deteriorated boards, prep, and repaint
- Trim & Porches: wood repair/replacement, where needed, prep and repaint
- Chimneys: add screening to cap openings, where missing, and repoint, as needed
- Exterior Windows: repair of storm windows, installation of new storm windows where missing, removal of window air condition units, installation of screened louvers throughout building
- Exterior Doors: repair exterior storm doors
- Repair of flashing at south elevation porch and north elevation chimney
- Interior Doors: block in open position
- Stairs: remove carpet, new Unit B attic access stair

<b>Cost Range<sup>5</sup></b>	<b>Average Cost/SF<sup>6</sup></b>	<b>Building 839 SF (1<sup>st</sup> 2<sup>nd</sup> 3<sup>rd</sup> Floors)</b>	<b>Stabilization/Mothballing Cost</b>
<i>Low</i>	\$49/SF	5,420 SF	<i>\$265,580</i>
<i>Medium</i>	\$70/SF	5,420 SF	<i>\$379,400</i>
<i>High</i>	\$105/SF	5,420 SF	<i>\$569,100</i>
<i>Average</i>	\$75/SF	5,420 SF	<i>\$406,500</i>

The generally accepted industry accuracy range of Class C Construction Cost Estimates is -30% to +50%.

<sup>5</sup> Derived from RS Means Square Foot Costs, 2017. These represent construction costs only and do not include traditional contractor's overhead and profit or the architectural design fees.

<sup>6</sup> Derived from RS Means Quick Estimating Tool for metro Washington, D.C.

Stabilization/Mothballing: Class C Cost Estimate Range based on average cost of \$406,500.

Accepted industry accuracy range:

-30% [-\$121,950] to + 50% [+\$203,250] = \$284,550 to \$609,750

Mean cost equals approximately **\$894,300** in FY17 dollars, or **\$165/SF**.

NOTE: Allowances for inflation are required in future out-year estimates.

### Option 4: Demolition

This treatment consists of the complete demolition and removal of Building 839 with no replacement. The cost below does not include site work after removal or removal of utilities to the building.

Cost Range <sup>7</sup>	Average Cost/SF <sup>8</sup>	Building 839 SF (B 1 <sup>st</sup> 2 <sup>nd</sup> 3 <sup>rd</sup> Floors)	Stabilization/ Mothballing Cost
<i>Low</i>	\$35/SF	7,427 SF	\$259,945
<i>Medium</i>	\$50/SF	7,427 SF	\$371,350
<i>High</i>	\$75/SF	7,427 SF	\$557,025
<i>Average</i>	\$53/SF	7,427 SF	<u>\$393,631</u>

The generally accepted industry accuracy range of Class C Construction Cost Estimates is -30% to +50%.

Rehabilitation: Class C Cost Estimate Range based on average cost of \$393,631.

Accepted industry accuracy range:

-30% [-\$118,089] to + 50% [+\$196,816] = \$275,542 to \$590,447

Mean cost equals approximately **\$432,995** in FY17 dollars, or **\$58.30/SF**.

NOTE: Allowances for inflation are required in future out-year estimates.

<sup>7</sup> Derived from RS Means Square Foot Costs, 2017. These represent construction costs only and do not include traditional contractor's overhead and profit or the architectural design fees.

<sup>8</sup> Derived from RS Means Quick Estimating Tool for metro Washington, D.C.

## Option 5: Relocation

This treatment consists of relocating Building 839 from its current location at Carlisle Barracks approximately 0.5 miles east-southeast to the U.S. Army Heritage and Education Center located at 950 Soldiers Drive, Carlisle, PA. The approximate relocation route would include transfer of the house to adjacent Post Road, left of Claremont Road, right on Army Heritage Drive, and transfer onto its new site.

After relocation, a building treatment and use (Options 1-3 above) would need to be select to properly maintain the building for an extended period of time. These treatment costs would be in addition to the actual relocation costs.

Relocation costs include:

- Construction of new foundations and slab at the new site
- Demolition of old foundations and slab
- Jacking, moving, leveling, and placing building on new foundation

NOTE: The cost below does not include site work after removal, or removal of utilities to the building or reestablishment of utilities to the building at its new location.

<b>Cost Range<sup>9</sup></b>	<b>Average Cost/SF<sup>10</sup></b>	<b>Building 839 SF (B 1<sup>st</sup> 2<sup>nd</sup> 3<sup>rd</sup> Floors)</b>	<b>Relocation Cost</b>
<i>Low</i>	\$30/SF	7,427 SF	<i>\$22,810</i>
<i>Medium</i>	\$45/SF	7,427 SF	<i>\$334,215</i>
<i>High</i>	\$68/SF	7,427 SF	<i>\$505,036</i>
<i>Average</i>	\$48/SF	7,427 SF	<i><u>\$356,496</u></i>

The generally accepted industry accuracy range of Class C Construction Cost Estimates is -30% to +50%.

<sup>9</sup> Derived from RS Means Square Foot Costs, 2017. These represent construction costs only and do not include traditional contractor's overhead and profit or the architectural design fees.

<sup>10</sup> Derived from RS Means Quick Estimating Tool for metro Washington, D.C.

Rehabilitation: Class C Cost Estimate Range based on average cost of \$356,496.

Accepted industry accuracy range:

-30% [-\$106,949] to + 50% [+\$178,248] = \$249,547 to \$534,744

Mean cost equals approximately **\$392,146** in FY17 dollars, or **\$53/SF**.

NOTE: Allowances for inflation are required in future out-year estimates.

End of Chapter 4.



## **Appendix A**

### Preservation Standards and Guidelines



## **PRESERVATION STANDARDS AND GUIDELINES**

**Preservation** is defined as the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property. Work, including preliminary measures to protect and stabilize the property, generally focuses upon the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. New exterior additions are not within the scope of this treatment; however, the limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties functional is appropriate within a preservation project.

### **Standards for Preservation**

1. A property will be used as it was historically, or be given a new use that maximizes the retention of distinctive materials, features, spaces, and spatial relationships. Where a treatment and use have not been identified, a property will be protected and, if necessary, stabilized until additional work may be undertaken.
2. The historic character of a property will be retained and preserved. The replacement of intact or repairable historic materials or alteration of features, spaces, and spatial relationships that characterize a property will be avoided.
3. Each property will be recognized as a physical record of its time, place, and use. Work needed to stabilize, consolidate, and conserve existing historic materials and features will be physically and visually compatible, identifiable upon close inspection, and properly documented for future research.
4. Changes to a property that have acquired historic significance in their own right will be retained and preserved.
5. Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize a property will be preserved.
6. The existing condition of historic features will be evaluated to determine the appropriate level of intervention needed. Where the severity of deterioration requires repair or limited replacement of a distinctive feature, the new material will match the old in composition, design, color, and texture.
7. Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.

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

## **Guidelines for Preservation**

### *Choosing Preservation as a Treatment*

In Preservation, the options for replacement are less extensive than in the treatment, Rehabilitation. This is because it is assumed at the outset that building materials and character-defining features are essentially intact, i.e., which more historic fabric has survived, unchanged over time. The expressed goal of the **Standards for Preservation and Guidelines for Preserving Historic Buildings** is retention of the building's existing form, features and detailing. This may be as simple as basic maintenance of existing materials and features or may involve preparing a historic structure report, undertaking laboratory testing such as paint and mortar analysis, and hiring conservators to perform sensitive work such as reconstituting interior finishes. Protection, maintenance, and repair are emphasized while replacement is minimized.

### *Identify, Retain, and Preserve Historic Materials and Features*

The guidance for the treatment **Preservation** begins with recommendations to identify the form and detailing of those architectural materials and features that are important in defining the building's historic character and which must be retained in order to preserve that character. Therefore, guidance on **identifying, retaining, and preserving** character-defining features is always given first. The character of a historic building may be defined by the form and detailing of exterior materials, such as masonry, wood, and metal; exterior features, such as roofs, porches, and windows; interior materials, such as plaster and paint; and interior features, such as moldings and stairways, room configuration and spatial relationships, as well as structural and mechanical systems; and the building's site and setting.

### *Stabilize Deteriorated Historic Materials and Features as a Preliminary Measure*

Deteriorated portions of a historic building may need to be protected thorough preliminary stabilization measures until additional work can be undertaken. **Stabilizing** may include structural reinforcement, weatherization, or correcting unsafe conditions. Temporary stabilization should always be carried out in such a manner that it detracts as little as possible from the historic building's appearance. Although it may not be necessary in every preservation project, stabilization is nonetheless an integral part of the treatment Preservation; it is equally applicable, if circumstances warrant, for the other treatments.

*Protect and Maintain Historic Materials and Features*

After identifying those materials and features that are important and must be retained in the process of **Preservation** work, then **protecting and maintaining** them are addressed. Protection generally involves the least degree of intervention and is preparatory to other work. For example, protection includes the maintenance of historic materials through treatments such as rust removal, caulking, limited paint removal, and re-application of protective coatings; the cyclical cleaning of roof gutter systems; or installation of fencing, alarm systems and other temporary protective measures. Although a historic building will usually require more extensive work, an overall evaluation of its physical condition should always begin at this level.

*Repair (Stabilize, Consolidate, and Conserve) Historic Materials and Features*

Next, when the physical condition of character-defining materials and features requires additional work, **repairing** by **stabilizing, consolidating, and conserving** is recommended. **Preservation** strives to retain existing materials and features while employing as little new material as possible. Consequently, guidance for repairing a historic material, such as masonry, again begins with the least degree of intervention possible such as strengthening fragile materials through consolidation, when appropriate, and repointing with mortar of an appropriate strength. Repairing masonry as well as wood and architectural metal features may also include patching, splicing, or otherwise reinforcing them using recognized preservation methods. Similarly, within the treatment **Preservation**, portions of a historic structural system could be reinforced using contemporary materials such as steel rods. All work should be physically and visually compatible, identifiable upon close inspection and documented for future research.

*Limited Replacement in Kind of Extensively Deteriorated Portions of Historic Features*

If repair by stabilization, consolidation, and conservation proves inadequate, the next level of intervention involves the **limited replacement in kind** of extensively deteriorated or missing parts of features when there are surviving prototypes (for example, brackets, dentils, steps, plaster, or portions of slate or tile roofing). The replacement material needs to match the old both physically and visually, i.e., wood with wood, etc. Thus, with the exception of hidden structural reinforcement and new mechanical system components, substitute materials are not appropriate in the treatment **Preservation**. Again, it is important that all new material be identified and properly documented for future research. If prominent features are

missing, such as an interior staircase, exterior cornice, or a roof dormer, then a Rehabilitation or Restoration treatment may be more appropriate.

### *Energy Efficiency/Accessibility Considerations and Health & Safety Code Considerations*

These sections of the **Preservation** guidance address work done to meet accessibility requirements and health and safety code requirements; or limited retrofitting measures to improve energy efficiency. Although this work is quite often an important aspect of preservation projects, it is usually not part of the overall process of protecting, stabilizing, conserving, or repairing character-defining features; rather, such work is assessed for its potential negative impact on the building's historic character. For this reason, particular care must be taken not to obscure, damage, or destroy character-defining materials or features in the process of undertaking work to meet code and energy requirements.

### **Preservation Maintenance Treatment**

This project has been determined to be a preservation maintenance project. By its definition this includes cyclical maintenance planning. The information gathered from the building survey directs the prioritization process for preservation maintenance work tasks (recommended treatments).

Recommendations in this report address the actual condition of the historic building and present recommended treatments to maintain the structure for a five (5) to ten (10) year period. Certain treatments will inherently have a service life that will exceed 5 - 10 years if maintained in good condition.

It is important there is a clear understanding of the treatment. The *NPS Cultural Resource Management Guidelines* (formerly NPS-28, Release No. 5, 1997) define preservation maintenance as follows:

*Action to mitigate wear and deterioration of a historic property without altering its historic character by protecting its condition, repairing when its condition warrants with the least degree of intervention including limited replacement in-kind, replacing an entire feature in-kind when the level of deterioration or damage of materials precludes repair, and stabilization to protect damaged materials and features from additional damage.*



Types of preservation maintenance are:

- Housekeeping: the removal of undesirable deposits of soil in ways that minimize harm to the surfaces treated, repeated at short intervals so that the gentlest and least radical methods can be used.
- Routine Maintenance: usually consists of service activities such as tightening, adjusting, oiling, pruning, etc.
- Cyclic Maintenance: maintenance performed less frequently than annually, usually involves replacement or at least mending of material.
- Stabilization: action to render an unsafe, damaged, or deteriorated property stable while retaining its present form.

## REHABILITATION STANDARDS AND GUIDELINES

**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.

### Standards for Rehabilitation

1. A property will 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 will be retained and preserved. The removal of distinctive materials or alteration of features, spaces, and spatial relationships that characterize a property will be avoided.
3. Each property will 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 historic properties, will not be undertaken.
4. Changes to a property that have acquired historic significance in their own right will be retained and preserved.
5. Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize a property will be preserved.
6. Deteriorated historic features will be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature will match the old in design, color, texture, and, where possible, materials. Replacement of missing features will be substantiated by documentary and physical evidence.
7. Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.
8. Archeological resources will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.
9. New additions, exterior alterations, or related new construction will not destroy historic materials, features, and spatial relationships that characterize the

property. The new work shall be differentiated from the old and will 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 will 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.

## **Guidelines for Rehabilitation**

### *Choosing Rehabilitation as a Treatment*

In **Rehabilitation**, historic building materials and character-defining features are protected and maintained as they are in the treatment Preservation; however, an assumption is made prior to work that existing historic fabric has become damaged or deteriorated over time and, as a result, more repair and replacement will be required. Thus, latitude is given in the **Standards for Rehabilitation and Guidelines for Rehabilitation** to replace extensively deteriorated, damaged, or missing features using either traditional or substitute materials. Of the four treatments, only Rehabilitation includes an opportunity to make possible an efficient contemporary use through alterations and additions.

### *Identify, Retain, and Preserve Historic Materials and Features*

Like Preservation, guidance for the treatment **Rehabilitation** begins with recommendations to identify the form and detailing of those architectural materials and features that are important in defining the building's historic character and which must be retained in order to preserve that character. Therefore, guidance on **identifying, retaining, and preserving** character-defining features is always given first. The character of a historic building may be defined by the form and detailing of exterior materials, such as masonry, wood, and metal; exterior features, such as roofs, porches, and windows; interior materials, such as plaster and paint; and interior features, such as moldings and stairways, room configuration and spatial relationships, as well as structural and mechanical systems.

### *Protect and Maintain Historic Materials and Features*

After identifying those materials and features that are important and must be retained in the process of **Rehabilitation** work, then **protecting and maintaining** them are addressed. Protection generally involves the least degree of intervention and is preparatory to other work. For example, protection includes the maintenance

of historic material through treatments such as rust removal, caulking, limited paint removal, and re-application of protective coatings; the cyclical cleaning of roof gutter systems; or installation of fencing, alarm systems and other temporary protective measures. Although a historic building will usually require more extensive work, an overall evaluation of its physical condition should always begin at this level.

### *Repair Historic Materials and Features*

Next, when the physical condition of character-defining materials and features warrants additional work **repairing** is recommended. **Rehabilitation** guidance for the repair of historic materials such as masonry, wood, and architectural metals again begins with the least degree of intervention possible such as patching, piecing-in, splicing, consolidating, or otherwise reinforcing or upgrading them according to recognized preservation methods. Repairing also includes the limited replacement in kind--or with compatible substitute material--of extensively deteriorated or missing parts of features when there are surviving prototypes (for example, brackets, dentils, steps, plaster, or portions of slate or tile roofing). Although using the same kind of material is always the preferred option, substitute material is acceptable if the form and design as well as the substitute material itself convey the visual appearance of the remaining parts of the feature and finish.

### *Replace Deteriorated Historic Materials and Features*

Following repair in the hierarchy, **Rehabilitation** guidance is provided for **replacing** an entire character-defining feature with new material because the level of deterioration or damage of materials precludes repair (for example, an exterior cornice; an interior staircase; or a complete porch or storefront). If the essential form and detailing are still evident so that the physical evidence can be used to re-establish the feature as an integral part of the rehabilitation, then its replacement is appropriate. Like the guidance for repair, the preferred option is always replacement of the entire feature in kind, that is, with the same material. Because this approach may not always be technically or economically feasible, provisions are made to consider the use of a compatible substitute material. It should be noted that, while the National Park Service guidelines recommend the replacement of an entire character-defining feature that is extensively deteriorated, they never recommend removal and replacement with new material of a feature that--although damaged or deteriorated--could reasonably be repaired and thus preserved.

*Design for the Replacement of Missing Historic Features*

When an entire interior or exterior feature is missing (for example, an entrance, or cast iron facade; or a principal staircase), it no longer plays a role in physically defining the historic character of the building unless it can be accurately recovered in form and detailing through the process of carefully documenting the historical appearance. Although accepting the loss is one possibility, where an important architectural feature is missing, its replacement is always recommended in the **Rehabilitation** guidelines as the first or preferred, course of action. Thus, if adequate historical, pictorial, and physical documentation exists so that the feature may be accurately reproduced, and if it is desirable to re-establish the feature as part of the building's historical appearance, then designing and constructing a new feature based on such information is appropriate. However, a second acceptable option for the replacement feature is a new design that is compatible with the remaining character-defining features of the historic building. The new design should always take into account the size, scale, and material of the historic building itself and, most importantly, should be clearly differentiated so that a false historical appearance is not created.

*Alterations/Additions for the New Use*

Some exterior and interior alterations to a historic building are generally needed to assure its continued use, but it is most important that such alterations do not radically change, obscure, or destroy character-defining spaces, materials, features, or finishes. Alterations may include providing additional parking space on an existing historic building site; cutting new entrances or windows on secondary elevations; inserting an additional floor; installing an entirely new mechanical system; or creating an atrium or light well. Alteration may also include the selective removal of buildings or other features of the environment or building site that are intrusive and therefore detract from the overall historic character. The construction of an exterior addition to a historic building may seem to be essential for the new use, but it is emphasized in the **Rehabilitation** guidelines that such new additions should be avoided, if possible, and considered only after it is determined that those needs cannot be met by altering secondary, i.e., non character-defining interior spaces. If, after a thorough evaluation of interior solutions, an exterior addition is still judged to be the only viable alternative, it should be designed and constructed to be clearly differentiated from the historic building and so that the character-defining features are not radically changed, obscured, damaged, or destroyed. Additions and alterations to historic buildings are referenced within specific sections of the Rehabilitation guidelines such as Site, Roofs, Structural Systems, etc., but are addressed in detail in New Additions to Historic Buildings.

*Energy Efficiency/Accessibility Considerations and Health & Safety Code Considerations*

These sections of the guidance address work done to meet accessibility requirements and health and safety code requirements; or retrofitting measures to improve energy efficiency. Although this work is quite often an important aspect of **Rehabilitation** projects, it is usually not a part of the overall process of protecting or repairing character-defining features; rather, such work is assessed for its potential negative impact on the building's historic character. For this reason, particular care must be taken not to radically change, obscure, damage, or destroy character-defining materials or features in the process of meeting code and energy requirements.

End of Appendix A



## **Appendix B**

Building Feature Master List (Uniformat II)



## **Building Feature Master List (Uniformat II)**

The Building Feature Master List is the overall outline checklist used in the condition assessment of Building 839. This outline creates a hierarchical structure based on industry standards adopted by the government.

The category, topic, code and sub-code nomenclature is derived from current NPS condition assessment systems, which, in turn, utilize the format and structure of the *Uniformat* system used by many facility management industry leaders. Refer to Section 1 for a description of this methodology.

The following document is the blank master condition assessment outline designed for Building 839 and may be used for future reference.

<b>BUILDING FEATURE MASTER LIST (FMSS)</b> <b>UNIFORMAT II Work Breakdown Structure (WBS)</b> <b>(Rev. 2/13/2008)</b>				
<b>A</b>	<b>SUBSTRUCTURE</b>			
	<i>All work below the lowest floor construction and the enclosing elements required to a form basement.</i>			
	<b>A10</b>	<b>FOUNDATIONS</b>		
		A1010	Standard Foundations <i>Continuous footings, spread footings, grade beams, foundation walls, pile caps, and column piers.</i>	
			A101001	Wall Foundations
		A1030	Slab On Grade <i>A slab poured on earth.</i>	
			A103001	Standard Slab On Grade
<b>B</b>	<b>SHELL</b>			
	<i>All structural slabs, and decks and supports within basements and above grade. Includes both horizontal items and vertical structural components.</i>			
	<b>B10</b>	<b>SUPERSTRUCTURE</b>		
		B1010	Floor Construction <i>Could consist of wood, concrete, CMU, steel frame, etc.</i>	
			B101001	Structural Floor Frame
		B1020	Roof Construction <i>Framework supporting the roof and roof decks.</i>	
			B102001	Structural Roof Frame
	<b>B20</b>	<b>EXTERIOR ENCLOSURE</b>		
		<i>Exterior facing of the building, including all vertical and horizontal exterior closure facilities excluding roof.</i>		
		B2010	Exterior Walls <i>All materials associated with exterior wall construction.</i>	
			B201001	Exterior Skin
			B201001-1	Brick
			B201001-2	Wood Siding
			B201008	Exterior Soffits
			B201099	Masonry Chimneys
		B2020	Exterior Windows <i>All windows located in exterior walls.</i>	
			B2020-1	Basement Windows
			B2020-2	1 <sup>st</sup> Floor Windows
			B2020-3	2 <sup>nd</sup> Floor Windows
			B2020-4	Attic Windows
		B2030	Exterior Doors <i>All doors located in exterior walls.</i>	
			B2030-1	Basement Doors
			B2030-2	1 <sup>st</sup> Floor Doors

	<b>B30</b>	<b>ROOFING</b>	
		B3010	Roof Coverings <i>All waterproof roof coverings and insulation, together with skylights, hatches, ventilators, and all required trim.</i>
		B301001	Roof Finishes
		B301004	Flashings & Trim
		B301005	Gutters & Downspouts
<b>C</b>	<b>INTERIORS</b>		
	<i>Construction which takes place inside the exterior wall or exterior skin, excluding interior structural walls.</i>		
	<b>C10</b>	<b>INTERIOR CONSTRUCTION</b>	
		C1010	Partitions
		C101001	Fixed Partitions
		C1020	Interior Doors
		C102001	Standard Interior Doors
		C1030	Fittings
	<b>C20</b>	<b>STAIRS</b>	
		C2010	Stair Construction
		C201001	Interior Stair Structure
		C2020	Stair Finishes
	<b>C30</b>	<b>INTERIOR FINISHES</b>	
		C3010	Wall Finishes
		C3020	Floor Finishes
		C3030	Ceiling Finishes
<b>D</b>	<b>SERVICES</b>		
	<b>D20</b>	<b>PLUMBING</b>	
		<i>The plumbing system's primary function is the transfer of liquids and gases. System includes all water supply and waste items within the building.</i>	
	<b>D30</b>	<b>HVAC</b>	
		<i>All equipment, distribution systems, controls, and energy supply systems required by the heating, ventilating, and air conditioning system.</i>	
	<b>D40</b>	<b>FIRE PROTECTION SYSTEMS</b>	
		<i>Standard and special fire protection systems. See D503001 for fire alarm systems.</i>	
		D4030	Fire Protection Specialties
		D403001	Fire Extinguishing Devices
		D4090	Other Fire Protection Systems
		D409099	Smoke/Heat Detectors

	<b>D50</b>	<b>ELECTRICAL</b> <i>This system is defined by the electric current used or regarded as a source of power.</i>		
		D5010	Electrical Service & Distribution	
		D5020	Lighting & Branch Wiring	
		D5030	Communications & Security	
			D503001	Fire Alarm System
			D503003	Telecommunication System
			D503008	Security System
<b>G</b>	<b>BUILDING SITEWORK</b>			
	<b>G20</b>	<b>Site Improvements</b> <i>Includes improvements such as parking lots, sidewalks, roadways, fencing, retaining walls, and landscaping.</i>		
		G2020	Parking Lots	
		G2030	Pedestrian Paving	
		G2050	Landscaping	
	<b>G90</b>	<b>Other Site Work</b>		
		G9087	Overall Building Site Drainage	
END OF TABLE				

## **Appendix C**

### **Selected NPS Preservation Briefs**

- 2     Repointing Mortar Joints in Historic Masonry Buildings, 1998
- 4     Roofing for Historic Buildings, 1978
- 6     Dangers of Abrasive Cleaning to Historic Buildings, 1979
- 9     The Repair of Historic Wooden Windows, 1981
- 10    Exterior Paint Problems on Historic Woodwork, 1982
- 16    The Use of Substitute Materials on Historic Building Exteriors, 1988
- 17    Architectural Character - Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character, 1988
- 18    Rehabilitating Interiors in Historic Buildings - Identifying Character-Defining Elements, 1988
- 19    The Repair and Replacement of Historic Wooden Shingle Roofs, 1989
- 21    Repairing Historic Flat Plaster--Walls and Ceilings, 1989
- 24    Heating, Ventilating, and Cooling Historic Buildings: Problems and Recommended Approaches, 1991
- 31    Mothballing Historic Buildings, 1993
- 35    Understanding Old Buildings: The Process of Architectural Investigation, 1994
- 37    Appropriate Methods of Reducing Lead-Paint Hazards in Historic Housing, 2006
- 39    Holding the Line: Controlling Unwanted Moisture in Historic Buildings, 1996
- 47    Maintaining the Exterior of Small and Medium Size Historic Buildings, 2006

### **Selected Preservation Tech Notes**

- 10    Windows: Temporary Window Vents in Unoccupied Historic Buildings, 1985

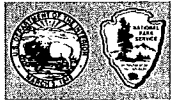




# 2 PRESERVATION BRIEFS

## Repointing Mortar Joints in Historic Masonry Buildings

Robert C. Mack, FAIA  
John P. Speweik



U.S. Department of the Interior  
National Park Service  
Cultural Resources  
Heritage Preservation Services

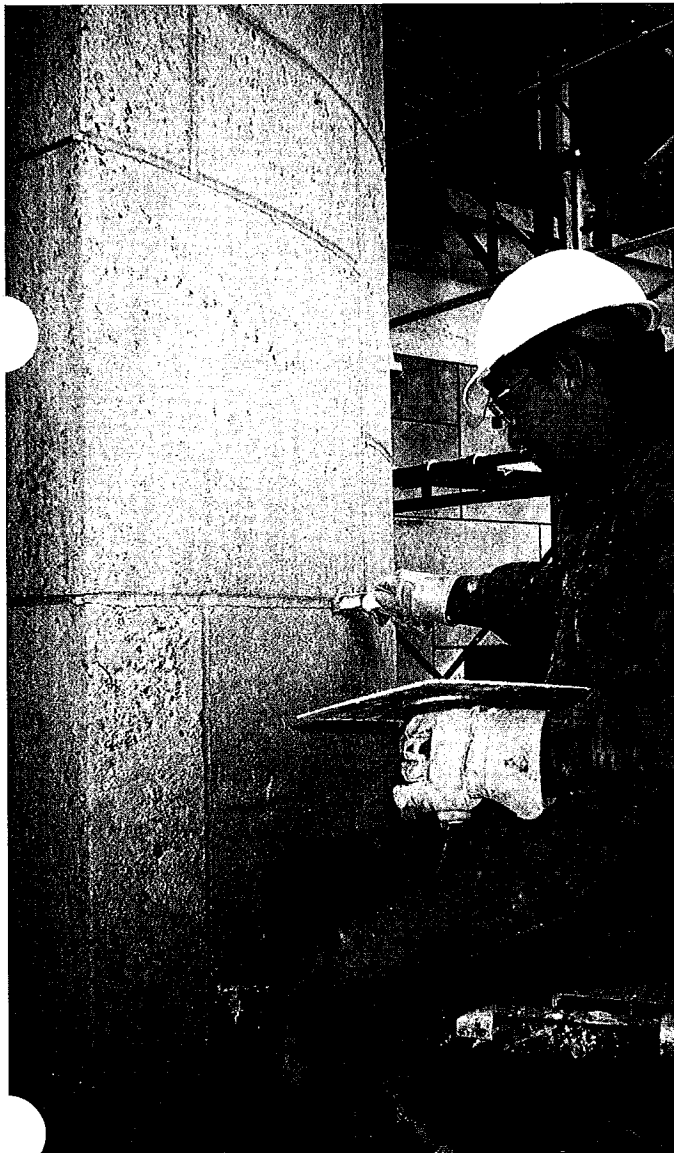
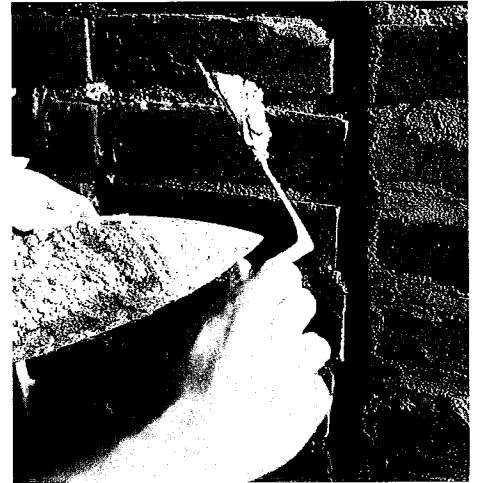


Figure 1. After removing deteriorated mortar, an experienced mason repoints a portion of this early-20th century limestone building. Photo: Robert C. Mack, FAIA.

Masonry — brick, stone, terra-cotta, and concrete block — is found on nearly every historic building. Structures with all-masonry exteriors come to mind immediately, but most other buildings at least have masonry foundations or chimneys. Although generally considered “permanent,” masonry is subject to deterioration, especially at the mortar joints. Repointing, also known simply as “pointing” or—somewhat inaccurately—“tuck pointing”\*, is the process of removing deteriorated mortar from the joints of a masonry wall and replacing it with new mortar (Fig. 1). Properly done, repointing restores the visual and physical integrity of the masonry. Improperly done, repointing not only detracts from the appearance of the building, but may also cause physical damage to the masonry units themselves.

The purpose of this Brief is to provide general guidance on appropriate materials and methods for repointing historic masonry buildings and it is intended to benefit building owners, architects, and contractors. The Brief should serve as a guide to prepare specifications for repointing historic masonry buildings. It should also help develop sensitivity to the particular needs of historic masonry, and to assist historic building owners in working cooperatively with architects, architectural conservators and historic preservation consultants, and contractors. Although specifically intended for historic buildings, the guidance is appropriate for other masonry buildings as well. This publication updates *Preservation Briefs 2: Repointing Mortar Joints in Historic Brick Buildings* to include all types of historic unit masonry. The scope of the earlier Brief has also been expanded to acknowledge that the many buildings constructed in the first half of the 20th century are now historic and eligible for listing in the National Register of Historic Places, and that they may have been originally constructed with portland cement mortar.

\*Tuckpointing technically describes a primarily decorative application of a raised mortar joint or lime putty joint on top of flush mortar joints.

## Historical Background

Mortar consisting primarily of lime and sand has been used as an integral part of masonry structures for thousands of years. Up until about the mid-19th century, lime or quicklime (sometimes called lump lime) was delivered to construction sites, where it had to be slaked, or combined with water. Mixing with water caused it to boil and resulted in a wet lime putty that was left to mature in a pit or wooden box for several weeks, up to a year. Traditional mortar was made from lime putty, or slaked lime, combined with local sand, generally in a ratio of 1 part lime putty to 3 parts sand by volume. Often other ingredients, such as crushed marine shells (another source of lime), brick dust, clay, natural cements, pigments, and even animal hair were also added to mortar, but the basic formulation for lime putty and sand mortar remained unchanged for centuries until the advent of portland cement or its forerunner, Roman cement, a natural, hydraulic cement.

**Portland cement** was patented in Great Britain in 1824. It was named after the stone from Portland in Dorset which it resembled when hard. This is a fast-curing, hydraulic cement which hardens under water. Portland cement was first manufactured in the United States in 1872, although it was imported before this date. But it was not in common use throughout the country until the early 20th century. Up until the turn of the century portland cement was considered primarily an additive, or "minor ingredient" to help accelerate mortar set time. By the 1930s, however, most masons used a mix of equal parts portland cement and lime putty. Thus, the mortar found in masonry structures built between 1873 and 1930 can range from pure lime and sand mixes to a wide variety of lime, portland cement, and sand combinations.

In the 1930s more new mortar products intended to hasten and simplify masons' work were introduced in the U.S. These included **masonry cement**, a premixed, bagged mortar which is a combination of portland cement and ground limestone, and **hydrated lime**, machine-slaked lime that eliminated the necessity of slaking quicklime into putty at the site.

## Identifying the Problem Before Repointing

The decision to repoint is most often related to some obvious sign of deterioration, such as disintegrating mortar, cracks in mortar joints, loose bricks or stones, damp walls, or damaged plasterwork. It is, however, erroneous to assume that repointing alone will solve deficiencies that result from other problems (Fig. 2). The root cause of the deterioration—leaking roofs or gutters, differential settlement of the building, capillary action causing rising damp, or extreme weather exposure—should always be dealt with prior to beginning work. Without appropriate repairs to eliminate the source of the problem, mortar deterioration will continue and any repointing will have been a waste of time and money.

**Use of Consultants.** Because there are so many possible causes for deterioration in historic buildings, it may be desirable to retain a consultant, such as a historic architect or architectural conservator, to analyze the building. In addition to determining the most appropriate solutions to the problems, a consultant can

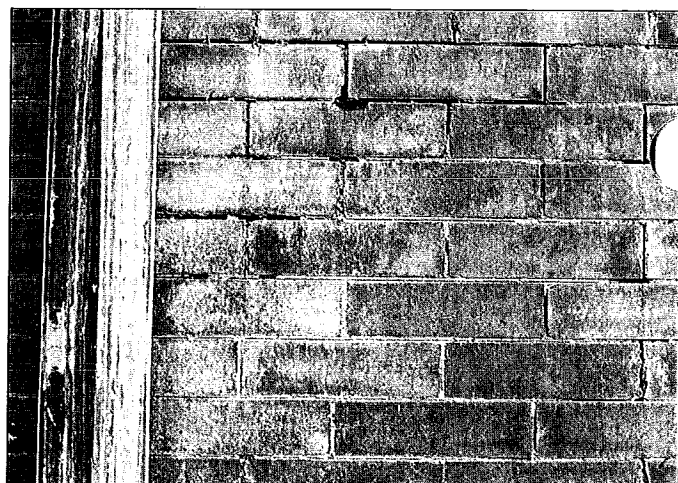


Figure 2. Much of the mortar on this building has been leached away by water from a leaking downspout. The downspout must be replaced and any other drainage problems repaired before repointing. Photo: Robert C. Mack, FAIA.

prepare specifications which reflect the particular requirements of each job and can provide oversight of the work in progress. Referrals to preservation consultants frequently can be obtained from State Historic Preservation Offices, the American Institute for Conservation of Historic and Artistic Works (AIC), the Association for Preservation Technology (APT), and local chapters of the American Institute of Architects (AIA).

## Finding an Appropriate Mortar Match

Preliminary research is necessary to ensure that the proposed repointing work is both physically and visually appropriate to the building. Analysis of unweathered portions of the historic mortar to which the new mortar will be matched can suggest appropriate mixes for the repointing mortar so that it will not damage the building because it is excessively strong or vapor impermeable. Examination and analysis of the masonry units—brick, stone or terra cotta—and the techniques used in the original construction will assist in maintaining the building's historic appearance (Figs. 3-4). A simple, non-technical, evaluation of the masonry units and mortar can provide information concerning the relative strength and permeability of each—critical factors in selecting the repointing mortar—while a visual analysis of the historic mortar can provide the information necessary for developing the new mortar mix and application techniques.

Although not crucial to a successful repointing project, for projects involving properties of special historic significance, a mortar analysis by a qualified laboratory can be useful by providing information on the original ingredients. However, there are limitations with such an analysis, and replacement mortar specifications should not be based solely on laboratory analysis. Analysis requires interpretation, and there are important factors which affect the condition and performance of the mortar that cannot be established through laboratory analysis. These may include: the original water content, rate of curing, weather conditions during original construction, the method of mixing and placing the mortar, and the cleanliness and condition of the sand. *The most useful information that can come out of laboratory analysis is the identification of sand by*

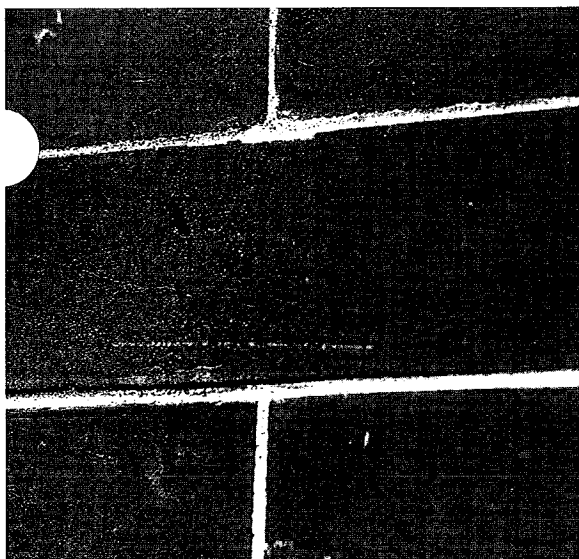


Figure 3. Good-quality repointing closely replicates the original in composition, texture, joint type and profile on this 19th century brick building (left), and on this late-19th century granite on H.H. Richardson's Glessner House in Chicago (right). Photos: Charles E. Fisher; Sharon C. Park, FAIA.

*gradation and color.* This allows the color and the texture of the mortar to be matched with some accuracy because sand is the largest ingredient by volume.

In creating a repointing mortar that is compatible with the masonry units, the objective is to achieve one that matches the historic mortar as closely as possible, so that the new material can coexist with the old in a sympathetic, supportive and, if necessary, sacrificial capacity. The exact physical and chemical properties of the historic mortar are of major significance as long as the new mortar conforms to the following criteria:

- The new mortar must match the historic mortar in color, texture and tooling. (If a laboratory analysis is undertaken, it may be possible to match the binder components and their proportions with the historic mortar, if those materials are available.)
- The sand must match the sand in the historic mortar. (The color and texture of the new mortar will usually fall in place if the sand is matched successfully.)

- The new mortar must have **greater vapor permeability** and be **softer** (measured in compressive strength) than the masonry units.

- The new mortar must be **as vapor permeable** and **as soft or softer** (measured in compressive strength) than the historic mortar. (Softness or hardness is not necessarily an indication of permeability; old, hard lime mortars can still retain high permeability.)

### Properties of Mortar

Mortars for repointing should be softer or more permeable than the masonry units and no harder or more impermeable than the historic mortar to prevent damage to the masonry units. It is a common error to assume that hardness or high strength is a measure of appropriateness, particularly for lime-based historic mortars. Stresses within a wall caused by expansion, contraction, moisture migration, or settlement must be accommodated in some manner; in a masonry wall these



Figure 4. (left) The poor quality of this repointing—it appears to have been “tooled” with the mason’s finger—does not match the delicacy of the original beaded joint on this 19th-century brick wall. (right) It is obvious that the repointing on this “test patch” is not an appropriate replacement mortar joint for this early-19th century stone foundation. Photos: Lee H. Nelson, FAIA.

stresses should be relieved by the mortar rather than by the masonry units. A mortar that is stronger in compressive strength than the masonry units, will not "give," thus causing the stresses to be relieved through the masonry units—resulting in permanent damage to the masonry, such as cracking and spalling, that cannot be repaired easily (Fig. 5). While stresses can also break the bond between the mortar and the masonry units, permitting water to penetrate the resulting hairline cracks, this is easier to correct in the joint through repointing than if the break occurs in the masonry units.

Permeability, or rate of vapor transmission, is also critical. High lime mortars are more permeable than denser cement mortars. Historically, mortar acted as a bedding material—not unlike an expansion joint—rather than a "glue" for the masonry units, and moisture was able to migrate through the mortar joints rather than the masonry units. When moisture evaporates from the masonry it deposits any soluble salts either on the surface as *efflorescence* or below the surface as *subflorescence*. While salts deposited on the surface of masonry units are usually relatively harmless, salt crystallization within a masonry unit creates pressure that can cause parts of the outer surface to spall off or delaminate. If the mortar does not permit moisture or moisture vapor to migrate out of the wall and evaporate, the result will be damage to the masonry units.

## Components of Mortar

**Sand.** Sand is the largest component of mortar and the material that gives mortar its distinctive color, texture and cohesiveness. Sand must be free of impurities, such as salts or clay. The three key characteristics of sand are: particle shape, gradation and void ratios.



Figure 5. The use of hard, portland-cement mortar that is less permeable than the soft bricks has resulted in severe damage to this brick wall. Moisture trapped in the wall was unable to evaporate through the mortar which is intended to be sacrificial, and thus protect the bricks. As a result the moisture remained in the walls until water pressure eventually popped the surface off the bricks. Photo: National Park Service Files.

When viewed under a magnifying glass or low-power microscope, particles of sand generally have either rounded edges, such as found in beach and river sand, or sharp, angular edges, found in crushed or manufactured sand. For repointing mortar, rounded or natural sand is preferred for two reasons. It is usually similar to the sand in the historic mortar and provides a better visual match. It also has better working qualities or plasticity and can thus be forced into the joint more easily, forming a good contact with the remaining historic mortar and the surface of the adjacent masonry units. Although manufactured sand is frequently more readily available, it is usually possible to locate a supply of rounded sand.

The gradation of the sand (particle size distribution) plays a very important role in the durability and cohesive properties of a mortar. Mortar must have a certain percentage of large to small particle sizes in order to deliver the optimum performance. Acceptable guidelines on particle size distribution may be found in ASTM C 144 (American Society for Testing and Materials). However, in actuality, since neither historic nor modern sands are always in compliance with ASTM C 144, matching the same particle appearance and gradation usually requires sieving the sand.

A scoop of sand contains many small voids between the individual grains. A mortar that performs well fills all these small voids with binder (cement/lime combination or mix) in a balanced manner. Well-graded sand generally has a 30 per cent void ratio by volume. Thus, 30 per cent binder by volume generally should be used unless the historic mortar had a different binder: aggregate ratio. This represents the 1:3 binder to sand ratios often seen in mortar specifications.

For repointing, sand generally should conform to ASTM C 144 to assure proper gradation and freedom from impurities; some variation may be necessary to match the original size and gradation. Sand color and texture also should match the original as closely as possible to provide the proper color match without other additives.

**Lime.** Mortar formulations prior to the late-19th century used lime as the primary binding material. Lime is derived from heating limestone at high temperatures which burns off the carbon dioxide, and turns the limestone into quicklime. There are three types of limestone—calcium, magnesium, and dolomitic—differentiated by the different levels of magnesium carbonate they contain which impart specific qualities to mortar. Historically, calcium lime was used for mortar rather than the dolomitic lime (calcium magnesium carbonate) most often used today. But it is also important to keep in mind the fact that the historic limes, and other components of mortar, varied a great deal because they were natural, as opposed to modern lime which is manufactured and, therefore, standardized. Because some of the kinds of lime, as well as other components of mortar, that were used historically are no longer readily available, even when a conscious effort made to replicate a "historic" mix, this may not be achievable due to the differences between modern and historic materials.



Lime, itself, when mixed with water into a paste is very plastic and creamy. It will remain workable and soft indefinitely, if stored in a sealed container. Lime (calcium hydroxide) hardens by carbonation absorbing carbon dioxide primarily from the air, converting itself to calcium carbonate. Once a lime and sand mortar is mixed and placed in a wall, it begins the process of carbonation. If lime mortar is left to dry too rapidly, carbonation of the mortar will be reduced, resulting in poor adhesion and poor durability. In addition, lime mortar is slightly water soluble and thus is able to re-seal any hairline cracks that may develop during the life of the mortar. Lime mortar is soft, porous, and changes little in volume during temperature fluctuations, thus making it a good choice for historic buildings. *Because of these qualities, high calcium lime mortar may be considered for many repointing projects, not just those involving historic buildings.*

For repointing, lime should conform to ASTM C 207, Type S, or Type SA, Hydrated Lime for Masonry Purposes. This machine-slaked lime is designed to assure high plasticity and water retention. The use of quicklime which must be slaked and soaked by hand may have advantages over hydrated lime in some restoration projects if time and money allow.

**Lime putty.** Lime putty is slaked lime that has a putty or paste-like consistency. It should conform to ASTM C 5. Mortar can be mixed using lime putty according to ASTM C 270 property or proportion specification.

**Portland cement.** More recent, 20th-century mortar has used portland cement as a primary binding material. A straight portland cement and sand mortar is extremely hard, resists the movement of water, shrinks upon setting, and undergoes relatively large thermal movements. When mixed with water, portland cement forms a harsh, stiff paste that is quite unworkable, becoming hard very quickly. (Unlike lime, portland cement will harden regardless of weather conditions and does not require wetting and drying cycles.) Some portland cement assists the workability and plasticity of the mortar without adversely affecting the finished project; it also provides early strength to the mortar and speeds setting. Thus, it may be appropriate to add some portland cement to an essentially lime-based mortar even when repointing relatively soft 18th or 19th century brick under some circumstances when a slightly harder mortar is required. The more portland cement that is added to a mortar formulation the harder it becomes—and the faster the initial set.

For repointing, portland cement should conform to ASTM C 150. White, non-staining portland cement may provide a better color match for some historic mortars than the more commonly available grey portland cement. But, it should not be assumed, however, that white portland cement is always appropriate for all historic buildings, since the original mortar may have been mixed with grey cement. The cement should not have more than 0.60 per cent alkali to help avoid efflorescence.

**Masonry cement.** Masonry cement is a preblended mortar mix commonly found at hardware and home repair stores. It is designed to produce mortars with a compressive strength of 750 psi or higher when mixed

## MORTAR ANALYSIS

Methods for analyzing mortars can be divided into two broad categories: **wet chemical** and **instrumental**. Many laboratories that analyze historic mortars use a simple **wet-chemical** method called *acid digestion*, whereby a sample of the mortar is crushed and then mixed with a dilute acid. The acid dissolves all the carbonate-containing minerals not only in the binder, but also in the aggregate (such as oyster shells, coral sands, or other carbonate-based materials), as well as any other acid-soluble materials. The sand and fine-grained acid-insoluble material is left behind. There are several variations on the simple acid digestion test. One involves collecting the carbon dioxide gas given off as the carbonate is digested by the acid; based on the gas volume the carbonate content of the mortar can be accurately determined (Jedrzejewska, 1960). Simple acid digestion methods are rapid, inexpensive, and easy to perform, but the information they provide about the original composition of a mortar is limited to the color and texture of the sand. The gas collection method provides more information about the binder than a simple acid digestion test.

**Instrumental** analysis methods that have been used to evaluate mortars include polarized light or thin-section microscopy, scanning electron microscopy, atomic absorption spectroscopy, X-ray diffraction, and differential thermal analysis. All instrumental methods require not only expensive, specialized equipment, but also highly-trained experienced analysts. However, instrumental methods can provide much more information about a mortar. Thin-section microscopy is probably the most commonly used instrumental method. Examination of thin slices of a mortar in transmitted light is often used to supplement acid digestion methods, particularly to look for carbonate-based aggregate. For example, the new ASTM test method, ASTM C 1324-96 "Test Method for Examination and Analysis of Hardened Mortars" which was designed specifically for the analysis of modern lime-cement and masonry cement mortars, combines a complex series of wet chemical analyses with thin-section microscopy.

The drawback of most mortar analysis methods is that mortar samples of known composition have not been analyzed in order to evaluate the method. Historic mortars were not prepared to narrowly defined specifications from materials of uniform quality; they contain a wide array of locally derived materials combined at the discretion of the mason. While a particular method might be able to accurately determine the original proportions of a lime-cement-sand mortar prepared from modern materials, the usefulness of that method for evaluating historic mortars is questionable unless it has been tested against mortars prepared from materials more commonly used in the past.

**Lorraine Schnabel.**

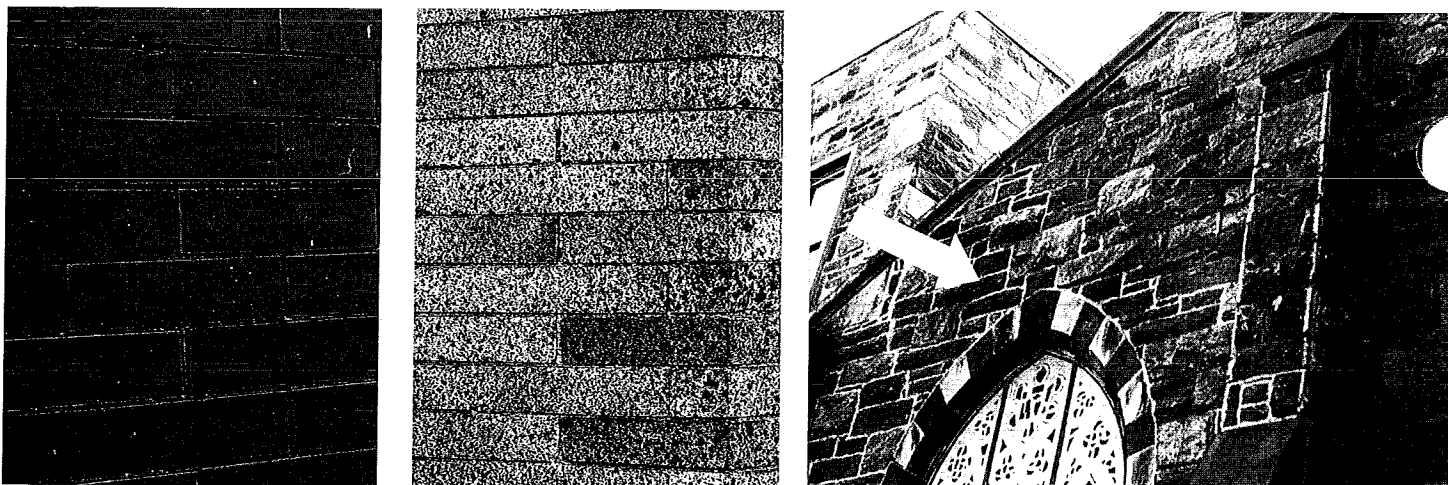


Figure 6. Tinted mortar. (left) Black mortar with a beaded joint was used here on this late-19th century hard pressed red brick and, (center) a dark brown tinted mortar with an almost flush joint was used on this early-20th century Roman brick. (right) When constructed at the turn-of-the-century, this building was pointed with a dark gray mortar to blend with the color of the stone, but the light-colored mortar used in spot repointing has destroyed this harmony and adversely impacts the building's historic character. Photos: Anne Grimmer.

with sand and water at the job site. It may contain hydrated lime, but it always contains a large amount of portland cement, as well as ground limestone and other workability agents, including air-entraining agents. Because masonry cements are not required to contain hydrated lime, and generally do not contain lime, they produce high strength mortars that can damage historic masonry. *For this reason, they generally are not recommended for use on historic masonry buildings.*

**Lime mortar (pre-blended).** Hydrated lime mortars, and pre-blended lime putty mortars with or without a matched sand are commercially available. Custom mortars are also available with color. In most instances, pre-blended lime mortars containing sand may not provide an exact match; however, if the project calls for total repointing, a pre-blended lime mortar may be worth considering as long as the mortar is compatible in strength with the masonry. If the project involves only selected, "spot" repointing, then it may be better to carry out a mortar analysis which can provide a custom pre-blended lime mortar with a matching sand. In either case, if a preblended lime mortar is to be used, it should contain Type S or SA hydrated lime conforming to ASTM C 207.

**Water.** Water should be potable—clean and free from acids, alkalis, or other dissolved organic materials.

### Other Components

**Historic components.** In addition to the color of the sand, the texture of the mortar is of critical importance in duplicating historic mortar. Most mortars dating from the mid-19th century on—with some exceptions—have a fairly homogeneous texture and color. Some earlier mortars are not as uniformly textured and may contain lumps of partially burned lime or "dirty lime", shell (which often provided a source of lime, particularly in coastal areas), natural cements, pieces of clay, lampblack or other pigments, or even animal hair. The visual characteristics of these mortars can be duplicated through the use of similar materials in the repointing mortar.

Replicating such unique or individual mortars will require writing new specifications for each project. If possible, suggested sources for special materials should

be included. For example, crushed oyster shells can be obtained in a variety of sizes from poultry supply dealers.

**Pigments.** Some historic mortars, particularly in the late 19th century, were tinted to match or contrast with the brick or stone (Fig. 6). Red pigments, sometimes in the form of brick dust, as well as brown, and black pigments were commonly used. Modern pigments are available which can be added to the mortar at the job site, but they should not exceed 10 per cent by weight of the portland cement in the mix, and carbon black should be limited to 2 per cent. Only synthetic mineral oxides, which are alkali-proof and sun-fast, should be used to prevent bleaching and fading.

**Modern components.** Admixtures are used to create specific characteristics in mortar, and whether they should be used will depend upon the individual project. *Air-entraining agents*, for example, help the mortar to resist freeze-thaw damage in northern climates. *Accelerators* are used to reduce mortar freezing prior to setting while *retarders* help to extend the mortar life in hot climates. Selection of admixtures should be made by the architect or architectural conservator as part of the specifications, not something routinely added by the masons.

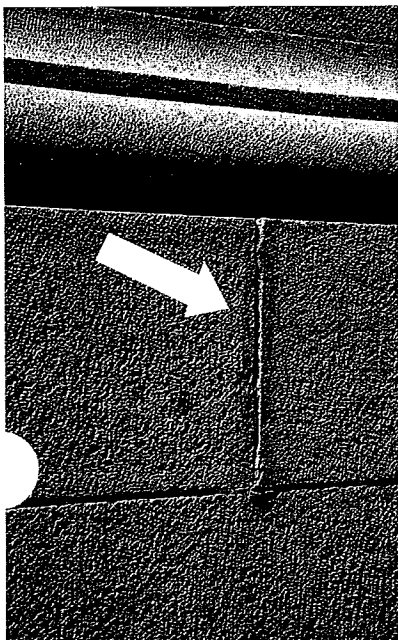
Generally, modern chemical additives are unnecessary and may, in fact, have detrimental effects in historic masonry projects. The use of antifreeze compounds is not recommended. They are not very effective with high lime mortars and may introduce salts, which may cause efflorescence later. A better practice is to warm the sand and water, and to protect the completed work from freezing. No definitive study has determined whether air-entraining additives should be used to resist frost action and enhance plasticity, but in areas of extreme exposure requiring high-strength mortars with lower permeability, air-entrainment of 10-16 percent may be desirable (see formula for "severe weather exposure" in **Mortar Type and Mix**). Bonding agents are not a substitute for proper joint preparation, and they should generally be avoided. If the joint is properly prepared, there will be a good bond between the new mortar and the adjacent surfaces. In addition, a bonding agent is difficult to remove if smeared on a masonry surface (Fig. 7).



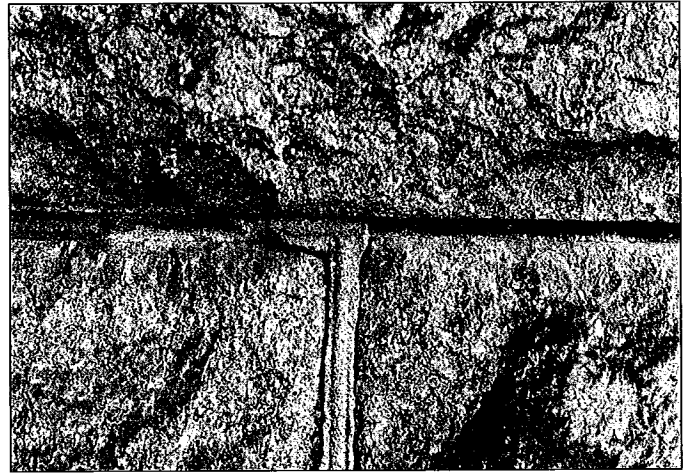
## Mortar Type and Mix

Mortars for repointing projects, especially those involving historic buildings, typically are custom mixed in order to ensure the proper physical and visual qualities. These materials can be combined in varying proportions to create a mortar with the desired performance and durability. The actual specification of a particular mortar type should take into consideration all of the factors affecting the life of the building including: current site conditions, present condition of the masonry, function of the new mortar, degree of weather exposure, and skill of the mason. Thus, no two repointing projects are exactly the same. Modern materials specified for use in repointing mortar should conform to specifications of the American Society for Testing and Materials (ASTM) or comparable federal specifications, and the resulting mortar should conform to ASTM C 270, Mortar for Unit Masonry.

Specifying the proportions for the repointing mortar for a specific job is not as difficult as it might seem. Five mortar types, each with a corresponding recommended mix, have been established by ASTM to distinguish high strength mortar from soft flexible mortars. The ASTM designated them in decreasing order of approximate general strength as Type M (2,500 psi), Type S (1,800 psi), Type N (750 psi), Type O (350 psi) and Type K (75 psi). (The letters identifying the types are from the words MASON WORK using every other letter.) Type K has the highest lime content of the mixes that contain portland cement, although it is seldom used today, except for some historic preservation projects. The designation "L" in the accompanying chart identifies a straight lime and sand mix. Specifying the appropriate ASTM mortar by proportion of ingredients, will ensure the desired physical properties. Unless specified otherwise, measurements or proportions for mortar mixes are always given in the following order: cement-lime-sand. Thus, a Type K mix, for example, would be referred to as 1-3-10, or 1 part cement to 3 parts lime to 10 parts sand. Other requirements to create the desired visual qualities should be included in the specifications.



*Figure 7. The dark stain on either side of the vertical joint on this sandstone watertable probably resulted from the use of a bonding agent that was not properly cleaned off the masonry after repointing. Photo: Anne Grimmer.*



*Figure 8. Due to inadequate joint preparation, the repointing mortar has not adhered properly and is falling out of the joint. Photo: Robert C. Mack, FAIA.*

The strength of a mortar can vary. If mixed with higher amounts of portland cement, a harder mortar is obtained. The more lime that is added, the softer and more plastic the mortar becomes, increasing its workability. A mortar strong in compressive strength might be desirable for a hard stone (such as granite) pier holding up a bridge deck, whereas a softer, more permeable lime mortar would be preferable for a historic wall of soft brick. Masonry deterioration caused by salt deposition results when the mortar is less permeable than the masonry unit. A strong mortar is still more permeable than hard dense stone. However, in a wall constructed of soft bricks where the masonry unit itself has a relatively high permeability or vapor transmission rate, a soft, high lime mortar is necessary to retain sufficient permeability.

## Budgeting and Scheduling

Repointing is both expensive and time consuming due to the extent of handwork and special materials required. It is preferable to repoint only those areas that require work rather than an entire wall, as is often specified. But, if 25 to 50 per cent or more of a wall needs to be repointed, repointing the entire wall may be more cost effective than spot repointing. Total repointing may also be more sensible when access is difficult, requiring the erection of expensive scaffolding (unless the majority of the mortar is sound and unlikely to require replacement in the foreseeable future). Each project requires judgement based on a variety of factors. Recognizing this at the outset will help to prevent many jobs from becoming prohibitively expensive.

In scheduling, seasonal aspects need to be considered first. Generally speaking, wall temperatures between 40 and 95 degrees F (8 and 38 degrees C) will prevent freezing or excessive evaporation of the water in the mortar. Ideally, repointing should be done in shade, away from strong sunlight in order to slow the drying process, especially during hot weather. If necessary, shade can be provided for large-scale projects with appropriate modifications to scaffolding.

The relationship of repointing to other work proposed on the building must also be recognized. For example, if paint removal or cleaning is anticipated, and if the mortar joints are basically sound and need only selective repointing, it is generally better to postpone repointing

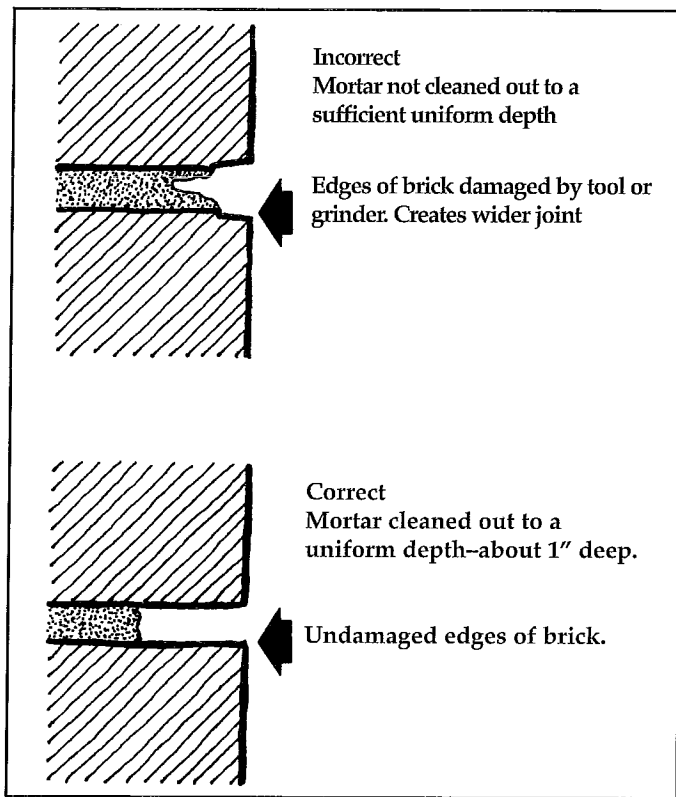


Figure 9. Comparison of incorrect and correct preparation of mortar joints for repointing. Drawing: Robert C. Mack, FAIA, and David W. Look, AIA.

until after completion of these activities. However, if the mortar has eroded badly, allowing moisture to penetrate deeply into the wall, repointing should be accomplished before cleaning. Related work, such as structural or roof repairs, should be scheduled so that they do not interfere with repointing and so that all work can take maximum advantage of erected scaffolding.

Building managers also must recognize the difficulties that a repointing project can create. The process is time consuming, and scaffolding may need to remain in place for an extended period of time. The joint preparation process can be quite noisy and can generate large quantities of dust which must be controlled, especially at air intakes to protect human health, and also where it might damage operating machinery. Entrances may be blocked from time to time making access difficult for both building tenants and visitors. Clearly, building managers will need to coordinate the repointing work with other events at the site.

## Contractor Selection

The ideal way to select a contractor is to ask knowledgeable owners of recently repointed historic buildings for recommendations. Qualified contractors then can provide lists of other repointing projects for inspection. More commonly, however, the contractor for a repointing project is selected through a competitive bidding process over which the client or consultant has only limited control. In this situation it is important to ensure that the specifications stipulate that masons must have a minimum of five years' experience with repointing historic masonry buildings to be eligible to bid on the project. Contracts are awarded to the lowest responsible

bidder, and bidders who have performed poorly on other projects usually can be eliminated from consideration on this basis, even if they have the lowest prices.

The contract documents should call for unit prices as well as a base bid. Unit pricing forces the contractor to determine in advance what the cost addition or reduction will be for work which varies from the scope of the base bid. If, for example, the contractor has fifty linear feet less of stone repointing than indicated on the contract documents but thirty linear feet more of brick repointing, it will be easy to determine the final price for the work. Note that each type of work—brick repointing, stone repointing, or similar items—will have its own unit price. The unit price also should reflect quantities; one linear foot of pointing in five different spots will be more expensive than five contiguous linear feet.

## Execution of the Work

**Test Panels.** These panels are prepared by the contractor using the same techniques that will be used on the remainder of the project. Several panel locations—preferably not on the front or other highly visible location of the building—may be necessary to include all types of masonry, joint styles, mortar colors, and other problems likely to be encountered on the job. If cleaning tests, for



Figure 10. Using a hammer and masonry chisel is the least damaging and, thus, generally the preferred method of removing old mortar in preparation for repointing historic masonry. Photo: John P. Speweik.



Figure 11. The damage to the edges and corners of these historic bricks was caused by using a mechanical grinder to rake out the joints. Note the overcutting of the head joint and the damage to the arises (corners) of the bricks. Photo: Lee H. Nelson, FAIA.

example, are also to be undertaken, they should be carried out in the same location. Usually a 3 foot by 3 foot area is sufficient for brickwork, while a somewhat larger area may be required for stonework. These panels establish an acceptable standard of work and serve as a benchmark for evaluating and accepting subsequent work on the building.

**Joint Preparation.** Old mortar should be removed to a minimum depth of 2 to 2- $\frac{1}{2}$  times the width of the joint to ensure an adequate bond and to prevent mortar “popouts” (Fig. 8). For most brick joints, this will require removal of the mortar to a depth of approximately  $\frac{1}{2}$  to 1 inch; for stone masonry with wide joints, mortar may need to be removed to a depth of several inches. Any loose or disintegrated mortar beyond this minimum depth also should be removed (Fig. 9).

Although some damage may be inevitable, careful joint preparation can help limit damage to masonry units. The traditional manner of removing old mortar is through the use of hand chisels and mash hammers (Fig. 10). Though labor-intensive, in most instances this method poses the least threat for damage to historic masonry units and produces the best final product.

The most common method of removing mortar, however, is through the use of power saws or grinders. The use of power tools by unskilled masons can be disastrous for historic masonry, particularly soft brick. Using power saws on walls with thin joints, such as most brick walls, almost always will result in damage to the masonry units by breaking the edges and by overcutting on the head, or vertical joints (Fig. 11).

However, small pneumatically-powered chisels generally can be used safely and effectively to remove mortar on historic buildings as long as the masons maintain appropriate control over the equipment.



Figure 12.. A power grinder, operated correctly by a skilled mason may be used in preparation for repointing to cut wide, horizontal mortar joints, typical of many early-20th century brick structures without causing damage to the brick. Note the use of protective safety equipment. Photo: Robert C. Mack, FAIA.

Under certain circumstances, thin diamond-bladed grinders may be used to cut out *horizontal* joints only on hard portland cement mortar common to most early-20th century masonry buildings (Fig. 12). Usually, automatic tools most successfully remove old mortar without damaging the masonry units when they are used in combination with hand tools in preparation for repointing. Where horizontal joints are uniform and fairly wide, it may be possible to use a power masonry saw to assist the removal of mortar, such as by cutting along the middle of the joint; final mortar removal from the sides of the joints still should be done with a hand chisel and hammer. Caulking cutters with diamond blades can sometimes be used successfully to cut out joints without damaging the masonry. Caulking cutters are slow; they do not rotate, but vibrate at very high speeds, thus minimizing the possibility of damage to masonry units (Fig. 13). Although mechanical tools may be used safely in limited circumstances to cut out horizontal joints in preparation for repointing, they should never be used on vertical joints because of the danger of slipping and cutting into the brick above or below the vertical joint. Using power tools to remove mortar without damaging the surrounding masonry units also necessitates highly skilled masons experienced in working on historic masonry buildings. Contractors



Figure 13. (left) In preparation for repointing, the mortar joints on these granite steps are first cut out mechanically (note the vacuum attached to the cutting tool in foreground to cut down on dust). (right) Final removal of the old mortar is done by hand to avoid damage to the edges of the joints. Mechanical preparation of horizontal joints by an experienced mason may sometimes be acceptable, especially where the joints are quite wide and the masonry is a very hard stone. Photos: Anne Grimmer.

should demonstrate proficiency with power tools before their use is approved.

Using any of these power tools may also be more acceptable on hard stone, such as quartzite or granite, than on terra cotta with its glass-like glaze, or on soft brick or stone. The test panel should determine the acceptability of power tools. If power tools are to be permitted, the contractor should establish a quality control program to account for worker fatigue and similar variables.

Mortar should be removed cleanly from the masonry units, leaving square corners at the back of the cut. Before filling, the joints should be rinsed with a jet of water to remove all loose particles and dust. At the time of filling, the joints should be damp, but with no standing water present. For masonry walls—limestone, sandstone and common brick—that are extremely absorbent, it is recommended that a continual mist of water be applied for a few hours before repointing begins.

**Mortar Preparation.** Mortar components should be measured and mixed carefully to assure the uniformity of visual and physical characteristics. Dry ingredients are measured by volume and thoroughly mixed before the addition of any water. Sand must be added in a damp, loose condition to avoid over sanding. Repointing mortar is typically pre-hydrated by adding water so it will just hold together, thus allowing it to stand for a period of time before the final water is added. Half the water should be added, followed by mixing for approximately 5 minutes. The remaining water should then be added in small portions until a mortar of the desired consistency is reached. The total volume of water necessary may vary from batch to batch, depending on weather conditions. It is important

to keep the water to a minimum for two reasons: first, a drier mortar is cleaner to work with, and it can be compacted tightly into the joints; second, with no excess water to evaporate, the mortar cures without shrinkage cracks. Mortar should be used within approximately 3 minutes of final mixing, and "retempering," or adding more water, should not be permitted.

**Using Lime Putty to Make Mortar.** Mortar made with lime putty and sand, sometimes referred to as roughage or course stuff, should be measured by volume, and may require slightly different proportions from those used with hydrated lime (Fig. 14). No additional water is usually needed to achieve a workable consistency because enough water is already contained in the putty. Sand is proportioned first, followed by the lime putty, then mixed for five minutes or until all the sand is thoroughly coated with the lime putty. But mixing, in the familiar sense of turning over with a hoe, sometimes may not be sufficient if the best possible performance is to be obtained from a lime putty mortar. Although the old practice of chopping, beating and ramming the mortar has largely been forgotten, recent field work has confirmed that lime putty and sand rammed and beaten with a wooden mallet or ax handle, interspersed by chopping with a hoe, can significantly improve workability and performance. The intensity of this action increases the overall lime/sand contact and removes any surplus water by compacting the other ingredients. It may also be advantageous for larger projects to use a mortar pan mill for mixing. Mortar pan mills which have a long tradition in Europe produce a superior lime putty mortar not attainable with today's modern paddle and drum type mixers.

For larger repointing projects the lime putty and sand can be mixed together ahead of time and stored indefinitely, on or off site, which eliminates the need for piles of sand on the job site. This mixture, which resembles damp brown sugar, must be protected from the air in sealed containers with a wet piece of burlap over the top or sealed in a large plastic bag to prevent evaporation and premature carbonation. The lime putty and sand mixture can be recombined into a workable plastic state months later with no additional water.

If portland cement is specified in a lime putty and sand mortar—Type O (1:2:9) or Type K (1:3:11)—the portland cement should first be mixed into a slurry paste before adding it to the lime putty and sand. Not only will this ensure that the portland cement is evenly distributed throughout the mixture, but if dry portland cement is added to wet ingredients it tends to "ball up," jeopardizing dispersion. (Usually water must be added to the lime putty and sand anyway once the portland cement is introduced.) Any color pigments should be added at this stage and mixed for a full five minutes. The mortar should be used within 30 minutes to 1 ½ hours and it should not be retempered. Once portland cement has been added the mortar can no longer be stored.

**Filling the Joint.** Where existing mortar has been removed to a depth of greater than 1 inch, these deeper areas should be filled first, compacting the new mortar in several layers. The back of the entire joint should be filled successively by applying approximately ¼ inch of mortar, packing it well into the back corners. This



Figure 14. Mixing mortar using lime putty: (a) proportioning sand; (b) proportioning lime putty; (c) placing lime putty on top of sand; (d) mixing sand over lime putty; (e) hand mixing mortar; and, (f) sample of mortar after mixing. Photos: John P. Speweik.

application may extend along the wall for several feet. As soon as the mortar has reached thumb-print hardness, another  $\frac{1}{4}$  inch layer of mortar—approximately the same thickness—may be applied. Several layers will be needed to fill the joint flush with the outer surface of the masonry. It is important to allow each layer time to harden before the next layer is applied; most of the mortar shrinkage occurs during the hardening process and layering thus minimizes overall shrinkage.

When the final layer of mortar is thumb-print hard, the joint should be tooled to match the historic joint (Fig. 15). Proper timing of the tooling is important for uniform color and appearance. If tooled when too soft, the color will be lighter than expected, and hairline cracks may occur; if tooled when too hard, there may be dark streaks called “tool burning,” and good closure of the mortar against the masonry units will not be achieved.

If the old bricks or stones have worn, rounded edges, it is best to recess the final mortar slightly from the face of the masonry. This treatment will help avoid a joint which is visually wider than the actual joint; it also will avoid creation of a large, thin featheredge which is easily damaged, thus admitting water (Fig. 16). After tooling, excess mortar can be removed from the edge of the joint by brushing with a natural bristle or nylon brush. Metal bristle brushes should never be used on historic masonry.

**Curing Conditions.** The preliminary hardening of high-lime content mortars—those mortars that contain more lime by volume than portland cement, i.e., Type O (1:2:9), Type K (1:3:11), and straight lime/sand, Type “L” (0:1:3)—takes place fairly rapidly as water in the mix is lost to the porous surface of the masonry and through evaporation. A high lime mortar (especially Type “L”) left to dry out too rapidly can result in chalking, poor adhesion, and poor durability. Periodic wetting of the repointed area after the mortar joints are thumb-print hard and have been finish tooled may significantly accelerate the carbonation process. When feasible, misting using a hand sprayer with a fine nozzle can be simple to do for a day or two after repointing. Local conditions will dictate the frequency of wetting, but initially it may be as often as every hour and gradually reduced to every three or four hours. Walls should be covered with burlap for the first three days after repointing. (Plastic may be used, but it should be tented out and not placed directly against the wall.) This helps keep the walls damp and protects them from direct sunlight. Once carbonation of the lime has begun, it will continue for many years and the lime will gain strength as it reverts back to calcium carbonate within the wall.

**Aging the Mortar.** Even with the best efforts at matching the existing mortar color, texture, and materials, there will usually be a visible difference between the old and

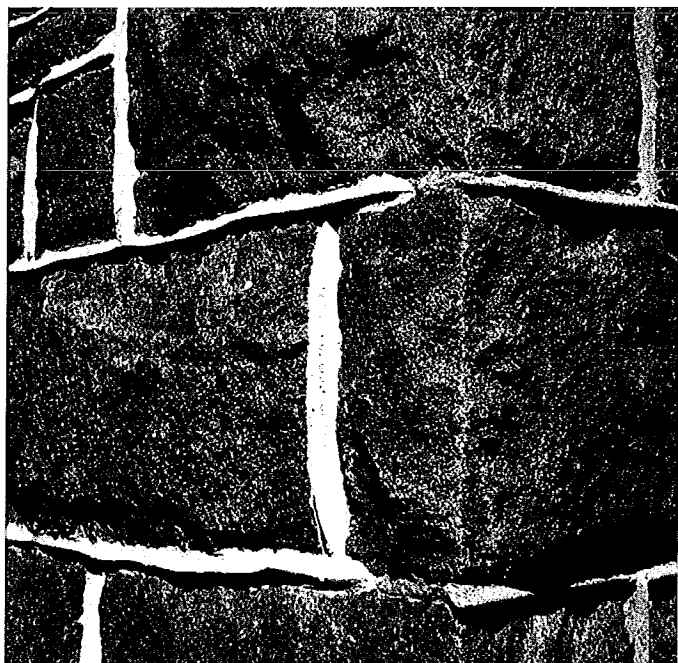


Figure 15. The profile of the repointed joints on the left replicate the historic joints around the corner to the right on the front of this stone building in Leesburg, VA. The contractor's pride in the repointing work is evident by the signature in the vertical joint. Photo: Anne Grimmer.

new work, partly because the new mortar has been matched to the unweathered portions of the historic mortar. Another reason for a slight mismatch may be that the sand is more exposed in old mortar due to the slight erosion of the lime or cement. Although spot repointing is generally preferable and some color difference should be acceptable, if the difference between old and new mortar is too extreme, it may be advisable in some instances to repoint an entire area of a wall, or an entire feature such as a bay, to minimize the difference between the old and the new mortar. If the mortars have been properly matched, usually the best way to deal with surface color differences is to let the mortars age naturally. Other treatments to overcome these differences, including cleaning the non-repointed areas or staining the new mortar, should be carefully tested prior to implementation.

Staining the new mortar to achieve a better color match is generally not recommended, but it may be appropriate in some instances. Although staining may provide an initial match, the old and new mortars may weather at different rates, leading to visual differences after a few seasons. In addition, the mixtures used to stain the mortar may be harmful to the masonry; for example, they may introduce salts into the masonry which can lead to efflorescence.

**Cleaning the Repointed Masonry.** If repointing work is carefully executed, there will be little need for cleaning other than to remove the small amount of mortar from the edge of the joint following tooling. This can be done with a stiff natural bristle or nylon brush after the mortar has dried, but before it is initially set (1-2 hours). Mortar that has hardened can usually be removed with a wooden paddle or, if necessary, a chisel.

Further cleaning is best accomplished with plain water and natural bristle or nylon brushes. If chemicals must

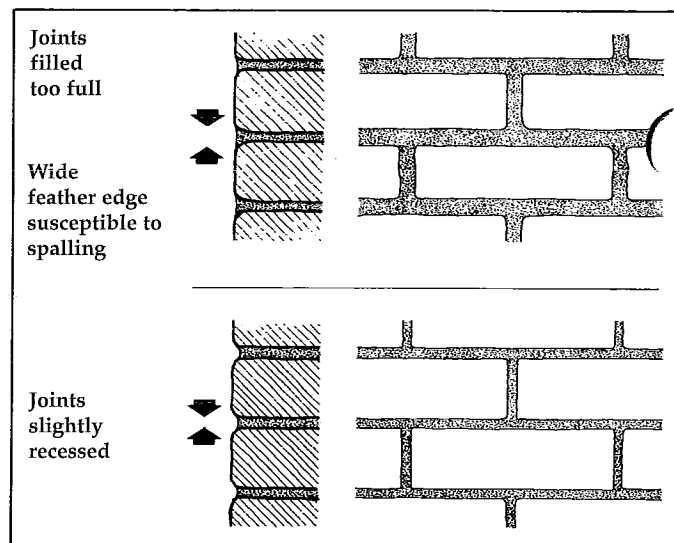


Figure 16. Comparison of visual effect of full mortar joints vs. slightly recessed joints. Filling joints too full hides the actual joint thickness and changes the character of the original brickwork. Drawing: Robert C. Mack, FAIA.

be used, they should be selected with extreme caution. Improper cleaning can lead to deterioration of the masonry units, deterioration of the mortar, mortar smear, and efflorescence. New mortar joints are especially susceptible to damage because they do not become fully cured for several months. Chemical cleaners, particularly acids, should never be used on dry masonry. The masonry should always be completely soaked once with water before chemicals are applied. After cleaning, the walls should be flushed again with plain water to remove all traces of the chemicals.

Several precautions should be taken if a freshly repointed masonry wall is to be cleaned. First, the mortar should be fully hardened before cleaning. Thirty days is usually sufficient, depending on weather and exposure; as mentioned previously, the mortar will continue to cure even after it has hardened. Test panels should be prepared to evaluate the effects of different cleaning



Figure 17. This photograph shows the significant visual change to the character of this historic brick building that has resulted from improper repointing procedures and a noticeably increased thickness of the mortar joints. Photo: Lee H. Nelson, FAIA.



Mortar Types				Suggested Mortar Types for Different Exposures			
(Measured by volume)				Exposure			
Designation	Cement	Hydrated Lime or Lime Putty	Sand	Masonry Material	Sheltered	Moderate	Severe
M	1	1/4	3 - 3 3/4	Very Durable: granite, hard-cored brick, etc.	O	N	S
S	1	1/2	4 - 4 1/2				
N	1	1	5 - 6				
O	1	2	8 - 9	Moderately Durable: limestone, durable stone, molded brick	K	O	N
K	1	3	10 - 12				
"L"	0	1	2 1/4 - 3	Minimally Durable: soft hand-made brick	"L"	K	O

methods. Generally, on newly repointed masonry walls, only very low pressure (100 psi) water washing supplemented by stiff natural bristle or nylon brushes should be used, except on glazed or polished surfaces, where only soft cloths should be used.\*\*

New construction "bloom" or efflorescence occasionally appears within the first few months of repointing and usually disappears through the normal process of weathering. If the efflorescence is not removed by natural processes, the safest way to remove it is by dry brushing with stiff natural or nylon bristle brushes followed by wet brushing. Hydrochloric (muriatic) acid, is generally ineffective, and it should not be used to remove efflorescence. It may liberate additional salts, which, in turn, can lead to more efflorescence.

**Surface Grouting** is sometimes suggested as an alternative to repointing brick buildings, in particular. This process involves the application of a thin coat of cement-based grout to the mortar joints and the mortar/brick interface. To be effective the grout must extend slightly onto the face of the masonry units, thus widening the joint visually. The change in the joint appearance can alter the historic character of the structure to an unacceptable degree. In addition, although masking of the bricks is intended to keep the grout off the remainder of the face of the bricks, some level of residue, called "veiling," will inevitably remain. Surface grouting cannot substitute for the more extensive work of repointing, and it is not a recommended treatment for historic masonry.

## Summary

**For the Owner/Administrator.** The owner or administrator of a historic building should remember that repointing is likely to be a lengthy and expensive process. First, there must be adequate time for evaluation of the building and investigation into the cause of problems. Then, there will be time needed for preparation of the contract documents. The work itself is precise, time-consuming and noisy, and scaffolding may cover the face of the building for some time. Therefore, the owner must carefully plan the work to avoid problems. Schedules for both repointing and other activities will thus require careful coordination to avoid unanticipated conflicts. The owner must avoid the tendency to rush the work or cut corners if the historic building is to retain its visual integrity and the job is to be durable.

**For the Architect/Consultant.** Because the primary role of the consultant is to ensure the life of the building, a knowledge of historic construction techniques and the special problems found in older buildings is essential. The consultant must assist the owner in planning for logistical problems relating to research and construction. It is the consultant's responsibility to determine the *cause* of the mortar deterioration and ensure that it is corrected before the masonry is repointed. The consultant must also be prepared to spend more time in project inspections than is customary in modern construction.

**For the Masons.** Successful repointing depends on the masons themselves. Experienced masons understand the special requirements for work on historic buildings and the added time and expense they require. The entire masonry crew must be willing and able to perform the work in conformance with the specifications, even when the specifications may not be in conformance with standard practice. At the same time, the masons should not hesitate to question the specifications if it appears that the work specified would damage the building.

\*\*Additional information on masonry cleaning is presented in *Preservation Briefs 1: The Cleaning and Waterproof Coating of Masonry Buildings*, Robert C. Mack, AIA, Washington, D.C.: Technical Preservation Services, National Park Service, U.S. Department of the Interior, 1975; and *Keeping it Clean: Removing Exterior Dirt, Paint, Stains & Effluents from Historic Masonry Buildings*, Anne E. Grimmer, Washington, D.C.: Technical Preservation Services, National Park Service, U.S. Department of the Interior, 1988.

## Visually Examining the Mortar and the Masonry Units

A simple in-situ comparison will help determine the hardness and condition of the mortar and the masonry units. Begin by scraping the mortar with a screwdriver, and gradually tapping harder with a cold chisel and mason's hammer. Masonry units can be tested in the same way beginning, even more gently, by scraping with a fingernail. This relative analysis which is derived from the 10-point hardness scale used to describe minerals, provides a good starting point for selection of an appropriate mortar. It is described more fully in "The Russack System for Brick & Mortar Description" referenced in **Selected Reading** at the end of this Brief.

Mortar samples should be chosen carefully, and picked from a variety of locations on the building to find unweathered mortar, if possible. Portions of the building may have been repointed in the past while other areas may be subject to conditions causing unusual deterioration. There may be several colors of mortar dating from different construction periods or sand used from different sources during the initial construction. Any of these situations can give false readings to the visual or physical characteristics required for the new mortar. Variations should be noted which may require developing more than one mix.

- 1) Remove with a chisel and hammer three or four unweathered samples of the mortar to be matched from several locations on the building. (Set the largest sample aside—this will be used later for comparison with the repointing mortar). Removing a full representation of samples will allow selection of a "mean" or average mortar sample.
- 2) Mash the remaining samples with a wooden mallet, or hammer if necessary, until they are separated into their constituent parts. There should be a good handful of the material.
- 3) Examine the powdered portion—the lime and/or cement matrix of the mortar. Most particularly, note the color. There is a tendency to think of historic mortars as having white binders, but grey portland cement was available by the last quarter of the 19th century, and traditional limes were also sometimes grey. Thus, in some instances, the natural color of the historic binder may be grey, rather than white. The mortar may also have been tinted to create a colored mortar, and this color should be identified at this point.
- 4) Carefully blow away the powdery material (the lime and/or cement matrix which bound the mortar together).
- 5) With a low power (10 power) magnifying glass, examine the remaining sand and other materials such as lumps of lime or shell.
- 6) Note and record the wide range of color as well as the varying sizes of the individual grains of sand, impurities, or other materials.

### Other Factors to Consider

**Color.** Regardless of the color of the binder or colored additives, the sand is the primary material that gives mortar



Figure 19. Mortar joints of 18th century brick buildings were often as much as 1/2 inch wide, cut flush and struck with a grapevine joint, but for window and door surrounds where a finer quality rubbed brick was used, mortar joints were very thin. Photo: National Park Service Files.

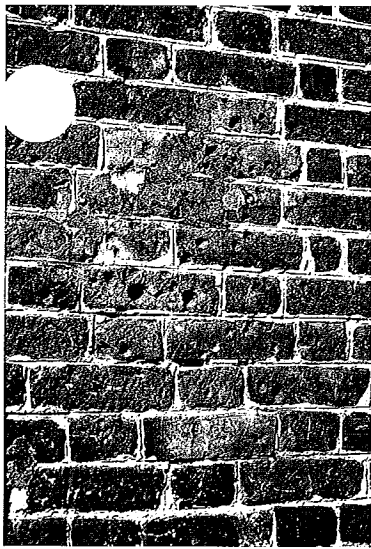
its color. A surprising variety of colors of sand may be found in a single sample of historic mortar, and the different sizes of the grains of sand or other materials, such as incompletely ground lime or cement, play an important role in the texture of the repointing mortar. Therefore, when specifying sand for repointing mortar, it may be necessary to obtain sand from several sources and to combine or screen them in order to approximate the range of sand colors and grain sizes in the historic mortar sample.

**Pointing Style.** Close examination of the historic masonry wall and the techniques used in the original construction will assist in maintaining the visual qualities of the building (Fig. 18). Pointing styles and the methods of producing them should be examined. It is important to look at both the horizontal and the vertical joints to determine the order in which they were tooled and whether they were the same style. Some late-19th and early-20th century buildings, for example, have horizontal joints that were raked back while the vertical joints were finished flush and stained to match the bricks, thus creating the illusion of horizontal bands. Pointing styles may also differ from one facade to another; front walls often received greater attention to mortar detailing than side and rear walls (Fig. 19). **Tuckpointing** is not true repointing but the

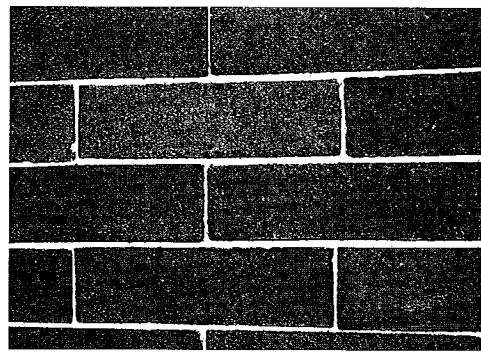


Figure 20. This stone garden wall was tuckpointed to match the tuckpointing on the c. 1920s house on the property. Photo: Anne Grimmer.

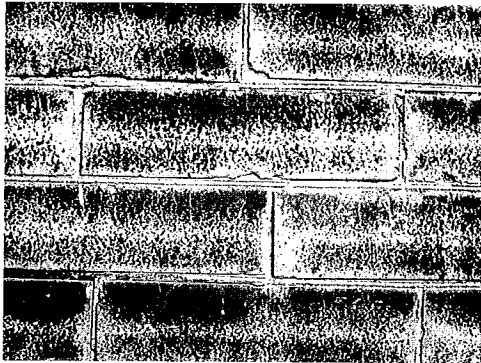




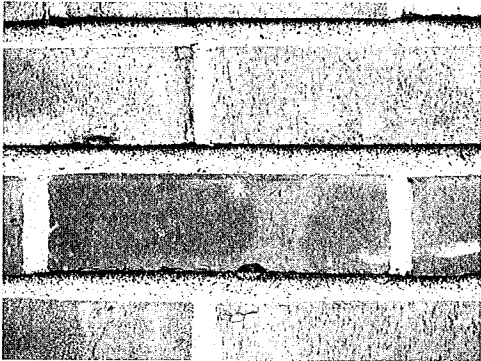
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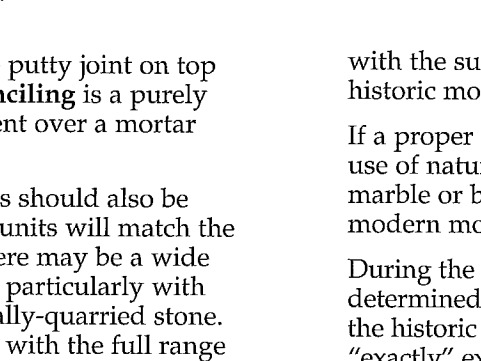
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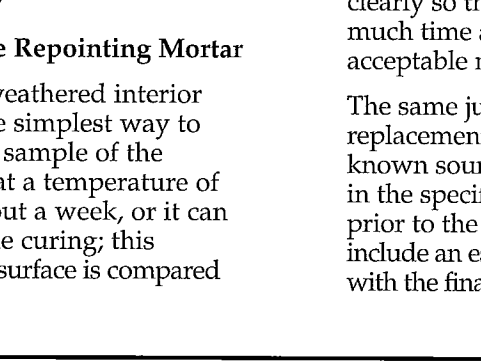
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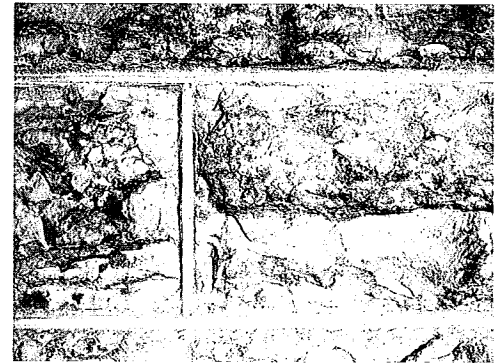


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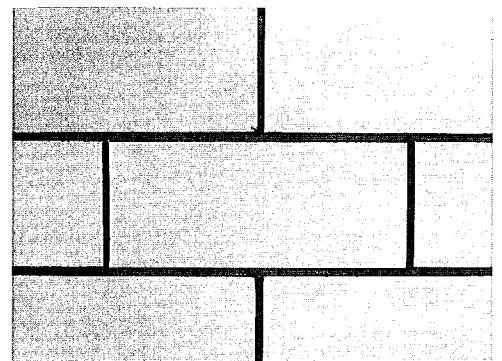


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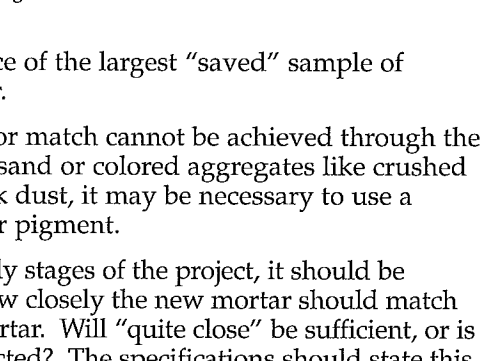
Figure 18. A cross-section of mortar joint types. (a) Grapevine joints on a mid-18th century brick building; (b) flush joints on a mid-to-late 19th century brick building; (c) beaded joints on a late-19th century brick building; (d) early-20th century beaded joints on rough-cut limestone where the vertical joints were struck prior to the horizontal joints; (e) raked joints on 1920s wire brick; (f) horizontal joints on a 1934 building designed by Frank Lloyd Wright were raked back from the face of the bricks, and the vertical joints were filled with a red-tinted mortar to emphasize the horizontality of the narrow bricks, and struck flush with the face of the bricks; (g) the joints on this 20th century glazed terra-cotta tile building are raked slightly, emphasizing the glazed block face. Photos: National Park Service Files (a,b,e); Robert C. Mack, FAIA (c,d,f,g).



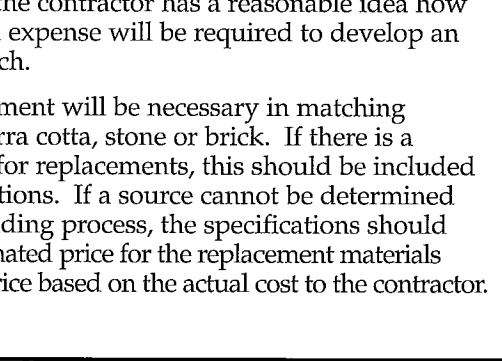
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application of a raised joint or lime putty joint on top of flush mortar joints (Fig. 20). **Pencil**ing is a purely decorative, painted surface treatment over a mortar joint, often in a contrasting color.

**Masonry Units.** The masonry units should also be examined so that any replacement units will match the historic masonry. Within a wall there may be a wide range of colors, textures, and sizes, particularly with hand-made brick or rough-cut, locally-quarried stone. Replacement units should blend in with the full range of masonry units rather than a single brick or stone.

### Matching Color and Texture of the Repointing Mortar

New mortar should match the unweathered interior portions of the historic mortar. The simplest way to achieve the match is to make a small sample of the proposed mix and allow it to cure at a temperature of approximately 70 degrees F for about a week, or it can be baked in an oven to speed up the curing; this sample is then broken open and the surface is compared

with the surface of the largest "saved" sample of historic mortar.

If a proper color match cannot be achieved through the use of natural sand or colored aggregates like crushed marble or brick dust, it may be necessary to use a modern mortar pigment.

During the early stages of the project, it should be determined how closely the new mortar should match the historic mortar. Will "quite close" be sufficient, or is "exactly" expected? The specifications should state this clearly so that the contractor has a reasonable idea how much time and expense will be required to develop an acceptable match.

The same judgment will be necessary in matching replacement terra cotta, stone or brick. If there is a known source for replacements, this should be included in the specifications. If a source cannot be determined prior to the bidding process, the specifications should include an estimated price for the replacement materials with the final price based on the actual cost to the contractor.

## Conclusion

A good repointing job is meant to last, at least 30 years, and preferably 50-100 years. Shortcuts and poor craftsmanship result not only in diminishing the historic character of a building, but also in a job that looks bad, and will require future repointing sooner than if the work had been done correctly (Fig. 17). The mortar joint in a historic masonry building has often been called a wall's "first line of defense." Good repointing practices guarantee the long life of the mortar joint, the wall, and the historic structure. Although careful maintenance will help preserve the freshly repointed mortar joints, it is important to remember that mortar joints are intended to be sacrificial and will probably require repointing some time in the future. Nevertheless, if the historic mortar joints proved durable for many years, then careful repointing should have an equally long life, ultimately contributing to the preservation of the entire building.

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"Bonds and Patterns in Brickwork." 30 Reissued. September 1988.

## Useful Addresses

Brick Institute of America  
11490 Commerce Park Drive  
Reston, VA 22091

Portland Cement Association  
5420 Old Orchard Road  
Skokie, IL 60077

National Lime Association  
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Arlington, VA 22203

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Robert C. Mack, FAIA, is a principal in the firm of MacDonald & Mack, Architects, Ltd., an architectural firm that specializes in historic buildings in Minneapolis, Minnesota. John P. Speweik, CSI, Toledo, Ohio, is a 5th-generation stonemason, and principal in U.S. Heritage Group, Inc., Chicago, Illinois, which does custom historic mortar matching. Anne Grimmer, Senior Architectural Historian, Heritage Preservation Services Program, National Park Service, was responsible for developing and coordinating the revision of this Preservation Brief, incorporating professional comments, and the technical editing.

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This publication has been prepared pursuant to the National Historic Preservation Act of 1966, as amended, which directs the Secretary of the Interior to develop and make available information concerning historic properties. Comments about this publication should be directed to de Teel Patterson Tiller, Chief, Heritage Preservation Services Program, National Park Service, 1849 C Street, N.W. Suite NC200, Washington, D.C. 20240. This publication is not copyrighted and can be reproduced without penalty. Normal procedures for credit to the authors and the National Park Service are appreciated.

Front Cover: Repointing a historic brick building using a lime-based mortar. Traditional lime mortars have a consistency that enables the mortar to cling to a repointing tool while in a vertical position. Photo: John P. Speweik.

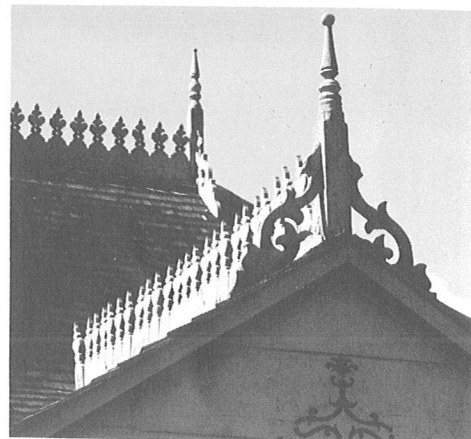
# 4 PRESERVATION BRIEFS

## Roofing for Historic Buildings

Sarah M. Sweetser



U.S. Department of the Interior  
National Park Service  
Cultural Resources  
Heritage Preservation Services



HABS

### Significance of the Roof

A weather-tight roof is basic in the preservation of a structure, regardless of its age, size, or design. In the system that allows a building to work as a shelter, the roof sheds the rain, shades from the sun, and buffers the weather.

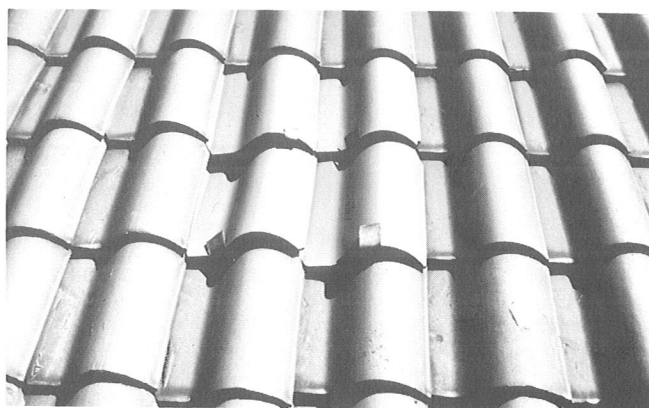
During some periods in the history of architecture, the roof imparts much of the architectural character. It defines the style and contributes to the building's aesthetics. The hipped roofs of Georgian architecture, the turrets of Queen Anne, the Mansard roofs, and the graceful slopes of the Shingle Style and Bungalow designs are examples of the use of roofing as a major design feature.

But no matter how decorative the patterning or how compelling the form, the roof is a highly vulnerable element of a shelter that will inevitable fail. A poor roof will permit the accelerated deterioration of historic building materials—masonry, wood, plaster, paint—and will cause general disintegration of the basic structure. Furthermore, there is an urgency involved in repairing a leaky roof since such repair costs will quickly become prohibitive. Although such action is desirable as soon as a failure is discovered, temporary patching methods should be carefully chosen to prevent inadvertent damage to sound or historic roofing materials and related features. Before any repair work is performed, the historic value of the materials used on the roof should be understood. Then a complete internal and external inspection of the roof should be planned to determine all the causes of failure and to identify the alternatives for repair or replacement of the roofing.

### Historic Roofing Materials in America

**Clay Tile:** European settlers used clay tile for roofing as early as the mid-17th century; many pantiles (S-curved tiles), as well as flat roofing tiles, were used in Jamestown, Virginia. In some cities such as New York and Boston, clay was popularly used as a precaution against such fire as those that engulfed London in 1666 and scorched Boston in 1679.

Tiles roofs found in the mid-18th century Moravian settlements in Pennsylvania closely resembled those found in Germany. Typically, the tiles were 14–15" long, 6–7" wide with a curved butt. A lug on the back allowed the tiles to hang on the lathing without nails or pegs. The tile surface was usually scored with finger marks to promote drainage. In the Southwest, the tile roofs of the Spanish missionaries (mission tiles) were first manufactured (ca. 1780) at the Mission San Antonio de Padua in California. These semicircular tiles were



*Repairs on this pantile roof were made with new tiles held in place with metal hangers. (Main Building, Ellis Island, New York)*

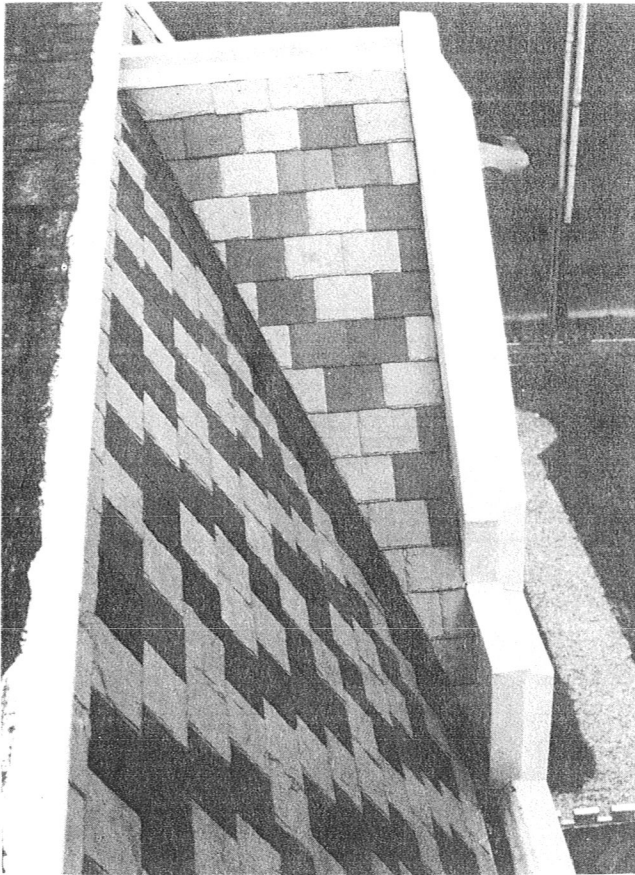
made by molding clay over sections of logs, and they were generally 22" long and tapered in width.

The plain or flat rectangular tiles most commonly used from the 17th through the beginning of the 19th century measured about 10" by 6" by ½", and had two holes at one end for a nail or peg fastener. Sometimes mortar was applied between the courses to secure the tiles in a heavy wind.

In the mid-19th century, tile roofs were often replaced by sheet-metal roofs, which were lighter and easier to install and maintain. However, by the turn of the century, the Romanesque Revival and Mission style buildings created a new demand and popularity for this picturesque roofing material.

**Slate:** Another practice settlers brought to the New World was slate roofing. Evidence of roofing slates have been found also among the ruins of mid-17th-century Jamestown. But because of the cost and the time required to obtain the material, which was mostly imported from Wales, the use of slate was initially limited. Even in Philadelphia (the second largest city in the English-speaking world at the time of the Revolution) slates were so rare that "The Slate Roof House" distinctly referred to William Penn's home built late in the 1600s. Sources of native slate were known to exist along the eastern seaboard from Maine to Virginia, but difficulties in inland transportation limited its availability to the cities, and contributed to its expense. Welsh slate continued to be imported until the development of canals and railroads in the mid-19th century made American slate more accessible and economical.

Slate was popular for its durability, fireproof qualities, and



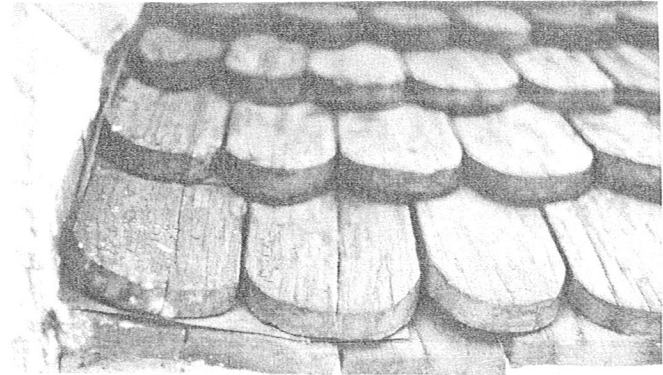
*The Victorians loved to use different colored slates to create decorative patterns on their roofs, an effect which cannot be easily duplicated by substitute materials. Before any repair work on a roof such as this, the slate sizes, colors, and position of the patterning should be carefully recorded to assure proper replacement. (Ebenezer Maxwell Mansion, Philadelphia, Pennsylvania, photo courtesy of William D. Hershey)*

aesthetic potential. Because slate was available in different colors (red, green, purple, and blue-gray), it was an effective material for decorative patterns on many 19th-century roofs (Gothic and Mansard styles). Slate continued to be used well into the 20th century, notably on many Tudor revival style buildings of the 1920s.

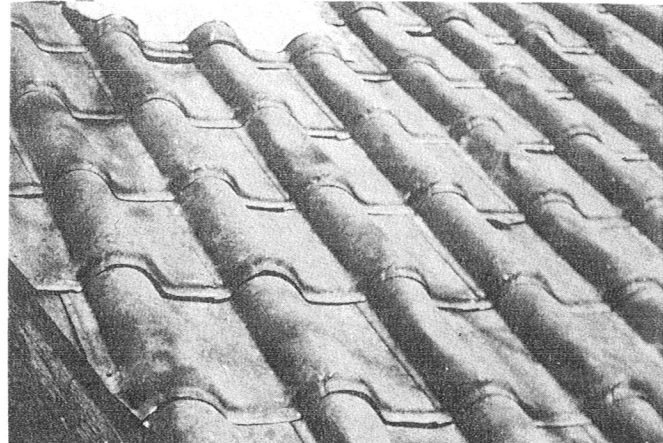
**Shingles:** Wood shingles were popular throughout the country in all periods of building history. The size and shape of the shingles as well as the detailing of the shingle roof differed according to regional craft practices. People within particular regions developed preferences for the local species of wood that most suited their purposes. In New England and the Delaware Valley, white pine was frequently used; in the South, cypress and oak; in the far west, red cedar or redwood. Sometimes a protective coating was applied to increase the durability of the shingle such as a mixture of brick dust and fish oil, or a paint made of red iron oxide and linseed oil.

Commonly in urban areas, wooden roofs were replaced with more fire resistant materials, but in rural areas this was not a major concern. On many Victorian country houses, the practice of wood shingling survived the technological advances of metal roofing in the 19th century, and near the turn of the century enjoyed a full revival in its namesake, the Shingle Style. Colonial revival and the Bungalow styles in the 20th century assured wood shingles a place as one of the most fashionable, domestic roofing materials.

**Metal:** Metal roofing in America is principally a 19th-century phenomenon. Before then the only metals commonly



*Replacement of particular historic details is important to the individual historic character of a roof, such as the treatment at the eaves of this rounded butt wood shingle roof. Also note that the surface of the roof was carefully sloped to drain water away from the side of the dormer. In the restoration, this function was augmented with the addition of carefully concealed modern metal flashing. (Mount Vernon, Virginia)*



*Galvanized sheet-metal shingles imitating the appearance of pantiles remained popular from the second half of the 19th century into the 20th century. (Episcopal Church, now the Jerome Historical Society Building, Jerome, Arizona, 1927)*

used were lead and copper. For example, a lead roof covered "Rosewell," one of the grandest mansions in 18th-century Virginia. But more often, lead was used for protective flashing. Lead, as well as copper, covered roof surfaces where wood, tile, or slate shingles were inappropriate because of the roof's pitch or shape.

Copper with standing seams covered some of the more notable early American roofs including that of Christ Church (1727-1744) in Philadelphia. Flat-seamed copper was used on many domes and cupolas. The copper sheets were imported from England until the end of the 18th century when facilities for rolling sheet metal were developed in America.

Sheet iron was first known to have been manufactured here by the Revolutionary War financier, Robert Morris, who had a rolling mill near Trenton, New Jersey. At his mill Morris produced the roof of his own Philadelphia mansion, which he started in 1794. The architect Benjamin H. Latrobe used sheet iron to replace the roof on Princeton's "Nassau Hall," which had been gutted by fire in 1802.

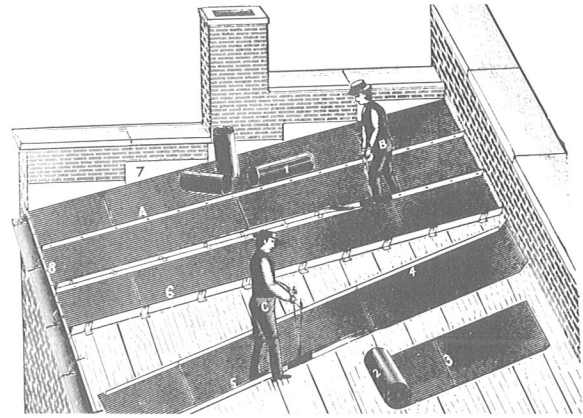
The method for corrugating iron was originally patented in England in 1829. Corrugating stiffened the sheets, and allowed greater span over a lighter framework, as well as reduced installation time and labor. In 1834 the American architect William Strickland proposed corrugated iron to cover his design for the market place in Philadelphia.

Galvanizing with zinc to protect the base metal from rust was developed in France in 1837. By the 1850s the material was used on post offices and customhouses, as well as on train sheds and factories. In 1857 one of the first metal roofs in the

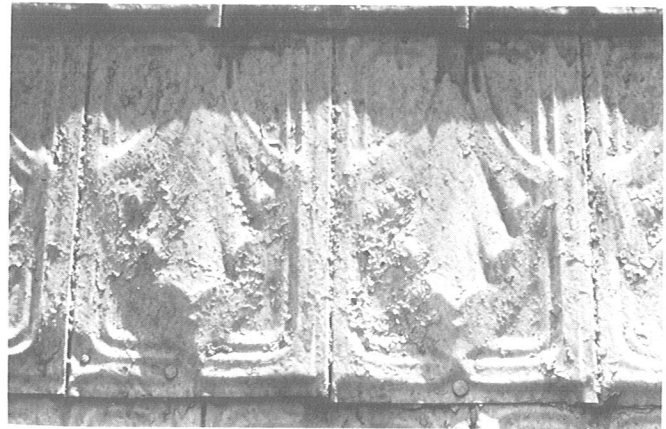




*Repeated repair with asphalt, which cracks as it hardens, has created a blistered surface on this sheet-metal roof and built-in gutter, which will retain water. Repairs could be made by carefully heating and scraping the surface clean, repairing the holes in the metal with a flexible mastic compound or a metal patch, and coating the surface with a fibre paint. (Roane County Courthouse, Kingston, Tennessee, photo courtesy of Building Conservation Technology, Inc.)*



*A Chicago firm's catalog dated 1896 illustrates a method of unrolling, turning the edges, and finishing the standing seam on a metal roof.*



*Tin shingles, commonly embossed to imitate wood or tile, or with a decorative design, were popular as an inexpensive, textured roofing material. These shingles  $8\frac{1}{8}$  inch by  $12\frac{1}{2}$  inch on the exposed surface) were designed with interlocking edges, but they have been repaired by surface nailing, which may cause future leakage. (Ballard House, Yorktown, Virginia, photo by Gordie Whittington, National Park Service)*

South was installed on the U.S. Mint in New Orleans. The Mint was thereby "fireproofed" with a 20-gauge galvanized, corrugated iron roof on iron trusses.

Tin-plate iron, commonly called "tin roofing," was used extensively in Canada in the 18th century, but it was not as common in the United States until later. Thomas Jefferson was an early advocate of tin roofing, and he installed a standing-seam tin roof on "Monticello" (ca. 1770–1802). The Arch Street Meetinghouse (1804) in Philadelphia had tin shingles laid in a herringbone pattern on a "piazza" roof.

However, once rolling mills were established in this country, the low cost, light weight, and low maintenance of tin plate made it the most common roofing material. Embossed tin shingles, whose surfaces created interesting patterns, were popular throughout the country in the late 19th century. Tin roofs were kept well-painted, usually red; or, as the architect A. J. Davis suggested, in a color to imitate the green patina of copper.

Terne plate differed from tin plate in that the iron was dipped in an alloy of lead and tin, giving it a duller finish. Historic, as well as modern, documentation often confuses the two, so much that it is difficult to determine how often actual "terne" was used.

Zinc came into use in the 1820s, at the same time tin plate was becoming popular. Although a less expensive substitute for lead, its advantages were controversial, and it was never widely used in this country.

**Other Materials:** Asphalt shingles and roll roofing were used in the 1890s. Many roofs of asbestos, aluminum, stainless steel, galvanized steel, and lead-coated copper may soon have historic values as well. Awareness of these and other traditions of roofing materials and their detailing will contribute to more sensitive preservation treatments.

### Locating the Problem

#### Failures of Surface Materials

When trouble occurs, it is important to contact a professional, either an architect, a reputable roofing contractor, or a craftsman familiar with the inherent characteristics of the particular historic roofing system involved. These professionals may be able to advise on immediate patching procedures and help plan more permanent repairs. A thorough examination of the roof should start with an appraisal of the existing condition and quality of the roofing material itself. Particular attention should be given to any southern slope because year-round exposure to direct sun may cause it to break down first.

**Wood:** Some historic roofing materials have limited life expectancies because of normal organic decay and "wear." For example, the flat surfaces of wood shingles erode from exposure to rain and ultraviolet rays. Some species are more hardy than others, and heartwood, for example, is stronger and more durable than sapwood.

Ideally, shingles are split with the grain perpendicular to

the surface. This is because if shingles are sawn across the grain, moisture may enter the grain and cause the wood to deteriorate. Prolonged moisture on or in the wood allows moss or fungi to grow, which will further hold the moisture and cause rot.

**Metal:** Of the inorganic roofing materials used on historic buildings, the most common are perhaps the sheet metals: lead, copper, zinc, tin plate, terne plate, and galvanized iron. In varying degrees each of these sheet metals are likely to deteriorate from chemical action by pitting or streaking. This can be caused by airborne pollutants; acid rainwater; acids from lichen or moss; alkalis found in lime mortars or portland cement, which might be on adjoining features and washes down on the roof surface; or tannic acids from adjacent wood sheathings or shingles made of red cedar or oak.

Corrosion from "galvanic action" occurs when dissimilar metals, such as copper and iron, are used in direct contact. Corrosion may also occur even though the metals are physically separated; one of the metals will react chemically against the other in the presence of an electrolyte such as rainwater. In roofing, this situation might occur when either a copper roof is decorated with iron cresting, or when steel nails are used in copper sheets. In some instances the corrosion can be prevented by inserting a plastic insulator between the dissimilar materials. Ideally, the fasteners should be a metal sympathetic to those involved.

Iron rusts unless it is well-painted or plated. Historically this problem was avoided by use of tin plating or galvanizing. But this method is durable only as long as the coating remains intact. Once the plating is worn or damaged, the exposed iron will rust. Therefore, any iron-based roofing material needs to be undercoated, and its surface needs to be kept well-painted to prevent corrosion.

One cause of sheet metal deterioration is fatigue. Depending upon the size and the gauge of the metal sheets, wear and metal failure can occur at the joints or at any protrusions in the sheathing as a result from the metal's alternating movement to thermal changes. Lead will tear because of "creep," or the gravitational stress that causes the material to move down the roof slope.

**Slate:** Perhaps the most durable roofing materials are slate and tile. Seemingly indestructible, both vary in quality. Some slates are hard and tough without being brittle. Soft slates are more subject to erosion and to attack by airborne and rain-

water chemicals, which cause the slates to wear at nail holes, to delaminate, or to break. In winter, slate is very susceptible to breakage by ice, or ice dams.

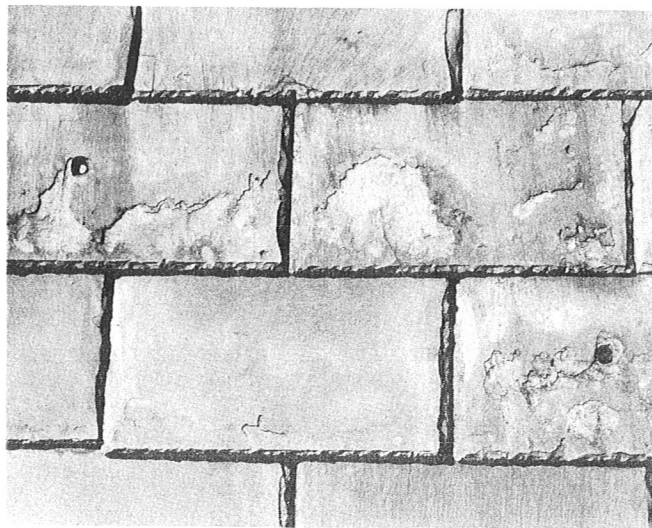
**Tile:** Tiles will weather well, but tend to crack or break if hit, as by tree branches, or if they are walked on improperly. Like slates, tiles cannot support much weight. Low quality tiles that have been insufficiently fired during manufacture, will craze and spall under the effects of freeze and thaw cycles on their porous surfaces.

### Failures of Support Systems

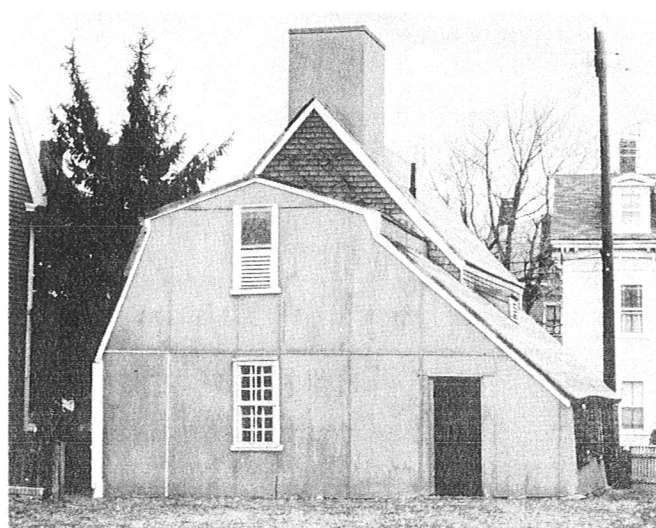
Once the condition of the roofing material has been determined, the related features and support systems should be examined on the exterior and on the interior of the roof. The gutters and downspouts need periodic cleaning and maintenance since a variety of debris fill them, causing water to back up and seep under roofing units. Water will eventually cause fasteners, sheathing, and roofing structure to deteriorate. During winter, the daily freeze-thaw cycles can cause ice floes to develop under the roof surface. The pressure from these ice floes will dislodge the roofing material, especially slates, shingles, or tiles. Moreover, the buildup of ice dams above the gutters can trap enough moisture to rot the sheathing or the structural members.

Many large public buildings have built-in gutters set within the perimeter of the roof. The downspouts for these gutters may run within the walls of the building, or drainage may be through the roof surface or through a parapet to exterior downspouts. These systems can be effective if properly maintained; however, if the roof slope is inadequate for good runoff, or if the traps are allowed to clog, rainwater will form pools on the roof surface. Interior downspouts can collect debris and thus back up, perhaps leaking water into the surrounding walls. Exterior downspouts may fill with water, which in cold weather may freeze and crack the pipes. Conduits from the built-in gutter to the exterior downspout may also leak water into the surrounding roof structure or walls.

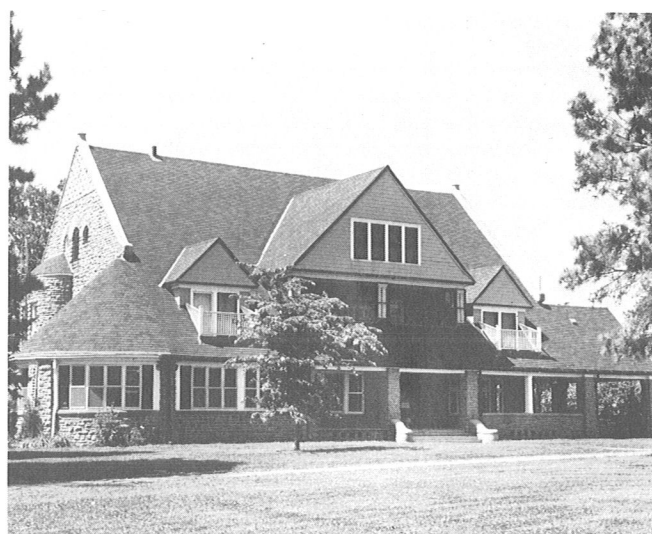
Failure of the flashing system is usually a major cause of roof deterioration. Flashing should be carefully inspected for failure caused by either poor workmanship, thermal stress, or metal deterioration (both of flashing material itself and of the fasteners). With many roofing materials, the replacement of flashing on an existing roof is a major operation, which may require taking up large sections of the roof surface. Therefore, the installation of top quality flashing material on



*This detail shows slate delamination caused by a combination of weathering and pollution. In addition, the slates have eroded around the repair nails, incorrectly placed in the exposed surface of the slates. (Lower Pontalba Building, New Orleans, photo courtesy of Building Conservation Technology, Inc.)*



*Temporary stabilization or "mothballing" with materials such as plywood and building paper can protect the roof of a project until it can be properly repaired or replaced. (Narbonne House, Salem, Massachusetts)*



*These two views of the same house demonstrate how the use of a substitute material can drastically affect the overall character of a structure. The textural interest of the original tile roof was lost with the use of asphalt shingles. Recent preservation efforts are replacing the tile roof. (Frank House, Kearney, Nebraska, photo courtesy of the Nebraska State Historical Society, Lincoln, Nebraska)*

a new or replaced roof should be a primary consideration. Remember, some roofing and flashing materials are not compatible.

Roof fasteners and clips should also be made of a material compatible with all other materials used, or coated to prevent rust. For example, the tannic acid in oak will corrode iron nails. Some roofs such as slate and sheet metals may fail if nailed too rigidly.

If the roof structure appears sound and nothing indicates recent movement, the area to be examined most closely is the roof substrate—the sheathing or the battens. The danger spots would be near the roof plates, under any exterior patches, at the intersections of the roof planes, or at vertical surfaces such as dormers. Water penetration, indicating a breach in the roofing surface or flashing, should be readily apparent, usually as a damp spot or stain. Probing with a small pen knife may reveal any rot which may indicate previously undetected damage to the roofing membrane. Insect infestation evident by small exit holes and frass (a sawdust-like debris) should also be noted. Condensation on the underside of the roofing is undesirable and indicates improper ventilation. Moisture will have an adverse effect on any roofing material; a good roof stays dry inside and out.

### Repair or Replace

Understanding potential weaknesses of roofing material also requires knowledge of repair difficulties. Individual slates can be replaced normally without major disruption to the rest of the roof, but replacing flashing on a slate roof can require substantial removal of surrounding slates. If it is the substrate or a support material that has deteriorated, many surface materials such as slate or tile can be reused if handled carefully during the repair. Such problems should be evaluated at the outset of any project to determine if the roof can be effectively patched, or if it should be completely replaced.

Will the repairs be effective? Maintenance costs tend to multiply once trouble starts. As the cost of labor escalates, repeated repairs could soon equal the cost of a new roof.

The more durable the surface is initially, the easier it will be to maintain. Some roofing materials such as slate are expensive to install, but if top quality slate and flashing are used, it will last 40–60 years with minimal maintenance. Although the installation cost of the roof will be high, low maintenance needs will make the lifetime cost of the roof less expensive.

### Historical Research

In a restoration project, research of documents and physical investigation of the building usually will establish the roof's history. Documentary research should include any original plans or building specifications, early insurance surveys, newspaper descriptions, or the personal papers and files of people who owned or were involved in the history of the building. Old photographs of the building might provide evidence of missing details.

Along with a thorough understanding of any written history of the building, a physical investigation of the roofing and its structure may reveal information about the roof's construction history. Starting with an overall impression of the structure, are there any changes in the roof slope, its configuration, or roofing materials? Perhaps there are obvious patches or changes in patterning of exterior brickwork where a gable roof was changed to a gambrel, or where a whole upper story was added. Perhaps there are obvious stylistic changes in the roof line, dormers, or ornamentation. These observations could help one understand any important alteration, and could help establish the direction of further investigation.

Because most roofs are physically out of the range of careful scrutiny, the “principle of least effort” has probably limited the extent and quality of previous patching or replacing, and usually considerable evidence of an earlier roof surface remains. Sometimes the older roof will be found as an underlayment of the current exposed roof. Original roofing may still be intact in awkward places under later features on a roof. Often if there is any unfinished attic space, remnants of roofing may have been dropped and left when the roof was being built or repaired. If the configuration of the roof has been changed, some of the original material might still be in place under the existing roof. Sometimes whole sections of the roof and roof framing will have been left intact under the higher roof. The profile and/or flashing of the earlier roof may be apparent on the interior of the walls at the level of the alteration. If the sheathing or lathing appears to have survived changes in the roofing surface, they may contain evidence of the roofing systems. These may appear either as dirt marks, which provide “shadows” of a roofing material, or as nails broken or driven down into the wood, rather than pulled out during previous alterations or repairs. Wooden headers in the roof framing may indicate that earlier chimneys or skylights have been removed. Any metal ornamentation that might have existed may be indicated by anchors or unusual markings along the ridge or at other edges of the roof. This primary



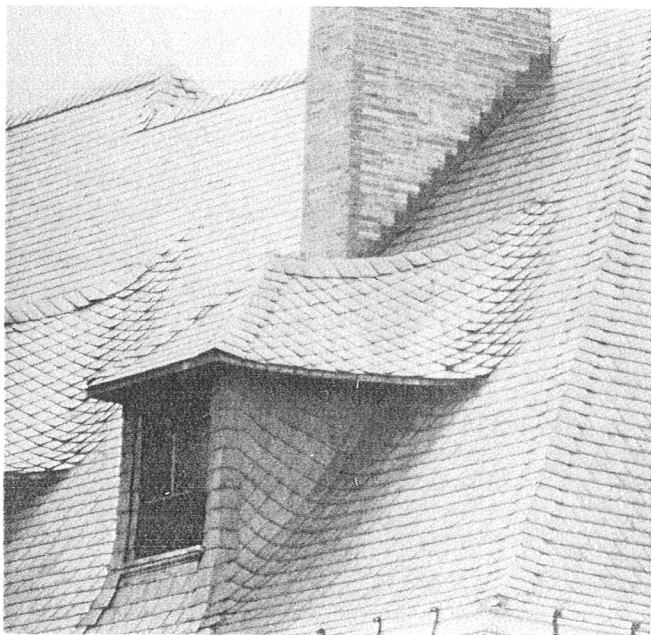
evidence is essential for a full understanding of the roof's history.

Caution should be taken in dating early "fabric" on the evidence of a single item, as recycling of materials is not a mid-20th-century innovation. Carpenters have been reusing materials, sheathing, and framing members in the interest of economy for centuries. Therefore, any analysis of the materials found, such as nails or sawmarks on the wood, requires an accurate knowledge of the history of local building practices before any final conclusion can be accurately reached. It is helpful to establish a sequence of construction history for the roof and roofing materials; any historic fabric or pertinent evidence in the roof should be photographed, measured, and recorded for future reference.

During the repair work, useful evidence might unexpectedly appear. It is essential that records be kept of any type of work on a historic building, before, during, and after the project. Photographs are generally the easiest and fastest method, and should include overall views and details at the gutters, flashing, dormers, chimneys, valleys, ridges, and eaves. All photographs should be immediately labeled to insure accurate identification at a later date. Any patterning or design on the roofing deserves particular attention. For example, slate roofs are often decorative and have subtle changes in size, color, and texture, such as a gradually decreasing coursing length from the eave to the peak. If not carefully noted before a project begins, there may be problems in replacing the surface. The standard reference for this phase of the work is *Recording Historic Buildings*, compiled by Harley J. McKee for the Historic American Buildings Survey, National Park Service, Washington, D.C., 1970.

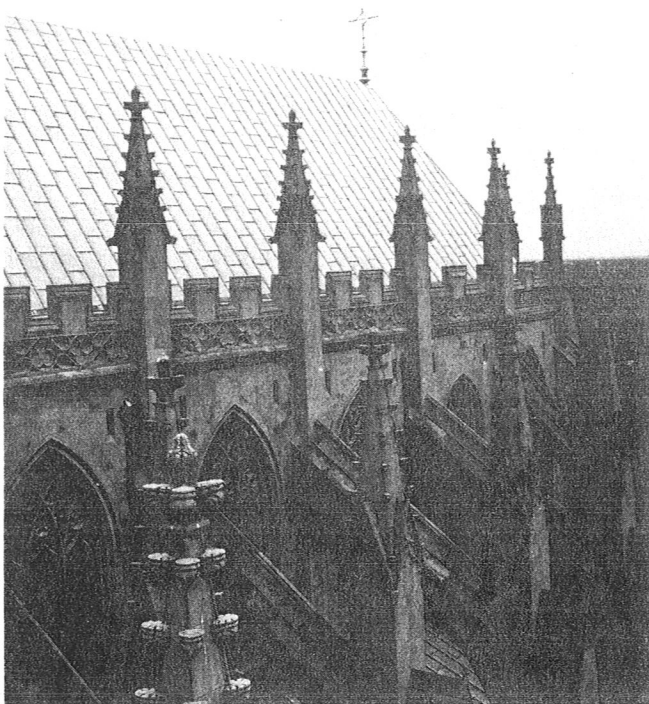
#### Replacing the Historic Roofing Material

Professional advice will be needed to assess the various aspects of replacing a historic roof. With some exceptions, most historic roofing materials are available today. If not, an architect or preservation group who has previously worked with the same type material may be able to recommend suppliers. Special roofing materials, such as tile or embossed metal shingles, can be produced by manufacturers of related products that are commonly used elsewhere, either on the exterior or interior of a structure. With some creative thinking and research, the historic materials usually can be found.



*Because of the roof's visibility, the slate detailing around the dormers is important to the character of this structure. Note how the slates swirl from a horizontal pattern on the main roof to a diamond pattern on the dormer roofs and side walls. (18th and Que Streets, NW, Washington, D.C.)*

**Craft Practices:** Determining the craft practices used in the installation of a historic roof is another major concern in roof restoration. Early builders took great pride in their work, and experience has shown that the "rustic" or irregular designs commercially labeled "Early American" are a 20th-century invention. For example, historically, wood shingles underwent several distinct operations in their manufacture including splitting by hand, and smoothing the surface with a draw knife. In modern nomenclature, the same item would be a "tapersplit" shingle which has been dressed. Unfortunately, the rustic appearance of today's commercially available "handsplit" and re-sawn shingle bears no resemblance to the hand-made roofing materials used on early American buildings.



*Good design and quality materials for the roof surface, fastenings, and flashing minimize roofing failures. This is essential on roofs such as on the National Cathedral where a thorough maintenance inspection and minor repairs cannot be done easily without special scaffolding. However, the success of the roof on any structure depends on frequent cleaning and repair of the gutter system. (Washington, D.C., photo courtesy of John Burns, A.I.A.)*

Early craftsmen worked with a great deal of common sense; they understood their materials. For example they knew that wood shingles should be relatively narrow; shingles much wider than about 6" would split when walked on, or they may curl or crack from varying temperature and moisture. It is important to understand these aspects of craftsmanship, remembering that people wanted their roofs to be weather-tight and to last a long time. The recent use of "mother-goose" shingles on historic structures is a gross underestimation of the early craftsman's skills.

**Supervision:** Finding a modern craftsman to reproduce historic details may take some effort. It may even involve some special instruction to raise his understanding of certain historic craft practices. At the same time, it may be pointless (and expensive) to follow historic craft practices in any construction that will not be visible on the finished product. But if the roofing details are readily visible, their appearance should be based on architectural evidence or on historic prototypes. For instance, the spacing of the seams on a standing-seam metal roof will affect the building's overall scale and should therefore match the original dimensions of the seams.



Many older roofing practices are no longer performed because of modern improvements. Research and review of specific detailing in the roof with the contractor before beginning the project is highly recommended. For example, one early craft practice was to finish the ridge of a wood shingle roof with a roof “comb”—that is, the top course of one slope of the roof was extended uniformly beyond the peak to shield the ridge, and to provide some weather protection for the raw horizontal edges of the shingles on the other slope. If the “comb” is known to have been the correct detail, it should be used. Though this method leaves the top course vulnerable to the weather, a disguised strip of flashing will strengthen this weak point.

Detail drawings or a sample mock-up will help ensure that the contractor or craftsman understands the scope and special requirements of the project. It should never be assumed that the modern carpenter, slater, sheet metal worker, or roofer will know all the historic details. Supervision is as important as any other stage of the process.



*Special problems inherent in the design of an elaborate historic roof can be controlled through the use of good materials and regular maintenance. The shape and detailing are essential elements of the building's historic character, and should not be modified, despite the use of alternative surface materials. (Gamwell House, Bellingham, Washington)*

### Alternative Materials

The use of the historic roofing material on a structure may be restricted by building codes or by the availability of the materials, in which case an appropriate alternative will have to be found.

Some municipal building codes allow variances for roofing materials in historic districts. In other instances, individual variances may be obtained. Most modern heating and cooking is fueled by gas, electricity, or oil—none of which emit the hot embers that historically have been the cause of roof fires. Where wood burning fireplaces or stoves are used, spark arrestor screens at the top of the chimneys help to prevent flaming material from escaping, thus reducing the number of fires that start at the roof. In most states, insurance rates have been equalized to reflect revised considerations for the risks involved with various roofing materials.

In a rehabilitation project, there may be valid reasons for replacing the roof with a material other than the original. The historic roofing may no longer be available, or the cost of obtaining specially fabricated materials may be prohibitive. But

the decision to use an alternative material should be weighed carefully against the primary concern to keep the historic character of the building. If the roof is flat and is not visible from any elevation of the building, and if there are advantages to substituting a modern built-up composition roof for what might have been a flat metal roof, then it may make better economic and construction sense to use a modern roofing method. But if the roof is readily visible, the alternative material should match as closely as possible the scale, texture, and coloration of the historic roofing material.

Asphalt shingles or ceramic tiles are common substitute materials intended to duplicate the appearance of wood shingles, slates, or tiles. Fire-retardant, treated wood shingles are currently available. The treated wood tends, however, to be brittle, and may require extra care (and expense) to install. In some instances, shingles laid with an interlay of fire-retardant building paper may be an acceptable alternative.

Lead-coated copper, terne-coated steel, and aluminum/zinc-coated steel can successfully replace tin, terne plate, zinc, or lead. Copper-coated steel is a less expensive (and less durable) substitute for sheet copper.

The search for alternative roofing materials is not new. As early as the 18th century, fear of fire cause many wood shingle or board roofs to be replaced by sheet metal or clay tile. Some historic roofs were failures from the start, based on over-ambitious and naive use of materials as they were first developed. Research on a structure may reveal that an inadequately designed or a highly combustible roof was replaced early in its history, and therefore restoration of a later roof material would have a valid precedent. In some cities, the substitution of sheet metal on early row houses occurred as soon as the rolled material became available.

Cost and ease of maintenance may dictate the substitution of a material wholly different in appearance from the original. The practical problems (wind, weather, and roof pitch) should be weighed against the historical consideration of scale, texture, and color. Sometimes the effect of the alternative material will be minimal. But on roofs with a high degree of visibility and patterning or texture, the substitution may seriously alter the architectural character of the building.

### Temporary Stabilization

It may be necessary to carry out an immediate and temporary stabilization to prevent further deterioration until research can determine how the roof should be restored or rehabilitated, or until funding can be provided to do a proper job. A simple covering of exterior plywood or roll roofing might provide adequate protection, but any temporary covering should be applied with caution. One should be careful not to overload the roof structure, or to damage or destroy historic evidence or fabric that might be incorporated into a new roof at a later date. In this sense, repairs with caulking or bituminous patching compounds should be recognized as potentially harmful, since they are difficult to remove, and at their best, are very temporary.

### Precautions

The architect or contractor should warn the owner of any precautions to be taken against the specific hazards in installing the roofing material. Soldering of sheet metals, for instance, can be a fire hazard, either from the open flame or from overheating and undetected smoldering of the wooden substrate materials.

Thought should be given to the design and placement of any modern roof appurtenances such as plumbing stacks, air vents, or TV antennas. Consideration should begin with the placement of modern plumbing on the interior of the building, otherwise a series of vent stacks may pierce the roof membrane at various spots creating maintenance problems as well as aesthetic ones. Air handling units placed in the attic space will require vents which, in turn, require sensitive design. Incorporating these in unused chimneys has been very successful

in the past.

Whenever gutters and downspouts are needed that were not on the building historically, the additions should be made as unobtrusively as possible, perhaps by painting them out with a color compatible with the nearby wall or trim.

### Maintenance

Although a new roof can be an object of beauty, it will not be protective for long without proper maintenance. At least twice a year, the roof should be inspected against a checklist. All changes should be recorded and reported. Guidelines should be established for any foot traffic that may be required for the maintenance of the roof. Many roofing materials should not be walked on at all. For some—slate, asbestos, and clay tile—a self-supporting ladder might be hung over the ridge of the roof, or planks might be spanned across the roof surface. Such items should be specifically designed and kept in a storage space accessible to the roof. If exterior work ever requires hanging scaffolding, use caution to insure that the anchors do not penetrate, break, or wear the roofing surface, gutters, or flashing.

Any roofing system should be recognized as a membrane that is designed to be self-sustaining, but that can be easily damaged by intrusions such as pedestrian traffic or fallen tree branches. Certain items should be checked at specific times. For example, gutters tend to accumulate leaves and debris during the spring and fall and after heavy rain. Hidden gutter screening both at downspouts and over the full length of the gutter could help keep them clean. The surface material would require checking after a storm as well. Periodic checking of the underside of the roof from the attic after a storm or winter freezing may give early warning of any leaks. Generally, damage from water or ice is less likely on a roof that has good flashing on the outside and is well ventilated and insulated on the inside. Specific instructions for the maintenance of the different roof materials should be available from the architect or contractor.

### Summary

The essential ingredients for replacing and maintaining a historic roof are:

- Understanding the historic character of the building and being sympathetic to it.
- Careful examination and recording of the existing roof and any evidence of earlier roofs.
- Consideration of the historic craftsmanship and detailing and implementing them in the renewal wherever visible.
- Supervision of the roofers or maintenance personnel to assure preservation of historic fabric and proper understanding of the scope and detailing of the project.
- Consideration of alternative materials where the original cannot be used.
- Cyclical maintenance program to assure that the staff understands how to take care of the roof and of the particular trouble spots to safeguard.

With these points in mind, it will be possible to preserve the architectural character and maintain the physical integrity of the roofing on a historic building.

This Preservation Brief was written by Sarah M. Sweetser, Architectural Historian, Technical Preservation Services Division. Much of the technical information was based upon an unpublished report prepared under contract for this office by John G. and Diana S. Waite. Some of the historical information was from Charles E. Peterson, FAIA, "American Notes," *Journal of the Society of Architectural Historians*.

The illustrations for this brief not specifically credited are from the files of the Technical Preservation Services Division.

This publication was prepared pursuant to Executive Order 11593, "Protection and Enhancement of the Cultural Environment," which directs the Secretary of the Interior to "develop and make available to Federal agencies and State and local governments information concerning professional methods and tech-



Decorative features such as cupolas require extra maintenance. The flashing is carefully detailed to promote run-off, and the wooden ribbing must be kept well-painted. This roof surface, which was originally tin plate, has been replaced with lead-coated copper for maintenance purposes. (Lyndhurst, Tarrytown, New York, photo courtesy of the National Trust for Historic Preservation)

niques for preserving, improving, restoring and maintaining historic properties." The Brief 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 welcome and can be sent to Mr. Nelson at the above address. This publication is not copyrighted and can be reproduced without penalty. Normal procedures for credit to the author and the National Park Service are appreciated. February 1978.

Additional readings on the subject of roofing are listed below.

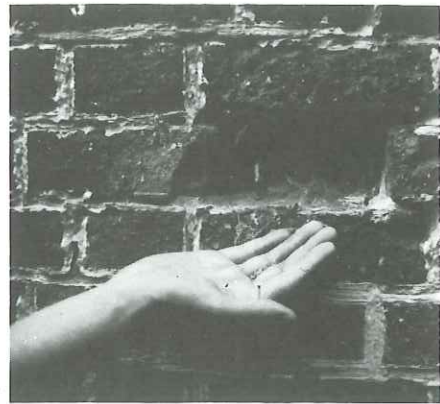
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# 6 PRESERVATION BRIEFS

## Dangers of Abrasive Cleaning to Historic Buildings

Anne E. Grimmer



U.S. Department of the Interior  
National Park Service  
Cultural Resources  
Heritage Preservation Services

"The surface cleaning of structures shall be undertaken with the gentlest means possible. Sandblasting and other cleaning methods that will damage the historic building materials shall not be undertaken."—The Secretary of the Interior's "Standards for Historic Preservation Projects."

Abrasive cleaning methods are responsible for causing a great deal of damage to historic building materials. To prevent indiscriminate use of these potentially harmful techniques, this brief has been prepared to explain abrasive cleaning methods, how they can be physically and aesthetically destructive to historic building materials, and why they generally are not acceptable preservation treatments for historic structures. There are alternative, less harsh means of cleaning and removing paint and stains from historic buildings. However, careful testing should precede general cleaning to assure that the method selected will not have an adverse effect on the building materials. A historic building is irreplaceable, and should be cleaned using only the "gentlest means possible" to best preserve it.

### What is Abrasive Cleaning?

Abrasive cleaning methods include all techniques that physically abrade the building surface to remove soils, discolorations or coatings. Such techniques involve the use of certain *materials* which impact or abrade the surface under pressure, or abrasive *tools and equipment*. Sand, because it is readily available, is probably the most commonly used type of grit material. However, any of the following materials may be substituted for sand, and all can be classified as abrasive substances: ground slag or volcanic ash, crushed (pulverized) walnut or almond shells, rice husks, ground corncobs, ground coconut shells, crushed eggshells, silica flour, synthetic particles, glass beads and micro-balloons. Even *water* under pressure can be an abrasive substance. Tools and equipment that are abrasive to historic building materials include wire

brushes, rotary wheels, power sanding disks and belt sanders.

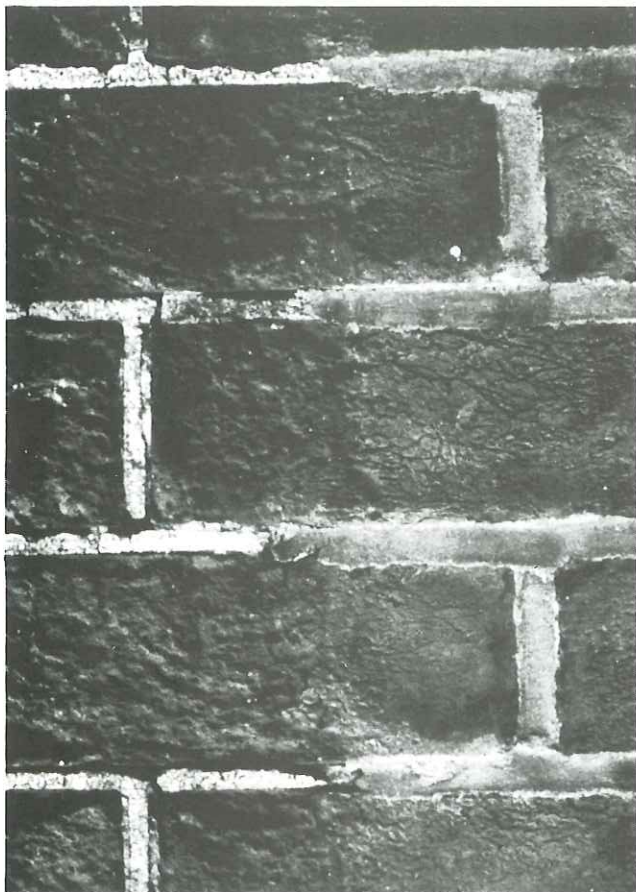
The use of water in combination with grit may also be classified as an abrasive cleaning method. Depending on the manner in which it is applied, water *may* soften the impact of the grit, but water that is too highly pressurized can be very abrasive. There are basically two different methods which can be referred to as "wet grit," and it is important to differentiate between the two. One technique involves the addition of a stream of water to a regular sandblasting nozzle. This is done primarily to cut down dust, and has very little, if any, effect on reducing the aggressiveness, or cutting action of the grit particles. With the second technique, a very small amount of grit is added to a pressurized water stream. This method may be controlled by regulating the amount of grit fed into the water stream, as well as the pressure of the water.

### Why Are Abrasive Cleaning Methods Used?

Usually, an abrasive cleaning method is selected as an expeditious means of quickly removing years of dirt accumulation, unsightly stains, or deteriorating building fabric or finishes, such as stucco or paint. The fact that sandblasting is one of the best known and most readily available building cleaning treatments is probably the major reason for its frequent use.

Many mid-19th century brick buildings were painted immediately or soon after completion to protect poor quality brick or to imitate another material, such as stone. Sometimes brick buildings were painted in an effort to produce what was considered a more harmonious relationship between a building and its natural surroundings. By the 1870s, brick buildings



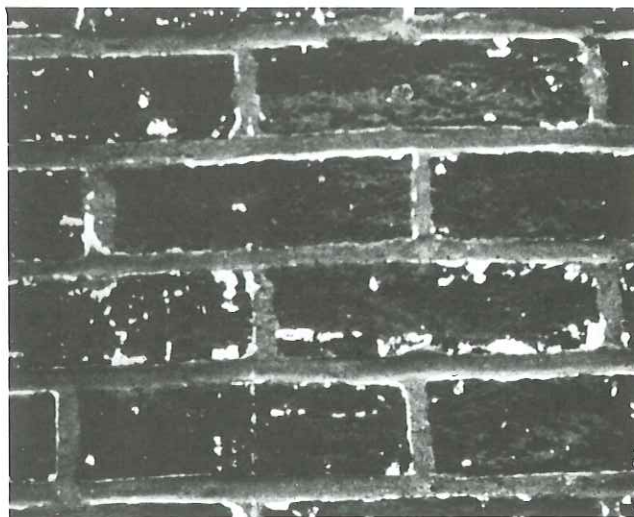


**Abrasively Cleaned vs. Untouched Brick.** Two brick rowhouses with a common façade provide an excellent point of comparison when only one of the houses has been sandblasted. It is clear that abrasive blasting, by removing the outer surface, has left the brickwork on the left rough and pitted, while that on the right still exhibits an undamaged and relatively smooth surface. Note that the abrasive cleaning has also removed a considerable portion of the mortar from the joints of the brick on the left side, which will require repointing.

were often left unpainted as mechanization in the brick industry brought a cheaper pressed brick and fashion decreed a sudden preference for dark colors. However, it was still customary to paint brick of poorer quality for the additional protection the paint afforded.

It is a common 20th-century misconception that all historic masonry buildings were initially unpainted. If the intent of a modern restoration is to return a building to its original appearance, removal of the paint not only may be historically inaccurate, but also harmful. Many older buildings were painted or stuccoed at some point to correct recurring maintenance problems caused by faulty construction techniques, to hide alterations, or in an attempt to solve moisture problems. If this is the case, removal of paint or stucco may cause these problems to reoccur.

Another reason for paint removal, particularly in rehabilitation projects, is to give the building a "new image" in response to contemporary design trends and to attract investors or tenants. Thus, it is necessary to consider the purpose of the intended cleaning. While it is clearly important to remove unsightly stains, heavy encrustations of dirt, peeling paint or other surface coatings, it may not be equally desirable to remove paint from a building which originally was painted. Many historic buildings which show only a slight amount of soil or discoloration are much better left as they are. A thin layer of soil is more often protective of the building fabric than it is harmful, and seldom detracts from the building's



**Abrasing the Surface without Removing the Paint.** Even though the entire outer surface layer of the brick has been sandblasted off, spots of paint still cling to the masonry. Sandblasting or other similarly abrasive methods are not always a successful means of removing paint.

architectural and/or historic character. Too thorough cleaning of a historic building may not only sacrifice some of the building's character, but also, misguided cleaning efforts can cause a great deal of damage to historic building fabric. Unless there are stains, graffiti or dirt and pollution deposits which are destroying the building fabric, it is generally preferable to do as little cleaning as possible, or to repaint where necessary. It is important to remember that a historic building does not have to look as if it were newly constructed to be an attractive or successful restoration or rehabilitation project. For a more thorough explanation of the philosophy of cleaning historic buildings see Preservation Briefs: No. 1 "The Cleaning and Waterproof Coating of Masonry Buildings," by Robert C. Mack, AIA.

### Problems of Abrasive Cleaning

The crux of the problem is that abrasive cleaning is just that—abrasive. An abrasively cleaned historic structure may be physically as well as aesthetically damaged. Abrasive methods "clean" by eroding dirt or paint, but at the same time they also tend to erode the surface of the building material. In this way, abrasive cleaning is destructive and causes irreversible harm to the historic building fabric. If the fabric is brick, abrasive methods remove the hard, outer protective surface, and therefore make the brick more susceptible to rapid weathering and deterioration. Grit blasting may also increase the water permeability of a brick wall. The impact of the grit particles tends to erode the bond between the mortar and the brick, leaving cracks or enlarging existing cracks where water can enter. Some types of stone develop a protective patina or "quarry crust" parallel to the worked surface (created by the movement of moisture towards the outer edge), which also may be damaged by abrasive cleaning. The rate at which the material subsequently weathers depends on the quality of the inner surface that is exposed.

Abrasive cleaning can destroy, or substantially diminish, decorative detailing on buildings such as a molded brickwork or architectural terra-cotta, ornamental carving on wood or stone, and evidence of historic craft techniques, such as tool marks and other surface textures. In addition, perfectly sound and/or "tooled" mortar joints can be worn away by abrasive techniques. This not only results in the loss of historic craft detailing but also requires repointing, a step involving con-



siderable time, skill and expense, and which might not have been necessary had a gentler method been chosen. Erosion and pitting of the building material by abrasive cleaning creates a greater surface area on which dirt and pollutants collect. In this sense, the building fabric "attracts" more dirt, and will require more frequent cleaning in the future.

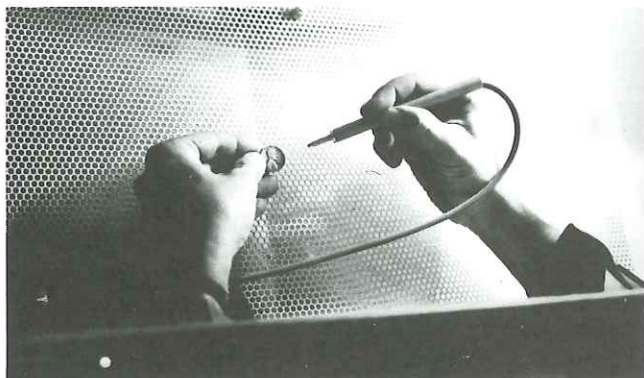
In addition to causing physical and aesthetic harm to the historic fabric, there are several adverse environmental effects of dry abrasive cleaning methods. Because of the friction caused by the abrasive medium hitting the building fabric, these techniques usually create a considerable amount of dust, which is unhealthy, particularly to the operators of the abrasive equipment. It further pollutes the environment around the job site, and deposits dust on neighboring buildings, parked vehicles and nearby trees and shrubbery. Some adjacent materials not intended for abrasive treatment such as wood or glass, may also be damaged because the equipment may be difficult to regulate.

Wet grit methods, while eliminating dust, deposit a messy slurry on the ground or other objects surrounding the base of the building. In colder climates where there is the threat of frost, any wet cleaning process applied to historic masonry structures must be done in warm weather, allowing ample time for the wall to dry out thoroughly before cold weather sets in. Water which remains and freezes in cracks and openings of the masonry surface eventually may lead to spalling. High-pressure wet cleaning may force an inordinate amount of water into the walls, affecting interior materials such as plaster or joist ends, as well as metal building components within the walls.

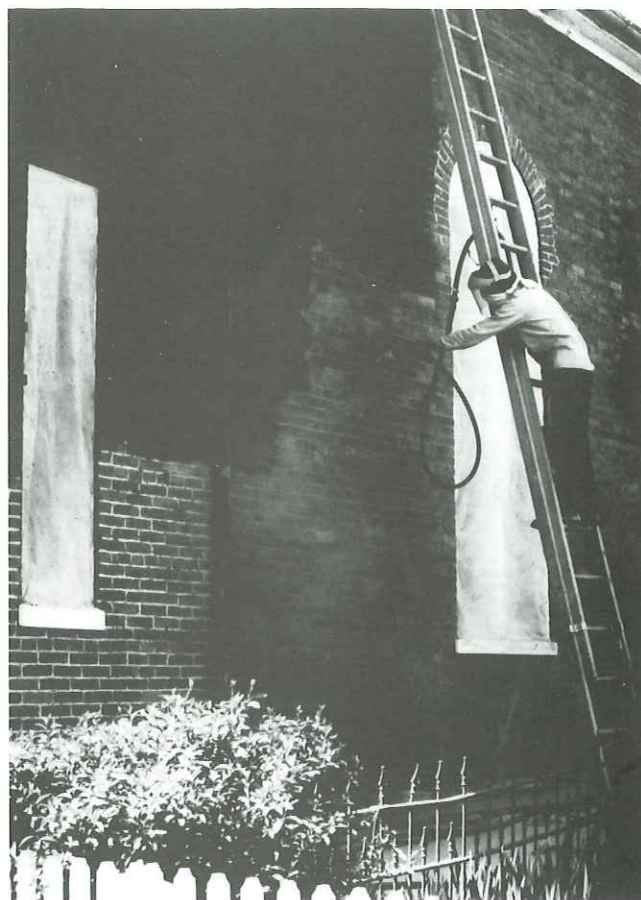
#### Variable Factors

The greatest problem in developing practical guidelines for cleaning any historic building is the large number of variable and unpredictable factors involved. Because these variables make each cleaning project unique, it is difficult to establish specific standards at this time. This is particularly true of abrasive cleaning methods because their inherent potential for causing damage is multiplied by the following factors:

- the type and condition of the material being cleaned;
- the size and sharpness of the grit particles or the mechanical equipment;
- the pressure with which the abrasive grit or equipment is applied to the building surface;
- the skill and care of the operator; and
- the constancy of the pressure on all surfaces during the cleaning process.



**Micro-Abrasive Cleaning.** This small, pencil-sized micro-abrasive unit is used by some museum conservators to clean small objects. This particular micro-abrasive unit is operated within the confines of a box (approximately 2 cubic feet of space), but a similar and slightly larger unit may be used for cleaning larger pieces of sculpture, or areas of architectural detailing on a building. Even a pressure cleaning unit this small is capable of eroding a surface, and must be carefully controlled.



**"Line Drop."** Even though the operator of the sandblasting equipment is standing on a ladder to reach the higher sections of the wall, it is still almost impossible to have total control over the pressure. The pressure of the sand hitting the lower portion of the wall will still be greater than that above, because of the "line drop" in the distance from the pressure source to the nozzle. (Hugh Miller)

**Pressure:** The damaging effects of most of the variable factors involved in abrasive cleaning are self evident. However, the matter of pressure requires further explanation. In cleaning specifications, pressure is generally abbreviated as "psi" (pounds per square inch), which technically refers to the "tip" pressure, or the amount of pressure at the nozzle of the blasting apparatus. Sometimes "psig," or pressure at the gauge (which may be many feet away, at the other end of the hose), is used in place of "psi." These terms are often incorrectly used interchangeably.

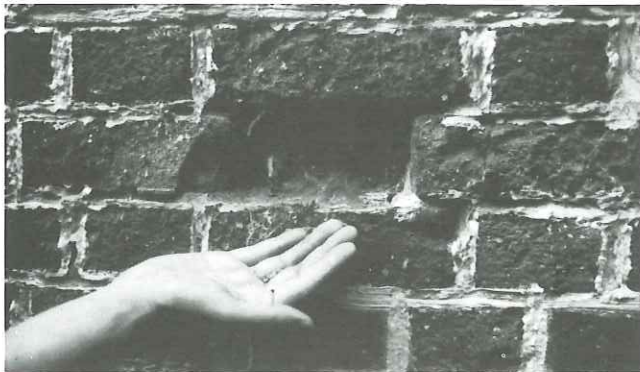
Despite the apparent care taken by most architects and building cleaning contractors to prepare specifications for pressure cleaning which will not cause harm to the delicate fabric of a historic building, it is very difficult to ensure that the same amount of pressure is applied to all parts of the building. For example, if the operator of the pressure equipment stands on the ground while cleaning a two-story structure, the amount of force reaching the first story will be greater than that hitting the second story, even if the operator stands on scaffolding or in a cherry picker, because of the "line drop" in the distance from the pressure source to the nozzle. Although technically it may be possible to prepare cleaning specifications with tight controls that would eliminate all but a small margin of error, it may not be easy to find professional cleaning firms willing to work under such restrictive conditions. The fact is that many professional building cleaning firms do not really understand the extreme delicacy of historic building fabric, and how it differs from modern construction materials. Consequently, they may ac-



cept building cleaning projects for which they have no experience.

The amount of pressure used in any kind of cleaning treatment which involves pressure, whether it is dry or wet grit, chemicals or just plain water, is crucial to the outcome of the cleaning project. Unfortunately, no standards have been established for determining the correct pressure for cleaning each of the many historic building materials which would not cause harm. The considerable discrepancy between the way the building cleaning industry and architectural conservators define "high" and "low" pressure cleaning plays a significant role in the difficulty of creating standards.

**Nonhistoric/Industrial:** A representative of the building cleaning industry might consider "high" pressure water cleaning to be anything over 5,000 psi, or even as high as 10,000 to 15,000 psi! Water under this much pressure may be necessary to clean industrial structures or machinery, but would destroy most historic building materials. Industrial chemical cleaning commonly utilizes pressures between 1,000 and 2,500 psi.



**Spalling Brick.** This soft, early 19th-century brick was sandblasted in the 1960s; consequently, severe spalling has resulted. Some bricks have almost totally disintegrated, and will eventually have to be replaced. (Robert S. Gamble)

**Historic:** By contrast, conscientious dry or wet abrasive cleaning of a historic structure would be conducted within the range of 20 to 100 psi at a range of 3 to 12 inches. Cleaning at this low pressure requires the use of a very fine 00 or 0 mesh grit forced through a nozzle with a 1/4 inch opening. A similar, even more delicate method being adopted by architectural conservators uses a micro-abrasive grit on small, hard-to-clean areas of carved, cut or molded ornament on a building façade. Originally developed by museum conservators for cleaning sculpture, this technique may employ glass beads, micro-balloons, or another type of micro-abrasive gently powered at approximately 40 psi by a very small, almost pencil-like pressure instrument. Although a slightly larger pressure instrument may be used on historic buildings, this technique still has limited practical applicability on a large scale building cleaning project because of the cost and the relatively few technicians competent to handle the task. In general, architectural conservators have determined that only through very controlled conditions can most historic building material be abrasively cleaned of soil or paint without measurable damage to the surface or profile of the substrate.

Yet some professional cleaning companies which specialize in cleaning historic masonry buildings use chemicals and water at a pressure of approximately 1,500 psi, while other cleaning firms recommend lower pressures ranging from 200 to 800 psi for a similar project. An architectural conservator might decide, *after testing*, that some historic structures could be cleaned properly using a moderate pressure (200–600 psi), or even a high pressure (600–1800 psi) water rinse. However,

cleaning historic buildings under such high pressure should be considered an exception rather than the rule, and would require *very careful* testing and supervision to assure that the historic surface materials could withstand the pressure without gouging, pitting or loosening.

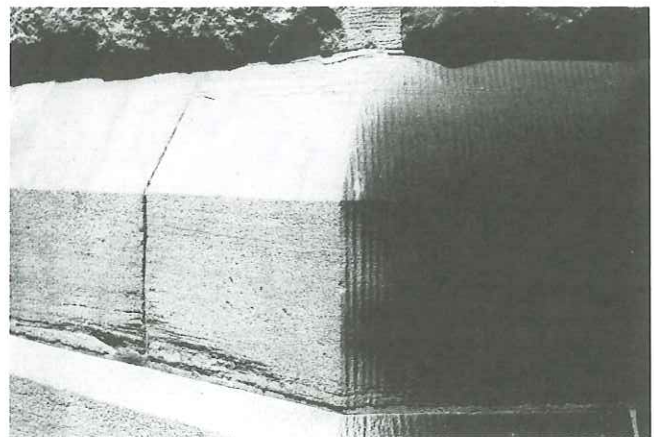
These differences in the amount of pressure used by commercial or industrial building cleaners and architectural conservators point to one of the main problems in using abrasive means to clean historic buildings: misunderstanding of the potentially fragile nature of historic building materials. There is no one cleaning formula or pressure suitable for all situations. Decisions regarding the proper cleaning process for historic structures can be made only after careful analysis of the building fabric, and testing.

### How Building Materials React to Abrasive Cleaning Methods

**Brick and Architectural Terra-Cotta:** Abrasive blasting does not affect all building materials to the same degree. Such techniques quite logically cause greater damage to softer and more porous materials, such as brick or architectural terracotta. When these materials are cleaned abrasively, the hard, outer layer (closest to the heat of the kiln) is eroded, leaving the soft, inner core exposed and susceptible to accelerated weathering. Glazed architectural terracotta and ceramic veneer have a baked-on glaze which is also easily damaged by abrasive cleaning. Glazed architectural terracotta was designed for easy maintenance, and generally can be cleaned using detergent and water; but chemicals or steam may be needed to remove more persistent stains. Large areas of brick or architectural terracotta which have been painted are best left painted, or repainted if necessary.

**Plaster and Stucco:** Plaster and stucco are types of masonry finish materials that are softer than brick or terracotta; if treated abrasively these materials will simply disintegrate. Indeed, when plaster or stucco is treated abrasively it is usually with the intention of removing the plaster or stucco from whatever base material or substrate it is covering. Obviously, such abrasive techniques should not be applied to clean sound plaster or stuccoed walls, or decorative plaster wall surfaces.

**Building Stones:** Building stones are cut from the three main categories of natural rock: dense, igneous rock such as granite; sandy, sedimentary rock such as limestone or sandstone; and crystalline, metamorphic rock such as marble. As op-



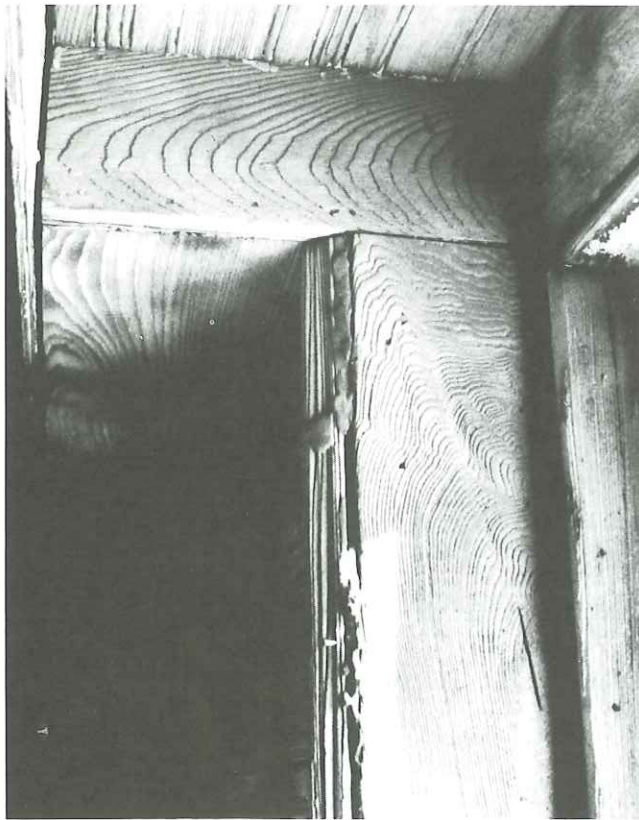
**Abrasive Cleaning of Tooled Granite.** Even this carefully controlled "wet grit" blasting has erased vertical tooling marks in the cut granite blocks on the left. Not only has the tooling been destroyed, but the damaged stone surface is now more susceptible to accelerated weathering.



posed to kiln-dried masonry materials such as brick and architectural terra-cotta, building stones are generally homogeneous in character at the time of a building's construction. However, as the stone is exposed to weathering and environmental pollutants, the surface may become friable, or may develop a protective skin or patina. These outer surfaces are very susceptible to damage by abrasive or improper chemical cleaning.

Building stones are frequently cut into ashlar blocks or "dressed" with tool marks that give the building surface a specific texture and contribute to its historic character as much as ornately carved decorative stonework. Such detailing is easily damaged by abrasive cleaning techniques; the pattern of tooling or cutting is erased, and the crisp lines of moldings or carving are worn or pitted.

Occasionally, it may be possible to clean small areas of rough-cut granite, limestone or sandstone having a heavy dirt encrustation by using the "wet grit" method, whereby a small amount of abrasive material is injected into a controlled, pressurized water stream. However, this technique requires very careful supervision in order to prevent damage to the stone. Polished or honed marble or granite should *never* be treated abrasively, as the abrasion would remove the finish in much the way glass would be etched or "frosted" by such a process. It is generally preferable to underclean, as too strong a cleaning procedure will erode the stone, exposing a new and increased surface area to collect atmospheric moisture and dirt. Removing paint, stains or graffiti from most types of stone may be accomplished by a chemical treatment carefully selected to best handle the removal of the particular type of paint or stain without damaging the stone. (See section on the "Gentlest Means Possible")



**Abrasive Cleaning of Wood.** This wooden windowsill, molding and paneling have been sandblasted to remove layers of paint in the rehabilitation of this commercial building. Not only is some paint still embedded in cracks and crevices of the woodwork, but more importantly, grit blasting has actually eroded the summer wood, in effect raising the grain, and resulting in a rough surface.

**Wood:** Most types of wood used for buildings are soft, fibrous and porous, and are particularly susceptible to damage by abrasive cleaning. Because the summer wood between the lines of the grain is softer than the grain itself, it will be worn away by abrasive blasting or power tools, leaving an uneven surface with the grain raised and often frayed or "fuzzy." Once this has occurred, it is almost impossible to achieve a smooth surface again except by extensive hand sanding, which is expensive and will quickly negate any costs saved earlier by sandblasting. Such harsh cleaning treatment also obliterates historic tool marks, fine carving and detailing, which precludes its use on any interior or exterior woodwork which has been hand planed, milled or carved.

**Metals:** Like stone, metals are another group of building materials which vary considerably in hardness and durability. Softer metals which are used architecturally, such as tin, zinc, lead, copper or aluminum, generally should not be cleaned abrasively as the process deforms and destroys the original surface texture and appearance, as well as the acquired patina. Much applied architectural metal work used on historic buildings—tin, zinc, lead and copper—is often quite thin and soft, and therefore susceptible to denting and pitting. Galvanized sheet metal is especially vulnerable, as abrasive treatment would wear away the protective galvanized layer.

In the late 19th and early 20th centuries, these metals were often cut, pressed or otherwise shaped from sheets of metal into a wide variety of practical uses such as roofs, gutters and flashing, and façade ornamentation such as cornices, friezes, dormers, panels, cupolas, oriel windows, etc. The architecture of the 1920s and 1930s made use of metals such as chrome, nickel alloys, aluminum and stainless steel in decorative exterior panels, window frames, and doorways. Harsh abrasive blasting would destroy the original surface finish of most of these metals, and would increase the possibility of corrosion.

However, conservation specialists are now employing a sensitive technique of glass bead peening to clean some of the harder metals, in particular large bronze outdoor sculpture. Very fine (75–125 micron) glass beads are used at a low pressure of 60 to 80 psi. Because these glass beads are completely spherical, there are no sharp edges to cut the surface of the metal. After cleaning, these statues undergo a lengthy process of polishing. Coatings are applied which protect the surface from corrosion, but they must be renewed every 3 to 5 years. A similarly delicate cleaning technique employing glass beads has been used in Europe to clean historic masonry structures without causing damage. But at this time the process has not been tested sufficiently in the United States to recommend it as a building conservation measure.

Sometimes a very fine *smooth* sand is used at a low pressure to clean or remove paint and corrosion from copper flashing and other metal building components. Restoration architects recently found that a mixture of crushed walnut shells and copper slag at a pressure of approximately 200 psi was the only way to remove corrosion successfully from a mid-19th century terne-coated iron roof. Metal cleaned in this manner must be painted immediately to prevent rapid recurrence of corrosion. It is thought that these methods "work harden" the surface by compressing the outer layer, and actually may be good for the surface of the metal. But the extremely complex nature and the time required by such processes make it very expensive and impractical for large-scale use at this time.

Cast and wrought iron architectural elements may be gently sandblasted or abrasively cleaned using a wire brush to remove layers of paint, rust and corrosion. Sandblasting was, in fact, developed originally as an efficient maintenance procedure for engineering and industrial structures and heavy machinery—iron and steel bridges, machine tool frames, engine frames, and railroad rolling stock—in order to clean and prepare them for repainting. Because iron is hard, its surface,



which is naturally somewhat uneven, will not be noticeably damaged by controlled abrasion. Such treatment will, however, result in a small amount of pitting. But this slight abrasion creates a good surface for paint, since the iron must be repainted immediately to prevent corrosion. Any abrasive cleaning of metal building components will also remove the caulking from joints and around other openings. Such areas must be recaulked quickly to prevent moisture from entering and rusting the metal, or causing deterioration of other building fabric inside the structure.

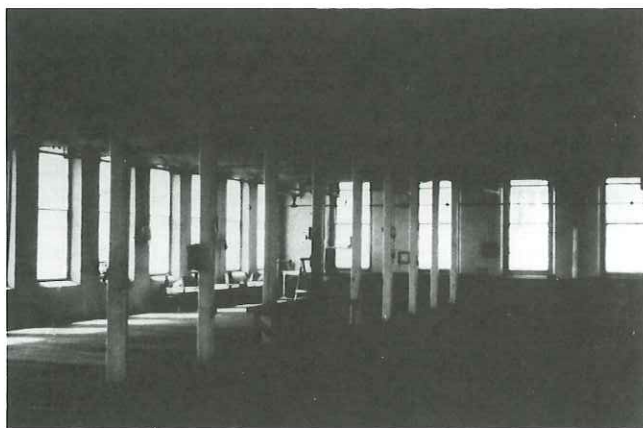
#### When is Abrasive Cleaning Permissible?

For the most part, abrasive cleaning is destructive to historic building materials. A limited number of special cases have been explained when it may be appropriate, if supervised by a skilled conservator, to use a delicate abrasive technique on some historic building materials. The type of "wet grit" cleaning which involves a small amount of grit injected into a stream of low pressure water may be used on small areas of stone masonry (i.e., rough cut limestone, sandstone or unpolished granite), where milder cleaning methods have not been totally successful in removing harmful deposits of dirt and pollutants. Such areas may include stone window sills, the tops of cornices or column capitals, or other detailed areas of the façade.

This is still an abrasive technique, and without proper caution in handling, it can be *just as harmful to the building surface as any other abrasive cleaning method*. Thus, the decision to use this type of "wet grit" process should be made only after consultation with an experienced building conservator. Remember that *it is very time consuming and expensive to use any abrasive technique on a historic building in such a manner that it does not cause harm to the often fragile and friable building materials*.

At this time, and only under certain circumstances, abrasive cleaning methods may be used in the rehabilitation of interior spaces of warehouse or industrial buildings for contemporary uses.

Interior spaces of factories or warehouse structures in which the masonry or plaster surfaces do not have significant design, detailing, tooling or finish, and in which wooden architectural features are not finished, molded, beaded or worked by hand, may be cleaned abrasively in order to remove layers of paint and industrial discolorations such as smoke, soot, etc. It is expected after such treatment that brick surfaces will be rough and pitted, and wood will be somewhat frayed or "fuzzy"



**Permissible Abrasive Cleaning.** In accordance with the Secretary of the Interior's Guidelines for Rehabilitation Projects, it may be acceptable to use abrasive techniques to clean an industrial interior space such as that illustrated here, because the masonry surfaces do not have significant design, detailing, tooling or finish, and the wooden architectural features are not finished, molded, beaded or worked by hand.

with raised wood grain. These nonsignificant surfaces will be damaged and have a roughened texture, but because they are interior elements, they will not be subject to further deterioration caused by weathering.

#### Historic Interiors that Should Not Be Cleaned Abrasively

Those instances (generally industrial and some commercial properties), when it may be acceptable to use an abrasive treatment on the interior of historic structures have been described. But for the majority of historic buildings, the Secretary of the Interior's *Guidelines for Rehabilitation* do not recommend "changing the texture of exposed wooden architectural features (including structural members) and masonry surfaces through sandblasting or use of other abrasive techniques to remove paint, discolorations and plaster. . . ."

Thus, it is not acceptable to clean abrasively interiors of historic residential and commercial properties which have *finished* interior spaces featuring milled woodwork such as doors, window and door moldings, wainscoting, stair balustrades and mantelpieces. Even the most modest historic house interior, although it may not feature elaborate detailing, contains plaster and woodwork that is architecturally significant to the original design and function of the house. Abrasive cleaning of such an interior would be destructive to the historic integrity of the building.

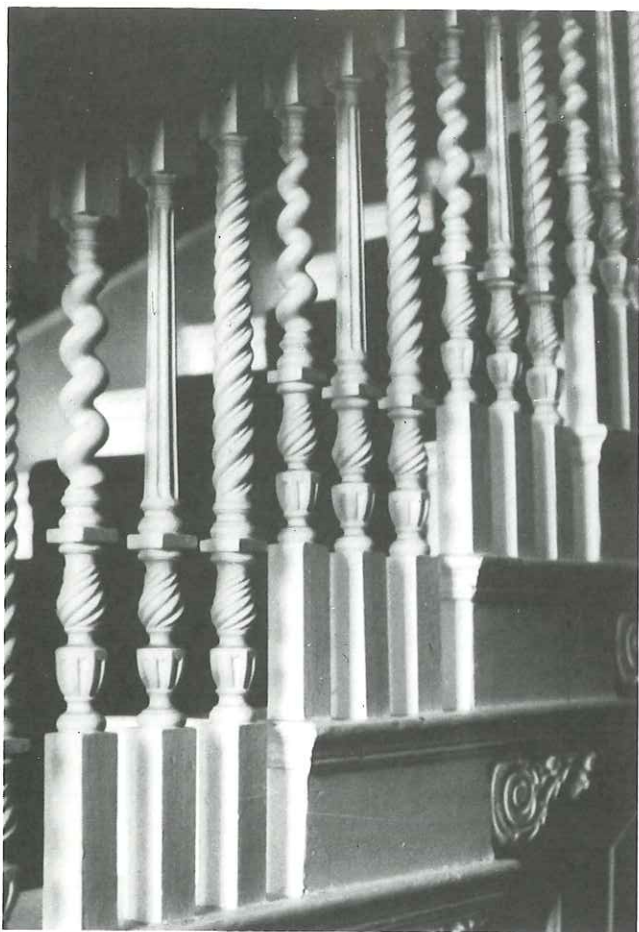
Abrasive cleaning is also impractical. Rough surfaces of abrasively cleaned wooden elements are hard to keep clean. It is also difficult to seal, paint or maintain these surfaces which can be splintery and a problem to the building's occupants. The force of abrasive blasting may cause grit particles to lodge in cracks of wooden elements, which will be a nuisance as the grit is loosened by vibrations and gradually sifts out. Removal of plaster will reduce the thermal and insulating value of the walls. Interior brick is usually softer than exterior brick, and generally of a poorer quality. Removing surface plaster from such brick by abrasive means often exposes gaping mortar joints and mismatched or repaired brickwork which was never intended to show. The resulting bare brick wall may require repointing, often difficult to match. It also may be necessary to apply a transparent surface coating (or sealer) in order to prevent the mortar and brick from "dusting." However, a sealer may not only change the color of the brick, but may also compound any existing moisture problems by restricting the normal evaporation of water vapor from the masonry surface.

#### "Gentlest Means Possible"

There are alternative means of removing dirt, stains and paint from historic building surfaces that can be recommended as more efficient and less destructive than abrasive techniques. The "gentlest means possible" of removing dirt from a building surface can be achieved by using a low-pressure water wash, scrubbing areas of more persistent grime with a natural bristle (never metal) brush. Steam cleaning can also be used effectively to clean some historic building fabric. Low-pressure water or steam will soften the dirt and cause the deposits to rise to the surface, where they can be washed away.

A third cleaning technique which may be recommended to remove dirt, as well as stains, graffiti or paint, involves the use of commercially available chemical cleaners or paint removers, which, when applied to masonry, loosen or dissolve the dirt or stains. These cleaning agents may be used in combination with water or steam, followed by a clear water wash to remove the residue of dirt and the chemical cleaners from the masonry. A natural bristle brush may also facilitate this type of chemically assisted cleaning, particularly in areas of heavy dirt deposits or stains, and a wooden scraper can be





**Do not Abrasively Clean these Interiors.** *Most historic residential and some commercial interior spaces contain finished plaster and wooden elements such as this stair balustrade and paneling which contribute to the historic and architectural character of the structure. Such interiors should not be subjected to abrasive techniques for the purpose of removing paint, dirt, discoloration or plaster.*

useful in removing thick encrustations of soot. A limewash or absorbent talc, whitening or clay poultice with a solvent can be used effectively to draw out salts or stains from the surface of the selected areas of a building façade. It is almost impossible to remove paint from masonry surfaces without causing some damage to the masonry, and it is best to leave the surfaces as they are or repaint them if necessary.

Some physicists are experimenting with the use of pulsed laser beams and xenon flash lamps for cleaning historic masonry surfaces. At this time it is a slow, expensive cleaning method, but its initial success indicates that it may have an increasingly important role in the future.

There are many chemical paint removers which, when applied to painted wood, soften and dissolve the paint so that it can be scraped off by hand. Peeling paint can be removed from wood by hand scraping and sanding. Particularly thick layers of paint may be softened with a heat gun or heat plate, providing appropriate precautions are taken, and the paint film scraped off by hand. Too much heat applied to the same spot can burn the wood, and the fumes caused by burning paint are dangerous to inhale, and can be explosive. Furthermore, the hot air from heat guns can start fires in the building cavity. Thus, adequate ventilation is important when using a heat gun or heat plate, as well as when using a chemical stripper. A torch or open flame should never be used.

**Preparations for Cleaning:** It cannot be overemphasized that all of these cleaning methods must be approached with cau-

tion. When using any of these procedures which involve water or other liquid cleaning agents on masonry, it is imperative that *all* openings be tightly covered, and all cracks or joints be well pointed in order to avoid the danger of water penetrating the building's facade, a circumstance which might result in serious moisture related problems such as efflorescence and/or subflorescence. Any time water is used on masonry as a cleaning agent, either in its pure state or in combination with chemical cleaners, it is very important that the work be done in warm weather when there is no danger of frost for several months. Otherwise water which has penetrated the masonry may freeze, eventually causing the surface of the building to crack and spall, which may create another conservation problem more serious to the health of the building than dirt.

Each kind of masonry has a unique composition and reacts differently with various chemical cleaning substances. Water and/or chemicals may interact with minerals in stone and cause new types of stains to leach out to the surface immediately, or more gradually in a delayed reaction. What may be a safe and effective cleaner for certain stain on one type of stone, may leave unattractive discolorations on another stone, or totally dissolve a third type.

**Testing:** Cleaning historic building materials, particularly masonry, is a technically complex subject, and thus, should never be done without expert consultation and testing. No cleaning project should be undertaken without first applying the intended cleaning agent to a representative test patch area in an inconspicuous location on the building surface. The test patch or patches should be allowed to weather for a period of time, preferably through a complete seasonal cycle, in order to determine that the cleaned area will not be adversely affected by wet or freezing weather or any by-products of the cleaning process.

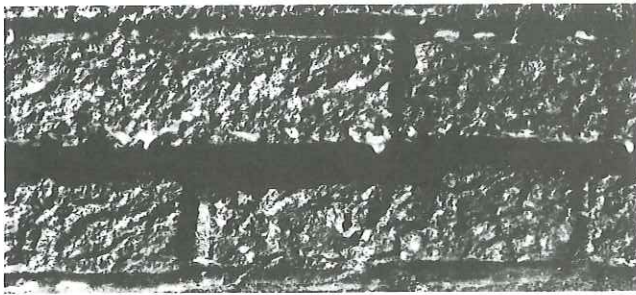
### Mitigating the Effects of Abrasive Cleaning

There are certain restoration measures which can be adopted to help preserve a historic building exterior which has been damaged by abrasive methods. Wood that has been sandblasted will exhibit a frayed or "fuzzed" surface, or a harder wood will have an exaggerated raised grain. The only way to remove this rough surface or to smooth the grain is by laborious sanding. Sandblasted wood, unless it has been extensively sanded, serves as a dustcatcher, will weather faster, and will present a continuing and ever worsening maintenance problem. Such wood, after sanding, should be painted or given a clear surface coating to protect the wood, and allow for somewhat easier maintenance.

There are few successful preservative treatments that may be applied to grit-blasted exterior masonry. Harder, denser stone may have suffered only a loss of crisp edges or tool marks, or other indications of craft technique. If the stone has a compact and uniform composition, it should continue to weather with little additional deterioration. But some types of sandstone, marble and limestone will weather at an accelerated rate once their protective "quarry crust" or patina has been removed.

Softer types of masonry, particularly brick and architectural terra-cotta, are the most likely to require some remedial treatment if they have been abrasively cleaned. Old brick, being essentially a soft, baked clay product, is greatly susceptible to increased deterioration when its hard, outer skin is removed through abrasive techniques. This problem can be minimized by painting the brick. An alternative is to treat it with a clear sealer or surface coating but this will give the masonry a glossy or shiny look. It is usually preferable to paint the brick rather than to apply a transparent sealer since





**Hazards of Sandblasting and Surface Coating.** In order to "protect" this heavily sandblasted brick, a clear surface coating or sealer was applied. Because the air temperature was too cold at the time of application, the sealer failed to dry properly, dripping in places, and giving the brick surface a cloudy appearance.

sealers reduce the transpiration of moisture, allowing salts to crystallize as subflorescence that eventually spalls the brick. If a brick surface has been so extensively damaged by abrasive cleaning and weathering that spalling has already begun, it may be necessary to cover the walls with stucco, if it will adhere.

Of course, the application of paint, a clear surface coating (sealer), or stucco to deteriorating masonry means that the historical appearance will be sacrificed in an attempt to conserve the historic building materials. However, the original color and texture will have been changed already by the abrasive treatment. At this point it is more important to try to preserve the brick, and there is little choice but to protect it from "dusting" or spalling too rapidly. As a last resort, in the case of severely spalling brick, there may be no option but to replace the brick—a difficult, expensive (particularly if custom-made reproduction brick is used), and lengthy process. As described earlier, sandblasted interior brick work, while not subject to change of weather, may require the application of a transparent surface coating or painting as a maintenance procedure to contain loose mortar and brick dust. (See Preservation Briefs: No. 1 for a more thorough discussion of coatings.)

Metals, other than cast or wrought iron, that have been pitted and dented by harsh abrasive blasting usually cannot be smoothed out. Although fillers may be satisfactory for smoothing a painted surface, exposed metal that has been damaged usually will have to be replaced.

## Summary

Sandblasting or other abrasive methods of cleaning or paint removal are by their nature destructive to historic building materials and should not be used on historic buildings except in a few well-monitored instances. There are exceptions when certain types of abrasive cleaning may be permissible, but only if conducted by a trained conservator, and if cleaning is necessary for the preservation of the historic structure.

There is no one formula that will be suitable for cleaning all historic building surfaces. Although there are many commercial cleaning products and methods available, it is impossible to state definitively which of these will be the most effective without causing harm to the building fabric. It is often difficult to identify ingredients or their proportions contained in cleaning products; consequently it is hard to predict how a product will react to the building materials to be cleaned. Similar uncertainties affect the outcome of other cleaning methods as they are applied to historic building materials. Further advances in understanding the complex nature of the many variables of the cleaning techniques may someday provide a better and simpler solution to the problems. But until that time, the process of cleaning historic buildings must be approached with caution through trial and error.

It is important to remember that historic building materials are neither indestructible, nor are they renewable. They must be treated in a responsible manner, which may mean little or no cleaning at all if they are to be preserved for future generations to enjoy. If it is in the best interest of the building to clean it, then it should be done "using the gentlest means possible."



## Selected Reading List

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# Preservation Briefs: 9

## The Repair of Historic Wooden Windows

John H. Myers

The windows on many historic buildings are an important aspect of the architectural character of those buildings. Their design, craftsmanship, or other qualities may make them worthy of preservation. This is self-evident for ornamental windows, but it can be equally true for warehouses or factories where the windows may be the most dominant visual element of an otherwise plain building (see figure 1). Evaluating the significance of these windows and planning for their repair or replacement can be a complex process involving both objective and subjective considerations. The *Secretary of the Interior's Standards for Rehabilitation*, and the accompanying guidelines, call for respecting the significance of original materials and features, repairing and retaining them wherever possible, and when necessary, replacing them in kind. This Brief is based on the issues of significance and repair which are implicit in the standards, but the primary emphasis is on the technical issues of planning for the repair of windows including evaluation of their physical condition, techniques of repair, and design considerations when replacement is necessary.

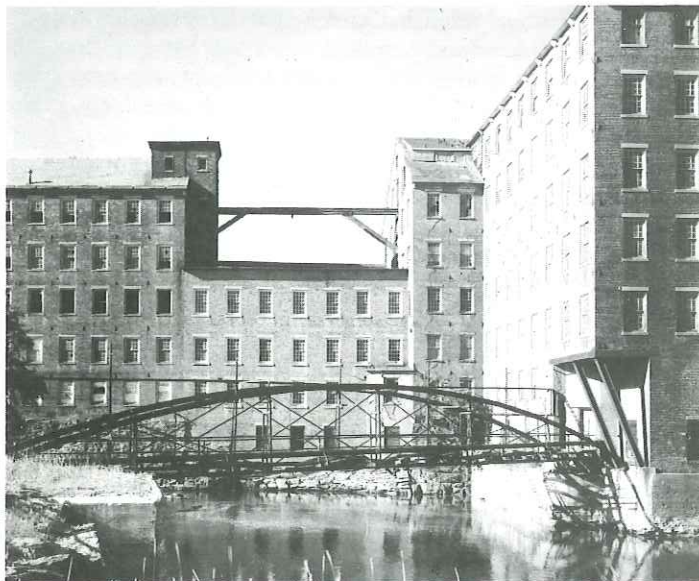


Figure 1. Windows are frequently important visual focal points, especially on simple facades such as this mill building. Replacement of the multi-pane windows here with larger panes could dramatically change the appearance of the building. The areas of missing windows convey the impression of such a change. Photo: John T. Lowe

Much of the technical section presents repair techniques as an instructional guide for the do-it-yourselfer. The information will be useful, however, for the architect, contractor, or developer on large-scale projects. It presents a methodology for approaching the evaluation and repair of existing windows, and considerations for replacement, from which the professional can develop alternatives and specify appropriate materials and procedures.

### Architectural or Historical Significance

Evaluating the architectural or historical significance of windows is the first step in planning for window treatments, and a general understanding of the function and history of windows is vital to making a proper evaluation. As a part of this evaluation, one must consider four basic window functions: admitting light to the interior spaces, providing fresh air and ventilation to the interior, providing a visual link to the outside world, and enhancing the appearance of a building. No single factor can be disregarded when planning window treatments; for example, attempting to conserve energy by closing up or reducing the size of window openings may result in the use of more energy by increasing electric lighting loads and decreasing passive solar heat gains.

Historically, the first windows in early American houses were casement windows; that is, they were hinged at the side and opened outward. In the beginning of the eighteenth century single- and double-hung windows were introduced. Subsequently many styles of these vertical sliding sash windows have come to be associated with specific building periods or architectural styles, and this is an important consideration in determining the significance of windows, especially on a local or regional basis. Site-specific, regionally oriented architectural comparisons should be made to determine the significance of windows in question. Although such comparisons may focus on specific window types and their details, the ultimate determination of significance should be made within the context of the whole building, wherein the windows are one architectural element (see figure 2).

After all of the factors have been evaluated, *windows should be considered significant to a building if they:* 1) are original, 2) reflect the original design intent for the building, 3) reflect period or regional styles or building practices, 4) reflect changes to the building resulting from major periods or events, or 5) are examples of exceptional craftsmanship or design. Once this evaluation of significance has been completed, it is possible to pro-



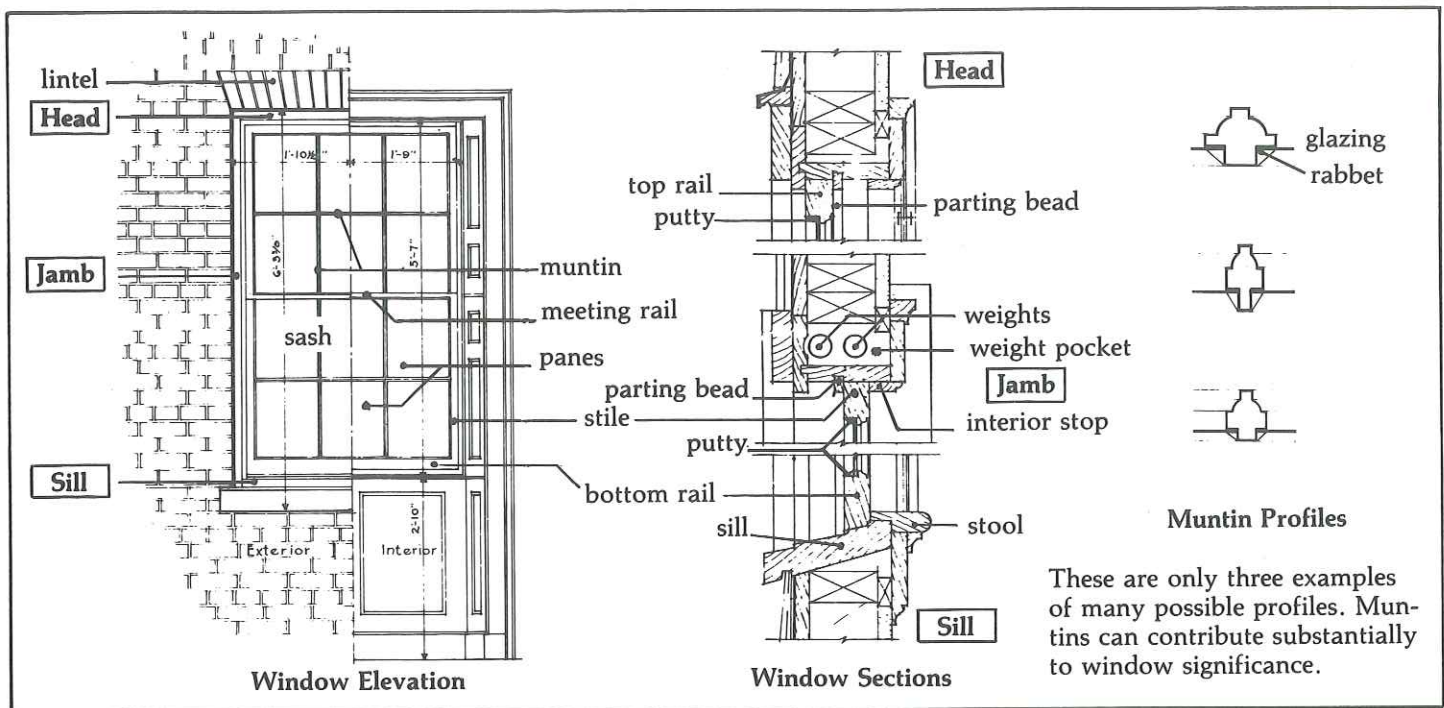


Figure 2. These drawings of window details identify major components, terminology, and installation details for a wooden double-hung window.

ceed with planning appropriate treatments, beginning with an investigation of the physical condition of the windows.

### Physical Evaluation

The key to successful planning for window treatments is a careful evaluation of existing physical conditions on a unit-by-unit basis. A graphic or photographic system may be devised to record existing conditions and illustrate the scope of any necessary repairs. Another effective tool is a window schedule which lists all of the parts of each window unit. Spaces by each part allow notes on existing conditions and repair instructions. When such a schedule is completed, it indicates the precise tasks to be performed in the repair of each unit and becomes a part of the specifications. In any evaluation, one should note at a minimum, 1) window location, 2) condition of the paint, 3) condition of the frame and sill, 4) condition of the sash (rails, stiles and muntins), 5) glazing problems, 6) hardware, and 7) the overall condition of the window (excellent, fair, poor, and so forth).

Many factors such as poor design, moisture, vandalism, insect attack, and lack of maintenance can contribute to window deterioration, but moisture is the primary contributing factor in wooden window decay. All window units should be inspected to see if water is entering around the edges of the frame and, if so, the joints or seams should be caulked to eliminate this danger. The glazing putty should be checked for cracked, loose, or missing sections which allow water to saturate the wood, especially at the joints. The back putty on the interior side of the pane should also be inspected, because it creates a seal which prevents condensation from running down into the joinery. The sill should be examined to insure that it slopes downward away from the building and allows water to drain off. In addition, it may be advisable to cut a dripline along the underside of the sill. This almost invisible treatment will insure proper water run-off, particu-

larly if the bottom of the sill is flat. Any conditions, including poor original design, which permit water to come in contact with the wood or to puddle on the sill must be corrected as they contribute to deterioration of the window.

One clue to the location of areas of excessive moisture is the condition of the paint; therefore, each window should be examined for areas of paint failure. Since excessive moisture is detrimental to the paint bond, areas of paint blistering, cracking, flaking, and peeling usually identify points of water penetration, moisture saturation, and potential deterioration. Failure of the paint should not, however, be mistakenly interpreted as a sign that the wood is in poor condition and hence, irreparable. Wood is frequently in sound physical condition beneath unsightly paint. After noting areas of paint failure, the next step is to inspect the condition of the wood, particularly at the points identified during the paint examination.

Each window should be examined for operational soundness beginning with the lower portions of the frame and sash. Exterior rainwater and interior condensation can flow downward along the window, entering and collecting at points where the flow is blocked. The sill, joints between the sill and jamb, corners of the bottom rails and muntin joints are typical points where water collects and deterioration begins (see figure 3). The operation of the window (continuous opening and closing over the years and seasonal temperature changes) weakens the joints, causing movement and slight separation. This process makes the joints more vulnerable to water which is readily absorbed into the end-grain of the wood. If severe deterioration exists in these areas, it will usually be apparent on visual inspection, but other less severely deteriorated areas of the wood may be tested by two traditional methods using a small ice pick.

An ice pick or an awl may be used to test wood for soundness. The technique is simply to jab the pick into a wetted wood surface at an angle and pry up a small sec-



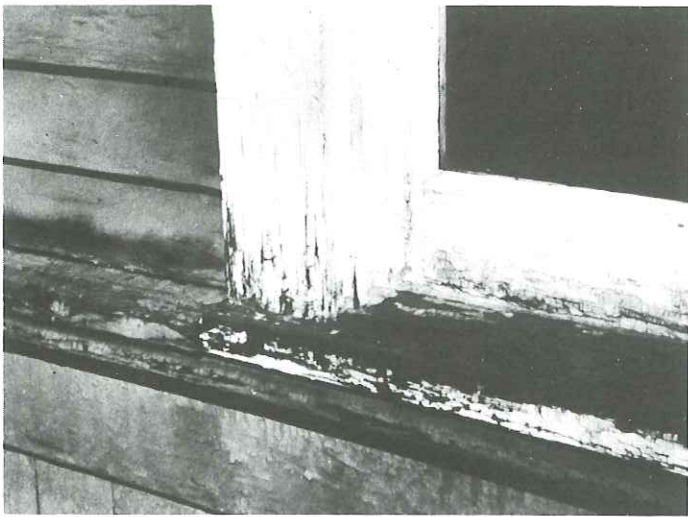


Figure 3. Deterioration of poorly maintained windows usually begins on horizontal surfaces and at joints where water can collect and saturate the wood. The problem areas are clearly indicated by paint failure due to moisture. Photo: Baird M. Smith, AIA

tion of the wood. Sound wood will separate in long fibrous splinters, but decayed wood will lift up in short irregular pieces due to the breakdown of fiber strength.

Another method of testing for soundness consists of pushing a sharp object into the wood, perpendicular to the surface. If deterioration has begun from the hidden side of a member and the core is badly decayed, the visible surface may appear to be sound wood. Pressure on the probe can force it through an apparently sound skin to penetrate deeply into decayed wood. This technique is especially useful for checking sills where visual access to the underside is restricted.

Following the inspection and analysis of the results, the scope of the necessary repairs will be evident and a plan for the rehabilitation can be formulated. Generally the actions necessary to return a window to "like new" condition will fall into three broad categories: 1) routine maintenance procedures, 2) structural stabilization, and 3) parts replacement. These categories will be discussed in the following sections and will be referred to respectively as Repair Class I, Repair Class II, and Repair Class III. Each successive repair class represents an increasing level of difficulty, expense, and work time. Note that most of the points mentioned in Repair Class I are routine maintenance items and should be provided in a regular maintenance program for any building. The neglect of these routine items can contribute to many common window problems.

Before undertaking any of the repairs mentioned in the following sections all sources of moisture penetration should be identified and eliminated, and all existing decay fungi destroyed in order to arrest the deterioration process. Many commercially available fungicides and wood preservatives are toxic, so it is extremely important to follow the manufacturer's recommendations for application, and store all chemical materials away from children and animals. After fungicidal and preservative treatment the windows may be stabilized, retained, and restored with every expectation for a long service life.

### Repair Class I: Routine Maintenance

Repairs to wooden windows are usually labor intensive and relatively uncomplicated. On small scale projects this

allows the do-it-yourselfer to save money by repairing all or part of the windows. On larger projects it presents the opportunity for time and money which might otherwise be spent on the removal and replacement of existing windows, to be spent on repairs, subsequently saving all or part of the material cost of new window units. Regardless of the actual costs, or who performs the work, the evaluation process described earlier will provide the knowledge from which to specify an appropriate work program, establish the work element priorities, and identify the level of skill needed by the labor force.

The routine maintenance required to upgrade a window to "like new" condition normally includes the following steps: 1) some degree of interior and exterior paint removal, 2) removal and repair of sash (including reglazing where necessary), 3) repairs to the frame, 4) weatherstripping and reinstallation of the sash, and 5) repainting. These operations are illustrated for a typical double-hung wooden window (see figures 4a-f), but they may be adapted to other window types and styles as applicable.

Historic windows have usually acquired many layers of paint over time. Removal of excess layers or peeling and flaking paint will facilitate operation of the window and restore the clarity of the original detailing. Some degree of paint removal is also necessary as a first step in the proper surface preparation for subsequent refinishing (if paint color analysis is desired, it should be conducted prior to the onset of the paint removal). There are several safe and effective techniques for removing paint from wood, depending on the amount of paint to be removed. Several techniques such as scraping, chemical stripping, and the use of a hot air gun are discussed in "Preservation Briefs: 10 Paint Removal from Historic Woodwork" (see Additional Reading section at end).

Paint removal should begin on the interior frames, being careful to remove the paint from the interior stop and the parting bead, particularly along the seam where these stops meet the jamb. This can be accomplished by running a utility knife along the length of the seam, breaking the paint bond. It will then be much easier to remove the stop, the parting bead and the sash. The interior stop may be initially loosened from the sash side to avoid visible scarring of the wood and then gradually pried loose using a pair of putty knives, working up and down the stop in small increments (see figure 4b). With the stop removed, the lower or interior sash may be withdrawn. The sash cords should be detached from the sides of the sash and their ends may be pinned with a nail or tied in a knot to prevent them from falling into the weight pocket.

Removal of the upper sash on double-hung units is similar but the parting bead which holds it in place is set into a groove in the center of the stile and is thinner and more delicate than the interior stop. After removing any paint along the seam, the parting bead should be carefully pried out and worked free in the same manner as the interior stop. The upper sash can be removed in the same manner as the lower one and both sash taken to a convenient work area (in order to remove the sash the interior stop and parting bead need only be removed from one side of the window). Window openings can be covered with polyethylene sheets or plywood sheathing while the sash are out for repair.

The sash can be stripped of paint using appropriate techniques, but if any heat treatment is used (see figure 4c), the glass should be removed or protected from the sudden temperature change which can cause breakage. An



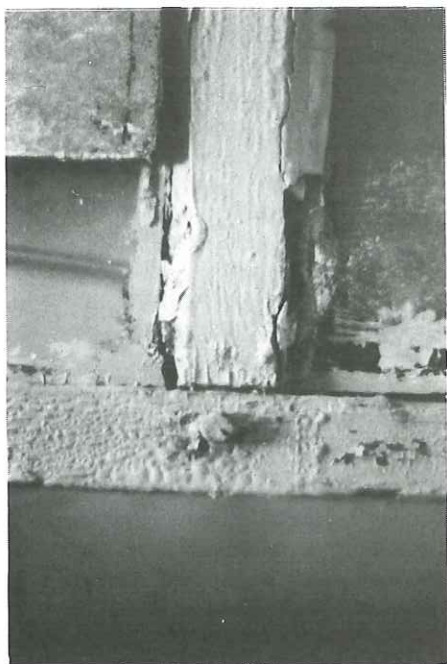


Figure 4a. The following series of photographs of the repair of a historic double-hung window use a unit which is structurally sound but has many layers of paint, some cracked and missing putty, slight separation at the joints, broken sash cords, and one cracked pane. Photo: John H. Myers

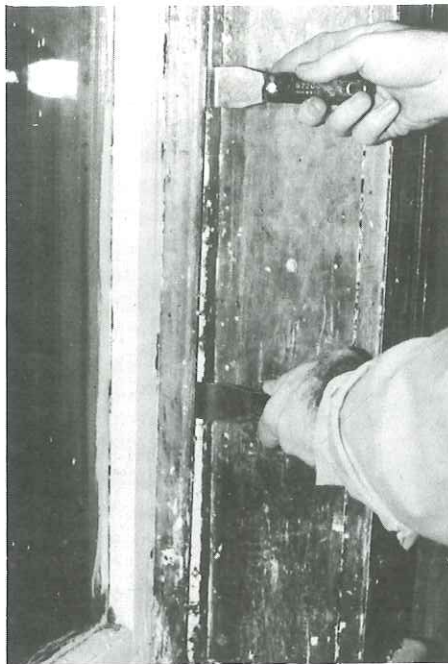


Figure 4b. After removing paint from the seam between the interior stop and the jamb, the stop can be pried out and gradually worked loose using a pair of putty knives as shown. To avoid visible scarring of the wood, the sash can be raised and the stop pried loose initially from the outer side. Photo: John H. Myers



Figure 4c. Sash can be removed and repaired in a convenient work area. Paint is being removed from this sash with a hot air gun while an asbestos sheet protects the glass from sudden temperature change. Photo: John H. Myers

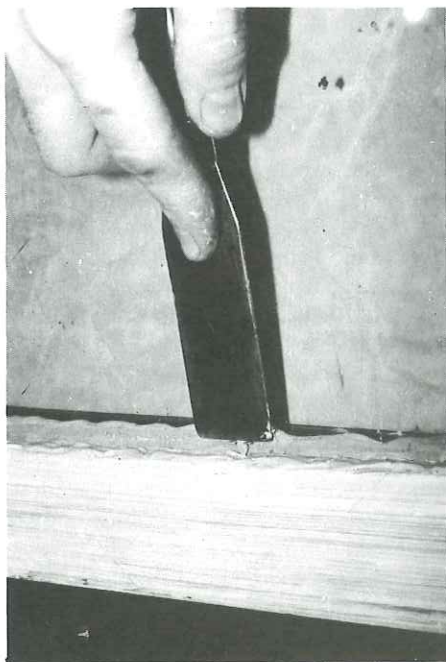


Figure 4d. Reglazing or replacement of the putty requires that the existing putty be removed manually, the glazing points be extracted, the glass removed, and the back putty scraped out. To reglaze, a bed of putty is laid around the perimeter of the rabbet, the pane is pressed into place, glazing points are inserted to hold the pane (shown), and a final seal of putty is beveled around the edge of the glass. Photo: John H. Myers



Figure 4e. A common repair is the replacement of broken sash cords with new cords (shown) or with chains. The weight pocket is often accessible through a removable plate in the jamb, or by removing the interior trim. Photo: John H. Myers

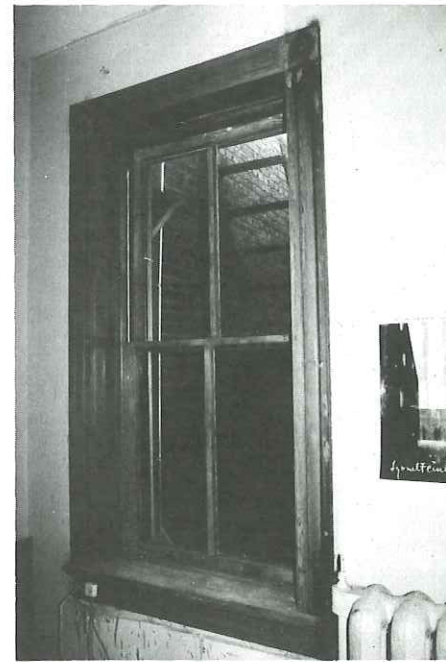


Figure 4f. Following the relatively simple repairs, the window is weathertight, like new in appearance, and serviceable for many years to come. Both the historic material and the detailing and craftsmanship of this original window have been preserved. Photo: John H. Myers



overlay of aluminum foil on gypsum board or asbestos can protect the glass from such rapid temperature change. It is important to protect the glass because it may be historic and often adds character to the window. Deteriorated putty should be removed manually, taking care not to damage the wood along the rabbet. If the glass is to be removed, the glazing points which hold the glass in place can be extracted and the panes numbered and removed for cleaning and reuse in the same openings. With the glass panes out, the remaining putty can be removed and the sash can be sanded, patched, and primed with a preservative primer. Hardened putty in the rabbets may be softened by heating with a soldering iron at the point of removal. Putty remaining on the glass may be softened by soaking the panes in linseed oil, and then removed with less risk of breaking the glass. Before reinstalling the glass, a bead of glazing compound or linseed oil putty should be laid around the rabbet to cushion and seal the glass. Glazing compound should only be used on wood which has been brushed with linseed oil and primed with an oil based primer or paint. The pane is then pressed into place and the glazing points are pushed into the wood around the perimeter of the pane (see figure 4d). The final glazing compound or putty is applied and beveled to complete the seal. The sash can be refinished as desired on the inside and painted on the outside as soon as a "skin" has formed on the putty, usually in 2 or 3 days. Exterior paint should cover the beveled glazing compound or putty and lap over onto the glass slightly to complete a weathertight seal. After the proper curing times have elapsed for paint and putty, the sash will be ready for reinstallation.

While the sash are out of the frame, the condition of the wood in the jamb and sill can be evaluated. Repair and refinishing of the frame may proceed concurrently with repairs to the sash, taking advantage of the curing times for the paints and putty used on the sash. One of the most common work items is the replacement of the sash cords with new rope cords or with chains (see figure 4e). The weight pocket is frequently accessible through a door on the face of the frame near the sill, but if no door exists, the trim on the interior face may be removed for access. Sash weights may be increased for easier window operation by elderly or handicapped persons. Additional repairs to the frame and sash may include consolidation or replacement of deteriorated wood. Techniques for these repairs are discussed in the following sections.

The operations just discussed summarize the efforts necessary to restore a window with minor deterioration to "like new" condition (see figure 4f). The techniques can be applied by an unskilled person with minimal training and experience. To demonstrate the practicality of this approach, and photograph it, a Technical Preservation Services staff member repaired a wooden double-hung, two over two window which had been in service over ninety years. The wood was structurally sound but the window had one broken pane, many layers of paint, broken sash cords and inadequate, worn-out weatherstripping. The staff member found that the frame could be stripped of paint and the sash removed quite easily. Paint, putty and glass removal required about one hour for each sash, and the reglazing of both sash was accomplished in about one hour. Weatherstripping of the sash and frame, replacement of the sash cords and reinstallation of the sash, parting bead, and stop required an hour and a half. These times refer only to individual operations; the entire proc-

ess took several days due to the drying and curing times for putty, primer, and paint, however, work on other window units could have been in progress during these lag times.

## Repair Class II: Stabilization

The preceding description of a window repair job focused on a unit which was operationally sound. Many windows will show some additional degree of physical deterioration, especially in the vulnerable areas mentioned earlier, but even badly damaged windows can be repaired using simple processes. Partially decayed wood can be water-proofed, patched, built-up, or consolidated and then painted to achieve a sound condition, good appearance, and greatly extended life. Three techniques for repairing partially decayed or weathered wood are discussed in this section, and all three can be accomplished using products available at most hardware stores.

One established technique for repairing wood which is split, checked or shows signs of rot, is to: 1) dry the wood, 2) treat decayed areas with a fungicide, 3) water-proof with two or three applications of boiled linseed oil (applications every 24 hours), 4) fill cracks and holes with putty, and 5) after a "skin" forms on the putty, paint the surface. Care should be taken with the use of fungicide which is toxic. Follow the manufacturers' directions and use only on areas which will be painted. When using any technique of building up or patching a flat surface, the finished surface should be sloped slightly to carry water away from the window and not allow it to puddle. Caulking of the joints between the sill and the jamb will help reduce further water penetration.

When sills or other members exhibit surface weathering they may also be built-up using wood putties or home-made mixtures such as sawdust and resorcinol glue, or whiting and varnish. These mixtures can be built up in successive layers, then sanded, primed, and painted. The same caution about proper slope for flat surfaces applies to this technique.

Wood may also be strengthened and stabilized by consolidation, using semi-rigid epoxies which saturate the porous decayed wood and then harden. The surface of the consolidated wood can then be filled with a semi-rigid epoxy patching compound, sanded and painted (see figure 5). Epoxy patching compounds can be used to build up



Figure 5. This illustrates a two-part epoxy patching compound used to fill the surface of a weathered sill and rebuild the missing edge. When the epoxy cures, it can be sanded smooth and painted to achieve a durable and waterproof repair. Photo: John H. Myers



missing sections or decayed ends of members. Profiles can be duplicated using hand molds, which are created by pressing a ball of patching compound over a sound section of the profile which has been rubbed with butcher's wax. This can be a very efficient technique where there are many typical repairs to be done. Technical Preservation Services has published *Epoxy for Wood Repairs in Historic Buildings* (see Additional Reading section at end), which discusses the theory and techniques of epoxy repairs. The process has been widely used and proven in marine applications; and proprietary products are available at hardware and marine supply stores. Although epoxy materials may be comparatively expensive, they hold the promise of being among the most durable and long lasting materials available for wood repair.

Any of the three techniques discussed can stabilize and restore the appearance of the window unit. There are times, however, when the degree of deterioration is so advanced that stabilization is impractical, and the only way to retain some of the original fabric is to replace damaged parts.

### Repair Class III: Splices and Parts Replacement

When parts of the frame or sash are so badly deteriorated that they cannot be stabilized there are methods which permit the retention of some of the existing or original fabric. These methods involve replacing the deteriorated parts with new matching pieces, or splicing new wood into existing members. The techniques require more skill and are more expensive than any of the previously discussed alternatives. It is necessary to remove the sash and/or the affected parts of the frame and have a carpenter or woodworking mill reproduce the damaged or missing parts. Most millwork firms can duplicate parts, such as muntins, bottom rails, or sills, which can then be incorporated into the existing window, but it may be necessary to shop around because there are several factors controlling the practicality of this approach. Some woodworking mills do not like to repair old sash because nails or other foreign objects in the sash can damage expensive knives (which cost far more than their profits on small repair jobs); others do not have cutting knives to duplicate muntin profiles. Some firms prefer to concentrate on larger jobs with more profit potential, and some may not have a craftsman who can duplicate the parts. A little searching should locate a firm which will do the job, and at a reasonable price. If such a firm does not exist locally, there are firms which undertake this kind of repair and ship nationwide. It is possible, however, for the advanced do-it-yourselfer or craftsman with a table saw to duplicate moulding profiles using techniques discussed by Gordie Whittington in "Simplified Methods for Reproducing Wood Mouldings," *Bulletin of the Association for Preservation Technology*, Vol. III, No. 4, 1971, or illustrated more recently in *The Old House*, Time-Life Books, Alexandria, Virginia, 1979.

The repairs discussed in this section involve window frames which may be in very deteriorated condition, possibly requiring removal; therefore, caution is in order. The actual construction of wooden window frames and sash is not complicated. Pegged mortise and tenon units can be disassembled easily, if the units are out of the building. The installation or connection of some frames to the surrounding structure, especially masonry walls, can complicate the work immeasurably, and may even require

dismantling of the wall. It may be useful, therefore, to take the following approach to frame repair: 1) conduct regular maintenance of sound frames to achieve the longest life possible, 2) make necessary repairs in place wherever possible, using stabilization and splicing techniques, and 3) if removal is necessary, thoroughly investigate the structural detailing and seek appropriate professional consultation.

Another alternative may be considered if parts replacement is required, and that is sash replacement. If extensive replacement of parts is necessary and the job becomes prohibitively expensive it may be more practical to purchase new sash which can be installed into the existing frames. Such sash are available as exact custom reproductions, reasonable facsimiles (custom windows with similar profiles), and contemporary wooden sash which are similar in appearance. There are companies which still manufacture high quality wooden sash which would duplicate most historic sash. A few calls to local building suppliers may provide a source of appropriate replacement sash, but if not, check with local historical associations, the state historic preservation office, or preservation related magazines and supply catalogs for information.

If a rehabilitation project has a large number of windows such as a commercial building or an industrial complex, there may be less of a problem arriving at a solution. Once the evaluation of the windows is completed and the scope of the work is known, there may be a potential economy of scale. Woodworking mills may be interested in the work from a large project; new sash in volume may be considerably less expensive per unit; crews can be assembled and trained on site to perform all of the window repairs; and a few extensive repairs can be absorbed (without undue burden) into the total budget for a large number of sound windows. While it may be expensive for the average historic home owner to pay seventy dollars or more for a mill to grind a custom knife to duplicate four or five bad muntins, that cost becomes negligible on large commercial projects which may have several hundred windows.

Most windows should not require the extensive repairs discussed in this section. The ones which do are usually in buildings which have been abandoned for long periods or have totally lacked maintenance for years. It is necessary to thoroughly investigate the alternatives for windows which do require extensive repairs to arrive at a solution which retains historic significance and is also economically feasible. Even for projects requiring repairs identified in this section, if the percentage of parts replacement per window is low, or the number of windows requiring repair is small, repair can still be a cost effective solution.

### Weatherization

A window which is repaired should be made as energy efficient as possible by the use of appropriate weatherstripping to reduce air infiltration. A wide variety of products are available to assist in this task. Felt may be fastened to the top, bottom, and meeting rails, but may have the disadvantage of absorbing and holding moisture, particularly at the bottom rail. Rolled vinyl strips may also be tacked into place in appropriate locations to reduce infiltration. Metal strips or new plastic spring strips may be used on the rails and, if space permits, in



the channels between the sash and jamb. Weatherstripping is a historic treatment, but old weatherstripping (felt) is not likely to perform very satisfactorily. Appropriate contemporary weatherstripping should be considered an integral part of the repair process for windows. The use of sash locks installed on the meeting rail will insure that the sash are kept tightly closed so that the weatherstripping will function more effectively to reduce infiltration. Although such locks will not always be historically accurate, they will usually be viewed as an acceptable contemporary modification in the interest of improved thermal performance.

Many styles of storm windows are available to improve the thermal performance of existing windows. The use of exterior storm windows should be investigated whenever feasible because they are thermally efficient, cost-effective, reversible, and allow the retention of original windows (see "Preservation Briefs: 3"). Storm window frames may be made of wood, aluminum, vinyl, or plastic; however, the use of unfinished aluminum storms should be avoided. The visual impact of storms may be minimized by selecting colors which match existing trim color. Arched top storms are available for windows with special shapes. Although interior storm windows appear to offer an attractive option for achieving double glazing with minimal visual impact, the potential for damaging condensation problems must be addressed. Moisture which becomes trapped between the layers of glazing can condense on the colder, outer prime window, potentially leading to deterioration. The correct approach to using interior storms is to create a seal on the interior storm while allowing some ventilation around the prime window. In actual practice, the creation of such a durable, airtight seal is difficult.

## Window Replacement

Although the retention of original or existing windows is always desirable and this Brief is intended to encourage that goal, there is a point when the condition of a window may clearly indicate replacement. The decision process for selecting replacement windows should *not* begin with a survey of contemporary window products which are available as replacements, but should begin with a look at the windows which are being replaced. Attempt to understand the contribution of the window(s) to the appearance of the facade including: 1) the pattern of the openings and their size; 2) proportions of the frame and sash; 3) configuration of window panes; 4) muntin profiles; 5) type of wood; 6) paint color; 7) characteristics of the glass; and 8) associated details such as arched tops, hoods, or other decorative elements. Develop an understanding of how the window reflects the period, style, or regional characteristics of the building, or represents technological development.

Armed with an awareness of the significance of the existing window, begin to search for a replacement which retains as much of the character of the historic window as possible. There are many sources of suitable new windows. Continue looking until an acceptable replacement can be found. Check building supply firms, local wood-working mills, carpenters, preservation oriented magazines, or catalogs or suppliers of old building materials, for product information. Local historical associations and state historic preservation offices may be good sources of

information on products which have been used successfully in preservation projects.

Consider energy efficiency as one of the factors for replacements, but do not let it dominate the issue. Energy conservation is no excuse for the wholesale destruction of historic windows which can be made thermally efficient by historically and aesthetically acceptable means. In fact, a historic wooden window with a high quality storm window added should thermally outperform a new double-glazed metal window which does not have thermal breaks (insulation between the inner and outer frames intended to break the path of heat flow). This occurs because the wood has far better insulating value than the metal, and in addition many historic windows have high ratios of wood to glass, thus reducing the area of highest heat transfer. One measure of heat transfer is the U-value, the number of Btu's per hour transferred through a square foot of material. When comparing thermal performance, the lower the U-value the better the performance. According to *ASHRAE 1977 Fundamentals*, the U-values for single glazed wooden windows range from 0.88 to 0.99. The addition of a storm window should reduce these figures to a range of 0.44 to 0.49. A non-thermal break, double-glazed metal window has a U-value of about 0.6.

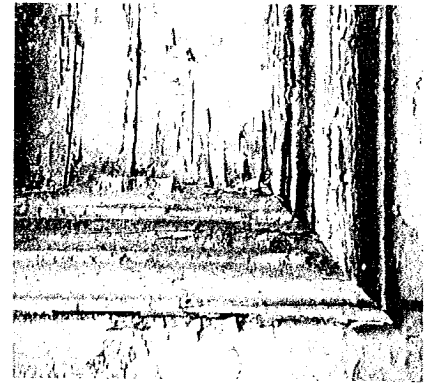
## Conclusion

Technical Preservation Services recommends the retention and repair of original windows whenever possible. We believe that the repair and weatherization of existing wooden windows is more practical than most people realize, and that many windows are unfortunately replaced because of a lack of awareness of techniques for evaluation, repair, and weatherization. Wooden windows which are repaired and properly maintained will have greatly extended service lives while contributing to the historic character of the building. Thus, an important element of a building's significance will have been preserved for the future.

## Additional Reading

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# 10 PRESERVATION BRIEFS



## Exterior Paint Problems on Historic Woodwork

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Preservation Assistance Division Technical Preservation Services

A cautionary approach to paint removal is included in the guidelines to "The Secretary of the Interior Standards for Historic Preservation Projects." Removing paints down to bare wood surfaces using harsh methods can permanently damage those surfaces; therefore such methods are not recommended. Also, total removal obliterates evidence of the historical paints and their sequence and architectural context.

This Brief expands on that advice for the architect, building manager, contractor, or homeowner by identifying and describing common types of paint surface conditions and failures, then recommending appropriate treatments for preparing exterior wood surfaces for repainting<sup>1</sup> to assure the best adhesion and greatest durability of the new paint. Although the Brief focuses on responsible methods of "paint removal," several paint surface conditions will be described which do not require any paint removal, and still others which can be successfully handled by limited paint removal. In all cases, the information is intended to address the concerns related to *exterior wood*. It will also be generally assumed that, because houses built before 1950 involve one or more layers of lead-base paint,<sup>2</sup> the majority of conditions warranting paint removal will mean dealing with this toxic substance along with the dangers of the paint removal tools and chemical strippers themselves.

### Purposes of Exterior Paint

Paint<sup>3</sup> applied to exterior wood must withstand yearly extremes of both temperature and humidity. While never expected to be more than a temporary physical shield—requiring re-application every 5-8 years—its importance should not be minimized. Because one of the main causes of wood deterioration is moisture penetration, a primary purpose for painting wood is to exclude such moisture, thereby slowing deterioration not only of a building's exterior siding and decorative features but, ultimately, its underlying structural members. Another important purpose for painting wood is, of course, to define and accent architectural features and to improve appearance.

### Treating Paint Problems in Historic Buildings

Exterior paint is constantly deteriorating through the processes of weathering, but in a program of regular maintenance—assuming all other building systems are functioning properly—surfaces can be cleaned, lightly scraped, and hand sanded in preparation for a new finish coat. Unfortunately, these are ideal conditions. More often, complex maintenance problems are inherited by owners of

historic buildings, including areas of paint that have failed<sup>4</sup> beyond the point of mere cleaning, scraping, and hand sanding (although much so-called "paint failure" is attributable to interior or exterior moisture problems or surface preparation and application mistakes with previous coats).

Although paint problems are by no means unique to historic buildings, treating multiple layers of hardened, brittle paint on complex, ornamental—and possibly fragile—exterior wood surfaces necessarily requires an extremely cautious approach (see figure 1). In the case of recent construction, this level of concern is not needed because the wood is generally less detailed and, in addition, retention of the sequence of paint layers as a partial record of the building's history is not an issue.

When historic buildings are involved, however, a special set of problems arises—varying in complexity depending upon their age, architectural style, historical importance, and physical soundness of the wood—which must be carefully evaluated so that decisions can be made that are sensitive to the longevity of the resource.

### Justification for Paint Removal

At the outset of this Brief, it must be emphasized that removing paint from historic buildings—with the exception of cleaning, light scraping, and hand sanding as part of routine maintenance—should be avoided unless absolutely essential. *Once conditions warranting removal have*

<sup>1</sup> General paint type recommendations will be made, but paint color recommendations are beyond the scope of this Brief.

<sup>2</sup> Douglas R. Shier and William Hall, *Analysis of Housing Data Collected in a Lead-Based Paint Survey in Pittsburgh, Pennsylvania, Part 1*, National Bureau of Standards, Inter-Report 77-1250, May 1977.

<sup>3</sup> Any pigmented liquid, liquefiable, or mastic composition designed for application to a substrate in a thin layer which is converted to an opaque solid film after application. *Paint and Coatings Dictionary*, 1978. Federation of Societies for Coatings and Technology.

<sup>4</sup> For purposes of the Brief, this includes any area of painted exterior woodwork displaying signs of peeling, cracking, or alligatoring to bare wood. See descriptions of these and other paint surface conditions as well as recommended treatments on pp. 5-10.



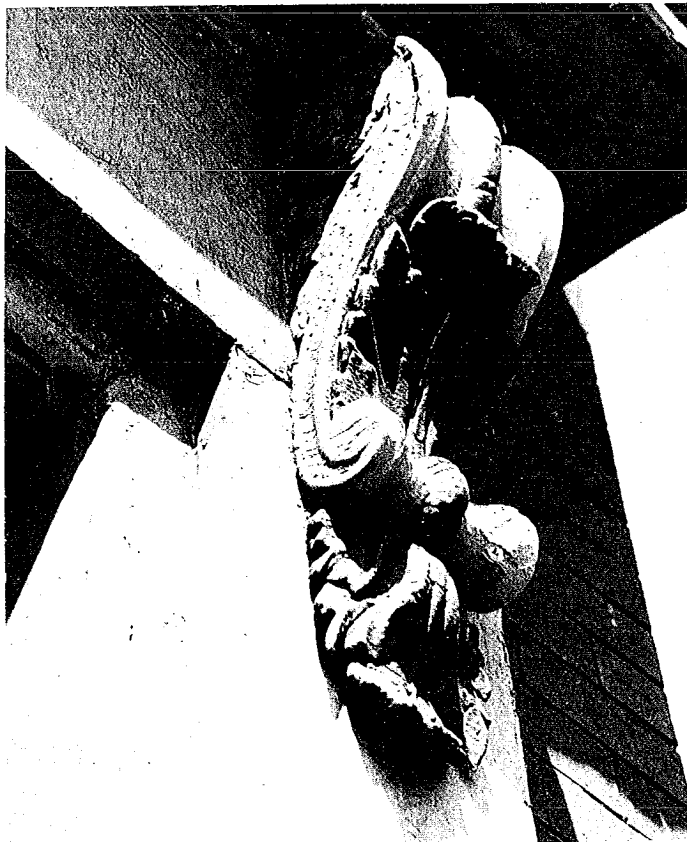


Fig. 1 Excessive paint build-up on architectural details such as this ornamental bracket does not in itself justify total paint removal. If paint is cracked and peeling down to bare wood, however, it should be removed using the gentlest means possible. Photo: David W. Look, AIA.

been identified, the general approach should be to remove paint to the next sound layer using the gentlest means possible, then to repaint (see figure 2). Practically speaking as well, paint can adhere just as effectively to existing paint as to bare wood, providing the previous coats of paint are also adhering uniformly and tightly to the wood and the surface is properly prepared for repainting—cleaned of dirt and chalk and dulled by sanding. But, if painted exterior wood surfaces display continuous patterns of deep cracks or if they are extensively blistering and peeling so that bare wood is visible, then the old paint should be completely removed before repainting. The only other justification for removing all previous layers of paint is if doors, shutters, or windows have literally been "painted shut," or if new wood is being pieced-in adjacent to old painted wood and a smooth transition is desired (see figure 3).

### Paint Removal Precautions

Because paint removal is a difficult and painstaking process, a number of costly, regrettable experiences have occurred—and continue to occur—for both the historic building and the building owner. Historic buildings have been set on fire with blow torches; wood irreversibly scarred by sandblasting or by harsh mechanical devices such as rotary sanders and rotary wire strippers; and layers of historic paint inadvertently and unnecessarily removed. In addition, property owners, using techniques that substitute speed for safety, have been injured by toxic lead vapors or dust from the paint they were trying to



Fig. 2 A traditionally painted bay window has been stripped to bare wood, then varnished. In addition to being historically inaccurate, the varnish will break down faster as a result of the sun's ultraviolet rays than would primer and finish coats of paint. Photo: David W. Look, AIA.

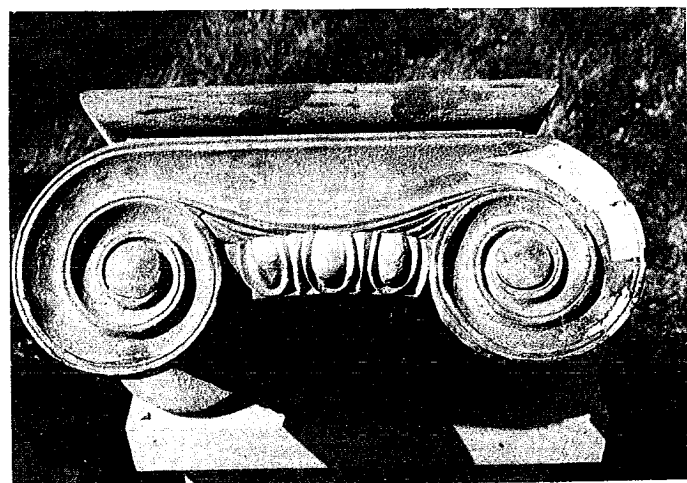


Fig. 3 If damage to parts of a wooden element is severe, new sections of wood will need to be pieced-in. When such piecing is required, paint on the adjacent woodwork should be removed so that the old and new woods will make a smooth profile when joined. After repainting, the repair should be virtually impossible to detect. Photo: Morgan W. Phillips.

remove or by misuse of the paint removers themselves.

Owners of historic properties considering paint removal should also be aware of the amount of time and labor involved. While removing damaged layers of paint from a door or porch railing might be readily accomplished within a reasonable period of time by one or two people, removing paint from larger areas of a building can, with-

out professional assistance, easily become unmanageable and produce less than satisfactory results. The amount of work involved in any paint removal project must therefore be analyzed on a case-by-case basis. Hiring qualified professionals will often be a cost-effective decision due to the expense of materials, the special equipment required, and the amount of time involved. Further, paint removal companies experienced in dealing with the inherent health and safety dangers of paint removal should have purchased such protective devices as are needed to mitigate any dangers and should also be aware of State or local environmental and/or health regulations for hazardous waste disposal.

All in all, paint removal is a messy, expensive, and potentially dangerous aspect of rehabilitating or restoring historic buildings and should not be undertaken without careful thought concerning first, its necessity, and second, which of the available recommended methods is the safest and most appropriate for the job at hand.

## Repainting Historic Buildings for Cosmetic Reasons

If existing exterior paint on wood siding, eaves, window sills, sash, and shutters, doors, and decorative features shows no evidence of paint deterioration such as chalking, blistering, peeling, or cracking, then there is no *physical reason* to repaint, much less remove paint! Nor is color fading, of itself, sufficient justification to repaint a historic building.

The decision to repaint may not be based altogether on paint failure. Where there is a new owner, or even where ownership has remained constant through the years, taste in colors often changes. Therefore, if repainting is primarily to alter a building's primary and accent colors, a technical factor of paint accumulation should be taken into consideration. When paint builds up to a thickness of approximately 1/16" (approximately 16-30 layers), one or more extra coats of paint may be enough to trigger cracking and peeling in limited or even widespread areas of the building's surface. This results because excessively thick paint is less able to withstand the shrinkage or pull of an additional coat as it dries and is also less able to tolerate thermal stresses. Thick paint invariably fails at the weakest point of adhesion—the oldest layers next to the wood. Cracking and peeling follow. Therefore, if there are no signs of paint failure, it may be somewhat risky to add still another layer of unneeded paint simply for color's sake (extreme changes in color may also require more than one coat to provide proper hiding power and full color). When paint appears to be nearing the critical thickness, a change of accent colors (that is, just to limited portions of the trim) might be an acceptable compromise without chancing cracking and peeling of paint on wooden siding.

If the decision to repaint is nonetheless made, the "new" color or colors should, at a minimum, be appropriate to the style and setting of the building. On the other hand, where the intent is to restore or accurately reproduce the colors originally used or those from a significant period in the building's evolution, they should be based on the results of a paint analysis.<sup>5</sup>

## Identification of Exterior Paint Surface Conditions/Recommended Treatments

It is assumed that a preliminary check will already have been made to determine, first, that the painted exterior surfaces are indeed wood—and not stucco, metal, or other wood substitutes—and second, that the wood has not decayed so that repainting would be superfluous. For example, if any area of bare wood such as window sills has been exposed for a long period of time to standing water, wood rot is a strong possibility (see figure 4). Repair or replacement of deteriorated wood should take place before repainting. After these two basic issues have been resolved, the surface condition identification process may commence.

The historic building will undoubtedly exhibit a variety of exterior paint surface conditions. For example, paint on the wooden siding and doors may be adhering firmly; paint on the eaves peeling; and paint on the porch balusters and window sills cracking and alligating. The accurate identification of each paint problem is therefore the first step in planning an appropriate overall solution.

Paint surface conditions can be grouped according to their relative severity: CLASS I conditions include minor blemishes or dirt collection and generally require *no* paint removal; CLASS II conditions include failure of the top layer or layers of paint and generally require *limited* paint removal; and CLASS III conditions include substantial or multiple-layer failure and generally require *total* paint removal. It is precisely because conditions will vary at different points on the building that a careful inspection is critical. Each item of painted exterior woodwork (i.e., siding, doors, windows, eaves, shutters, and decorative elements) should be examined early in the planning phase and surface conditions noted.

### CLASS I Exterior Surface Conditions Generally Requiring No Paint Removal

- Dirt, Soot, Pollution, Cobwebs, Insect Cocoons, etc.

#### Cause of Condition

Environmental "grime" or organic matter that tends to cling to painted exterior surfaces and, in particular, protected surfaces such as eaves, do not constitute a paint problem unless painted over rather than removed prior to repainting. If not removed, the surface deposits can be a barrier to proper adhesion and cause peeling.

#### Recommended Treatment

Most surface matter can be loosened by a strong, direct stream of water from the nozzle of a garden hose. Stubborn dirt and soot will need to be scrubbed off using ½ cup of household detergent in a gallon of water with a medium soft bristle brush. The cleaned surface should then be rinsed thoroughly, and permitted to dry before further inspection to determine if repainting is necessary. Quite often, cleaning provides a satisfactory enough result to postpone repainting.

<sup>5</sup> See the Reading List for paint research and documentation information. See also *The Secretary of the Interior's Standards for Historic Preservation Projects with Guidelines for Applying the Standards* for recommended approaches on paints and finishes within various types of project work treatments.

- **Mildew**

#### Cause of Condition

Mildew is caused by fungi feeding on nutrients contained in the paint film or on dirt adhering to any surface. Because moisture is the single most important factor in its growth, mildew tends to thrive in areas where dampness and lack of sunshine are problems such as window sills, under eaves, around gutters and downspouts, on the north side of buildings, or in shaded areas near shrubbery. It may sometimes be difficult to distinguish mildew from dirt, but there is a simple test to differentiate: if a drop of household bleach is placed on the suspected surface, mildew will immediately turn white whereas dirt will continue to look like dirt.

#### Recommended Treatment

Because mildew can only exist in shady, warm, moist areas, attention should be given to altering the environment that is conducive to fungal growth. The area in question may be shaded by trees which need to be pruned back to allow sunlight to strike the building; or may lack rain gutters or proper drainage at the base of the building. If the shady or moist conditions can be altered, the mildew is less likely to reappear. A recommend solution for removing mildew consists of one cup non-ammoniated detergent, one quart household bleach, and one gallon water. When the surface is scrubbed with this solution using a medium soft brush, the mildew should disappear; however, for particularly stubborn spots, an additional quart of bleach may be added. After the area is mildew-free, it should then be rinsed with a direct stream of water from the nozzle of a garden hose, and permitted to dry thoroughly. When repainting, specially formulated "mildew-resistant" primer and finish coats should be used.

- **Excessive Chalking**

#### Cause of Condition

Chalking—or powdering of the paint surface—is caused by the gradual disintegration of the resin in the paint film. (The amount of chalking is determined both by the formulation of the paint and the amount of ultraviolet light to which the paint is exposed.) In moderation, chalking is the ideal way for a paint to "age," because the chalk, when rinsed by rainwater, carries discoloration and dirt away with it and thus provides an ideal surface for repainting. In excess, however, it is not desirable because the chalk can wash down onto a surface of a different color beneath the painted area and cause streaking as well as rapid disintegration of the paint film itself. Also, if a paint contains too much pigment for the amount of binder (as the old white lead carbonate/oil paints often did), excessive chalking can result.

#### Recommended Treatment

The chalk should be cleaned off with a solution of  $\frac{1}{2}$  cup household detergent to one gallon water, using a medium soft bristle brush. After scrubbing to remove the chalk, the surface should be rinsed with a direct stream of water from the nozzle of a garden hose, allowed to dry thoroughly, (but not long enough for the chalking process to recur) and repainted, using a non-chalking paint.

- **Staining**

#### Cause of Condition

Staining of paint coatings usually results from excess

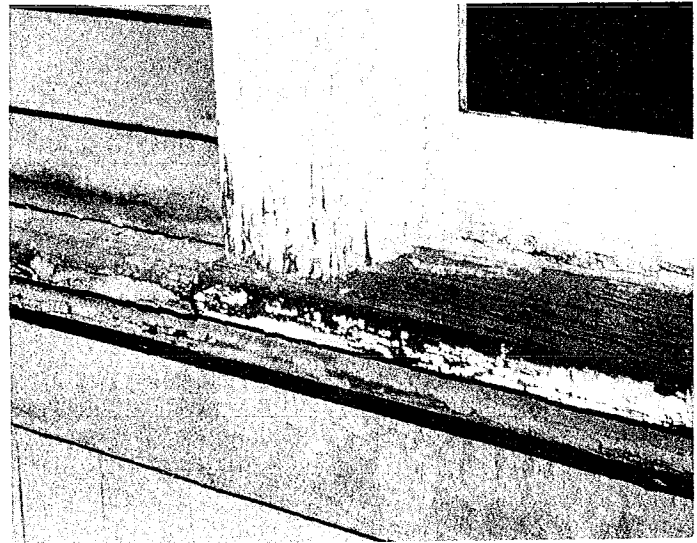


Fig. 4 Paint films wear unevenly depending on exposure and location. Exterior locations which are susceptible to accelerated deterioration are horizontal surfaces such as window sills. These and similar areas will require repainting more often than less vulnerable surfaces. In the case of this window sill where paint has peeled off and adjacent areas have cracked and alligatored, the paint should be totally removed. Prior to repainting, any weathered wood should be rejuvenated using a solution of 3 cups exterior varnish, 1 oz. paraffin wax, and mineral spirits/paint thinner/or turpentine to make 1 gallon. Liberal brush application should be made. This formula was tested over a 20-year period by the U.S. Department of Agriculture's Forest Products Laboratory and proved to be just as effective as water-repellent preservatives containing pentachlorophenol. After the surface has thoroughly dried (2-3 days of warm weather), the treated surface can be painted. A high quality oil-base primer followed by two top coats of a semi-gloss oil-enamel or latex-enamel paint is recommended. Photo: Baird M. Smith, AIA.

moisture reacting with materials within the wood substrate. There are two common types of staining, neither of which requires paint removal. The most prevalent type of stain is due to the oxidation or rusting of iron nails or metal (iron, steel, or copper) anchorage devices. A second type of stain is caused by a chemical reaction between moisture and natural extractives in certain woods (red cedar or redwood) which results in a surface deposit of colored matter. This is most apt to occur in new replacement wood within the first 10-15 years.

#### Recommended Treatment

In both cases, the source of the stain should first be located and the moisture problem corrected.

When stains are caused by rusting of the heads of nails used to attach shingles or siding to an exterior wall or by rusting or oxidizing iron, steel, or copper anchorage devices adjacent to a painted surface, the metal objects themselves should be hand sanded and coated with a rust-inhibitive primer followed by two finish coats. (Exposed nail heads should ideally be countersunk, spot primed, and the holes filled with a high quality wood filler except where exposure of the nail head was part of the original construction system or the wood is too fragile to withstand the countersinking procedure.)

Discoloration due to color extractives in replacement wood can usually be cleaned with a solution of equal parts denatured alcohol and water. After the affected area

has been rinsed and permitted to dry, a "stain-blocking primer" especially developed for preventing this type of stain should be applied (two primer coats are recommended for severe cases of bleeding prior to the finish coat). Each primer coat should be allowed to dry at least 48 hours.

## CLASS II Exterior Surface Conditions Generally Requiring Limited Paint Removal

### • **Crazing**

#### Cause of Condition

Crazing—fine, jagged interconnected breaks in the top layer of paint—results when paint that is several layers thick becomes excessively hard and brittle with age and is consequently no longer able to expand and contract with the wood in response to changes in temperature and humidity (see figure 5). As the wood swells, the bond between paint layers is broken and hairline cracks appear. Although somewhat more difficult to detect as opposed to other more obvious paint problems, it is well worth the time to scrutinize all surfaces for crazing. If not corrected, exterior moisture will enter the crazed surface, resulting in further swelling of the wood and, eventually, deep cracking and alligating, a Class III condition which requires total paint removal.

#### Recommended Treatment

Crazing can be treated by hand or mechanically sanding the surface, then repainting. Although the hairline cracks may tend to show through the new paint, the surface will be protected against exterior moisture penetration.

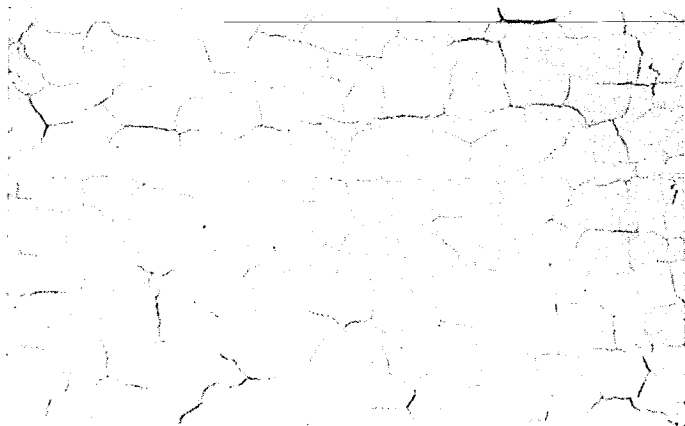


Fig. 5 Crazing—or surface cracking—is an exterior surface condition which can be successfully treated by sanding and painting. Photo: Courtesy, National Decorating Products Association.

### • **Intercoat Peeling**

#### Cause of Condition

Intercoat peeling can be the result of improper surface preparation prior to the last repainting. This most often occurs in protected areas such as eaves and covered porches because these surfaces do not receive a regular rinsing from rainfall, and salts from air-borne pollutants thus accumulate on the surface. If not cleaned off, the new paint coat will not adhere properly and that layer will peel.

Another common cause of intercoat peeling is incompatibility between paint types (see figure 6). For example, if oil paint is applied over latex paint, peeling of the top

coat can sometimes result since, upon aging, the oil paint becomes harder and less elastic than the latex paint. If latex paint is applied over old, chalking oil paint, peeling can also occur because the latex paint is unable to penetrate the chalky surface and adhere.

#### Recommended Treatment

First, where salts or impurities have caused the peeling, the affected area should be washed down thoroughly after scraping, then wiped dry. Finally, the surface should be hand or mechanically sanded, then repainted.

Where peeling was the result of using incompatible paints, the peeling top coat should be scraped and hand or mechanically sanded. Application of a high quality oil type exterior primer will provide a surface over which either an oil or a latex topcoat can be successfully used.

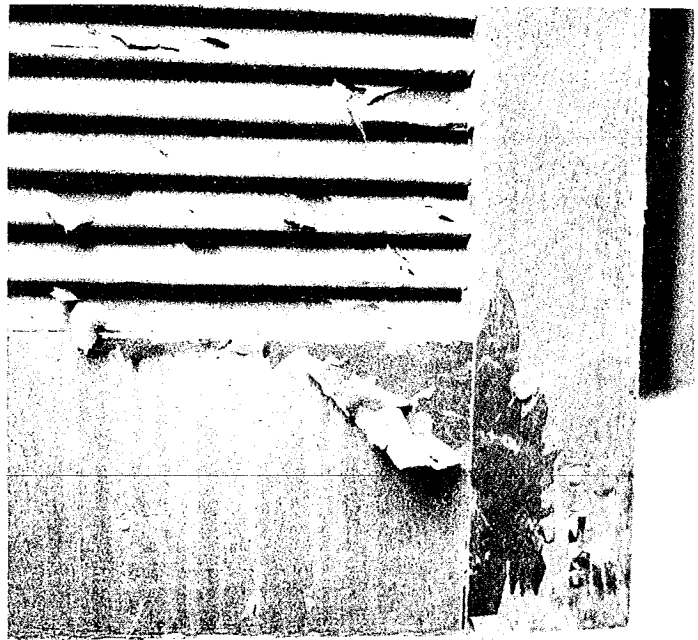


Fig. 6 This is an example of intercoat peeling. A latex top coat was applied directly over old oil paint and, as a result, the latex paint was unable to adhere. If latex is being used over oil, an oil-base primer should be applied first. Although much of the peeling latex paint can be scraped off, in this case, the best solution may be to chemically dip strip the entire shutter to remove all of the paint down to bare wood, rinse thoroughly, then repaint. Photo: Mary L. Oehrlein, AIA.

### • **Solvent Blistering**

#### Cause of Condition

Solvent blistering, the result of a less common application error, is not caused by moisture, but by the action of ambient heat on paint solvent or thinners in the paint film. If solvent-rich paint is applied in direct sunlight, the top surface can dry too quickly and, as a result, solvents become trapped beneath the dried paint film. When the solvent vaporizes, it forces its way through the paint film, resulting in surface blisters. This problem occurs more often with dark colored paints because darker colors absorb more heat than lighter ones. To distinguish between solvent blistering and blistering caused by moisture, a blister should be cut open. If another layer of paint is visible, then solvent blistering is likely the problem whereas if bare wood is revealed, moisture is probably to blame. Solvent blisters are generally small.

### Recommended Treatment

Solvent-blistered areas can be scraped, hand or mechanically sanded to the next sound layer, then repainted. In order to prevent blistering of painted surfaces, paint should not be applied in direct sunlight.

- **Wrinkling**

#### Cause of Condition

Another error in application that can easily be avoided is wrinkling (see figure 7). This occurs when the top layer of paint dries before the layer underneath. The top layer of paint actually moves as the paint underneath (a primer, for example) is drying. Specific causes of wrinkling include: (1) applying paint too thick; (2) applying a second coat before the first one dries; (3) inadequate brushing out; and (4) painting in temperatures higher than recommended by the manufacturer.

#### Recommended Treatment

The wrinkled layer can be removed by scraping followed by hand or mechanical sanding to provide as even a surface as possible, then repainted following manufacturer's application instructions.

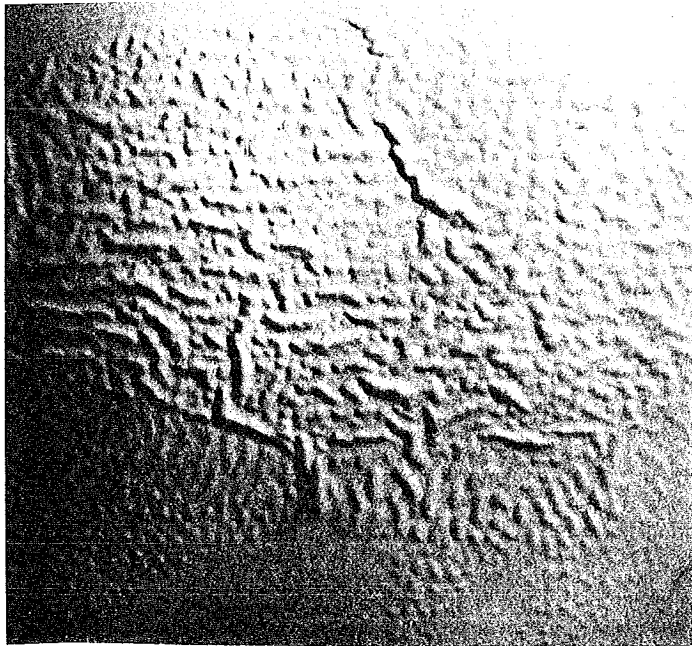


Fig. 7 Wrinkled layers can generally be removed by scraping and sanding as opposed to total paint removal. Following manufacturers' application instructions is the best way to avoid this surface condition. Photo: Courtesy, National Decorating Products Association.

### CLASS III Exterior Surface Conditions Generally Requiring Total Paint Removal

If surface conditions are such that the majority of paint will have to be removed prior to repainting, it is suggested that a small sample of intact paint be left in an inconspicuous area either by covering the area with a metal plate, or by marking the area and identifying it in some way. (When repainting does take place, the sample should not be painted over). This will enable future investigators to have a record of the building's paint history.

- **Peeling**

#### Cause of Condition

Peeling to bare wood is most often caused by excess interior or exterior moisture that collects behind the paint

film, thus impairing adhesion (see figure 8). Generally beginning as blisters, cracking and peeling occur as moisture causes the wood to swell, breaking the adhesion of the bottom layer.

#### Recommended Treatment

There is no sense in repainting before dealing with the moisture problems because new paint will simply fail. Therefore, the first step in treating peeling is to locate and remove the source or sources of the moisture, not only because moisture will jeopardize the protective coating of paint but because, if left unattended, it can ultimately cause permanent damage to the wood. Excess interior moisture should be removed from the building through installation of exhaust fans and vents. Exterior moisture should be eliminated by correcting the following conditions prior to repainting: faulty flashing; leaking gutters; defective roof shingles; cracks and holes in siding and trim; deteriorated caulking in joints and seams; and shrubbery growing too close to painted wood. After the moisture problems have been solved, the wood must be permitted to dry out thoroughly. The damaged paint can then be scraped off with a putty knife, hand or mechanically sanded, primed, and repainted.

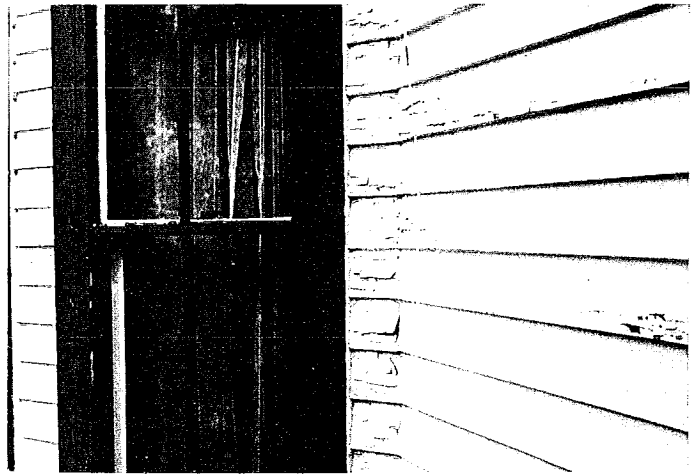


Fig. 8 Peeling to bare wood—one of the most common types of paint failure—is usually caused by an interior or exterior moisture problem. Photo: Anne E. Grimmer.

- **Cracking/Alligatoring**

#### Cause of Condition

Cracking and alligatoring are advanced stages of crazing (see figure 9). Once the bond between layers has been broken due to intercoat paint failure, exterior moisture is able to penetrate the surface cracks, causing the wood to swell and deeper cracking to take place. This process continues until cracking, which forms parallel to grain, extends to bare wood. Ultimately, the cracking becomes an overall pattern of horizontal and vertical breaks in the paint layers that looks like reptile skin; hence, "alligatoring." In advanced stages of cracking and alligatoring, the surfaces will also flake badly.

#### Recommended Treatment

If cracking and alligatoring are present only in the top layers they can probably be scraped, hand or mechanically sanded to the next sound layer, then repainted. However, if cracking and/or alligatoring have progressed to



bare wood and the paint has begun to flake, it will need to be totally removed. Methods include scraping or paint removal with the electric heat plate, electric heat gun, or chemical strippers, depending on the particular area involved. Bare wood should be primed within 48 hours, then repainted.



Fig. 9 Cracking, alligatoring, and flaking are evidence of long-term neglect of painted surfaces. The remaining paint on the clapboard shown here can be removed with an electric heat plate and wide-bladed scraper. In addition, unsound wood should be replaced and moisture problems corrected before primer and top coats of paint are applied. Photo: David W. Look, AIA.

## Selecting the Appropriate/Safest Method to Remove Paint

After having presented the “hierarchy” of exterior paint surface conditions—from a mild condition such as mildew which simply requires cleaning prior to repainting to serious conditions such as peeling and alligatoring which require total paint removal—one important thought bears repeating: if a paint problem has been identified that warrants either limited or total paint removal, the gentlest method possible for the particular wooden element of the historic building should be selected from the many available methods.

The treatments recommended—based upon field testing as well as onsite monitoring of Department of Interior grant-in-aid and certification of rehabilitation projects—are therefore those which take three over-riding issues into consideration (1) the continued protection and preservation of the historic exterior woodwork; (2) the retention of the sequence of historic paint layers; and (3) the health and safety of those individuals performing the paint removal. By applying these criteria, it will be seen that no paint removal method is without its drawbacks and all recommendations are qualified in varying degrees.

### Methods for Removing Paint

After a particular exterior paint surface condition has been identified, the next step in planning for repainting—if paint removal is required—is selecting an appropriate method for such removal.

The method or methods selected should be suitable for the specific paint problem as well as the particular wooden element of the building. Methods for paint removal can be divided into three categories (frequently, however, a combination of the three methods is used).

Each method is defined below, then discussed further and specific recommendations made:

**Abrasive**—“Abrading” the painted surface by manual and/or mechanical means such as scraping and sanding. Generally used for surface preparation and limited paint removal.

**Thermal**—Softening and raising the paint layers by applying heat followed by scraping and sanding. Generally used for total paint removal.

**Chemical**—Softening of the paint layers with chemical strippers followed by scraping and sanding. Generally used for total paint removal.

#### • Abrasive Methods (Manual)

If conditions have been identified that require limited paint removal such as crazing, intercoat peeling, solvent blistering, and wrinkling, scraping and hand sanding should be the first methods employed before using mechanical means. Even in the case of more serious conditions such as peeling—where the damaged paint is weak and already sufficiently loosened from the wood surface—scraping and hand sanding may be all that is needed prior to repainting.

#### Recommended Abrasive Methods (Manual)

**Putty Knife/Paint Scraper:** Scraping is usually accomplished with either a putty knife or a paint scraper, or both. Putty knives range in width from one to six inches and have a beveled edge. A putty knife is used in a pushing motion going under the paint and working from an area of loose paint toward the edge where the paint is still firmly adhered and, in effect, “beveling” the remaining layers so that as smooth a transition as possible is made between damaged and undamaged areas (see figure 10).

Paint scrapers are commonly available in 1 $\frac{5}{16}$ , 2 $\frac{1}{2}$ , and 3 $\frac{1}{2}$  inch widths and have replaceable blades. In addition, profiled scrapers can be made specifically for use on moldings. As opposed to the putty knife, the paint scraper is used in a pulling motion and works by raking the damaged areas of paint away.

The obvious goal in using the putty knife or the paint scraper is to selectively remove the affected layer or layers of paint; however, both of these tools, particularly the paint scraper with its hooked edge, must be used with care to properly prepare the surface and to avoid gouging the wood.

**Sandpaper/Sanding Block/Sanding sponge:** After manually removing the damaged layer or layers by scraping, the uneven surface (due to the almost inevitable removal of varying numbers of paint layers in a given area) will need to be smoothed or “feathered out” prior to repainting. As stated before, hand sanding, as opposed to harsher mechanical sanding, is recommended if the area is relatively limited. A coarse grit, open-coat flint sandpaper—the least expensive kind—is useful for this purpose because, as the sandpaper clogs with paint it must be discarded and this process repeated until all layers adhere uniformly.

Blocks made of wood or hard rubber and covered with sandpaper are useful for handsanding flat surfaces. Sanding sponges—rectangular sponges with an abrasive aggregate on their surfaces—are also available for detail work that requires reaching into grooves because the sponge easily conforms to curves and irregular surfaces. All sanding should be done with the grain.

### Summary of Abrasive Methods (Manual)

**Recommended:** Putty knife, paint scraper, sandpaper, sanding block, sanding sponge.

**Applicable areas of building:** All areas.

**For use on:** Class I, Class II, and Class III conditions.

**Health/Safety factors:** Take precautions against lead dust, eye damage; dispose of lead paint residue properly.

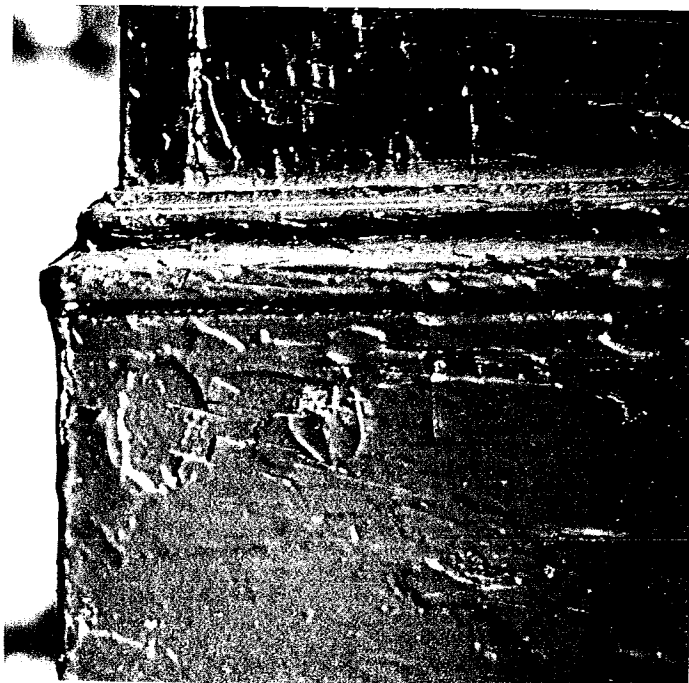


Fig. 10 An excellent example of inadequate scraping before repainting, the problems here are far more than cosmetic. This improperly prepared surface will permit moisture to get behind the paint film which, in turn, will result in chipping and peeling. Photo: Baird M. Smith, AIA.

### • Abrasive Methods (Mechanical)

If hand sanding for purposes of surface preparation has not been productive or if the affected area is too large to consider hand sanding by itself, mechanical abrasive methods, i.e., power-operated tools may need to be employed; however, it should be noted that the majority of tools available for paint removal can cause damage to fragile wood and must be used with great care.

#### Recommended Abrasive Methods (Mechanical)

**Orbital sander:** Designed as a finishing or smoothing tool—not for the removal of multiple layers of paint—the orbital sander is thus recommended when limited paint removal is required prior to repainting. Because it sands in a small diameter circular motion (some models can also be switched to a back-and-forth vibrating action), this tool is particularly effective for “feathering” areas where paint has first been scraped (see figure 11). The abrasive surface varies from about 3×7 inches to 4×9 inches and sandpaper is attached either by clamps or sliding clips. A medium grit, open-coat aluminum oxide sandpaper should be used; fine sandpaper clogs up so quickly that it is ineffective for smoothing paint.

**Belt sander:** A second type of power tool—the belt sander—can also be used for removing limited layers of paint but,

in this case, the abrasive surface is a continuous belt of sandpaper that travels at high speeds and consequently offers much less control than the orbital sander. Because of the potential for more damage to the paint or the wood, use of the belt sander (also with a medium grit sandpaper) should be limited to flat surfaces and only skilled operators should be permitted to operate it within a historic preservation project.

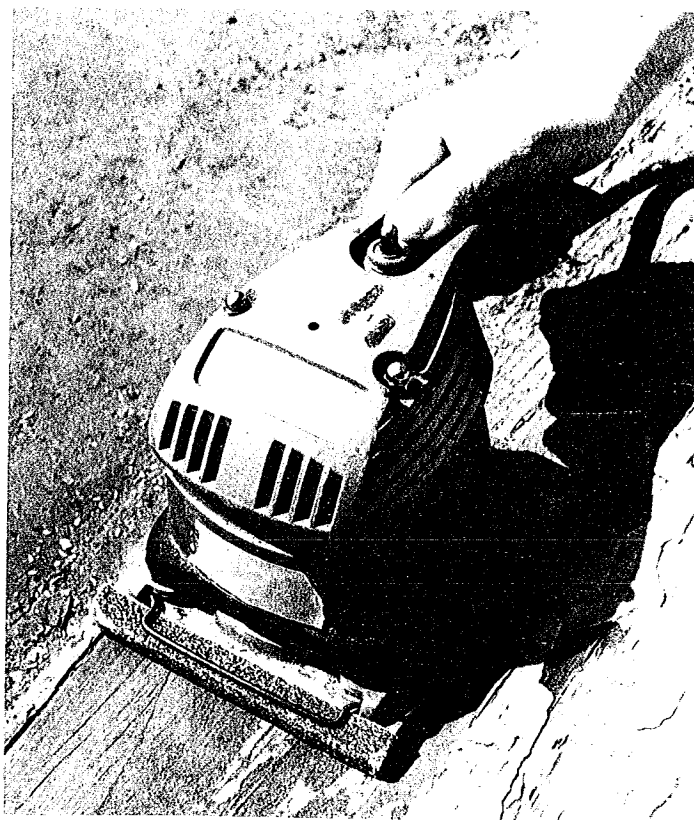


Fig. 11 The orbital sander can be used for limited paint removal, i.e., for smoothing flat surfaces after the majority of deteriorated paint has already been scraped off. Photo: Charles E. Fisher, III.

### Not Recommended

**Rotary Drill Attachments:** Rotary drill attachments such as the rotary sanding disc and the rotary wire stripper should be avoided. The disc sander—usually a disc of sandpaper about 5 inches in diameter secured to a rubber based attachment which is in turn connected to an electric drill or other motorized housing—can easily leave visible circular depressions in the wood which are difficult to hide, even with repainting. The rotary wire stripper—clusters of metals wires similarly attached to an electric drill-type unit—can actually shred a wooden surface and is thus to be used exclusively for removing corrosion and paint from metals.

**Waterblasting:** Waterblasting above 600 p.s.i. to remove paint is not recommended because it can force water into the woodwork rather than cleaning loose paint and grime from the surface; at worst, high pressure waterblasting causes the water to penetrate exterior sheathing and damages interior finishes. A detergent solution, a medium soft bristle brush, and a garden hose for purposes of rinsing, is the gentlest method involving water and is recommended when cleaning exterior surfaces prior to repainting.

**Sandblasting:** Finally—and undoubtedly most vehemently “not recommended”—sandblasting painted exterior woodwork will indeed remove paint, but at the same time can scar wooden elements beyond recognition. As with rotary wire strippers, sandblasting erodes the soft porous fibers (spring wood) faster than the hard, dense fibers (summer wood), leaving a pitted surface with ridges and valleys. Sandblasting will also erode projecting areas of carvings and moldings before it removes paint from concave areas (see figure 12). Hence, this abrasive method is potentially the most damaging of all possibilities, even if a contractor promises that blast pressure can be controlled so that the paint is removed without harming the historic exterior woodwork. (For Additional Information, See Preservation Briefs 6, “Dangers of Abrasive Cleaning to Historic Buildings”.)

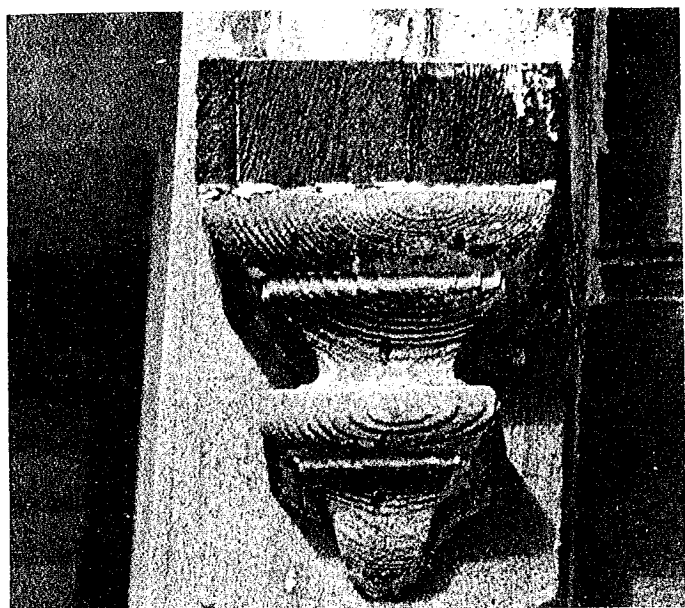


Fig. 12 Sandblasting has permanently damaged this ornamental bracket. Even paint will not be able to hide the deep erosion of the wood. Photo: David W. Look, AIA.

#### Summary of Abrasive Methods (Mechanical)

**Recommended:** Orbital sander, belt sander (skilled operator only).

**Applicable areas of building:** Flat surfaces, i.e., siding, eaves, doors, window sills.

**For use on:** Class II and Class III conditions.

**Health/Safety factors:** Take precautions against lead dust and eye damage; dispose of lead paint residue properly.

**Not Recommended:** Rotary drill attachments, high pressure waterblasting, sandblasting.

#### • Thermal Methods

Where exterior surface conditions have been identified that warrant total paint removal such as peeling, cracking, or alligatoring, two thermal devices—the electric heat plate and the electric heat gun—have proven to be quite successful for use on different wooden elements of the historic building. One thermal method—the blow torch—is not recommended because it can scorch the wood or even burn the building down!

#### Recommended Thermal Methods

**Electric heat plate:** The electric heat plate (see figure 13) operates between 500 and 800 degrees Fahrenheit (not hot enough to vaporize lead paint), using about 15 amps of power. The plate is held close to the painted exterior surface until the layers of paint begin to soften and blister, then moved to an adjacent location on the wood while the softened paint is scraped off with a putty knife (it should be noted that the heat plate is most successful when the paint is very thick!). With practice, the operator can successfully move the heat plate evenly across a flat surface such as wooden siding or a window sill or door in a continuous motion, thus lessening the risk of scorching the wood in an attempt to reheat the edge of the paint sufficiently for effective removal. Since the electric heat plate's coil is “red hot,” extreme caution should be taken to avoid igniting clothing or burning the skin. If an extension cord is used, it should be a heavy-duty cord (with 3-prong grounded plugs). A heat plate could overload a circuit or, even worse, cause an electrical fire; therefore, it is recommended that this implement be used with a single circuit and that a fire extinguisher always be kept close at hand.



Fig. 13 The electric heat plate (with paint scraper) is particularly useful for removing paint down to bare wood on flat surfaces such as doors, window frames, and siding. After scraping, some light sanding will probably be necessary to smooth the surface prior to application of primer and top coats. Photo: David W. Look, AIA.

**Electric heat gun:** The electric heat gun (electric hot-air gun) looks like a hand-held hairdryer with a heavy-duty metal case (see figure 14). It has an electrical resistance coil that typically heats between 500 and 750 degrees Fahrenheit and, again, uses about 15 amps of power which requires a heavy-duty extension cord. There are some heat guns that operate at higher temperatures but they should not be purchased for removing old paint

because of the danger of lead paint vapors. The temperature is controlled by a vent on the side of the heat gun. When the vent is closed, the heat increases. A fan forces a stream of hot air against the painted woodwork, causing a blister to form. At that point, the softened paint can be peeled back with a putty knife. It can be used to best advantage when a paneled door was originally varnished, then painted a number of times. In this case, the paint will come off quite easily, often leaving an almost pristine varnished surface behind. Like the heat plate, the heat gun works best on a heavy paint build-up. (It is, however, not very successful on only one or two layers of paint or on surfaces that have only been varnished. The varnish simply becomes sticky and the wood scorches.)

Although the heat gun is heavier and more tiring to use than the heat plate, it is particularly effective for removing paint from detail work because the nozzle can be directed at curved and intricate surfaces. Its use is thus more limited than the heat plate, and most successfully used in conjunction *with* the heat plate. For example, it takes about two to three hours to strip a paneled door with a heat gun, but if used in combination with a heat plate for the large, flat area, the time can usually be cut in half. Although a heat gun seldom scorches wood, it can cause fires (like the blow torch) if aimed at the dusty cavity between the exterior sheathing and siding and interior lath and plaster. A fire may smolder for hours before flames break through to the surface. Therefore, this thermal device is best suited for use on solid decorative elements, such as molding, balusters, fretwork, or "gingerbread."



Fig. 14 The nozzle on the electric heat gun permits hot air to be aimed into cavities on solid decorative elements such as this applied column. After the paint has been sufficiently softened, it can be removed with a profiled scraper. Photo: Charles E. Fisher, III.

## Not Recommended

**Blow Torch:** Blow torches, such as hand-held propane or butane torches, were widely used in the past for paint removal because other thermal devices were not available. With this technique, the flame is directed toward the paint until it begins to bubble and loosen from the surface. Then the paint is scraped off with a putty knife. Although this is a relatively fast process, at temperatures between 3200 and 3800 degrees Fahrenheit the open flame is not only capable of burning a careless operator and causing severe damage to eyes or skin, it can easily scorch or ignite the wood. The other fire hazard is more insidious. Most frame buildings have an air space between the exterior sheathing and siding and interior lath and plaster. This cavity usually has an accumulation of dust which is also easily ignited by the open flame of a blow torch. Finally, lead-base paints will vaporize at high temperatures, releasing toxic fumes that can be unknowingly inhaled. Therefore, because both the heat plate and the heat gun are generally safer to use—that is, the risks are much more controllable—the blow torch should definitely be avoided!

## Summary of Thermal Methods

**Recommended:** Electric heat plate, electric heat gun.

**Applicable areas of building:** Electric heat plate—flat surfaces such as siding, eaves, sash, sills, doors. Electric heat gun—solid decorative molding, balusters, fretwork, or "gingerbread."

**For use on:** Class III conditions.

**Health/Safety factors:** Take precautions against eye damage and fire. Dispose of lead paint residue properly.

**Not Recommended:** Blow torch.

## • Chemical Methods

With the availability of effective thermal methods for total paint removal, the need for chemical methods—in the context of preparing historic exterior woodwork for repainting—becomes quite limited. Solvent-base or caustic strippers may, however, play a supplemental role in a number of situations, including:

- Removing paint residue from intricate decorative features, or in cracks or hard to reach areas if a heat gun has not been completely effective;
- Removing paint on window muntins because heat devices can easily break the glass;
- Removing varnish on exterior doors after all layers of paint have been removed by a heat plate/heat gun if the original varnish finish is being restored;
- Removing paint from detachable wooden elements such as exterior shutters, balusters, columns, and doors by dip-stripping when other methods are too laborious.

## Recommended Chemical Methods (Use With Extreme Caution)

Because all chemical paint removers can involve potential health and safety hazards, no wholehearted recommendations can be made from that standpoint. Commonly known as "paint removers" or "strippers," both solvent-base or caustic products are commercially available that, when poured, brushed, or sprayed on painted exterior woodwork are capable of softening several layers of paint at a time so that the resulting "sludge"—which should be remembered is nothing less than the sequence of historic

paint layers—can be removed with a putty knife. Detachable wood elements such as exterior shutters can also be “dip-stripped.”

**Solvent-base Strippers:** The formulas tend to vary, but generally consist of combinations of organic solvents such as methylene chloride, isopropanol, toluol, xylol, and methanol; thickeners such as methyl cellulose; and various additives such as paraffin wax used to prevent the volatile solvents from evaporating before they have time to soak through multiple layers of paint. Thus, while some solvent-base strippers are quite thin and therefore unsuitable for use on vertical surfaces, others, called “semi-paste” strippers, are formulated for use on vertical surfaces or the underside of horizontal surfaces.

However, whether liquid or semi-paste, there are two important points to stress when using any solvent-base stripper: First, the vapors from the organic chemicals can be highly toxic if inhaled; skin contact is equally dangerous because the solvents can be absorbed; second, many solvent-base strippers are flammable. Even though application out-of-doors may somewhat mitigate health and safety hazards, a respirator with special filters for organic solvents is recommended and, of course, solvent-base strippers should never be used around open flames, lighted cigarettes, or with steel wool around electrical outlets.

Although appearing to be the simplest for exterior use, a particular type of solvent-base stripper needs to be mentioned here because it can actually cause the most problems. Known as “water-rinsable,” such products have a high proportion of methylene chloride together with emulsifiers. Although the dissolved paint can be rinsed off with water with a minimum of scraping, this ultimately creates more of a problem in cleaning up and properly disposing of the sludge. In addition, these strippers can leave a gummy residue on the wood that requires removal with solvents. Finally, water-rinsable strippers tend to raise the grain of the wood more than regular strippers.

On balance, then, the regular strippers would seem to work just as well for exterior purposes and are perhaps even better from the standpoint of proper lead sludge disposal because they must be hand scraped as opposed to rinsed off (a coffee-can with a wire stretched across the top is one effective way to collect the sludge; when the putty knife is run across the wire, the sludge simply falls into the can. Then, when the can is filled, the wire is removed, the can capped, and the lead paint sludge disposed of according to local health regulations).

**Caustic Strippers:** Until the advent of solvent-base strippers, caustic strippers were used exclusively when a chemical method was deemed appropriate for total paint removal prior to repainting or refinishing. Now, it is more difficult to find commercially prepared caustic solutions in hardware and paint stores for home-owner use with the exception of lye (caustic soda) because solvent-base strippers packaged in small quantities tend to dominate the market.

Most commercial dip stripping companies, however, continue to use variations of the caustic bath process because it is still the cheapest method available for removing paint. Generally, dip stripping should be left to professional companies because caustic solutions can dissolve skin and permanently damage eyes as well as present serious disposal problems in large quantities.

If exterior shutters or other detachable elements are be-

ing sent out<sup>6</sup> for stripping in a caustic solution, it is wise to see samples of the company's finished work. While some companies do a first-rate job, others can leave a residue of paint in carvings and grooves. Wooden elements may also be soaked too long so that the wood grain is raised and roughened, requiring extensive hand sanding later. In addition, assurances should be given by these companies that caustic paint removers will be neutralized with a mild acid solution or at least thoroughly rinsed with water after dipping (a caustic residue makes the wood feel slippery). If this is not done, the lye residue will cause new paint to fail.

### Summary of Chemical Methods

**Recommended, with extreme caution:** Solvent-base strippers, caustic strippers.

**Applicable areas of buildings:** decorative features, window muntins, doors, exterior shutters, columns, balusters, and railings.

**For use on:** Class III Conditions.

**Health/Safety factors:** Take precautions against inhaling toxic vapors; fire; eye damage; and chemical poisoning from skin contact. Dispose of lead residue properly

### General Paint Type Recommendations

Based on the assumption that the exterior wood has been painted with oil paint many times in the past and the existing top coat is therefore also an oil paint,\* it is recommended that for CLASS I and CLASS II paint surface conditions, a top coat of high quality oil paint be applied when repainting. The reason for recommending oil rather than latex paints is that a coat of latex paint applied directly over old oil paint is more apt to fail. The considerations are twofold. First, because oil paints continue to harden with age, the old surface is sensitive to the added stress of shrinkage which occurs as a new coat of paint dries. Oil paints shrink less upon drying than latex paints and thus do not have as great a tendency to pull the old paint loose. Second, when exterior oil paints age, the binder releases pigment particles, causing a chalky surface. Although for best results, the chalk (or dirt, etc.) should *always* be cleaned off prior to repainting, a coat of new oil paint is more able to penetrate a chalky residue and adhere than is latex paint. Therefore, unless it is possible to thoroughly clean a heavy chalked surface, oil paints—on balance—give better adhesion.

If however, a latex top coat is going to be applied over several layers of old oil paint, an oil primer should be applied first (the oil primer creates a flat, porous surface to which the latex can adhere). After the primer has thoroughly dried, a latex top coat may be applied. In the long run, changing paint types is more time consuming and expensive. An application of a new oil-type top coat on the old oil paint is, thus, the preferred course of action.

\* Marking the original location of the shutter by number (either by stamping numbers into the end grain with metal numeral dies or cutting numbers into the end with a pen knife) will minimize difficulties when rehanging them.

\* If the top coat is latex paint (when viewed by the naked eye or, preferably, with a magnifying glass, it looks like a series of tiny craters) it may either be repainted with new latex paint or with oil paint. Normal surface preparation should precede any repainting.



If CLASS III conditions have necessitated total paint removal, there are two options, both of which assure protection of the exterior wood: (1) an oil primer may be applied followed by an oil-type top coat, preferably by the same manufacturer; or (2) an oil primer may be applied followed by a latex top coat, again using the same brand of paint. It should also be noted that primers were never intended to withstand the effects of weathering; therefore, the top coat should be applied as soon as possible after the primer has dried.

## Conclusion

The recommendations outlined in this Brief are cautious because at present there is no completely safe and effective method of removing old paint from exterior woodwork. This has necessarily eliminated descriptions of several methods still in a developmental or experimental stage, which can therefore neither be recommended nor precluded from future recommendation. With the ever-increasing number of buildings being rehabilitated, however, paint removal technology should be stimulated and, in consequence, existing methods refined and new methods developed which will respect both the historic wood and the health and safety of the operator.

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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 advice and guidance in this brief will assist property owners in complying with the requirements of this law.

Preservation Briefs 10 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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September 1982

# 16 PRESERVATION BRIEFS

## The Use of Substitute Materials on Historic Building Exteriors

Sharon C. Park, AIA



U.S. Department of the Interior  
National Park Service  
Cultural Resources  
Heritage Preservation Services



The Secretary of the Interior's *Standards for Rehabilitation* require that "deteriorated architectural features be repaired rather than replaced, wherever possible. In the event that replacement is necessary, the new material should match the material being replaced in composition, design, color, texture, and other visual properties." Substitute materials should be used only on a limited basis and only when they will match the appearance and general properties of the historic material and will not damage the historic resource.

### Introduction

When deteriorated, damaged, or lost features of a historic building need repair or replacement, it is almost always best to use historic materials. In limited circumstances substitute materials that imitate historic materials may be used if the appearance and properties of the historic materials can be matched closely and no damage to the remaining historic fabric will result.

Great care must be taken if substitute materials are used on the exteriors of historic buildings. Ultra-violet light, moisture penetration behind joints, and stresses caused by changing temperatures can greatly impair the performance of substitute materials over time. Only after consideration of all options, in consultation with qualified professionals, experienced fabricators and contractors, and development of carefully written specifications should this work be undertaken.

The practice of using substitute materials in architecture is not new, yet it continues to pose practical problems and to raise philosophical questions. On the practical level the inappropriate choice or improper installation of substitute materials can cause a radical change in a building's appearance and can cause extensive physical damage over time. On the more philosophical level, the wholesale use of substitute materials can raise questions concerning the integrity of historic buildings largely comprised of new materials. In both cases the integrity of the historic resource can be destroyed.

Some preservationists advocate that substitute materials should be avoided in all but the most limited cases. The fact is, however, that substitute materials are being used more frequently than ever in preservation projects, and in many cases with positive results. They can be cost-effective, can permit

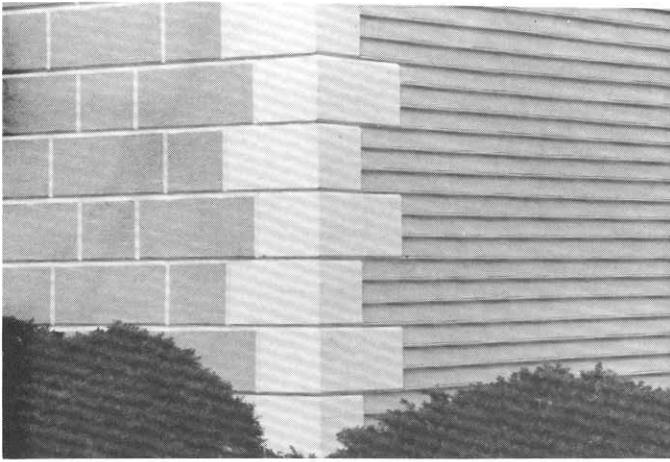
the accurate visual duplication of historic materials, and last a reasonable time. Growing evidence indicates that with proper planning, careful specifications and supervision, substitute materials can be used successfully in the process of restoring the visual appearance of historic resources.

This Brief provides general guidance on the use of substitute materials on the exteriors of historic buildings. While substitute materials are frequently used on interiors, these applications are not subject to weathering and moisture penetration, and will not be discussed in this Brief. Given the general nature of this publication, specifications for substitute materials are not provided. The guidance provided should not be used in place of consultations with qualified professionals. This Brief includes a discussion of when to use substitute materials, cautions regarding their expected performance, and descriptions of several substitute materials, their advantages and disadvantages. This review of materials is by no means comprehensive, and attitudes and findings will change as technology develops.

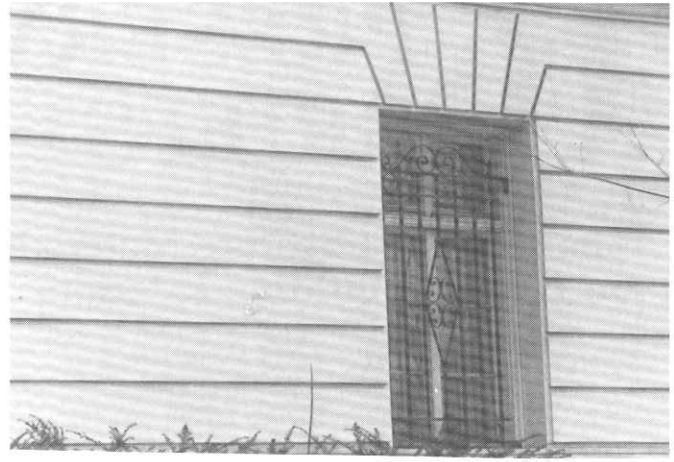
### Historical Use of Substitute Materials

The tradition of using cheaper and more common materials in imitation of more expensive and less available materials is a long one. George Washington, for example, used wood painted with sand-impregnated paint at Mount Vernon to imitate cut ashlar stone. This technique along with scoring stucco into block patterns was fairly common in colonial America to imitate stone (see illus. 1, 2).

Molded or cast masonry substitutes, such as dry-tamp cast stone and poured concrete, became popular in place of quarried stone during the 19th century. These masonry units were fabricated locally, avoiding



*Illus. 1. An early 18th-century technique for imitating carved or quarried stone was the use of sand-impregnated paint applied to wood. The facade stones and quoins are of wood. The Lindens (1754), Washington, D.C. Photo: Sharon C. Park, AIA.*



*Illus. 2. Stucco has for many centuries represented a number of building materials. Seen here is the ground floor of a Beaux Arts mansion, circa 1900, which represents a finely laid stone foundation wall executed in scored stucco. Photo: Sharon C. Park, AIA.*



*Illus. 3. Casting concrete to represent quarried stone was a popular late 19th-century technique seen in this circa 1910 mail-order house. While most components were delivered by rail, the foundations and exterior masonry were completed by local craftsmen. Photo: Sharon C. Park, AIA.*



*Illus. 4. The 19th-century also produced a variety of metal products used in imitation of other materials. In this case, the entire exterior of the Long Island Safety Deposit Company is cast-iron representing stone. Photo: Becket Logan, Friends of Cast Iron Architecture.*

expensive quarrying and shipping costs, and were versatile in representing either ornately carved blocks, plain wall stones or rough cut textured surfaces. The end result depended on the type of patterned or textured mold used and was particularly popular in conjunction with mail order houses (see illus. 3). Later, panels of cementitious perma-stone or formstone and less expensive asphalt and sheet metal panels were used to imitate brick or stone.

Metal (cast, stamped, or brake-formed) was used for storefronts, canopies, railings, and other features, such as galvanized metal cornices substituting for wood or stone, stamped metal panels for Spanish clay roofing tiles, and cast-iron column capitals and even entire building fronts in imitation of building stone (see illus. no. 4).

Terra cotta, a molded fired clay product, was itself a substitute material and was very popular in the late 19th and early 20th centuries. It simulated the ap-

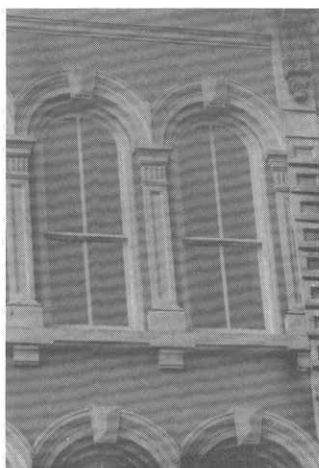
pearance of intricately carved stonework, which was expensive and time-consuming to produce. Terra cotta could be glazed to imitate a variety of natural stones, from brownstones to limestones, or could be colored for a polychrome effect.

Nineteenth century technology made a variety of materials readily available that not only were able to imitate more expensive materials but were also cheaper to fabricate and easier to use. Throughout the century, imitative materials continued to evolve. For example, ornamental window hoods were originally made of wood or carved stone. In an effort to find a cheaper substitute for carved stone and to speed fabrication time, cast stone, an early form of concrete, or cast-iron hoods often replaced stone. Toward the end of the century, even less expensive sheet metal hoods, imitating stone, also came into widespread use. All of these materials, stone, cast stone, cast-iron, and various pressed metals were in





a



b



c



d

*Illus. 5. The four historic examples of various window hoods shown are: (a) stone; (b) cast stone; (c) cast-iron; and (d) sheet metal. The criteria for selecting substitute materials today (availability, quality, delivery dates, cost) are not much different from the past. Photo: Sharon C. Park, AIA.*

production at the same time and were selected on the basis of the availability of materials and local craftsmanship, as well as durability and cost (see illus. 5). The criteria for selection today are not much different.

Many of the materials used historically to imitate other materials are still available. These are often referred to as the traditional materials: wood, cast stone, concrete, terra cotta and cast metals. In the last few decades, however, and partly as a result of the historic preservation movement, new families of synthetic materials, such as fiberglass, acrylic polymers, and epoxy resins, have been developed and are being used as substitute materials in construction. In some respects these newer products (often referred to as high tech materials) show great promise; in others, they are less satisfactory, since they are often difficult to integrate physically with the porous historic materials and may be too new to have established solid performance records.

## When to Consider Using Substitute Materials in Preservation Projects

Because the overzealous use of substitute materials can greatly impair the historic character of a historic structure, all preservation options should be explored thoroughly before substitute materials are used. It is important to remember that the purpose of repairing damaged features and of replacing lost and irreparably damaged ones is both to match visually what was there and to cause no further deterioration. For these reasons it is not appropriate to cover up historic materials with synthetic materials that will alter the appearance, proportions and details of a historic building and that will conceal future deterioration (see illus. 6).

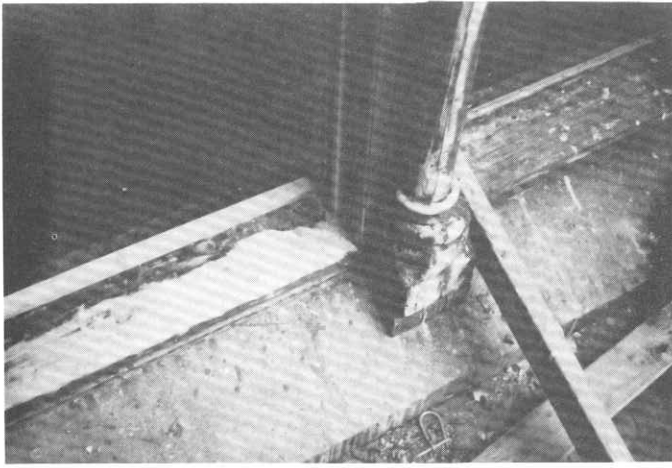
Some materials have been used successfully for the repair of damaged features such as epoxies for wood infilling, cementitious patching for sandstone repairs, or plastic stone for masonry repairs. Repairs are preferable to replacement whether or not the repairs are in kind or with a synthetic substitute material (see illus. 7).

In general, four circumstances warrant the consideration of substitute materials: 1) the unavailability of historic materials; 2) the unavailability of skilled craftsmen; 3) inherent flaws in the original materials; and 4) code-required changes (which in many cases can be extremely destructive of historic resources).

Cost may or may not be a determining factor in considering the use of substitute materials. Depending on the area of the country, the amount of material needed, and the projected life of less durable substitute materials, it may be cheaper in the long run to use the original material, even though it may be harder to find. Due to many early failures of substitute materials, some preservationist are looking abroad to find materials (especially stone) that match the historic materials in an effort to restore historic



*Illus. 6. Substitute materials should never be considered as a cosmetic cover-up for they can cause great physical damage and can alter the appearance of historic buildings. For example, a fiberglass coating was used at Ranchos de Taos, NM, in place of the historic adobe coating which had deteriorated. The waterproof coating sealed moisture in the walls and caused the spalling shown. It was subsequently removed and the walls were properly repaired with adobe. Photo: Lee H. Nelson, FAIA.*



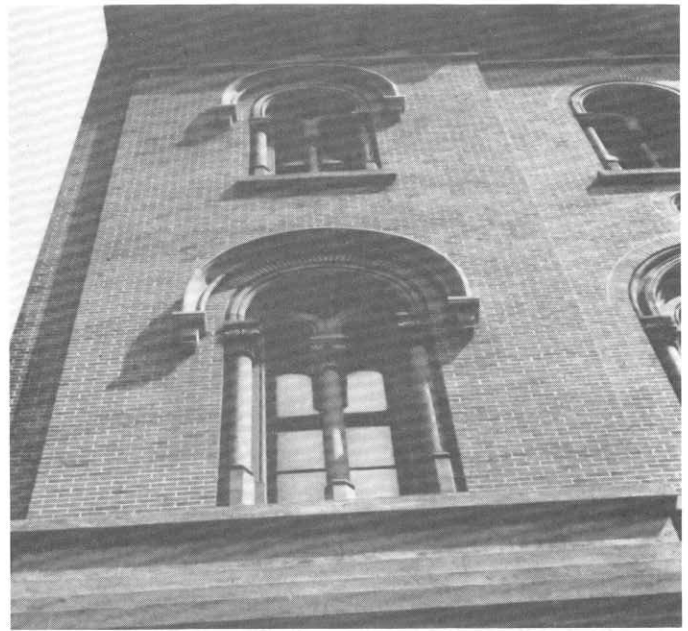
*Illus. 7. Whenever possible, historic materials should be repaired rather than replaced. Epoxy, a synthetic resin, has been used to repair the wood window frame and sill at the Auditors Building (1878) Washington, DC. The cured resin is white in this photo and will be primed and painted. Photo: Lee H. Nelson, FAIA.*



*Illus. 9. Simple solutions should not be overlooked when materials are no longer available. In the case of the Morse-Libby Mansion (1859), Portland, ME, the deteriorated brownstone porch beam was replaced with a carved wooden beam painted with sand impregnated paint. Photo: Stephen Sewall.*

buildings accurately and to avoid many of the uncertainties that come with the use of substitute materials.

**1. The unavailability of the historic material.** The most common reason for considering substitute materials is the difficulty in finding a good match for the historic material (particularly a problem for masonry materials where the color and texture are derived from the material itself). This may be due to the actual unavailability of the material or to protracted delivery dates. For example, the local quarry that supplied the sandstone for a building may no longer be in operation. All efforts should be made to locate another quarry that could supply a satisfactory match (see illus. 8). If this approach fails, substitute materials such as dry-tamp cast stone or textured precast concrete may be a suitable substitute if care is taken to ensure that the detail, color and texture of the original stone are matched. In some cases, it may be possible to use a sand-impregnated paint on wood



*Illus. 8. Even when materials are not locally available, it may be possible and cost effective to find sources elsewhere. For example, the local sandstone was no longer available for the restoration of the New York Shakespeare Festival Public Theater. The deteriorated sandstone window hoods, were replaced with stone from Germany that closely matched the color and texture of the historic sandstone. Photo: John G. Waite.*



*Illus. 10. The use of substitute materials is not necessarily cheaper or easier than using the original materials. The complex process of fabricating the polyester bronze reproduction pieces of the gilded wood molding for the clockcase at Independence Hall required talented artisans and substantial mold-making time. From left to right is the final molded polyester bronze detail; the plaster casting mold; the positive and negative interim neoprene rubber molds; and the expertly carved wooden master. Photo: Courtesy of Independence National Historical Park.*

as a replacement section, achieved using readily available traditional materials, conventional tools and work skills. (see illus. 9). Simple solutions should not be overlooked.

**2. The unavailability of historic craft techniques and lack of skilled artisans.** These two reasons complicate any preservation or rehabilitation project. This is particularly true for intricate ornamental work, such as carved wood, carved stone, wrought iron, cast iron, or molded terra cotta. However, a number of stone and wood cutters now employ sophisticated carving machines, some even computerized. It is also possible to cast substitute replacement pieces using





*Illus. 11. The unavailability of historic craft techniques is another reason to consider substitute materials. The original first floor cast iron front of the Grand Opera House, Wilmington, DE, was missing; the expeditious reproduction in cast aluminum was possible because artisans working in this medium were available. Photo: John G. Waite.*

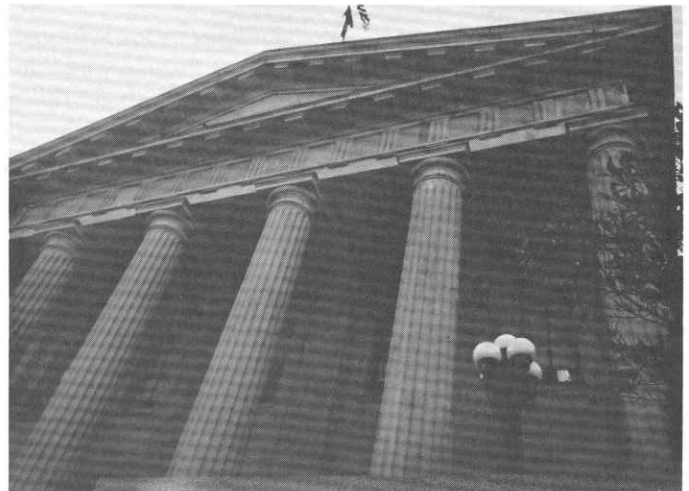
aluminum, cast stone, fiberglass, polymer concretes, glass fiber reinforced concretes and terra cotta. Mold making and casting takes skill and craftsmen who can undertake this work are available. (see illus. 10, 11). Efforts should always be made, prior to replacement, to seek out artisans who might be able to repair ornamental elements and thereby save the historic features in place.

**3. Poor original building materials.** Some historic building materials were of inherently poor quality or their modern counterparts are inferior. In addition, some materials were naturally incompatible with other materials on the building, causing staining or galvanic corrosion. Examples of poor quality materials were the very soft sandstones which eroded quickly. An example of poor quality modern replacement material is the tin coated steel roofing which is much less durable than the historic tin or terne iron which is no longer available. In some cases, more durable natural stones or precast concrete might be available as substitutes for the soft stones and modern terne-coated stainless steel or lead-coated copper might produce a more durable yet visually compatible replacement roofing (see illus. 12).

**4. Code-related changes.** Sometimes referred to as life and safety codes, building codes often require changes to historic buildings. Many cities in earthquake zones, for example, have laws requiring that overhanging masonry parapets and cornices, or freestanding urns or finials be securely reanchored to new structural frames or be removed completely. In some cases, it may be acceptable to replace these heavy historic elements with light replicas (see illus. 13). In other cases, the extent of historic fabric removed may be so great as to diminish the integrity of the resource. This could affect the significance of the structure and jeopardize National Register status. In addition, removal of repairable historic materials could result in loss of Federal tax credits for rehabilitation. Department of the Interior regulations make



*Illus. 12. Substitute materials may be considered when the original materials have not performed well. For example, early sheet metals used for roofing, such as tinplate, were reasonably durable, but the modern equivalent, terne-coated steel, is subject to corrosion once the thin tin plating is damaged. Terne-coated stainless steel or lead-coated copper (shown here) are now used as substitutes. Photo: John G. Waite.*



*Illus. 13. Code-related changes are of concern in historic preservation projects because the integrity of the historic resource may be irretrievably affected. In the case of the Old San Francisco Mint, the fiberglass cornice was used to bring the building into seismic conformance. The original cornice was deteriorated, and the replacement (1982) was limited to the projecting pediment. The historic stone fascia was retained as were the stone columns. The limited replacement of deteriorated material did not jeopardize the integrity of the building. Photo: Walter M. Sontheimer.*

clear that the Secretary of the Interior's Standards for Rehabilitation take precedence over other regulations and codes in determining whether a project is consistent with the historic character of the building undergoing rehabilitation.

Two secondary reasons for considering the use of substitute materials are their lighter weight and for some materials, a reduced need of maintenance. These reasons can become important if there is a

need to keep dead loads to a minimum or if the feature being replaced is relatively inaccessible for routine maintenance.

## Cautions and Concerns

In dealing with exterior features and materials, it must be remembered that moisture penetration, ultra-violet degradation, and differing thermal expansion and contraction rates of dissimilar materials make any repair or replacement problematic. To ensure that a repair or replacement will perform well over time, it is critical to understand fully the properties of both the original and the substitute materials, to install replacement materials correctly, to assess their impact on adjacent historic materials, and to have reasonable expectations of future performance.

Many high tech materials are too new to have been tested thoroughly. The differences in vapor permeability between some synthetic materials and the historic materials have in some cases caused unexpected further deterioration. It is therefore difficult to recommend substitute materials if the historic materials are still available. As previously mentioned, consideration should always be given first to using traditional materials and methods of repair or replacement before accepting unproven techniques, materials or applications.

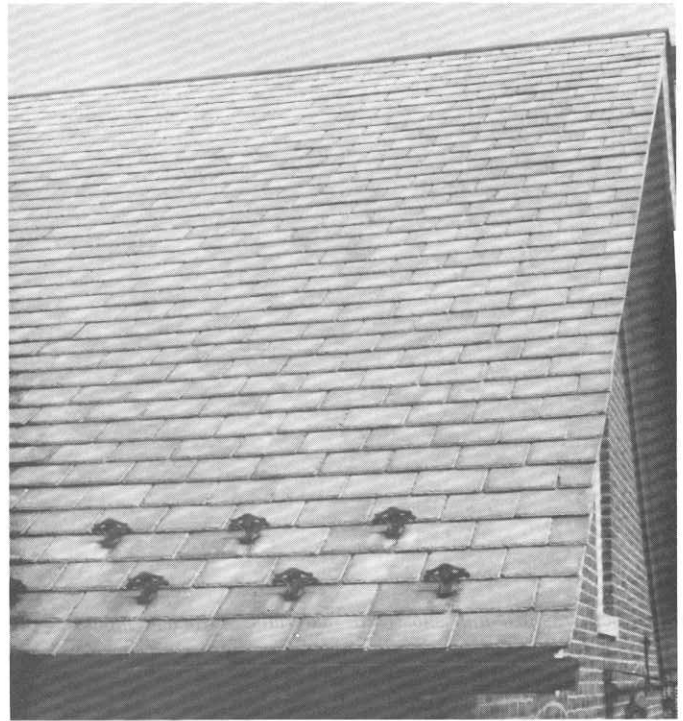
Substitute materials must meet three basic criteria before being considered: they must be compatible with the historic materials in appearance; their physical properties must be similar to those of the historic materials, or be installed in a manner that tolerates differences; and they must meet certain basic performance expectations over an extended period of time.

### Matching the Appearance of the Historic Materials

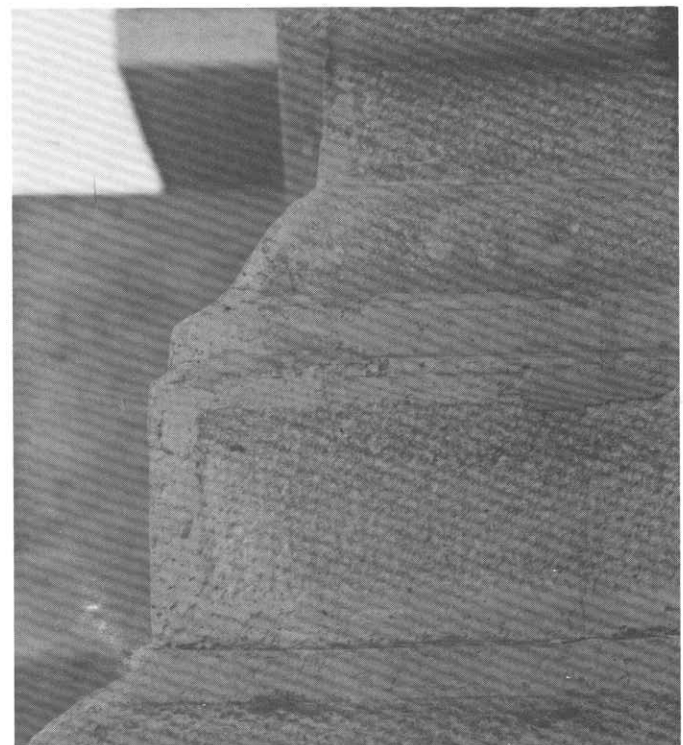
In order to provide an appearance that is compatible with the historic material, the new material should match the details and craftsmanship of the original as well as the color, surface texture, surface reflectivity and finish of the original material (see illus. 14). The closer an element is to the viewer, the more closely the material and craftsmanship must match the original.

Matching the color and surface texture of the historic material with a substitute material is normally difficult. To enhance the chances of a good match, it is advisable to clean a portion of the building where new materials are to be used. If pigments are to be added to the substitute material, a specialist should determine the formulation of the mix, the natural aggregates and the types of pigments to be used. As all exposed material is subject to ultra-violet degradation, if possible, samples of the new materials made during the early planning phases should be tested or allowed to weather over several seasons to test for color stability.

Fabricators should supply a sufficient number of samples to permit on-site comparison of color, texture, detailing, and other critical qualities (see illus. 15, 16). In situations where there are subtle variations in color and texture within the original materials, the

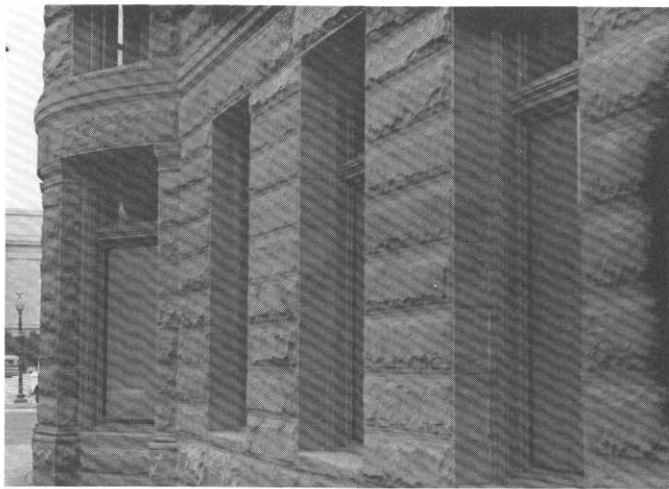


*Illus. 14. The visual qualities of the historic feature must be matched when using substitute materials. In this illustration, the lighter weight mineral fiber cement shingles used to replace the deteriorated historic slate roof were detailed to match the color, size, shape and pattern of the original roofing and the historic snow birds were reattached. Photo: Sharon C. Park, AIA.*



*Illus. 15. Poor quality workmanship can be avoided. In this example, the crudely cast concrete entrance pier (shown) did not match the visual qualities of the remaining historic sandstone (not shown). The aggregate is too large and exposed; the casting is not crisp; the banded tooling edges are not articulated; and the color is too pale. Photo: Sharon C. Park, AIA.*





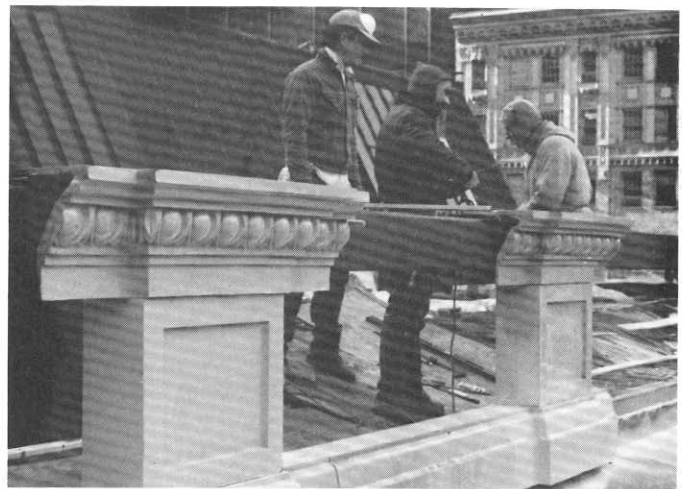
*Illus. 16. The good quality substitute materials shown here do match the historic sandstone in color, texture, tooling and surface details. Dry-tamp cast stone was used to match the red sandstone that was no longer available. The reconstructed first floor incorporated both historic and substitute materials. Sufficient molds were made to avoid the problem of detecting the substitutes by their uniformity. Photo: Sharon C. Park, AIA.*



*Illus. 17. Care must be taken to ensure that the replacement materials will work within a predesigned system. At the Norris Museum, Yellowstone National Park, the 12-inch diameter log rafters, part of an intricate truss system, had rotted at the inner core from the exposed ends back to a depth of 48 inches. The exterior wooden shells remained intact. Fiberglass rods (left photo) and specially formulated structural epoxy were used to fill the cleaned out cores and a cast epoxy wafer end with all the detail of the original wood graining was laminated onto the log end (right photo). This treatment preserved the original feature with a combination of repair and replacement using substitute materials as part of a well thought out system. Photos: Courtesy of Harrison Goodall.*

substitute materials should be similarly varied so that they are not conspicuous by their uniformity.

Substitute materials, notably the masonry ones, may be more water-absorbent than the historic material. If this is visually distracting, it may be appropriate to apply a protective vapor-permeable coating on the substitute material. However, these clear coatings tend to alter the reflectivity of the material, must be reapplied periodically, and may trap salts and moisture, which can in turn produce spalling. For these reasons, they are *not* recommended for use on historic materials.



*Illus. 18. Substitute materials must be properly installed to allow for expansion, contraction, and structural security. The new balustrade (a polymer concrete modified with glass fibers) at Carnegie Hall, New York City, was installed with steel structural supports to allow window-washing equipment to be suspended securely. In addition, the formulation of this predominantly epoxy material allowed for the natural expansion and contraction within the predesigned joints. Photo: Courtesy of MJM Studios.*

### Matching the Physical Properties

While substitute materials can closely match the appearance of historic ones, their physical properties may differ greatly. The chemical composition of the material (i.e., presence of acids, alkalines, salts, or metals) should be evaluated to ensure that the replacement materials will be compatible with the historic resource. Special care must therefore be taken to integrate and to anchor the new materials properly (see illus. 17). The thermal expansion and contraction coefficients of each adjacent material must be within tolerable limits. The function of joints must be understood and detailed either to eliminate moisture penetration or to allow vapor permeability. Materials that will cause galvanic corrosion or other chemical reactions must be isolated from one another.

To ensure proper attachment, surface preparation is critical. Deteriorated underlying material must be cleaned out. Non-corrosive anchoring devices or fasteners that are designed to carry the new material and to withstand wind, snow and other destructive elements should be used (see illus. 18). Properly chosen fasteners allow attached materials to expand and contract at their own rates. Caulking, flexible sealants or expansion joints between the historic material and the substitute material can absorb slight differences of movement. Since physical failures often result from poor anchorage or improper installation techniques, a structural engineer should be a member of any team undertaking major repairs.

Some of the new high tech materials such as epoxies and polymers are much stronger than historic materials and generally impermeable to moisture. These differences can cause serious problems unless the new materials are modified to match the expansion and contraction properties of adjacent historic materials more closely, or unless the new materials

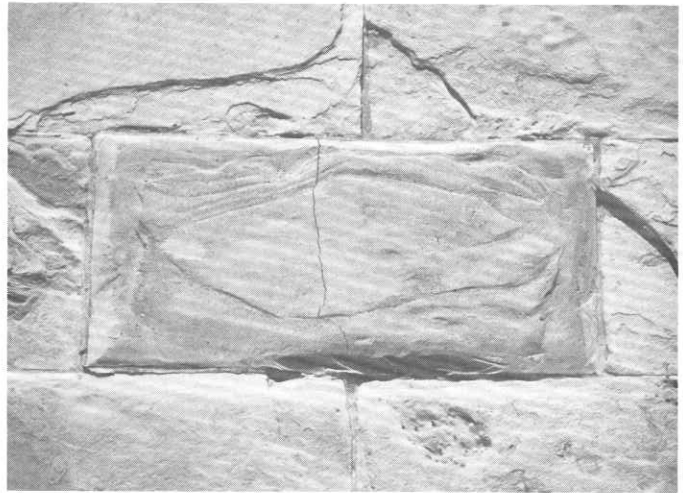
are isolated from the historic ones altogether. When stronger or vapor impermeable new materials are used alongside historic ones, stresses from trapped moisture or differing expansion and contraction rates generally hasten deterioration of the weaker historic material. For this reason, a conservative approach to repair or replacement is recommended, one that uses more pliant materials rather than high-strength ones (see illus. 19). Since it is almost impossible for substitute materials to match the properties of historic materials perfectly, the new system incorporating new and historic materials should be designed so that if material failures occur, they occur within the new material rather than the historic material.

### Performance Expectations

While a substitute material may appear to be acceptable at the time of installation, both its appearance and its performance may deteriorate rapidly. Some materials are so new that industry standards are not available, thus making it difficult to specify quality control in fabrication, or to predict maintenance requirements and long term performance. Where possible, projects involving substitute materials in similar circumstances should be examined. Material specifications outlining stability of color and texture; compressive or tensile strengths if appropriate; the acceptable range of thermal coefficients, and the durability of coatings and finishes should be included in the contract documents. Without these written documents, the owner may be left with little recourse if failure occurs (see illus. 20, 21).

The tight controls necessary to ensure long-term performance extend beyond having written performance standards and selecting materials that have a successful track record. It is important to select qualified fabricators and installers who know what they are doing and who can follow up if repairs are necessary. Installers and contractors unfamiliar with specific substitute materials and how they function in your local environmental conditions should be avoided.

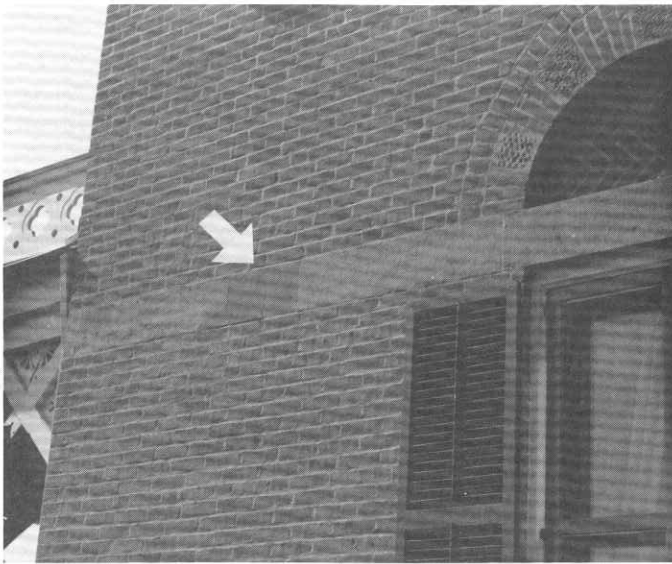
The surfaces of substitute materials may need special care once installed. For example, chemical residues or mold release agents should be removed completely prior to installation, since they attract pollutants and cause the replacement materials to appear dirtier than the adjacent historic materials. Furthermore, substitute materials may require more frequent cleaning, special cleaning products and protection from impact by hanging window-cleaning scaffolding. Finally, it is critical that the substitute materials be identified as part of the historical record of the building so that proper care and maintenance of all the building materials continue to ensure the life of the historic resource.



*Illus. 19. When the physical properties are not matched, particularly thermal expansion and contraction properties, great damage can occur. In this case, an extremely rigid epoxy replacement unit was installed in a historic masonry wall. Because the epoxy was not modified with fillers, it did not expand or contract systematically with the natural stones in the wall surrounding it. Pressure built up resulting in a vertical crack at the center of the unit, and spalled edges to every historic stone that was adjacent to the rigid unit. Photo: Walter M. Sontheimer.*



*Illus. 20. Long-term performance can be affected by where the substitute material is located. In this case, fiberglass was used as part of a storefront at street level. Due to the brittle nature of the material and the frequency of impact likely to occur at this location, an unsightly chip has resulted. Photo: Sharon C. Park, AIA.*

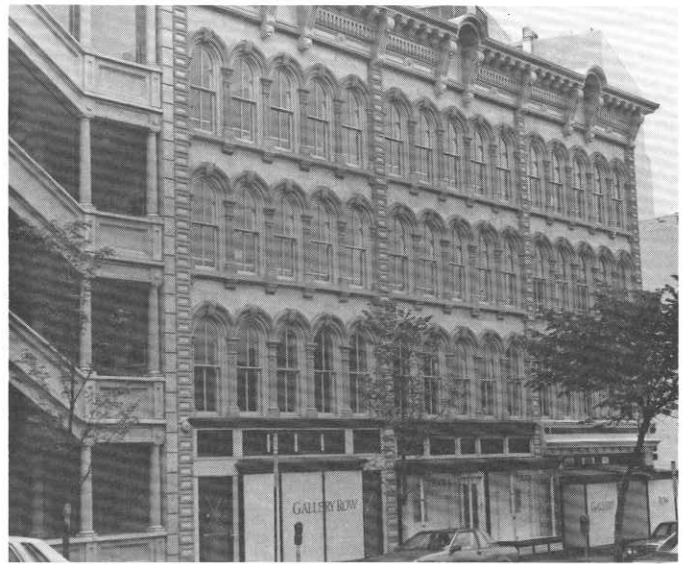


*Illus. 21. Change of color over time is one of the greatest problems of synthetic substitute materials used outdoors. Ultra-violet light can cause materials to change color over time; some will lighten and others will darken. In this photograph, the synthetic patching material to the sandstone banding to the left of the window has aged to a darker color. Photos: Sharon C. Park, AIA.*

### Choosing an Appropriate Substitute Material

Once all reasonable options for repair or replacement in kind have been exhausted, the choice among a wide variety of substitute materials currently on the market must be made (see illus. 22). The charts at the end of this Brief describe a number of such materials, many of them in the family of modified concretes which are gaining greater use. The charts do not include wood, stamped metal, mineral fiber cement shingles and some other traditional imitative materials, since their properties and performance are better known. Nor do the charts include vinyls or molded urethanes which are sometimes used as cosmetic claddings or as substitutes for wooden millwork. Because millwork is still readily available, it should be replaced in kind.

The charts describe the properties and uses of several materials finding greater use in historic preservation projects, and outline advantages and disadvantages of each. It should not be read as an endorsement of any of these materials, but serves as a reminder that numerous materials must be studied carefully before selecting the appropriate treatment. Included are three predominantly masonry materials (cast stone, precast concrete, and glass fiber reinforced concrete); two predominantly resinous materials (epoxy and glass fiber reinforced polymers also known as fiberglass), and cast aluminum which has been used as a substitute for various metals and woods.



*Illus. 22. A fiber reinforced polymer (fiberglass) cornice and precast concrete elements replaced deteriorated features on the 19th-century exterior. Photo: Sharon C. Park, AIA.*

### Summary

Substitute materials—those products used to imitate historic materials—should be used only after all other options for repair and replacement in kind have been ruled out. Because there are so many unknowns regarding the long-term performance of substitute materials, their use should not be considered without a thorough investigation into the proposed materials, the fabricator, the installer, the availability of specifications, and the use of that material in a similar situation in a similar environment.

Substitute materials are normally used when the historic materials or craftsmanship are no longer available, if the original materials are of a poor quality or are causing damage to adjacent materials, or if there are specific code requirements that preclude the use of historic materials. Use of these materials should be limited, since replacement of historic materials on a large scale may jeopardize the integrity of a historic resource. Every means of repairing deteriorating historic materials or replacing them with identical materials should be examined before turning to substitute materials.

The importance of matching the appearance and physical properties of historic materials and, thus, of finding a successful long-term solution cannot be overstated. The successful solutions illustrated in this Brief were from historic preservation projects involving professional teams of architects, engineers, fabricators, and other specialists. Cost was not necessarily a factor, and all agreed that whenever possible, the historic materials should be used. When substitute materials were selected, the solutions were often expensive and were reached only after careful consideration of all options, and with the assistance of expert professionals.



# PROs and CONs of VARIOUS SUBSTITUTE MATERIALS

## Cast Aluminum

**Material:** Cast aluminum is a molten aluminum alloy cast in permanent (metal) molds or one-time sand molds which must be adjusted for shrinkage during the curing process. Color is from paint applied to primed aluminum or from a factory finished coating. Small sections can be bolted together to achieve intricate or sculptural details. Unit castings are also available for items such as column plinth blocks.

**Application:** Cast aluminum can be a substitute for cast-iron or other decorative elements. This would include grillwork, roof crestings, cornices, ornamental spandrels, storefront elements, columns, capitals, and column bases and plinth blocks. If not self-supporting, elements are generally screwed or bolted to a structural frame. As a result of galvanic corrosion problems with dissimilar metals, joint details are very important.

### Advantages:

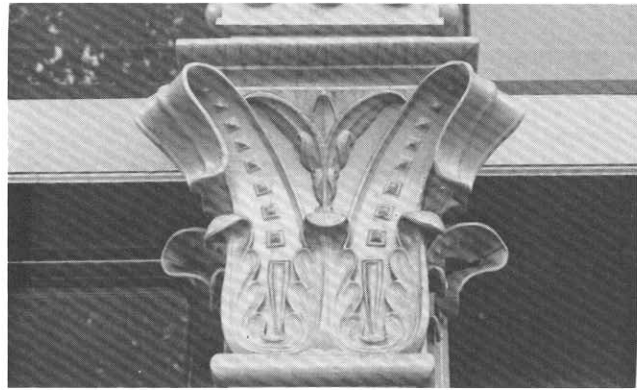
- light weight (1/2 of cast-iron)
- corrosion-resistant, non-combustible
- intricate castings possible
- easily assembled, good delivery time
- can be prepared for a variety of colors
- long life, durable, less brittle than cast iron

### Disadvantages:

- lower structural strength than cast-iron
- difficult to prevent galvanic corrosion with other metals
- greater expansion and contraction than cast-iron; requires gaskets or caulked joints
- difficult to keep paint on aluminum

### Checklist:

- Can existing be repaired or replaced in-kind?
- How is cast aluminum to be attached?
- Have full-size details been developed for each piece to be cast?
- How are expansion joints detailed?
- Will there be a galvanic corrosion problem?
- Have factory finishes been protected during installation?
- Are fabricators/installers experienced?



*Close-up detail showing the crisp casting in aluminum of this 19th-century replica column and capital for a storefront. Photo: Sharon C. Park, AIA.*



*The new cast aluminum storefront replaced the lost 19th-century cast-iron original. Photo: Sharon C. Park, AIA.*

## Cast Stone (dry-tamped):

**Material:** Cast stone is an almost-dry cement, lime and aggregate mixture which is dry-tamped into a mold to produce a dense stone-like unit. Confusion arises in the building industry as many refer to high quality precast concrete as cast stone. In fact, while it is a form of precast concrete, the dry-tamp fabrication method produces an outer surface resembling a stone surface. The inner core can be either dry-tamped or poured full of concrete. Reinforcing bars and anchorage devices can be installed during fabrication.

**Application:** Cast stone is often the most visually similar material as a replacement for unveined deteriorated stone, such as brownstone or sandstone, or terra cotta in imitation of stone. It is used both for surface wall stones and for ornamental features such as window and door surrounds, voussoirs, brackets and hoods. Rubber-like molds can be taken of good stones on site or made up at the factory from shop drawings.

### Advantages:

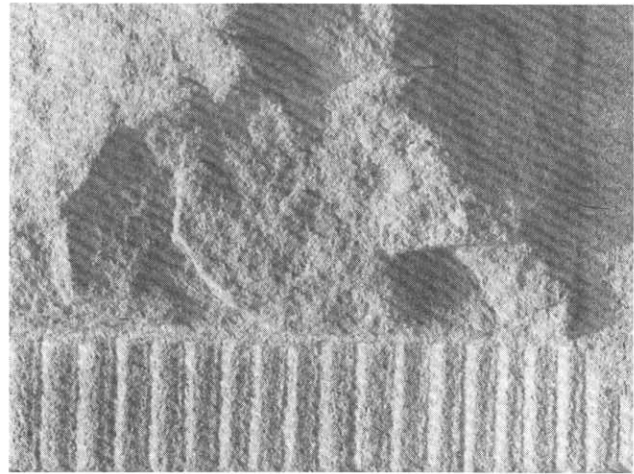
- replicates stone texture with good molds (which can come from extant stone) and fabrication
- expansion/contraction similar to stone
- minimal shrinkage of material
- anchors and reinforcing bars can be built in
- material is fire-rated
- range of color available
- vapor permeable

### Disadvantages:

- heavy units may require additional anchorage
- color can fade in sunlight
- may be more absorbent than natural stone
- replacement stones are obvious if too few models and molds are made

### Checklist:

- Are the original or similar materials available?
- How are units to be installed and anchored?
- Have performance standards been developed to ensure color stability?
- Have large samples been delivered to site for color, finish and absorption testing?
- Has mortar been matched to adjacent historic mortar to achieve a good color/tooling match?
- Are fabricators/installers experienced?



*Dry-tamped cast stone can reproduce the sandy texture of some natural stones. Photo: Sharon C. Park, AIA.*

## Glass Fiber Reinforced Concretes (GFRC)

**Material:** Glass fiber reinforced concretes are lightweight concrete compounds modified with additives and reinforced with glass fibers. They are generally fabricated as thin shelled panels and applied to a separate structural frame or anchorage system. The GFRC is most commonly sprayed into forms although it can be poured. The glass must be alkaline resistant to avoid deteriorating effects caused by the cement mix. The color is derived from the natural aggregates and if necessary a small percentage of added pigments.

**Application:** Glass fiber reinforced concretes are used in place of features originally made of stone, terra cotta, metal or wood, such as cornices, projecting window and door trims, brackets, finials, or wall murals. As a molded product it can be produced in long sections of repetitive designs or as sculptural elements. Because of its low shrinkage, it can be produced from molds taken directly from the building. It is installed with a separate non-corrosive anchorage system. As a predominantly cementitious material, it is vapor permeable.

### Advantages:

- lightweight, easily installed
- good molding ability, crisp detail possible
- weather resistant
- can be left uncoated or else painted
- little shrinkage during fabrication
- molds made directly from historic features
- cements generally breathable
- material is fire-rated

### Disadvantages:

- non-loadbearing use only
- generally requires separate anchorage system
- large panels must be reinforced
- color additives may fade with sunlight
- joints must be properly detailed
- may have different absorption rate than adjacent historic material

### Checklist:

- Are the original materials and craftsmanship still available?
- Have samples been inspected on the site to ensure detail/texture match?
- Has anchorage system been properly designed?
- Have performance standards been developed?
- Are fabricators/installers experienced?



*This glass fiber reinforced concrete sculptural wall panel will replace the seriously damaged resin and plaster original. A finely textured surface was achieved by spraying the GFRC mix into molds that were created from the historic panel and resculpted based on historic photographs. Photo: Courtesy of MJM Studios.*

# PROs and CONs of VARIOUS SUBSTITUTE MATERIALS

## Precast Concrete

**Material:** Precast concrete is a wet mix of cement and aggregate poured into molds to create masonry units. Molds can be made from existing good surfaces on the building. Color is generally integral to the mix as a natural coloration of the sand or aggregate, or as a small percentage of pigment. To avoid unsightly air bubbles that result from the natural curing process, great care must be taken in the initial and long-term vibration of the mix. Because of its weight it is generally used to reproduce individual units of masonry and not thin shell panels.

**Application:** Precast concrete is generally used in place of masonry materials such as stone or terra cotta. It is used both for flat wall surfaces and for textured or ornamental elements. This includes wall stones, window and door surrounds, stair treads, paving pieces, parapets, urns, balusters and other decorative elements. It differs from cast stone in that the surface is more dependent on the textured mold than the hand tamping method of fabrication.

### Advantages:

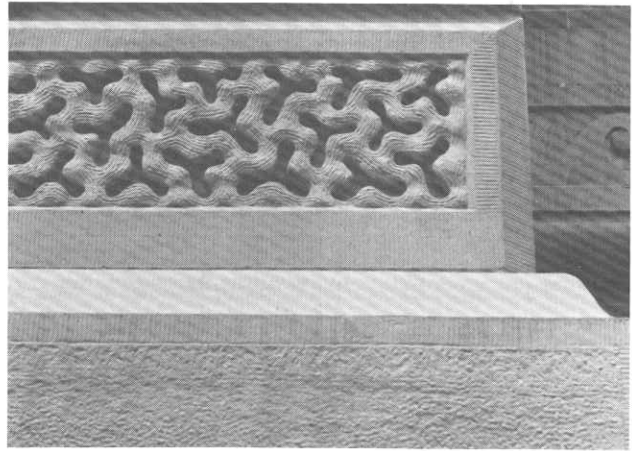
- easily fabricated, takes shape well
- rubber molds can be made from building stones
- minimal shrinkage of material
- can be load bearing or anchorage can be cast in
- expansion/contraction similar to stone
- material is fire-rated
- range of color and aggregate available
- vapor permeable

### Disadvantages:

- may be more moisture absorbent than stone although coatings may be applied
- color fades in sunlight
- heavy units may require additional anchorage
- small air bubbles may disfigure units
- replacement stones are conspicuous if too few models and molds are made

### Checklist:

- Is the historic material still available?
- What are the structural/anchorage requirements?
- Have samples been matched for color/texture/absorption?
- Have shop drawings been made for each shape?
- Are there performance standards?
- Has mortar been matched to adjacent historic mortar to achieve good color/tooling match?
- Are fabricators/installers experienced?



Textured molds can produce a variety of high quality carved, quarried, and tooled surfaces in concrete.

Photo: Sharon C. Park, AIA.

## Fiber Reinforced Polymers—

### Known as Fiberglass

**Material:** Fiberglass is the most well known of the FRP products generally produced as a thin rigid laminate shell formed by pouring a polyester or epoxy resin gel-coat into a mold. When tack-free, layers of chopped glass or glass fabric are added along with additional resins. Reinforcing rods and struts can be added if necessary; the gel coat can be pigmented or painted.

**Application:** Fiberglass, a non load-bearing material attached to a separate structural frame, is frequently used as a replacement where a lightweight element is needed or an inaccessible location makes frequent maintenance of historic materials difficult. Its good molding ability and versatility to represent stone, wood, metal and terra cotta make it an alternative to ornate or carved building elements such as column capitals, bases, spandrel panels, beltcourses, balustrades, window hoods or parapets. Its ability to reproduce bright colors is a great advantage.

### Advantages:

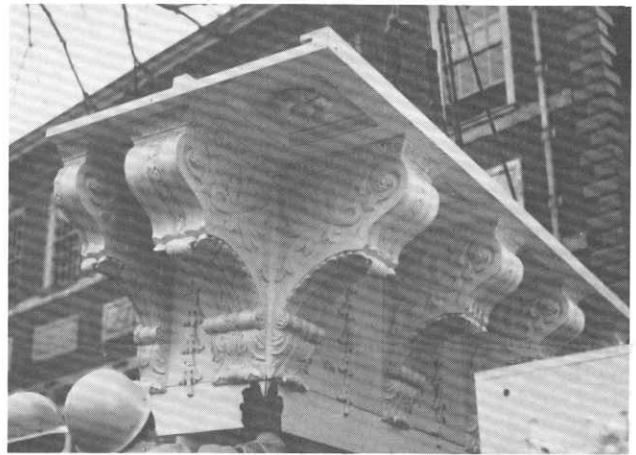
- lightweight, long spans available with a separate structural frame
- high ratio of strength to weight
- good molding ability
- integral color with exposed high quality pigmented gel-coat or takes paint well
- easily installed, can be cut, patched, sanded
- non-corrosive, rot-resistant

### Disadvantages:

- requires separate anchorage system
- combustible (fire retardants can be added); fragile to impact.
- high co-efficient of expansion and contraction requires frequently placed expansion joints
- ultra-violet sensitive unless surface is coated or pigments are in gel-coat
- vapor impermeability may require ventilation detail

### Checklist:

- Can original materials be saved/used?
- Have expansion joints been designed to avoid unsightly appearance?
- Are there standards for color stability/durability?
- Have shop drawings been made for each piece?
- Have samples been matched for color and texture?
- Are fabricators/installers experienced?
- Do codes restrict use of FRP?



A fiberglass cornice for the reconstruction of an 18th-century wooden clockcase is being lifted in pre-fabricated sections. The level of detail is intricate and of high quality. Photo: Courtesy of Independence National Historical Park.



## Epoxies (*Epoxy Concretes, Polymer Concretes*):

**Material:** Epoxy is a resinous two-part thermo-setting material used as a consolidant, an adhesive, a patching compound, and as a molding resin. It can repair damaged material or recreate lost features. The resins which are poured into molds are usually mixed with fillers such as sand, or glass spheres, to lighten the mix and modify their expansion/contraction properties. When mixed with aggregates, such as sand or stone chips, they are often called epoxy concrete or polymer concrete, which is a misnomer as there are no cementitious materials contained within the mix. Epoxies are vapor impermeable, which makes detailing of the new elements extremely important so as to avoid trapping moisture behind the replacement material. It can be used with wood, stone, terra cotta, and various metals.

**Application:** Epoxy is one of the most versatile of the new materials. It can be used to bind together broken fragments of terra cotta; to build up or infill missing sections of ornamental metal; or to cast missing elements of wooden ornaments. Small cast elements can be attached to existing materials or entire new features can be cast. The resins are poured into molds and due to the rapid setting of the material and the need to avoid cracking, the molded units are generally small or hollow inside. Multiple molds can be combined for larger elements. With special rods, the epoxies can be structurally reinforced. Examples of epoxy replacement pieces include: finials, sculptural details, small column capitals, and medallions.

### Advantages:

- can be used for repair/replacement
- lightweight, easily installed
- good casting ability; molds can be taken from building
- material can be sanded and carved.
- color and ultra-violet screening can be added; takes paint well
- durable, rot and fungus resistant

### Disadvantages:

- materials are flammable and generate heat as they cure and may be toxic when burned
- toxic materials require special protection for operator and adequate ventilation while curing
- material may be subject to ultra-violet deterioration unless coated or filters added
- rigidity of material often must be modified with fillers to match expansion coefficients
- vapor impermeable

### Checklist:

- Are historic materials available for molds, or for splicing-in as a repair option?
- Has the epoxy resin been formulated within the expansion/contraction coefficients of adjacent materials?
- Have samples been matched for color/finish?
- Are fabricators/installers experienced?
- Is there a sound sub-strate of material to avoid deterioration behind new material?
- Are there performance standards?



*This replica column capital was made using epoxy resins poured into a mold taken from the building. The historic wooden column shaft was repaired during the restoration. Photo: Courtesy Dell Corporation.*



*Columns were repaired and a capital was replaced in epoxy on this 19th-century 2-story porch. Photo: Dell Corporation*



## Further Reading: Substitute Materials

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This publication has been prepared pursuant to Section 101(h) of the National Historic Preservation Act, as amended, which directs the Secretary of the Interior to develop and make available information concerning historic properties. The guidance provided in this Brief will also assist property owners in complying with the requirements of the Internal Revenue Code of 1986.

Preservation Briefs: 16 has been developed under the technical editorship of Lee H. Nelson, FAIA, Chief, Preservation Assistance Division, National Park Service, U.S. Department of the Interior, P.O. Box 37127, Washington, D.C. 20013-7127. Comments on the usefulness of this information are welcome and can be sent to Mr. Nelson at the above address.

Cover photograph: Independence Hall, Philadelphia, PA; the 1972 installation of a combination wood and fiberglass clockcase duplicating the lost 18th century original. Photo: Courtesy of Independence National Historical Park.

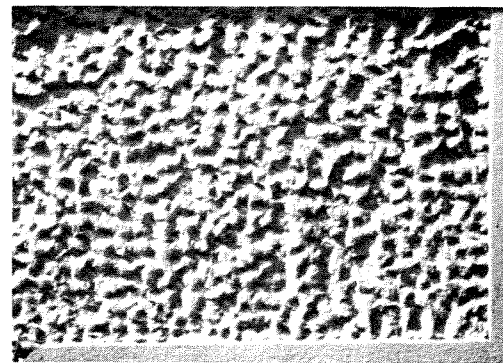
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# 17 PRESERVATION BRIEFS

## Architectural Character: Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character

Lee H. Nelson, FAIA

U.S. Department of the Interior  
National Park Service  
Preservation Assistance Division



The Secretary of the Interior's "Standards for Historic Preservation Projects" embody two important goals: 1) the preservation of historic materials and, 2) the preservation of a building's distinguishing character. Every old building is unique, with its own identity and its own distinctive character. Character refers to all those visual aspects and physical features that comprise the appearance of every historic building. Character-defining elements include the overall shape of the building, its materials, craftsmanship, decorative details, interior spaces and features, as well as the various aspects of its site and environment.

The purpose of this Brief is to help the owner or the architect identify those features or elements that give the building its *visual character* and that should be taken into account in order to preserve them to the maximum extent possible.

There are different ways of understanding old buildings. They can be seen as examples of specific building types, which are usually related to a building's function, such as schools, courthouses or churches. Buildings can be studied as examples of using specific materials such as concrete, wood, steel, or limestone. They can also be considered as examples of an historical period, which is often related to a specific architectural style, such as Gothic Revival farmhouses, one-story bungalows, or Art Deco apartment buildings.

There are many other facets of an historic building besides its functional type, its materials or construction or style that contribute to its historic qualities or significance. Some of these qualities are feelings conveyed by the sense of time and place or in buildings associated with events or people. A complete understanding of any property may require documentary research about its style, construction, function, its furnishings or contents; knowledge about the original builder, owners, and later occupants; and knowledge about the evolutionary history of the building. Even though buildings may be of historic, rather than architectural significance, it is their tangible elements that embody its significance for association with specific events or persons and it is those *tangible elements* both on the exterior and interior that should be preserved.

Therefore, the approach taken in this Brief is limited to identifying those visual and tangible aspects of the historic building. While this may aid in the planning process for carrying out any ongoing or new use or restoration of the building, this approach is not a

substitute for developing an understanding about the significance of an historic building and the district in which it is located.

If the various materials, features and spaces that give a building its visual character are not recognized and preserved, then essential aspects of its character may be damaged in the process of change.

A building's character can be irreversibly damaged or changed in many ways, for example, by inappropriate repointing of the brickwork, by removal of a distinctive side porch, by changes to the window sash, by changes to the setting around the building, by changes to the major room arrangements, by the introduction of an atrium, by painting previously unpainted woodwork, etc.

### A Three-Step Process to Identify A Building's Visual Character

This Brief outlines a three-step approach that can be used by anyone to identify those materials, features and spaces that contribute to the visual character of a building. This approach involves first examining the building from afar to understand its overall setting and architectural context; then moving up very close to appreciate its materials and the craftsmanship and surface finishes evident in these materials; and then going into and through the building to perceive those spaces, rooms and details that comprise its interior visual character.

#### Step 1: Identify the Overall Visual Aspects

Identifying the overall visual character of a building is nothing more than looking at its distinguishing physical aspects without focusing on its details. The major contributors to a building's overall character are embodied

in the general aspects of its *setting*; the *shape* of the building; its *roof* and roof features, such as chimneys or cupolas; the various *projections* on the building, such as porches or bay windows; the *recesses* or voids in a building, such as open galleries, arcades, or recessed balconies; the *openings* for windows and doorways; and finally the various exterior *materials* that contribute to the building's character. Step one involves looking at the building from a distance to understand the character of its site and setting, and it involves walking around the building where that is possible. Some buildings will have one or more sides that are more important than the others because they are more highly visible. This does not mean that the rear of the building is of no value whatever but it simply means that it is less important to the overall character. On the other hand, the rear may have an interesting back porch or offer a private garden space or some other aspect that may contribute to the visual character. Such a general approach to looking at the building and site will provide a better understanding of its overall character without having to resort to an infinitely long checklist of its possible features and details. Regardless of whether a building is complicated or relatively plain, it is these broad categories that contribute to an understanding of the overall character rather than the specifics of architectural features such as moldings and their profiles.

### **Step 2: Identify the Visual Character at Close Range**

Step two involves looking at the building at close range or arm's length, where it is possible to see all the surface qualities of the materials, such as their *color* and *texture*, or surface evidence of craftsmanship or age. In some instances, the visual character is the result of the juxtaposition of materials that are contrastingly different in their color and texture. The surface qualities of the materials may be important because they impart the very sense of craftsmanship and age that distinguishes historic buildings from other buildings. Furthermore, many of these close up qualities can be easily damaged or obscured by work that affects those surfaces. Examples of this could include painting previously unpainted masonry, rotary disk sanding of smooth wood siding to remove paint, abrasive cleaning of tooled stonework, or repointing reddish mortar joints with gray portland cement.

There is an almost infinite variety of surface materials, textures and finishes that are part of a building's character which are fragile and easily lost.

### **Step 3: Identify the Visual Character of the Interior Spaces, Features and Finishes**

Perceiving the character of interior spaces can be somewhat more difficult than dealing with the exterior.

In part, this is because so much of the exterior can be seen at one time and it is possible to grasp its essential character rather quickly. To understand the interior character, it is necessary to move through the spaces one at a time. While it is not difficult to perceive the character of one individual room, it becomes more difficult to deal with spaces that are interconnected and interrelated. Sometimes, as in office buildings, it is the vestibules or lobbies or corridors that are important to the interior character of the building. With other groups of buildings the visual qualities of the interior are related to the plan of the building, as in a church with its axial plan creating a narrow tunnel-like space which obviously has a different character than an open space like a sports pavilion. Thus the shape of the space may be an essential part of its character. With some buildings it is possible to perceive that there is a visual linkage in a sequence of spaces, as in a hotel, from the lobby to the grand staircase to the ballroom. Closing off the openings between those spaces would change the character from visually linked spaces to a series of closed spaces. For example, in a house that has a front and back parlor linked with an open archway, the two rooms are perceived together, and this visual relationship is part of the character of the building. To close off the open archway would change the character of such a residence.

The importance of interior features and finishes to the character of the building should not be overlooked. In relatively simple rooms, the primary visual aspects may be in features such as fireplace mantels, lighting fixtures or wooden floors. In some rooms, the absolute plainness is the character-defining aspect of the interior. So-called secondary spaces also may be important in their own way, from the standpoint of history or because of the family activities that occurred in those rooms. Such secondary spaces, while perhaps historically significant, are not usually perceived as important to the *visual* character of the building. Thus we do not take them into account in the visual understanding of the building.

### **Conclusion**

Using this three-step approach, it is possible to conduct a walk through and identify all those elements and features that help define the visual character of the building. In most cases, there are a number of aspects about the exterior and interior that are important to the character of an historic building. The visual emphasis of this brief will make it possible to ascertain those things that should be preserved because their loss or alteration would diminish or destroy aspects of the historic character whether on the outside, or on the inside of the building.



#### ***Overall Visual Character: Shape***

The shape of a building can be an important aspect of its overall visual character. The building illustrated here, for example, has a distinctive horizontal box-like shape with the middle portion of the box projecting up an extra story. This building has other visual aspects that help define its overall character, including the pattern of vertical bands of windows, the decorative horizontal bands which separate the base of the building from the upper floors, the dark brown color of the brick, the large arched entranceway, and the castle-like tower behind the building.



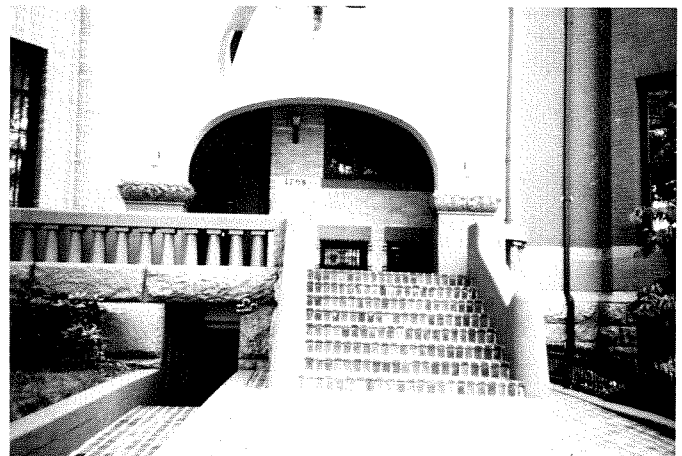
#### ***Overall Visual Character: Openings***

Window and door openings can be important to the overall visual character of historic buildings. This view shows only part of a much larger building, but the windows clearly help define its character, partly because of their shape and rhythm: the upper floor windows are grouped in a 4,3,4,1,4 rhythm, and the lower floor windows are arranged in a regular 1,1,1,... rhythm. The individual windows are tall, narrow and arched, and they are accented by the different colored arched heads, which are connected where there are multiple windows so that the color contrast is a part of its character. If additional windows were inserted in the gap of the upper floors, the character would be much changed, as it would if the window heads were painted to match the color of the brick walls. Photo by Susan I. Dynes



#### ***Overall Visual Character: Shape***

It should not be assumed that only large or unusual buildings have a shape that is distinctive or identifiable. The front wall of this modest commercial building has a simple three-part shape that is the controlling aspect of its overall visual character. It consists of a large center bay with a two story opening that combines the storefront and the windows above. The upward projecting parapet and the decorative stonework also relate to and emphasize its shape. The flanking narrow bays enframe the side windows and the small iron balconies, and the main entrance doorway into the store. Any changes to the center portion of this three-part shape, could drastically affect the visual character of this building. Photo by Emogene A. Bevitt



#### ***Overall Visual Character: Openings***

The opening illustrated here dominates the visual character of this building because of its size, shape, location, materials, and craftsmanship. Because of its relation to the generous staircase, this opening places a strong emphasis on the principal entry to the building. Enclosing this arcade-like entry with glass, for example, would materially and visually change the character of the building. Photo by Lee H. Nelson.





***Overall Visual Character: Roof and Related Features***

This building has a number of character-defining aspects which include the windows and the decorative stonework, but certainly the roof and its related features are visually important to its overall visual character. The roof is not only highly visible, it has elaborate stone dormers, and it also has decorative metalwork and slatework. The red and black slates of differing sizes and shapes are laid in patterns that extend around the roof of this large and freestanding building. Any changes to this patterned slatework, or to the other roofing details would damage the visual character of the building. Photo by Laurie R. Hammel



***Overall Visual Character: Roof and Related Features***

On this building, the most important visual aspects of its character are the roof and its related features such as the dormers and chimneys. The roof is important to the visual character because its steepness makes it highly visible, and its prominence is reinforced by the patterned tinwork, the six dormers and the two chimneys. Changes to the roof or its features, such as removal or alterations to the dormers, for example, would certainly change the character of this building. This does not discount the importance of its other aspects, such as the porch, the windows, the brickwork, or its setting; but the roof is clearly crucial to understanding the overall visual character of this building as seen from a distance. Photo by Lee H. Nelson



***Overall Visual Character: Projections***

A projecting porch or balcony can be very important to the overall visual character of almost any building and to the district in which it is located. Despite the size of this building (3 1/2 stories), and its distinctive roofline profile, and despite the importance of the very large window openings, the lacy wrap-around iron balcony is singularly important to the visual character of this building. It would seriously affect the character to remove the balcony, to enclose it, or to replace it with a balcony lacking the same degree of detail of the original material. Photo by Baird M. Smith



#### ***Overall Visual Character: Projections***

Since these are row houses, any evaluation of their visual exterior character is necessarily limited to the front and rear walls; and while there are a number of things competing for attention in the front, it is the half round projecting bays with their conical roofs that contribute most prominently to the visual character. Their removal would be a devastating loss to the overall character, but even if preserved, the character could be easily damaged by changes to their color (as seen in the left bay which has been painted a dark color), or changes to their windows, or changes to their tile roofs. Though these houses have other fine features that contribute to the visual character and are worthy of preservation, these half-round bays demonstrate the importance of projecting features on an already rich and complex facade. Because of the repetitive nature of these projecting bays on adjacent row houses, along with the buildings' size, scale, openings, and materials, they also contribute to the overall visual character of the streetscape in the historic district. Any evaluation of the visual character of such a building should take into account the context of this building within the district. Photo by Lee H. Nelson



#### ***Overall Visual Character: Projections***

Many buildings have projecting features such as porches, bay windows, or overhanging roofs, that help define their overall visual character. This projecting porch because of its size and shape, and because it copies the pitch and material of the main roof, is an important contributor to the visual character of this simple farmhouse. The removal or alteration of this porch would drastically alter the character of this building. If the porch were enclosed with wood or glass, or if gingerbread brackets were added to the porch columns, if the tin roof was replaced with asphalt, or if the porch railing was opened to admit a center stairway, the overall visual character could be seriously damaged. Although this projecting porch is an important feature, almost any other change to this house, such as changes to the window pattern, or changes to the main roof, or changes to the setting, would also change its visual character. Photo by Hugh C. Miller



#### ***Overall Visual Character: Trim***

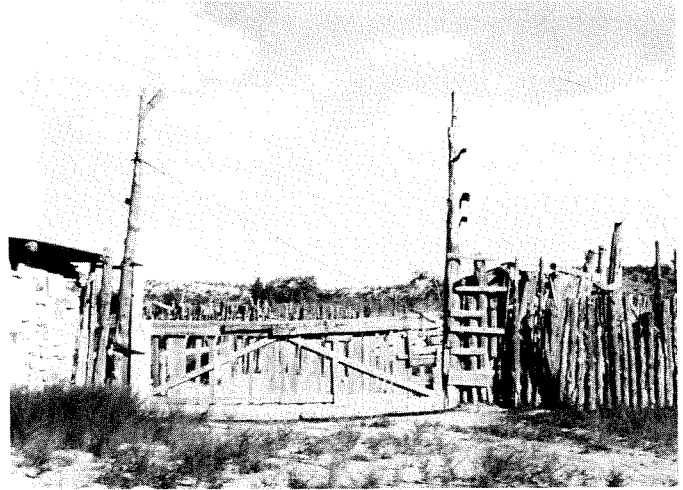
If one were to analyze the overall shape or form of this building, it would be seen that it is a gable-roofed house with dormers and a wrap-around porch. It is similar to many other houses of the period. It is the wooden trim on the eaves and around the porch that gives this building its own identity and its special visual character. Although such wooden trim is vulnerable to the elements, and must be kept painted to prevent deterioration; the loss of this trim would seriously damage the overall visual character of this building, and its loss would obliterate much of the close-up visual character so dependent upon craftsmanship for the moldings, carvings, and the see-through jigsaw work. Photo by Hugh C. Miller



**Overall Visual Character: Setting**

In the process of identifying the overall visual character, the aspect of setting should not be overlooked. Obviously, the setting of urban row houses differs from that of a mansion with a designed landscape. However, there are many instances where the relationship between the building and its place on the streetscape, or its place in the rural environment, in other words its setting, may be an important contributor to its overall character.

In this instance, the corner tower and the arched entryway are important contributors to the visual character of the building itself, but there is also a relationship between the building and the two converging streets that is also an important aspect of this historic building. The curb, sidewalk, fence, and the yard interrelate with each other to establish a setting that is essential to the overall visual character of the historic property. Removing these elements or replacing them with a driveway or parking court would destroy an important visual aspect. Photo by Lee H. Nelson



**Overall Visual Character: Setting**

Among the various visual aspects relating to the setting of an historic property are such site features as gardens, walks, fences, etc. This can include their design and materials. There is a dramatic difference in the visual character between these two fence constructions—one utilizing found materials with no particular regard to their uniformity of size or placement, and the other being a product of the machine age utilizing cast iron components assembled into a pattern of precision and regularity. If the corral fence were to be repaired or replaced with lumberyard materials its character would be dramatically compromised. The rhythm and regularity of the cast iron fence is so important to its visual character that its character could be altered by accidental damage or vandalism, if some of the fence top spikes were broken off thus interrupting the rhythm or pattern. Photos by Lee H. Nelson



**Overall Visual Character: Setting**

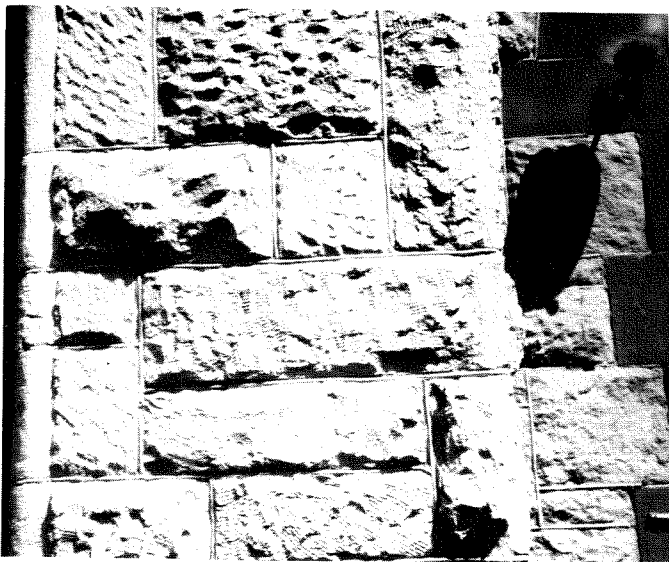
Even architecturally modest buildings frequently will have a setting that contributes to their overall character. In this very urban district, set-backs are the exception, so that the small front yard is something of a luxury, and it is important to the overall character because of its design and materials, which include the iron fence along the sidewalk, the curved walk leading to the porch, and the various plantings. In a district where parking spaces are in great demand, such front yards are sometimes converted to off-street parking, but in this instance, that would essentially destroy its setting and would drastically change the visual character of this historic property. Photo by Lee H. Nelson



### ***Arm's Length Visual Character: Materials***

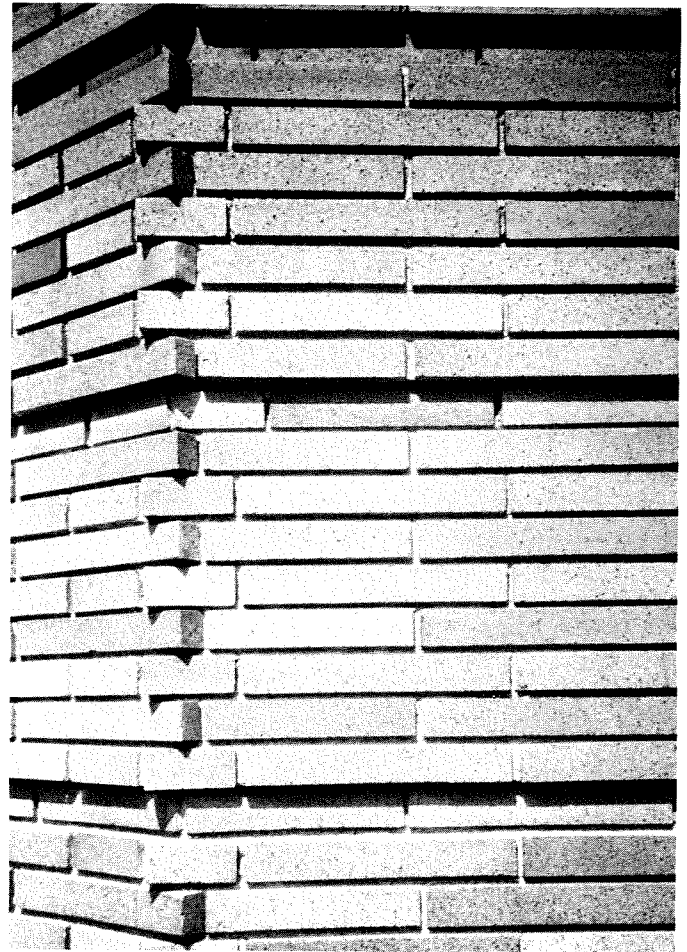
At arm's length, the visual character is most often determined by the surface qualities of the materials and craftsmanship; and while these aspects are often inextricably related, the original choice of materials often plays the dominant role in establishing the close-range character because of the color, texture, or shape of the materials.

In this instance, the variety and arrangement of the materials is important in defining the visual character, starting with the large pieces of broken stone which form the projecting base for the building walls, then changing to a wall of roughly rectangular stones which vary in size, color, and texture, all with accentuated, projecting beads of mortar, then there is a rather precise and narrow band of cut and dressed stones with minimal mortar joints, and finally, the main building walls are composed of bricks, rather uniform in color, with fairly generous mortar joints. It is the juxtaposition and variety of these materials (and of course, the craftsmanship) that is very important to the visual character. Changing the raised mortar joints, for example, would drastically alter the character at arm's length. Photo by Lee H. Nelson



### ***Arm's Length Visual Character: Craft Details***

There are many instances where craft details dominate the arm's length visual character. As seen here, the craft details are especially noticeable because the stones are all of a uniform color, and they are all squared off, but their surfaces were worked with differing tools and techniques to create a great variety of textures, resulting in a tour-de-force of craft details. This texture is very important at close range. It was a deliberately contrived surface that is an important contributor to the visual character of this building. Photo by Lee H. Nelson



### ***Arm's Length Visual Character: Craft Details***

The arm's length visual character of this building is a combination of the materials and the craft details. Most of the exterior walls of this building consist of early 20th century Roman brick, precisely made, unusually long bricks, in varying shades of yellow-brown, with a noticeable surface spotting of dark iron pyrites. While this brick is an important contributor to the visual character, the related craft details are perhaps more important, and they consist of: unusually precise coursing of the bricks, almost as though they were laid up using a surveyor's level; a row of recessed bricks every ninth course, creating a shadow pattern on the wall; deeply recessed mortar joints, creating a secondary pattern of shadows; and a toothed effect where the bricks overlap each other at the corner of the building. The cumulative effect of this artisanship is important to the arm's length visual character, and it is evident that it would be difficult to match if it were damaged, and the effect could be easily damaged through insensitive treatments such as painting the brickwork or by careless repointing. Photo by Lee H. Nelson





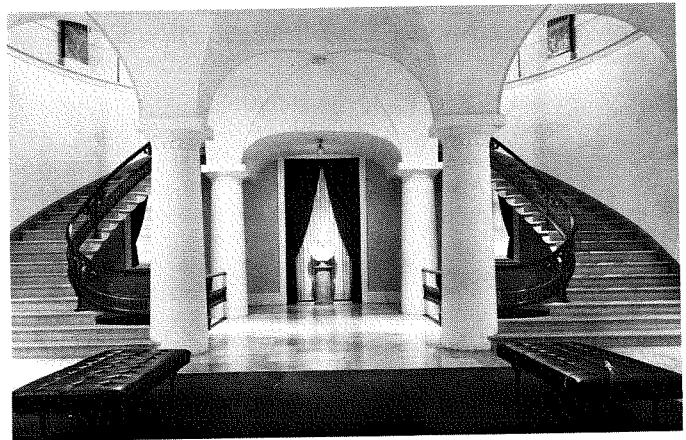
#### ***Arm's Length Visual Character: Craft Details***

On some buildings, there are subtle aspects of visual character that cannot be perceived from a distance. This is especially true of certain craft details that can be seen only at close range. On this building, it is easily understood that the narrow, unpainted, and weathered clapboards are an important aspect of its overall visual character; but at close range there are a number of subtle but very important craft details that contribute to the handmade quality of this building, and which clearly differentiate it from a building with machine sawn clapboards. The clapboards seen here were split by hand and the bottom edges were not dressed, so that the boards vary in width and thickness, and thus they give a very uneven shadow pattern. Because they were split from oak that is unpainted, there are occasional wavy rays in the wood that stand against the grain. Also noticeable is the fact that the boards are of relatively short lengths, and that they have feather-edged ends that overlap each other, a detail that is very different from butted joints. The occasional large nail heads and the differential silver-gray weathering add to the random quality of the clapboards. All of these qualities contribute to the arm's length visual character. Photo by Lee H. Nelson



#### ***Arm's Length Visual Character: Craft Details***

While hand-split clapboards are distinctive visual elements in their own way, machine-sawn and painted wood siding is equally important to the overall visual character in most other instances. At arm's length, however, the machine sawn siding may not be so distinctive; but there might be other details that add visual character to the wooden building, such as the details of wooden trim and louvered shutters around the windows (as seen here), or similar surface textures on other buildings, such as the saw marks on wall shingles, the joints in leaded glass, decorative tinwork on a rain conductor box, the rough surface of pebble-dash stuccowork, or the pebbly surface of exposed aggregate concrete. Such surfaces can only be seen at arm's length and they add to the visual character of a historic building. Photo by Hugh C. Miller



#### ***Interior Visual Character: Individually Important Spaces***

In assessing the interior visual character of any historic building, it is necessary to ask whether there are spaces that are important to the character of this particular building, whether the building is architecturally rich or modest, or even if it is a simple or utilitarian structure.

The character of the individually important space which is illustrated here is a combination of its size, the twin curving staircases, the massive columns and curving vaulted ceilings, in addition to the quality of the materials in the floor and in the stairs. If the ceiling were to be lowered to provide space for heating ducts, or if the stairways were to be enclosed for code reasons, the shape and character of this space would be damaged, even if there was no permanent physical damage. Such changes can easily destroy the visual character of an individually important interior space. Thus, it is important that the visual aspects of a building's interior character be recognized before planning any changes or alterations. Photo by National Portrait Gallery

### ***Interior Visual Character: Related Spaces***

Many buildings have interior spaces that are visually or physically related so that, as you move through them, they are perceived not as separate spaces, but as a sequence of related spaces that are important in defining the interior character of the building. The example which is illustrated here consists of three spaces that are visually linked to each other.

The first of these spaces is the vestibule which is of a generous size and unusual in its own right, but more important, it visually relates to the second space which is the main stairhall.

The hallway is the circulation artery for the building, and leads both horizontally and vertically to other rooms and spaces, but especially to the open and inviting stairway.

The stairway is the third part of this sequence of related spaces, and it provides continuing access to the upper floors.

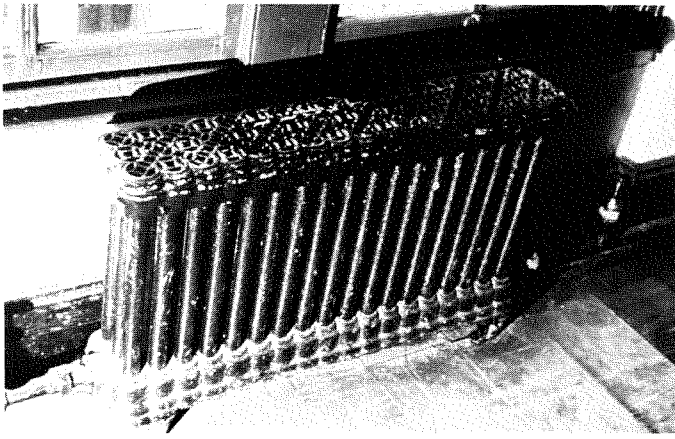
These related spaces are very important in defining the interior character of this building. Almost any change to these spaces, such as installing doors between the vestibule and the hallway, or enclosing the stair would seriously impact their character and the way that character is perceived. Top photo by Mel Chamowitz, others by John Tennant



### ***Interior Visual Character: Interior Features***

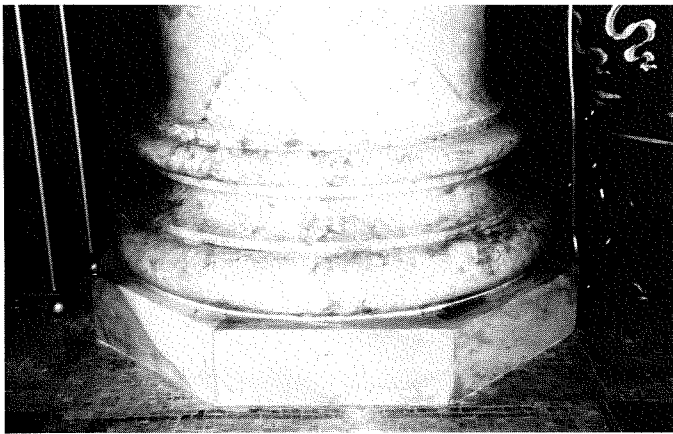
Interior features are three-dimensional building elements or architectural details that are an integral part of the building as opposed to furniture. Interior features are often important in defining the character of an individual room or space. In some instances, an interior feature, like a large and ornamental open stairway may dominate the visual character of an entire building. In other instances, a modest iron stairway (like the one illustrated here) may be an important interior feature, and its preservation would be crucial to preserving the interior character of the building. Such features can also include the obvious things like fireplace mantles, plaster ceiling medallions, or panelling, but they also extend to features like hardware, lighting fixtures, bank tellers cages, decorative elevator doors, etc. Photo by David W. Look





#### ***Interior Visual Character: Interior Features***

Modern heating or cooling devices usually add little to the interior character of a building; but historically, radiators, for instance, may have contributed to the interior character by virtue of their size or shape, or because of their specially designed bases, piping, and decorative grillage or enclosures. Sometimes they were painted with several colors to highlight their integral, cast-in details. In more recent times, it has been common to overpaint and conceal such distinctive aspects of earlier heating and plumbing devices, so that we seldom have the opportunity to realize how important they can be in defining the character of interior rooms and spaces. For that reason, it is important to identify their character-defining potential, and consider their preservation, retention, or restoration. Photo by David W. Look



#### ***Interior Visual Character: Surface Materials and Finishes***

When identifying the visual character of historic interior spaces one should not overlook the importance of those materials and finishes that comprise the surfaces of walls, floors and ceilings. The surfaces may have evidence of either hand-craft or machine-made products that are important contributors to the visual character, including patterned or inlaid designs in the wood flooring, decorative painting practices such as stenciling, imitation marble or wood grain, wallpapering, tinwork, tile floors, etc.

The example illustrated here involves a combination of real marble at the base of the column, imitation marble patterns on the plaster surface of the column (a practice called scagliola), and a tile floor surface that uses small mosaic tiles arranged to form geometric designs in several different colors. While such decorative materials and finishes may be important in defining the interior visual character of this particular building, it should be remembered that in much more modest buildings, the plainness of surface materials and finishes may be an essential aspect of their historic character. Photo by Lee H. Nelson



#### ***Fragility of A Building's Visual Character***

Some aspects of a building's visual character are fragile and are easily lost. This is true of brickwork, for example, which can be irreversibly damaged with inappropriate cleaning techniques or by insensitive repointing practices. At least two factors are important contributors to the visual character of brickwork, namely the brick itself and the craftsmanship. Between these, there are many more aspects worth noting, such as color range of bricks, size and shape variations, texture, bonding patterns, together with the many variable qualities of the mortar joints, such as color, width of joint and tooling. These qualities could be easily damaged by painting the brick, by raking out the joint with power tools, or repointing with a joint that is too wide. As seen here during the process of repointing, the visual character of this front wall is being dramatically changed from a wall where the bricks predominate, to a wall that is visually dominated by the mortar joints. Photo by Lee H. Nelson

# The Architectural Character Checklist/Questionnaire

Lee H. Nelson, FAIA  
National Park Service

This checklist can be taken to the building and used to identify those aspects that give the building and setting its essential visual qualities and character. This checklist consists of a series of questions that are designed to help in identifying those things that contribute to a building's character. The use of this checklist involves the three-step process of looking for: 1) the overall visual aspects, 2) the visual character at close range, and 3) the visual character of interior spaces, features and finishes.

Because this is a process to identify *architectural character*, it does not address those intangible qualities that give a property or building or its contents its historic significance, instead this checklist is organized on the assumption that historic significance is embodied in those *tangible* aspects that include the building's setting, its form and fabric.

## Step One

### 1. Shape

What is there about the form or shape of the building that gives the building its identity? Is the shape distinctive in relation to the neighboring buildings? Is it simply a low, squat box, or is it a tall, narrow building with a corner tower? Is the shape highly consistent with its neighbors? Is the shape so complicated because of wings, or ells, or differences in height, that its complexity is important to its character? Conversely, is the shape so simple or plain that adding a feature like a porch would change that character? Does the shape convey its historic function as in smoke stacks or silos?

Notes on the Shape or Form of the Building:

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### 2. Roof and Roof Features

Does the roof shape or its steep (or shallow) slope contribute to the building's character? Does the fact that the roof is highly visible (or not visible at all) contribute to the architectural identity of the building? Are certain roof features important to the profile of the building against the sky or its background, such as cupolas, multiple chimneys, dormers, cresting, or weathervanes? Are the roofing materials or their colors or their patterns (such as patterned slates) more noticeable than the shape or slope of the roof?

Notes on the Roof and Roof Features:

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### 3. Openings

Is there a rhythm or pattern to the arrangement of windows or other openings in the walls; like the rhythm of windows in a factory building, or a three-part window in the front bay of a house; or is there a noticeable relationship between the width of the window openings and the wall space between the window openings? Are there distinctive openings, like a large arched entranceway, or decorative window lintels that accentuate the importance of the window openings, or unusually shaped windows, or patterned window sash, like small panes of glass in the windows or doors, that are important to the character? Is the plainness of the window openings such that adding shutters or gingerbread trim would radically change its character? Is there a hierarchy of facades that make the front windows more important than the side windows? What about those walls where the absence of windows establishes its own character?

Notes on the Openings:

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### 4. Projections

Are there parts of the building that are character-defining because they project from the walls of the building like porches, cornices, bay windows, or balconies? Are there turrets, or widely overhanging eaves, projecting pediments or chimneys?

Notes on the Projections:

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### 5. Trim and Secondary Features

Does the trim around the windows or doors contribute to the character of the building? Is there other trim on the walls or around the projections that, because of its decoration or color or patterning contributes to the character of the building? Are there secondary features such as shutters, decorative gables, railings, or exterior wall panels?

Notes on the Trim and Secondary Features:

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### 6. Materials

Do the materials or combination of materials contribute to the overall character of the building as seen from a distance because of their color or patterning, such as broken faced stone, scalloped wall shingling, rounded rock foundation walls, boards and battens, or textured stucco?

Notes on the Materials:

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### 7. Setting

What are the aspects of the setting that are important to the visual character? For example, is the alignment of buildings along a city street and their relationship to the sidewalk the essential aspect of its setting? Or, conversely, is the essential character dependent upon the tree plantings and out buildings which surround the farmhouse? Is the front yard important to the setting of the modest house? Is the specific site important to the setting such as being on a hilltop, along a river, or, is the building placed on the site in such a way to enhance its setting? Is there a special relationship to the adjoining streets and other buildings? Is there a view? Is there fencing, planting, terracing, walkways or any other landscape aspects that contribute to the setting?

Notes on the Setting:

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## Step Two

### 8. Materials at Close Range

Are there one or more materials that have an inherent texture that contributes to the close range character, such as stucco, exposed aggregate concrete, or brick textured with vertical grooves? Or materials with inherent colors such as smooth orange-colored brick with dark spots of iron pyrites, or prominently veined stone, or green serpentine stone? Are there combinations of materials, used in juxtaposition, such as several different kinds of stone, combinations of stone and brick, dressed stones for window lintels used in conjunction with rough stones for the wall? Has the choice of materials or the combinations of materials contributed to the character?

Notes on the Materials at Close Range:

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### 9. Craft Details

Is there high quality brickwork with narrow mortar joints? Is there hand-tooled or patterned stonework? Do the walls exhibit carefully struck vertical mortar joints and recessed horizontal joints? Is the wall shinglework laid up in patterns or does it retain evidence of the circular saw marks or can the grain of the wood be seen through the semi-transparent stain? Are there hand split or hand-dressed clapboards, or machine smooth beveled siding, or wood rusticated to look like stone, or Art Deco zigzag designs executed in stucco?

Almost any evidence of craft details, whether handmade or machinemade, will contribute to the character of a building because it is a manifestation of the materials, of the times in which the work was done, and of the tools and processes that were used. It further reflects the effects of time, of maintenance (and/or neglect) that the building has received over the years. All of these aspects are a part of the surface qualities that are seen only at close range.

Notes on the Craft Details:

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## Step Three

### 10. Individual Spaces

Are there individual rooms or spaces that are important to this building because of their size, height, proportion, configuration, or function, like the center hallway in a house, or the bank lobby, or the school auditorium, or the ballroom in a hotel, or a courtroom in a county courthouse?

Notes on the Individual Spaces:

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### 11. Related Spaces and Sequences of Spaces

Are there adjoining rooms that are visually and physically related with large doorways or open archways so that they are perceived as related rooms as opposed to separate rooms? Is there an important sequence of spaces that are related to each other, such as the sequence from the entry way to the lobby to the stairway and to the upper balcony as in a theatre; or the sequence in a residence from the entry vestibule to the hallway to the front parlor, and on through the sliding doors to the back parlor; or the sequence in an office building from the entry vestibule to the lobby to the bank of elevators?

Notes on the Related Spaces and Sequences of Spaces:

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### 12. Interior Features

Are there interior features that help define the character of the building, such as fireplace mantels, stairways and balustrades, arched openings, interior shutters, inglenooks, cornices, ceiling medallions, light fixtures, balconies, doors,

windows, hardware, wainscotting, panelling, trim, church pews, courtroom bars, teller cages, waiting room benches?

Notes on the Interior Features:

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### 13. Surface Finishes and Materials

Are there surface finishes and materials that can affect the design, the color or the texture of the interior? Are there materials and finishes or craft practices that contribute to the interior character, such as wooden parquet floors, checkerboard marble floors, pressed metal ceilings, fine hardwoods, grained doors or marbled surfaces, or polychrome painted surfaces, or stencilling, or wallpaper that is important to the historic character? Are there surface finishes and materials that, because of their plainness, are imparting the essential character of the interior such as hard or bright, shiny wall surfaces of plaster or glass or metal?

Notes on the Surface Finishes and Materials:

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### 14. Exposed Structure

Are there spaces where the exposed structural elements define the interior character such as the exposed posts, beams, and trusses in a church or train shed or factory? Are there rooms with decorative ceiling beams (non-structural) in bungalows, or exposed vigas in adobe buildings?

Notes on the Exposed Structure:

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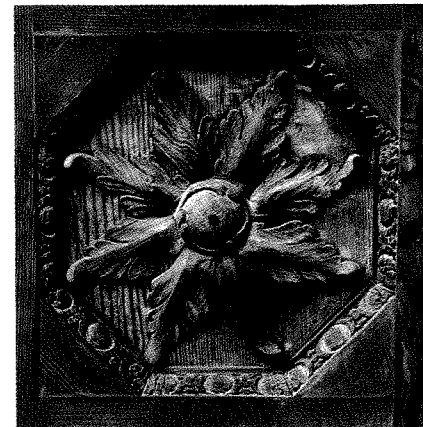
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This concludes the three-step process of identifying the visual aspects of historic buildings and is intended as an aid in preserving their character and other distinguishing qualities. It is not intended as a means of understanding the significance of historical properties or districts, nor of the events or people associated with them. That can only be done through other kinds of research and investigation.

This Preservation Brief was originally developed as a slide talk/methodology in 1982 to discuss the use of the Secretary of the Interior's Standards for Rehabilitation in relation to preserving historic character; and it was amplified and modified in succeeding years to help guide preservation decisionmaking, initially for maintenance personnel in the National Park Service. A number of people contributed to the evolution of the ideas presented here. Special thanks go to Emogene Bevitt and Gary Hume, primarily for the many and frequent discussions relating to this approach in its evolutionary stages; to Mark Fram, Ontario Heritage Foundation, Toronto, for suggesting several additions to the Checklist; and more recently, to my co-workers, both in Washington and in our regional offices, especially Ward Jandl, Sara Blumenthal, Charles Fisher, Sharon Park, AIA, Jean Travers, Camille Martone, Susan Dynes, Michael Auer, Anne Grimmer, Kay Weeks, Betsy Chittenden, Patrick Andrus, Carol Shull, Hugh Miller, FAIA, Jerry Rogers, Paul Alley, David Look, AIA, Margaret Pepin-Donat, Bonnie Halda, Keith Everett, Thomas Keohan, the Preservation Services Division, Mid-Atlantic Region, and several reviewers in state preservation offices, especially Ann Haaker, Illinois; and Stan Graves, AIA, Texas; for providing very critical and constructive review of the manuscript.

This publication has been prepared pursuant to the National Historic Preservation Act of 1966, as amended. Comments on the usefulness of this information are welcomed and can be sent to Mr. Nelson, Preservation Assistance Division, National Park Service, U.S. Department of the Interior, P.O. Box 37127, Washington, D.C. 20013-7127. This publication is not copyrighted and can be reproduced without penalty. Normal procedures for credit to the author and the National Park Service are appreciated.

# 18 PRESERVATION BRIEFS



## Rehabilitating Interiors in Historic Buildings

### Identifying and Preserving Character-defining Elements

H. Ward Jandl



U.S. Department of the Interior  
National Park Service  
Cultural Resources  
Heritage Preservation Services

A floor plan, the arrangement of spaces, and features and applied finishes may be individually or collectively important in defining the historic character of the building and the purpose for which it was constructed. Thus, their identification, retention, protection, and repair should be given prime consideration in every preservation project. Caution should be exercised in developing plans that would radically change character-defining spaces or that would obscure, damage or destroy interior features or finishes.

While the exterior of a building may be its most prominent visible aspect, or its “public face,” its interior can be even more important in conveying the building’s history and development over time. Rehabilitation within the context of the Secretary of the Interior’s Standards for Rehabilitation calls for the preservation of exterior *and* interior portions or features of the building that are significant to its historic, architectural and cultural values.

Interior components worthy of preservation may include the building’s **plan** (sequence of spaces and circulation patterns), the building’s **spaces** (rooms and volumes), individual architectural **features**, and the various **finishes** and **materials** that make up the walls, floors, and ceilings. A theater auditorium or sequences of rooms such as double parlors or a lobby leading to a stairway that ascends to a mezzanine may comprise a building’s most important spaces. Individual rooms may contain notable features such as plaster cornices, millwork, parquet wood floors, and hardware. Paints, wall coverings, and finishing techniques such as graining, may provide color, texture, and patterns which add to a building’s unique character.

Virtually all rehabilitations of historic buildings involve some degree of interior alteration, even if the buildings are to be used for their original purpose. Interior rehabilitation proposals may range from preservation of existing features and spaces to total reconfigurations. In some cases, depending on the building, restoration may be warranted to preserve historic character adequately; in other cases, extensive alterations may be perfectly acceptable.

This Preservation Brief has been developed to assist building owners and architects in identifying and evaluating those elements of a building’s interior that

contribute to its historic character and in planning for the preservation of those elements in the process of *rehabilitation*. The guidance applies to all building types and styles, from 18th century churches to 20th century office buildings. The Brief does not attempt to provide specific advice on preservation techniques and treatments, given the vast range of buildings, but rather suggests general preservation approaches to guide construction work.

### Identifying and Evaluating the Importance of Interior Elements Prior to Rehabilitation

Before determining what uses might be appropriate and before drawing up plans, a thorough professional assessment should be undertaken to identify those tangible architectural components that, prior to rehabilitation, convey the building’s sense of time and place—that is, its “historic character.” Such an assessment, accomplished by walking through and taking account of each element that makes up the interior, can help ensure that a truly compatible use for the building, one that requires minimal alteration to the building, is selected.

### Researching The Building’s History

A review of the building’s history will reveal why and when the building achieved significance or how it contributes to the significance of the district. This information helps to evaluate whether a particular rehabilitation treatment will be appropriate to the building and whether it will preserve those tangible components of the building that convey its significance for association with specific events or persons along with its architectural importance. In this regard, National Register files may prove useful in explaining why and for what period of time the

building is significant. In some cases research may show that later alterations are significant to the building; in other cases, the alterations may be without historical or architectural merit, and may be removed in the rehabilitation.

### Identifying Interior Elements

Interiors of buildings can be seen as a series of primary and secondary spaces. The goal of the assessment is to identify which elements contribute to the building's character and which do not. Sometimes it will be the sequence and flow of spaces, and not just the individual rooms themselves, that contribute to the building's character. This is particularly evident in buildings that have strong central axes or those that are consciously asymmetrical in design. In other cases, it may be the size or shape of the space that is distinctive. The importance of some interiors may not be readily apparent based on a visual inspection; sometimes rooms that do not appear to be architecturally distinguished are associated with important persons and events that occurred within the building.

**Primary spaces**, are found in all buildings, both monumental and modest. Examples may include foyers, corridors, elevator lobbies, assembly rooms, stairhalls, and parlors. Often they are the places in the building that the public uses and sees; sometimes they are the most architecturally detailed spaces in the building, carefully proportioned and finished with costly materials. They may be functionally and architecturally related to the building's external appearance. In a simpler building, a primary space may be distinguishable only by its location, size, proportions, or use. Primary spaces are always important to the character of the building and should be preserved.

**Secondary spaces** are generally more utilitarian in appearance and size than primary spaces. They may include areas and rooms that service the building, such as bathrooms, and kitchens. Examples of secondary spaces in a commercial or office structure may include storerooms, service corridors, and in some cases, the offices themselves. Secondary spaces tend to be of less importance to the building and may accept greater change in the course of work without compromising the building's historic character.

Spaces are often designed to interrelate both visually and functionally. The **sequence of spaces**, such as vestibule-hall-parlor or foyer-lobby-stair-auditorium or stairhall-corridor-classroom, can define and express the building's historic function and unique character. Important sequences of spaces should be identified and retained in the rehabilitation project.

Floor plans may also be distinctive and characteristic of a style of architecture or a region. Examples include Greek Revival and shotgun houses. Floor plans may also reflect social, educational, and medical theories of the period. Many 19th century psychiatric institutions, for example, had plans based on the ideas of Thomas Kirkbride, a Philadelphia doctor who authored a book on asylum design.

In addition to evaluating the relative importance of the various spaces, the assessment should identify architectural **features** and **finishes** that are part of the



Figure 1. This architect-designed interior reflects early 20th century American taste: the checkerboard tile floor, wood wainscot, coffered ceiling, and open staircase are richly detailed and crafted by hand. Not only are the individual architectural features worthy of preservation, but the planned sequence of spaces—entry hall, stairs, stair landings, and loggia—imparts a grandeur that is characteristic of high style residences of this period. This interior is of Greystone, Los Angeles, California. Photography for HABS by Jack E. Boucher



Figure 2. The interiors of mills and industrial buildings frequently are open, unadorned spaces with exposed structural elements. While the new uses to which this space could be put are many—retail, residential, or office—the generous floor-to-ceiling height and exposed truss system are important character-defining features and should be retained in the process of rehabilitation.

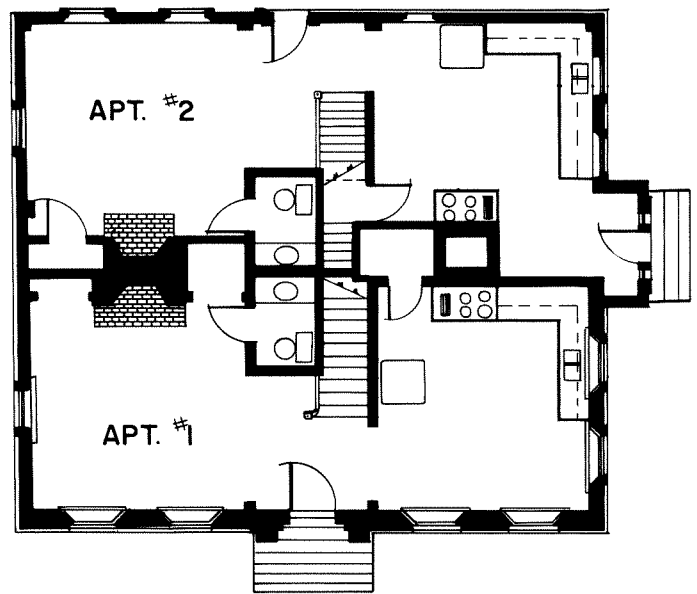
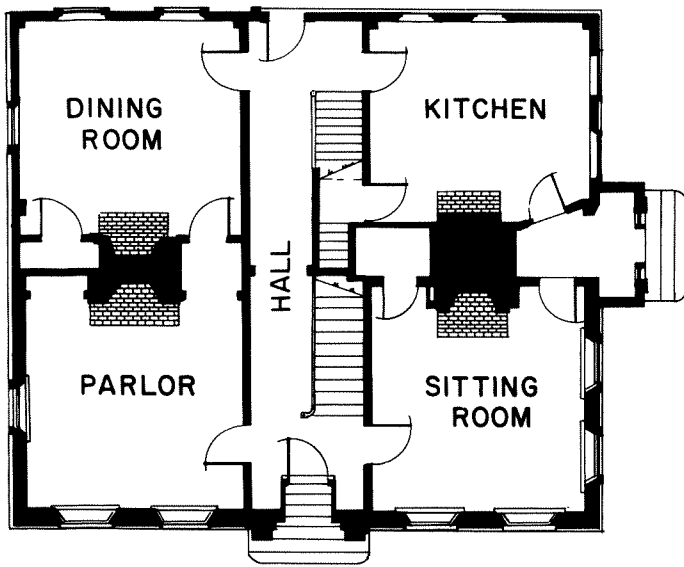


Figure 3. The floor plan at left is characteristic of many 19th century Greek Revival houses, with large rooms flanking a central hall. In the process of rehabilitation, the plan (at right) was drastically altered to accommodate two duplex apartments. The open stair was replaced with one that is enclosed, two fireplaces were eliminated, and Greek Revival trim around windows and doors was removed. The symmetry of the rooms themselves was destroyed with the insertion of bathrooms and kitchens. Few vestiges of the 19th century interior survived the rehabilitation. Drawing by Neal A. Vogel

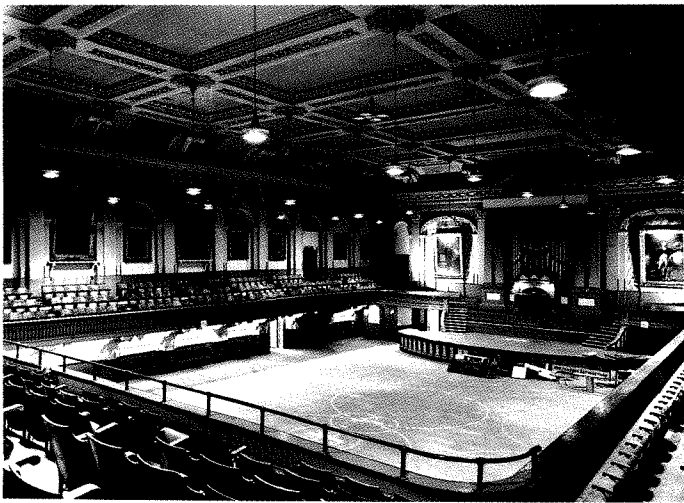


Figure 4. Many institutional buildings possess distinctive spaces or floor plans that are important in conveying the significance of the property. Finding new compatible uses for these buildings and preserving the buildings' historic character can be a difficult, if not impossible, task. One such case is Mechanics Hall in Worcester, Massachusetts, constructed between 1855 and 1857. This grand hall, which occupies the entire third floor of the building, could not be subdivided without destroying the integrity of the space.

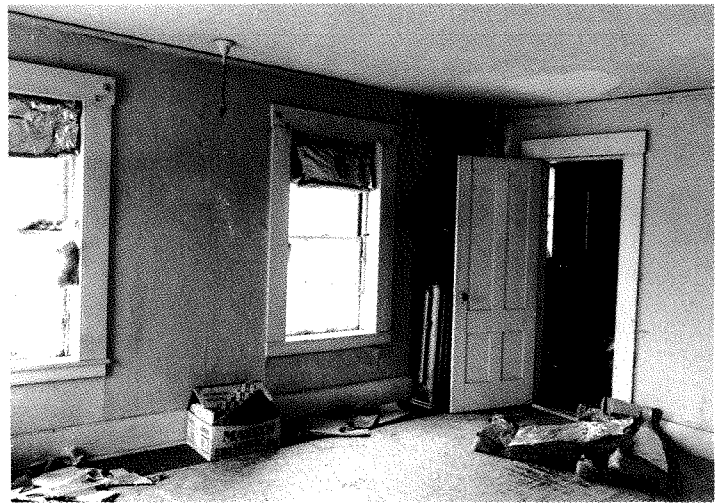


Figure 5. The interior of a simply detailed worker's house of the 19th century may be as important historically as the richly ornamented interior seen in figure 1. Although the interior of this house has not been properly maintained, the wide baseboards, flat window trim, and four-panel door are characteristic of workers' housing during this period and deserve retention during rehabilitation.

interior's history and character. Marble or wood wainscoting in corridors, elevator cabs, crown molding, baseboards, mantels, ceiling medallions, window and door trim, tile and parquet floors, and staircases are among those features that can be found in historic buildings. Architectural finishes of note may include grained woodwork, marbleized columns, and plastered walls. Those features that are characteristic of the building's style and period of construction should, again, be retained in the rehabilitation.

Features and finishes, even if machine-made and *not* exhibiting particularly fine craftsmanship, may be character-defining; these would include pressed metal ceilings and millwork around windows and doors. The interior of a plain, simple detailed worker's house of the 19th century may be as important historically as a richly ornamented, high-style townhouse of the same period. Both resources, if equally intact, convey important information about the early inhabitants and deserve the same careful attention to detail in the preservation process.



The location and condition of the building's existing heating, plumbing, and electrical systems also need to be noted in the assessment. The visible features of historic systems—radiators, grilles, light fixtures, switchplates, bathtubs, etc.—can contribute to the overall character of the building, even if the systems themselves need upgrading.

### Assessing Alterations and Deterioration

In assessing a building's interior, it is important to ascertain the extent of alteration and deterioration that may have taken place over the years; these factors help determine what degree of change is appropriate in the project. Close examination of existing fabric and original floorplans, where available, can reveal which alterations have been **additive**, such as new partitions inserted for functional or structural reasons and historic features covered up rather than destroyed. It can also reveal which have been **subtractive**, such as key walls removed and architectural features destroyed. If an interior has been modified by additive changes and if these changes have not acquired significance, it may be relatively easy to remove the alterations and return the interior to its historic appearance. If an interior has been greatly altered through subtractive changes, there may be more latitude in making further alterations in the process of rehabilitation because the integrity of the interior has been compromised. At the same time, if the interior had been exceptionally significant, and solid documentation on its historic condition is available, reconstruction of the missing features may be the preferred option.

It is always a recommended practice to photograph interior spaces and features thoroughly prior to rehabilitation. Measured floor plans showing the existing conditions are extremely useful. This documentation is invaluable in drawing up rehabilitation plans and specifications and in assessing the impact of changes to the property for historic preservation certification purposes.

### Drawing Up Plans and Executing Work

If the historic building is to be rehabilitated, it is critical that the new use not require substantial alteration of distinctive spaces or removal of character-defining architectural features or finishes. If an interior loses the physical vestiges of its past as well as its historic function, the sense of time and place associated both with the building and the district in which it is located is lost.

The recommended approaches that follow address common problems associated with the rehabilitation of historic interiors and have been adapted from the Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings. Adherence to these suggestions can help ensure that character-defining interior elements are preserved in the process of rehabilitation. The checklist covers a range of situations and is not intended to be all-inclusive. Readers are strongly encouraged to review the full set of guidelines before undertaking *any* rehabilitation project.



Figure 6. This corridor, located in the historic Monadnock Building in Chicago, has glazed walls, oak trim, and marble wainscoting, and is typical of those found in late 19th and early 20th century office buildings. Despite the simplicity of the features, a careful attention to detail can be noted in the patterned tile floor, bronze mail chute, and door hardware. The retention of corridors like this one should be a priority in rehabilitation projects involving commercial buildings.

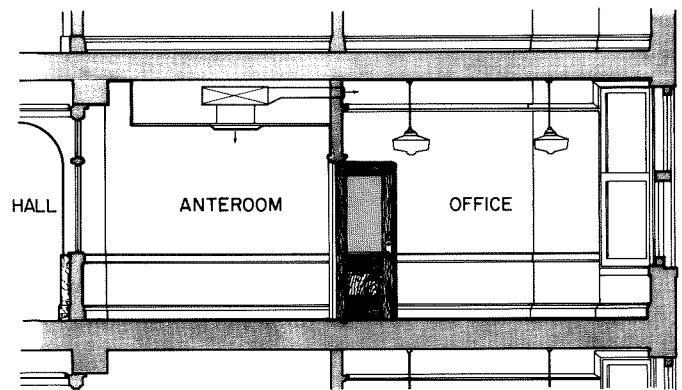


Figure 7. When the Monadnock Building was rehabilitated, architects retained the basic floor plan on the upper floors consisting of a double-loaded corridor with offices opening onto it. The original floor-to-ceiling height in the corridors and outside offices—the most important spaces—was maintained by installing needed air conditioning ductwork in the less important anterooms. In this way, the most significant interior spaces were preserved intact. Drawing by Neal A. Vogel

## Recommended Approaches for Rehabilitating Historic Interiors

1. Retain and preserve floor plans and interior spaces that are important in defining the overall historic character of the building. This includes the size, configuration, proportion, and relationship of rooms and corridors; the relationship of features to spaces; and the spaces themselves such as lobbies, reception halls, entrance halls, double parlors, theaters, auditoriums, and important industrial or commercial use spaces. Put service functions required by the building's new use, such as bathrooms, mechanical equipment, and office machines, in secondary spaces.
2. Avoid subdividing spaces that are characteristic of a building type or style or that are directly associated with specific persons or patterns of events. Space may be subdivided both vertically through the insertion of new partitions or horizontally through insertion of new floors or mezzanines. The insertion of new additional floors should be considered only when they will not damage or destroy the structural system or obscure, damage, or destroy character-defining spaces, features, or finishes. If rooms have already been subdivided through an earlier insensitive renovation, consider removing the partitions and restoring the room to its original proportions and size.
3. Avoid making new cuts in floors and ceilings where such cuts would change character-defining spaces and the historic configuration of such spaces. Inserting of a new atrium or a lightwell is appropriate only in very limited situations where the existing interiors are not historically or architecturally distinguished.
4. Avoid installing dropped ceilings below ornamental ceilings or in rooms where high ceilings are part of the building's character. In addition to obscuring or destroying significant details, such treatments will also change the space's proportions. If dropped ceilings are installed in buildings that lack character-defining spaces, such as mills and factories, they should be well set back from the windows so they are not visible from the exterior.
5. Retain and preserve interior features and finishes that are important in defining the overall historic character of the building. This might include columns, doors, cornices, baseboards, fireplaces and mantels, paneling, light fixtures, elevator cabs, hardware, and flooring; and wallpaper, plaster, paint, and finishes such as stenciling, marbleizing, and graining; and other decorative materials that accent interior features and provide color, texture, and patterning to walls, floors, and ceilings.
6. Retain stairs in their historic configuration and location. If a second means of egress is required, consider constructing new stairs in secondary spaces. (For guidance on designing compatible new additions, see Preservation Brief 14, "New Exterior Additions to Historic Buildings.") The application of fire-retardant coatings, such as intumescent paints; the installation of fire suppression systems, such as sprinklers; and the construction of glass enclosures can in many cases permit retention of stairs and other character-defining features.
7. Retain and preserve visible features of early mechanical systems that are important in defining the overall historic character of the building, such as radiators, vents, fans, grilles, plumbing fixtures, switchplates, and lights. If new heating, air conditioning, lighting and plumbing systems are installed, they should be done in a way that does not destroy character-defining spaces, features and finishes. Ducts, pipes, and wiring should be installed as inconspicuously as possible: in secondary spaces, in the attic or basement if possible, or in closets.
8. Avoid "furring out" perimeter walls for insulation purposes. This requires unnecessary removal of window trim and can change a room's proportions. Consider alternative means of improving thermal performance, such as installing insulation in attics and basements and adding storm windows.
9. Avoid removing paint and plaster from traditionally finished surfaces, to expose masonry and wood. Conversely, avoid painting previously unpainted millwork. Repairing deteriorated plasterwork is encouraged. If the plaster is too deteriorated to save, and the walls and ceilings are not highly ornamented, gypsum board may be an acceptable replacement material. The use of paint colors appropriate to the period of the building's construction is encouraged.
10. Avoid using destructive methods—propane and butane torches or sandblasting—to remove paint or other coatings from historic features. Avoid harsh cleaning agents that can change the appearance of wood. (For more information regarding appropriate cleaning methods, consult Preservation Brief 6, "Dangers of Abrasive Cleaning to Historic Buildings.")

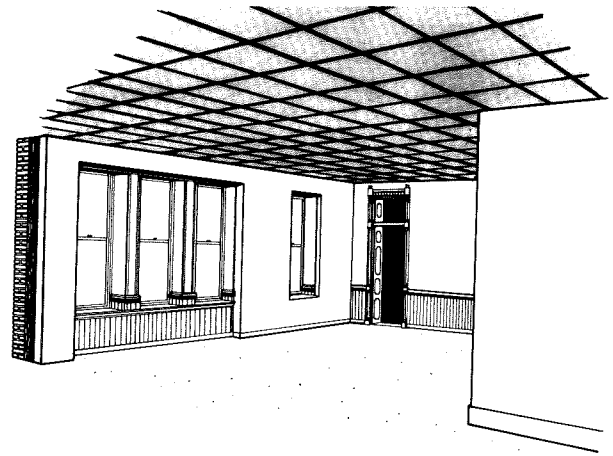
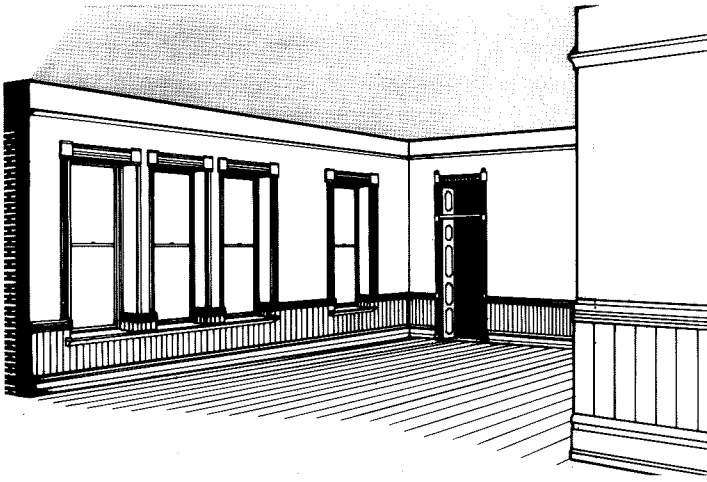


Figure 8. Furring out exterior walls to add insulation and suspending new ceilings to hide ductwork and wiring can change a room's proportions and can cause interior features to appear fragmented. In this case, a school was converted into apartments, and individual classrooms became living rooms, bedrooms, and kitchens. On the left is an illustration of a classroom prior to rehabilitation; note the generous floor-to-ceiling height, wood wainscoting, molded baseboard, picture molding, and Eastlake Style door and window trim. After rehabilitation, on the right, only fragments of the historic detailing survive: the ceiling has been dropped below the picture molding, the remaining wainscoting appears to be randomly placed, and some of the window trim has been obscured. Together with the subdivision of the classrooms, these rehabilitation treatments prevent a clear understanding of the original classroom's design and space. If thermal performance must be improved, alternatives to furring out walls and suspending new ceilings, such as installing insulation in attics and basements, should be considered. Drawings by Neal A. Vogel



Figure 9. The tangible reminders of early mechanical systems can be worth saving. In this example, in the Old Post Office in Washington, D.C., radiators encircle Corinthian columns in a decorative manner. Note, too, the period light fixtures. These features were retained when the building was rehabilitated as retail and office space. Photo: Historic American Buildings Survey



Figure 10. In this case plaster has been removed from perimeter walls, leaving brick exposed. In removing finishes from historic masonry walls, not only is there a loss of historic finish, but raw, unfinished walls are exposed, giving the interior an appearance it never had. Here, the exposed brick is of poor quality and the mortar joints are wide and badly struck. Plaster should have been retained and repaired, as necessary.



Figure 11. These dramatic “before” and “after” photographs show a severely deteriorated space restored to its original elegance: plaster has been repaired and painted, the scagliola columns have been restored to match marble using traditional craft techniques, and missing decorative metalwork has been re-installed in front of the windows. Although some reorganization of the space took place, notably the relocation of the front desk, the overall historic character of the space has been preserved. These views are of the lobby in the Willard Hotel, Washington, D.C. Credit: Commercial Photographers (left); Carol M. Highsmith (right)

## Meeting Building, Life Safety and Fire Codes

Buildings undergoing rehabilitation must comply with existing building, life safety and fire codes. The application of codes to specific projects varies from building to building, and town to town. Code requirements may make some reuse proposals impractical; in other cases, only minor changes may be needed to bring the project into compliance. In some situations, it may be possible to obtain a code variance to preserve distinctive interior features. (It should be noted that the Secretary’s Standards for Rehabilitation take precedence over other regulations and codes in determining whether a rehabilitation project qualifies for Federal tax benefits.) A thorough understanding of the applicable regulations and close coordination with code officials, building inspectors, and fire marshals can prevent the alteration of significant historic interiors.

## Sources of Assistance

Rehabilitation and restoration work should be undertaken by professionals who have an established reputation in the field.

Given the wide range of interior work items, from ornamental plaster repair to marble cleaning and the application of graining, it is possible that a number of specialists and subcontractors will need to be brought in to bring the project to completion. State Historic Preservation Officers and local preservation organizations may be a useful source of information in this regard. Good sources of information on appropriate preservation techniques for specific interior features and finishes include the *Bulletin* of the Association for Preservation Technology and *The Old-House Journal*; other useful publications are listed in the bibliography.

## Protecting Interior Elements During Rehabilitation

Architectural features and finishes to be preserved in the process of rehabilitation should be clearly marked on plans *and at the site*. This step, along with careful supervision of the interior demolition work and protection against arson and vandalism, can prevent the unintended destruction of architectural elements that contribute to the building’s historic character.

Protective coverings should be installed around architectural features and finishes to avoid damage in the course of construction work and to protect workers. Staircases and floors, in particular, are subjected to dirt and heavy wear, and the risk exists of incurring costly or irreparable damage. In most cases, the best, and least costly, preservation approach is to design and construct a protective system that enables stairs and floors to be used yet protects them from damage. Other architectural features such as mantels, doors, wainscoting, and decorative finishes may be protected by using heavy canvas or plastic sheets.

## Summary

In many cases, the interior of a historic building is as important as its exterior. The careful identification and evaluation of interior architectural elements, after undertaking research on the building’s history and use, is critically important *before* changes to the building are contemplated. Only *after* this evaluation should new uses be decided and plans be drawn up. The best rehabilitation is one that preserves and protects those rooms, sequences of spaces, features and finishes that define and shape the overall historic character of the building.



This Preservation Brief is based on a discussion paper prepared by the author for a National Park Service regional workshop held in March, 1987, and on a paper written by Gary Hume, "Interior Spaces in Historic Buildings," October, 1987. Appreciation is extended to the staff of Technical Preservation Services Branch and to the staff of NPS regional offices who reviewed the manuscript and provided many useful suggestions. Special thanks are given to Neal A. Vogel, a summer intern with the NPS, for many of the illustrations in this Brief.

This publication has been prepared pursuant to the National Historic Preservation Act of 1966, as amended. Preservation Briefs 18 was developed under the editorship of Lee H. Nelson, FAIA, Chief, Preservation Assistance Division, National Park Service, U.S. Department of the Interior, P.O. Box 37127, Washington, D.C. 20013-7127. Comments on the usefulness of this information are welcomed and may be sent to Mr. Nelson at the above address. This publication is not copyrighted and can be reproduced without penalty. Normal procedures for credit to the author and the National Park Service are appreciated.

### Selected Reading List

There are few books written exclusively on preserving historic interiors, and most of these tend to focus on residential interiors. Articles on the subject appear regularly in *The Old-House Journal*, the *Bulletin of the Association for Preservation Technology*, and *Historic Preservation Magazine*.

Ferro, Maximilian L., and Melissa L. Cook. *Electric Wiring and Lighting in Historic American Buildings*. New Bedford, Massachusetts: AFC/A Nortek Company, 1984.

Fisher, Charles E. *Temporary Protection of Historic Stairways During Rehabilitation Work*. Preservation Tech Note. Washington, D.C.: Preservation Assistance Division, National Park Service, U.S. Department of the Interior, 1985.

Jennings, Jan, and Herbert Gottfried. *American Vernacular Interior Architecture 1870-1940*. New York: Van Nostrand Reinhold Company, 1988.

Johnson, Ed. *Old House Woodwork Restoration: How to Restore Doors, Windows, Walls, Stairs and Decorative Trim to Their Original Beauty*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1983.

Labine, Clem, and Carolyn Flaherty (editors). *The Old-House Journal Compendium*. Woodstock, New York: The Overlook Press, 1980.

*The Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings*. Washington, D.C.: Preservation Assistance Division, National Park Service, U.S. Department of the Interior, rev. 1983.

U.S. Department of Housing and Urban Development. *Rehabilitation Guidelines*, volumes 1-11. Washington, D.C.: U.S. Department of Housing and Urban Development, 1980-84.

Winkler, Gail Caskey, and Roger W. Moss. *Victorian Interior Decoration: American Interiors 1830-1900*. New York: Henry Holt and Company, 1986.

October 1988

Cover: Detail of carving on interior shutter. Hammond-Harwood House, Annapolis, Maryland.

# 19 PRESERVATION BRIEFS

## The Repair and Replacement of Historic Wooden Shingle Roofs

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Preservation Assistance Division, Technical Preservation Services



The Secretary of the Interior's "Standards for Rehabilitation" call for the repair or replacement of missing architectural features "based on accurate duplication of features, substantiated by historic, physical, or pictorial evidence rather than on conjectural designs." On a wooden shingle roof, it is important not only to match the size, shape, texture, and configuration of historic shingles, but also to match the craftsmanship and details that characterize the historic roof. Proper installation and maintenance will extend the life of the new roof.

### Introduction

Wooden shingle roofs are important elements of many historic buildings. The special visual qualities imparted by both the *historic shingles* and the *installation patterns* should be preserved when a wooden shingle roof is replaced. This requires an understanding of the size, shape, and detailing of the historic shingle and the method of fabrication and installation. These combined to create roofs expressive of particular architectural styles, which were often influenced by regional craft practices. The use of wooden shingles from the early settlement days to the present illustrates an extraordinary range of styles (see illus. 1, 2, 3, 4).

Wooden shingle roofs need periodic replacement. They can last from 15 to over 60 years, but the shingles should be replaced before there is deterioration of other wooden components of the building. Appropriate replacement shingles are available, but careful research, design, specifications, and the selection of a skilled roofer are necessary to assure a job that will both preserve the appearance of the historic building and extend the useful life of the replacement roof.

Unfortunately, the wrong shingles are often selected or are installed in a manner incompatible with the appearance of the historic roof. There are a number of reasons why the wrong shingles are selected for replacement roofs. They include the failure to identify the appearance of the original shingles; unfamiliarity with available products; an inadequate budget; or a *confusion in terminology*. In any discussion about historic roofing materials and practices, it is important to understand the historic definitions of terms like "shingles," as well as the modern definitions or use of those terms by craftsmen and the industry. Historically, from the first buildings in America, these wooden roofing

products were called *shingles*, regardless of whether they were the earliest handsplit or the later machine-sawn type. The term *shake* is a relatively recent one, and today is used by the industry to distinguish the sawn products from the split products, but through most of our building history there has been no such distinction.

Considering the confusion among architects and others regarding these terms as they relate to the appearance of early roofs, it should be stated that there is a considerable body of documentary information about historic roofing practices and materials in this country, and that many actual specimens of historic shingles from various periods and places have been collected and preserved so that their historic appearances are well established. Essentially, the rustic looking shake that we see used so much today has little in common with the shingles that were used on most of our early buildings in America.

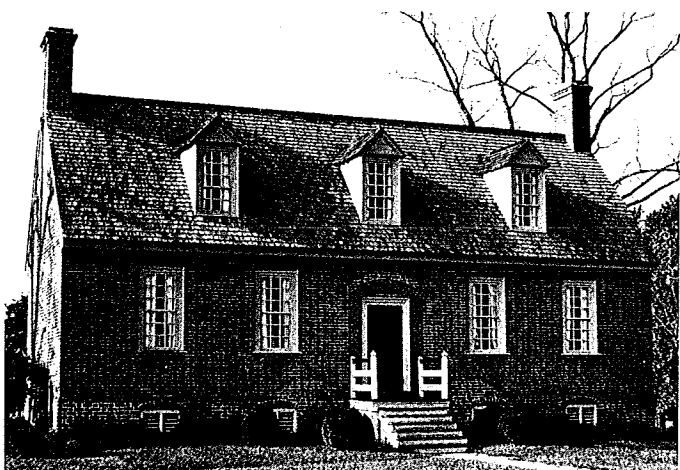
Throughout this **Brief**, the term *shingle* will be used to refer to historic wooden roofs in general, whether split or sawn, and the term *shake* will be used only when it refers to a commercially available product. The variety and complexity of terminology used for currently available products will be seen in the accompanying chart entitled "Shingles and Shakes."

This **Brief** discusses what to look for in historic wooden shingle roofs and when to replace them. It discusses ways to select or modify modern products to duplicate the appearance of a historic roof, offers guidance on proper installation, and provides information on coatings and maintenance procedures to help preserve the new roof.\*

(\*Preservation Brief 4: **Roofing for Historic Buildings** discusses research methods, analysis of deterioration, and the general significance of historic roofs.)

## Wooden Shingle Roofs in America

Because trees were plentiful from the earliest settlement days, the use of wood for all aspects of construction is not surprising. Wooden shingles were lightweight, made with simple tools, and easily installed. Wooden shingle roofs were prevalent in the Colonies, while in Europe at the same time, thatch, slate and tile were the prevalent roofing materials. Distinctive roofing patterns exist in various regions of the country that were settled by the English, Dutch, Germans, and Scandinavians. These patterns and features include the size, shape and exposure length of shingles, special treatments such as swept valleys, combed ridges, and decorative butt end or long side-lapped beveled handsplit shingles. Such features impart a special character to each building, and prior to any restoration or rehabilitation project the physical and photographic evidence should be carefully researched in order to document the historic building as much as



1. The Rolfe-Warren House, a tidewater Virginia property, was restored to its 18th-century appearance in 1933. The handsplit and dressed wooden shingles are typical of the tidewater area with special features such as curved butts, projecting ridge comb and closed swept valleys at the dormer roof connections. Circa 1970 Photo: Association for the Preservation of Virginia Antiquities.



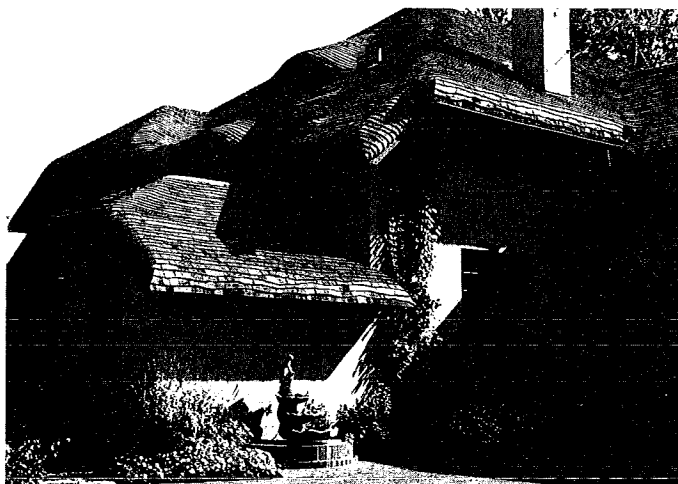
3. Readily available and inexpensive sawn shingles were used not only for roofs, but also for gables and wall surfaces. The circa 1891 Chambers House, Eugene, Oregon used straight sawn butts for the majority of the roof and hexagonal butts for the lower portion of the corner tower. Decorative shingles in the gable ends and an attractive wooden roof cresting feature were also used. Photo: Lane County Historical Society.

possible. Care should be taken not to assume that aged or deteriorated shingles in photographs represent the historic appearance.

**Shingle Fabrication.** Historically wooden shingles were usually thin (3/8"–3/4"), relatively narrow (3"–8"), of varying length (14"–36"), and almost always smooth. The traditional method for making wooden shingles in the 17th and 18th centuries was to handsplit them from log sections known as bolts (see illus. 5A). These bolts were quartered or split into wedges. A mallet and froe (or ax) were used to split or rive out thin planks of wood along the grain. If a tapered shingle was desired, the bolt was flipped after each successive strike with the froe and mallet. The wood species varied according to available local woods, but only the heartwood, or inner section, of the log was usually used. The softer sapwood generally was not used because it deteriorated quickly. Because handsplit shingles were somewhat irregular along the split surface, it was necessary



2. Handsplit and dressed shingles were also used on less elaborate buildings as seen in the restoration of the circa 1840 kitchen at the Winedale Inn, Texas. The uneven surfaces of the handsplit shingles were generally dressed or smoothed with a draw-knife to keep the rainwater from collecting in the wood grain and to ensure that the shingles lay flat on the sub-roof. Photo: Thomas Taylor.



4. With the popularity of the revival of historic styles in the late 19th and early 20th centuries, a new technique was developed to imitate English thatch roofs. For the Tudor Revival thatch cottages, steaming and curving of sawn shingles provided an undulating pattern to this picturesque roof shape. Photo: Courtesy of C.H. Roofing.

to dress or plane the shingles on a shavinghorse with a draw-knife or draw-shave (see illus. 5B) to make them fit evenly on the roof. This reworking was necessary to provide a tight-fitting roof over typically open shingle lath or sheathing boards. Dressing, or smoothing of shingles, was almost universal, no matter what wood was used or in what part of the country the building was located, except in those cases where a temporary or very utilitarian roof was needed.

Shingle fabrication was revolutionized in the early 19th century by steam-powered saw mills (see illus. 6). Shingle mills made possible the production of uniform

shingles in mass quantities. The sawn shingle of uniform taper and smooth surface eliminated the need to hand dress. The supply of wooden shingles was therefore no longer limited by local factors. These changes coincided with (and in turn increased) the popularity of architectural styles such as Carpenter Gothic and Queen Anne that used shingles to great effect.

Handsplit shingles continued to be used in many places well after the introduction of machine sawn shingles. There were, of course, other popular roofing materials, and some regions rich in slate had fewer examples of wooden shingle roofs. Some western



5. Custom Handsplit shingles are still made the traditional way with a mallet and froe or ax. For these cypress shingles, a "bolt" section of log (photo A) the length of the shingle has been sawn and is ready to be split into wedge-shaped segments. Handsplit shingles are fabricated with the ax or froe cutting the wood along the grain and separating, or riving, the shingle away from the remaining wedge. The rough surfaces are dressed on a shavinghorse using a draw-knife as shown above (photo B). Note the long wooden shingles covering the work shed in photo A. Photos: Al Honeycutt, North Carolina Division of Archives and History.



6. Modern machine-made shingles are sawn. Shown are: (photo A) Eastern White Pine quarter split shingle block on equalizer saw being trimmed to parallel the ends; and (photo B) the restored 19th-century shingle mill saw cutting tapered flitches or shingles. The thickness and taper can be precisely controlled. Photo: Steve Ruscio, The Shingle Mill.

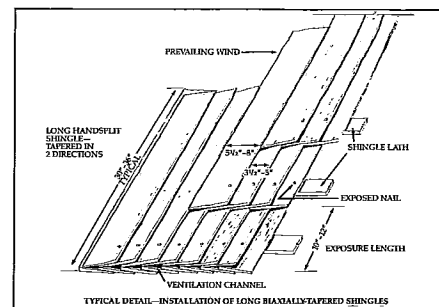


"boom" towns used sheet metal because it was light and easily shipped. Slate, terneplate, and clay tile were used on ornate buildings and in cities that limited the use of flammable wooden shingles. Wooden shingles, however, were never abandoned. Even in the 20th century, architectural styles such as the Colonial Revival and Tudor Revival, used wooden shingles.

Modern wooden shingles, both sawn and split, continue to be made, but it is important to understand how these new products differ from the historic ones and to know how they can be modified for use on historic buildings. Modern commercially available shakes are generally thicker than the historic handsplit counterpart and are usually left "undressed" with a rough, corrugated surface. The rough surface shake, furthermore, is often promoted as suitable for historic preservation projects because of its rustic appearance. It is an erroneous assumption that the more irregular the shingle, the more authentic or "historic" it will appear.

**Historic Detailing and Installation Techniques.** While the size, shape and finish of the shingle determine the roof's texture and scale, the installation patterns and details give the roof its unique character. Many details reflect the craft practices of the builders and the architectural style prevalent at the time of construction. Other details had specific purposes for reducing moisture penetration to the structure. In addition to the most visible aspects of a shingle roof, the details at the rake boards, eaves, ridges, hips, dormers, cupolas, gables, and chimneys should not be overlooked.

The way the shingles were laid was often based on functional and practical needs. Because a roof is the most vulnerable element of a building, many of the roofing details that have become distinctive features were first developed simply to keep water out. Roof combs on the windward side of a roof protect the ridge line. Wedges, or cant strips, at dormer cheeks roll the water away from the vertical wall. Swept valleys and fanned hips keep the grain of the wood in the shingle parallel to the angle of the building joint to aid water



8. The long biaxially tapered handsplit shingles on the Ephrata Cloisters in Pennsylvania were overlapped both vertically and horizontally. The insert sketch shows channels under the shingles that provided ventilation and drainage of any trapped moisture. The aged appearance of these handsplit and dressed shingles belies their original smoothness. Replacement shingles should match the original, not the aged appearance. Photo: National Park Service; Sketch: Reed Engle.



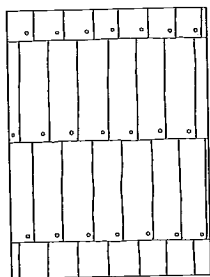
7. The reshingling of the circa 1856 Stovewood House in Decorah, Iowa, revealed the original open sheathing boards and pole rafters. Sawn cedar shingles were used as a replacement for the historic cedar shingles seen still in place at the ridge. A new starter course is being laid at the eaves. Photo: Norwegian-American Museum, Decorah, Iowa.



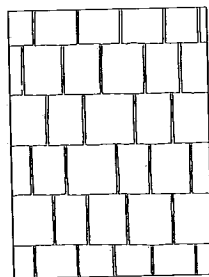
9. This 1927 view of the reshingling of the French Castle at Old Fort Niagara, N.Y., shows the wooden sleepers being laid (see arrow) over solid sheathing in order to raise the shingles up slightly to allow under-shingle ventilation. Note that the horizontal strips are not continuous to allow airflow and trapped moisture to drain away. This cedar roof has lasted for over 60 years in a harsh moist environment. Photo: Old Fort Niagara, Assoc. Inc.

## WOODEN SHINGLES—HISTORIC DETAILS AND INSTALLATION PATTERNS

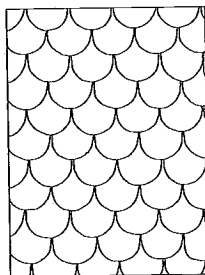
### Shingle Patterns



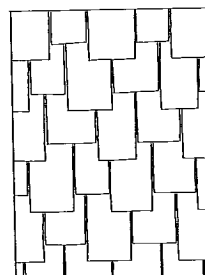
Long biaxially-tapered, sidelapped



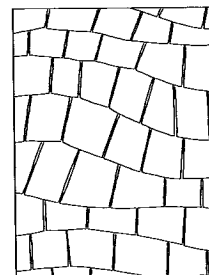
Traditional overlap



Fancy butts  
(fishscales shown)

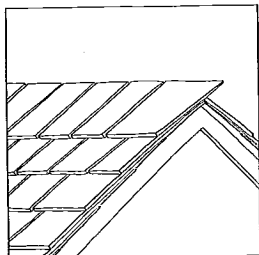


Staggered overlap

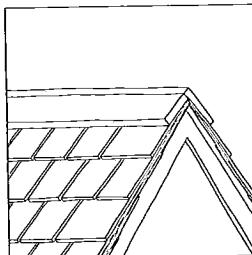


Steamed & bent  
"thatch"

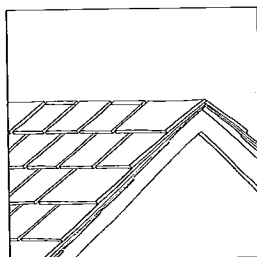
### Ridges



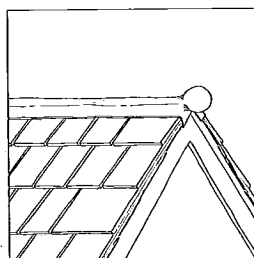
Projecting comb



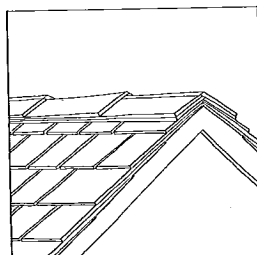
Board ridge



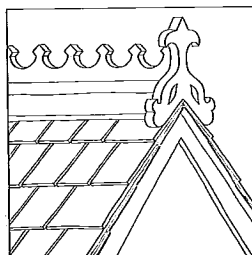
Alternating closed ridge



Rolled metal ridge cover

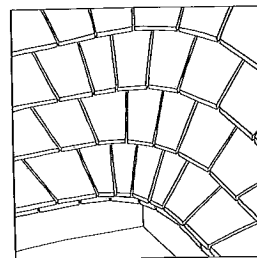


Boston capped ridge

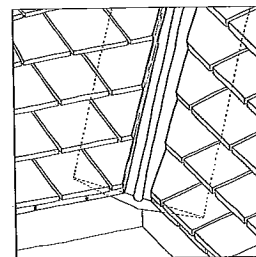


Wooden crest

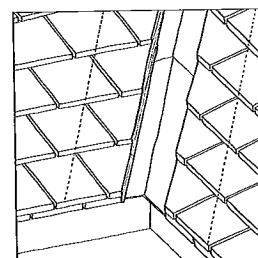
### Valleys



Closed swept valley

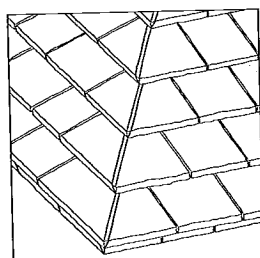


Open valley with wooden wedge

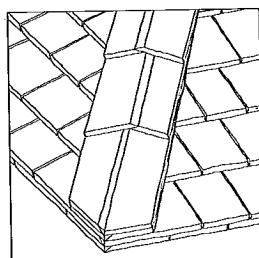


Open valley with metal flashing

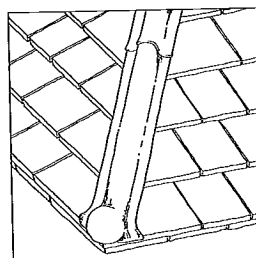
### Hips



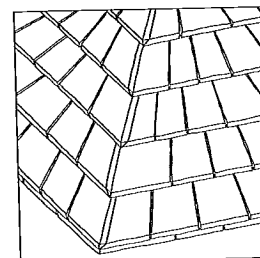
Traditional alternating shingle hip



Boston capped hip



Rolled metal hip cover



Fanned or swirled alternating shingle hip

10. The Historic Details and Installation Patterns Chart illustrates a number of special features found on wooden roofs. Documented examples of these features, different for every building and often reflecting regional variations, should be accurately reproduced when a replacement roof is installed. Chart: Sharon C. Park; delineation by Kaye Ellen Simonson.

run-off. The slight projection of the shingles at the eaves directs the water run-off either into a gutter or off the roof away from the exterior wall. These details varied from region to region and from style to style. They can be duplicated even with the added protection of modern flashing.

In order to have a weathertight roof, it was important to have adequate coverage, proper spacing of shingles, and straight grain shingles. Many roofs were laid on open shingle lath or open sheathing boards (see illus. 7). Roofers typically laid three layers of shingles with approximately 1/3 of each shingle exposed to the weather. Spaces between shingles (1/8"–1/2" depending on wood type) allowed the shingles to expand when wet. It was important to stagger each overlapping shingle by a minimum of 1-1/2" to avoid a direct path for moisture to penetrate a joint. Doubling or tripling the starter course at the eave gave added protection to this exposed surface. In order for the roof to lay as flat as possible, the thickness, taper and surface of the shingles was relatively uniform; any unevenness on handsplit shingles had already been smoothed away with a drawknife. To keep shingles from curling or cupping, the shingle width was generally limited to less than 10".

Not all shingles were laid in evenly spaced, overlapping, horizontal rows. In various regions of the country, there were distinct installation patterns; for example, the biaxially-tapered long shingles occasionally found in areas settled by the Germans (see illus. 8). These long shingles were overlapped on the side as well as on top. This formed a ventilation channel under the shingles that aided drying. Because ventilation of the shingles can prolong their life, roofers paid attention to these details (see illus. 9).

Early roofers believed that applied coatings would protect the wood and prolong the life of the roof. In many cases they did; but in many cases, the shingles were left to weather naturally and they, too, had a long life. Eighteenth-century coatings included a pine pitch coating not unlike turpentine, and boiled linseed oil or fish oil mixed with oxides, red lead, brick dust, or other minerals to produce colors such as yellow, Venetian red, Spanish brown, and slate grey. In the 19th century, in addition to the earlier colors, shingles were stained or painted to complement the building colors: Indian red, chocolate brown, or brown-green. During the Greek Revival and later in the 20th century with other revival styles, green was also used. Untreated shingles age to a silver-grey or soft brown depending on the wood species.

The craft traditions of the builders often played an important role in the final appearance of the building. The Historic Details and Installation Patterns Chart (see illus. 10) identifies many of the features found on historic wooden roofs. These elements, different on each building, should be preserved in a re-roofing project.

#### **Replacing Deteriorated Roofs: Matching the Historic Appearance**

Historic wooden roofs using straight edgegrain heartwood shingles have been known to last over sixty years. Fifteen to thirty years, however, is a more realistic lifespan for most premium modern wooden shingle roofs. Contributing factors to deterioration include the

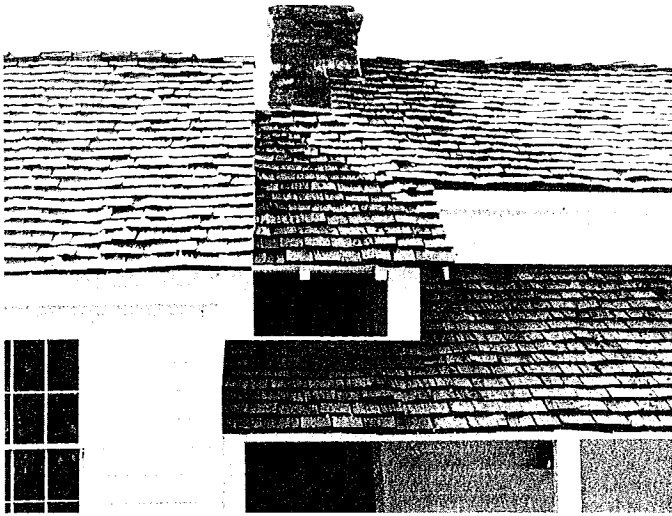


11. The replacement sawn red cedar shingles matched the deteriorated shingles exactly for this barn re-roofing. The old shingles, seen to the far left, were removed as the new shingles were installed. Even the horizontal coursing matched because the exposure length for both old and new shingles was the same. Photo: Williamsport Preservation Training Center.

thinness of the shingle, the durability of the wood species used, the exposure to the sun, the slope of the roof, the presence of lichens or moss growing on the shingle, poor ventilation levels under the shingle or in the roof, the presence of overhanging tree limbs, pollutants in the air, the original installation method, and the history of the roof maintenance. Erosion of the softer wood within the growth rings is caused by rainwater, wind, grit, fungus and the breakdown of cells by ultraviolet rays in sunlight. If the shingles cannot adequately dry between rains, if moss and lichens are allowed to grow, or if debris is not removed from the roof, moisture will be held in the wood and accelerate deterioration. Moisture trapped under the shingle, condensation, or poorly ventilated attics will also accelerate deterioration.

In addition to the eventual deterioration of wooden shingles, impact from falling branches and workmen walking on the roof can cause localized damage. If, however, over 20% of the shingles on any one surface appear eroded, cracked, cupped or split, or if there is evidence of pervasive moisture damage in the attic, replacement should be considered. If only a few shingles are missing or damaged, selective replacement may be possible. For limited replacement, the old shingle is removed and a new shingle can be inserted and held in place with a thin metal tab, or "babbie." This reduces disturbance to the sound shingles above. In instances where a few shingles have been cracked or the joint of overlapping shingles is aligned and thus forms a passage for water penetration, a metal flashing piece slipped under the shingle can stop moisture temporarily. If moisture is getting into the attic, repairs must be made quickly to prevent deterioration of the roof structural framing members.

When damage is extensive, replacement of the shingles will be necessary, but the historic sheathing or shingle lath under the shingles may be in satisfactory condition. Often, the historic sheathing or shingle laths, by their size, placement, location of early nail holes, and water stain marks, can give important infor-



12. Inappropriately selected and installed wooden shingles can drastically alter the historic character of a building. This tavern historically was roofed with handsplit and dressed shingles of a relatively smooth appearance. In this case, a commercially available shake was used to effect a "rustic" appearance. Photo: National Park Service.

mation regarding the early shingles used. Before specifying a replacement roof, it is important to *establish the original shingle material, configuration, detailing and installation* (see illus. 11). If the historic shingles are still in place, it is best to remove several to determine the size, shape, exposure length, and special features from the unweathered portions. If there are already replacement shingles on the roof, it may be necessary to verify through photographic or other research whether the shingles currently on the roof were an accurate replacement of the historic shingles.

The following information is needed in order to develop accurate specifications for a replacement shingle:

**Original wood type** (White Oak, Cypress, Eastern White Pine, Western, Red Cedar, etc.)

**Size of shingle** (length, width, butt thickness, taper)

**Exposure length and nailing pattern** (amount of exposure, placement and type of nails)

**Type of fabrication** (sawn, handsplit, dressed, beveled, etc.)

**Distinctive details** (hips, ridges, valleys, dormers, etc.)

**Decorative elements** (trimmed butts, variety of pattern, applied color coatings, exposed nails)

**Type of substrate** (open shingle lath or sheathing, closed sheathing, insulated attics, sleepers, etc.)

Replacement roofs must comply with local codes which may require, for example, the use of shingles treated with chemicals or pressure-impregnated salts to retard fire. These requirements can usually be met without long-term visual effects on the appearance of the replacement roof.

The accurate duplication of a wooden shingle roof will help ensure the preservation of the building's architectural integrity. Unfortunately, the choice of an inappropriate shingle or poor installation can severely detract from the building's historic appearance (see illus. 12). There are a number of commercially available wooden roofing products as well as custom roofers who can supply specially-made shingles for historic preservation projects (see Shingle and Shake Chart, illus. 13). Unless restoration or reconstruction is being

undertaken, shingles that match the visual appearance of the historic roof without replicating every aspect of the original shingles will normally suffice. For example, if the historic wood species is no longer readily available, Western Red Cedar or Eastern White Pine may be acceptable. Or, if the shingles are located high on a roof, sawn shingles or commercially available shakes with the rustic faces factory-sawn off may adequately reproduce the appearance of an historic handsplit and dressed shingle.

There will always be certain features, however, that are so critical to the building's character that they should be accurately reproduced. Following is guidance on matching the most important visual elements.

#### Highest Priority in Replacement Shingles:

- best quality wood with a similar surface texture
- matching size and shape: thickness, width, length
- matching installation pattern: exposure length, overlap, hips, ridges, valleys, etc.
- matching decorative features: fancy butts, color, exposed nails

#### Areas of Acceptable Differences:

- species of wood
- method of fabrication of shingle, if visual appearance matches
- use of fire-retardants, or preservative treatments, if visual impact is minimal
- use of modern flashing, if sensitively installed
- use of small sleepers for ventilation, if the visual impact is minimal and rake boards are sensitively treated
- method of nailing, if the visual pattern matches

#### Treatments and Materials to Avoid:

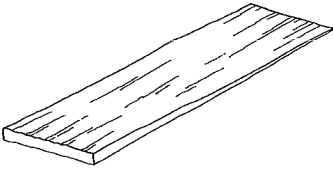
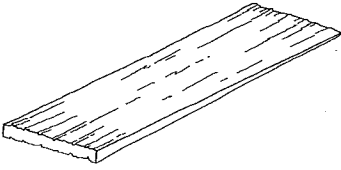
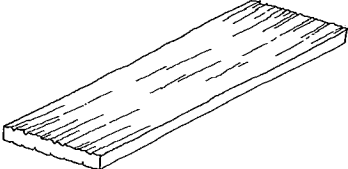
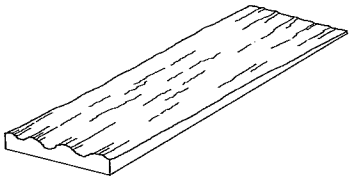
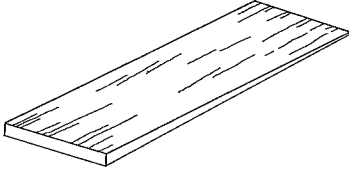
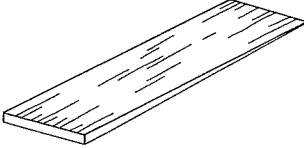
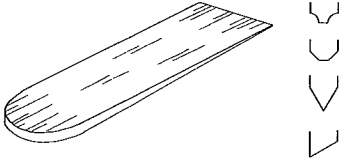
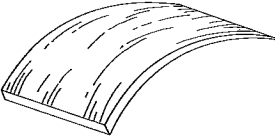
- highly textured wood surfaces and irregular butt ends, unless documented
- standardized details (prefab hips, ridges, panels, etc.) unless documented
- too wide shingles or those with flat grain (which may curl), unless documented

#### What is Currently Available

**Types of Wood:** Western Red Cedar, Eastern White Pine, and White Oak are most readily available today. For custom orders, cypress, red oak, and a number of other historically used woods may still be available. Some experiments using non-traditional woods (such as yellow pine and hemlock) treated with preservative chemicals are being tested for the new construction market, but are generally too thick, curl too easily, or have too pronounced a grain for use on historic buildings.

**Method of manufacture:** Commercially available modern shingles and shakes are for the most part machine-made. While commercially available shakes are promoted by the industry as handsplit, most are split by machine (this reduces the high cost of hand labor). True handsplit shingles, made the traditional way with a froe and mallet, are substantially more expensive, but are more authentic in appearance than the rough, highly textured machine-split shakes. An experienced shingler can control the thickness of the handsplit shingle and keep the shingle surface grain relatively



AVAILABLE WOODEN SHINGLES AND SHAKES FOR RE-ROOFING			
TYPE	SIZE	DESCRIPTION	NOTES
Custom split & dressed 	Made to match historic shingles	Handsplit the traditional way with froe & mallet. Tapered. Surfaces dressed for smoothness	Appropriate if: <ul style="list-style-type: none"> <li>• Worked to match uniformly dressed original shingles</li> </ul>
Tapersplit* 	Typically: L = 15", 18", 24" W = 4" - 14" Butts vary 1/2" - 3/4"	Commercially available. Handsplit the traditional way with froe & mallet. Tapered. Bundles contain varying widths & butt thicknesses. Surfaces may be irregular along grain.	Appropriate if: <ul style="list-style-type: none"> <li>• irregular surfaces are dressed</li> <li>• butt thicknesses ordered uniform</li> <li>• wide shingles are split</li> </ul>
Straightsplit 	Typically: L = 15", 18", 24" W = 4" - 14" Butts vary mediums = 3/8 - 3/4" heavies = 3/4 - 1 1/4"	Commercially available. Hand or machine split without taper. Bundles contain varying butt thicknesses; often very wide shingles. Surface may be irregular along the grain. Thick shingles not historic.	Not appropriate for most preservation projects <ul style="list-style-type: none"> <li>• Limited use of thin, even straightsplits on some cabins, barns, etc.</li> </ul>
Handsplit* resawn 	Typically: L = 15", 18", 24" W = 4" - 14" Butts vary mediums = 3/8 - 3/4" heavies = 3/4 - 1 1/4"	Commercially available. Machine split and sawn on the backs to taper. Split faces often irregular, even corrugated in appearance. Butt thickness vary and may be too wide.	Not appropriate for preservation projects
Tapersawn* 	Typically: L = 15", 18", 24" W = 4" - 14" Butts vary 1/2" - 3/4"	Commercially available. Made from split products with sawn surfaces. Tapered. Butt thicknesses vary and shingles may be too wide. Saw marks may be pronounced.	Appropriate if: <ul style="list-style-type: none"> <li>• butt thicknesses ordered uniform</li> <li>• wide shingles are split</li> <li>• pronounced saw marks sanded</li> </ul>
Sawn-straight butt 	Typically: L = 16" - .40 (< 3/8") 18" - .45 24" - .50 (1/2") W = Varies by order	Custom or commercially available. Tapered. Sawn by circular saw.	Appropriate to reproduce historic sawn shingles
Sawn-fancy butt 	Typically: L = 16" - .40 (< 3/8") 18" - .45 24" - .50 (1/2") W = Varies by order	Custom or commercially available. Tapered. Sawn by circular saw. A variety of fancy butts available	Appropriate to reproduce historic fancy butts
Steam-bent 	Varies by order to match, "Thatch" roofs	Custom or commercially available. Tapered. Thin sawn shingles are steamed and bent into rounded forms.	Appropriate to reproduce "thatch" shingles

13. This chart identifies a variety of shingles and shakes used for reroofing buildings. The \* identifies product names used by the Red Cedar Shingle and Handsplit Shake Bureau, although shingles and shakes of the types described are available in other woods. Manufacturers define "Shakes" as split products while "shingles" refer to sawn products. Shingle, however, is the historic term used to describe wooden roofing products, regardless of how they were made. Whether shingles or shakes are specified for re-roofing, they should match the size and appearance of the historic shingles. Chart: Sharon C. Park; delineation by Kaye Ellen Simonson.

even. To have an even roof installation, it is important to have handsplit shingles of uniform taper and to have less than 1/8th variation across the surface of the shingle. For that reason, it is important to dress the shingles or to specify uniform butt thickness, taper, and surfaces. Commercially available shakes are shipped with a range of butt sizes within a bundle (e.g., 1/2", 5/8", 3/4" as a mix) unless otherwise specified. Commercially available shakes with the irregular surfaces sawn off are also available. In many cases, except for the residual circular saw marks, these products appear not unlike a dressed handsplit shingle.

Sawn shingles are still made much the same way as they were historically—using a circular saw. The circular saw marks are usually evident on the surface of most sawn shingles. There are a number of grooved, striated, or steamed shingles of the type used in the 20th century to effect a rustic or thatched appearance. Custom sawn shingles with fancy butts or of a specified thickness are still available through mill shops. In fact, shingles can be fabricated to the weathered thickness in order to be integrated into an existing historic roof. If sawn shingles are being used as a substitute for dressed handsplit shingles, it may be desirable to belt sand the surface of the sawn shingles to reduce the prominence of the circular saw marks.

As seen from the Shingle and Shake chart, few of the commercially available shakes can be used without some modification or careful specification. Some, such as heavy shakes with a corrugated face, should be avoided altogether. While length, width, and butt configuration can be specified, it is more difficult to ensure that the thickness and the texture will be correct. For that reason, whatever shingle or shake is desired, it is important to view samples, preferably an entire bundle, before specifying or ordering. If shingles are to be trimmed at the site for special conditions, such as fanned hips or swept valleys, additional shingles should be ordered.

**Coatings and Treatments:** Shingles are treated to obtain a fire-retardant rating; to add a fungicide preservative (generally toxic); to revitalize the wood with a penetrating stain (oil as well as water-based); and to give color.

While shingles can be left untreated, local codes may require that only fire-retardant shingles be used. In those circumstances, there are several methods of obtaining rated shingles (generally class "B" or "C"). The most effective and longest-lasting treatment is to have treated salts pressure-impregnated into the wood cells after the shingles have been cut. Another method (which must be periodically renewed) is to apply chemicals to the surface of the shingles. If treated shingles need trimming at the site, it is important to check with the manufacturer to ensure that the fire-retardant qualities will not be lost. Pressure-impregnated shingles, however, may usually be trimmed without loss of fire-retardant properties.

The life of a shingle roof can be drastically shortened if moss, lichens, fungi or bacterial spores grow on the wood. Fungicides (such as chromated copper arsenate, CCA) have been found to be effective in inhibiting such fungal growth, but most are toxic. Red cedar has a natural fungicide in the wood cells and unless the shingles are used in unusually warm, moist environments, or where certain strains of spores are found, an

applied fungicide is usually not needed. For most woods, the Forest Products Laboratory of the U.S. Department of Agriculture has found that fungicides do extend the life of the shingles by inhibiting growth on or in the wood. There are a variety available. Care should be taken in applying these chemicals and meeting local code requirements for proper handling.

Penetrating stains and water repellent sealers are sometimes recommended to revitalize wood shingles subject to damage by ultraviolet rays. Some treatments are oil-borne, some are water-borne, and some are combined with a fungicide or a water repellent. If any of these treatments is to be used, they should be identified as part of the specifications. Manufacturers should be consulted regarding the toxicity or other potential complications arising from the use of a product or of several in combination. It is also important not to coat the shingles with vapor-impermeable solutions that will trap moisture within the shingle and cause rotting from beneath.

### Specifications for the Replacement Roof

Specifications and roofing details should be developed for each project. Standard specifications may be used as a basic format, but they should be modified to reflect the conditions of each job. Custom shingles can still be ordered that accurately replicate a historic roof, and if the roof is simple, an experienced shingler could install it without complicated instructions. Most rehabilitation projects will involve competitive bidding, and each contractor should be given very specific information as to what type of shingles are required and what the installation details should be. For that reason, both written specifications and detailed drawings should be part of the construction documents.

For particularly complex jobs, it may be appropriate to indicate that only roofing contractors with experience in historic preservation projects be considered (see illus. 14). By pre-qualifying the bidders, there is greater assurance that a proper job will be done. For smaller jobs, it is always recommended that the owner or architect find a roofing contractor who has recently completed a similar project and that the roofers are similarly experienced.

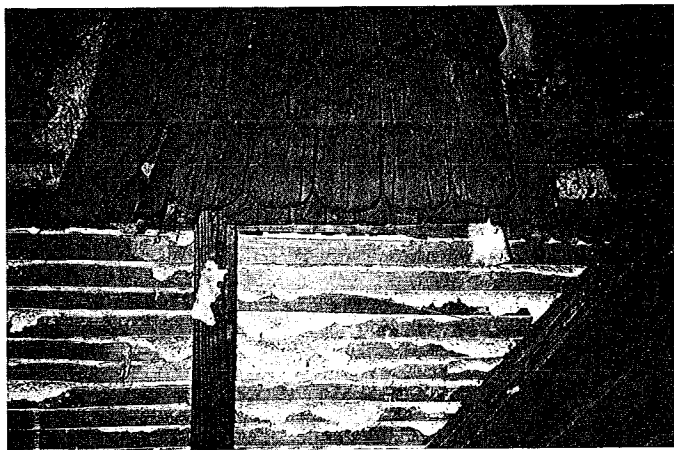
Specifications identify exactly what is to be received from the supplier, including the wooden shingles, nails, flashing, and applied coatings. The specifications also include instructions on removing the old roofing (sometimes two or more earlier roofs), and on preparing the surface for the new shingles, such as repairing damage to the lath or sheathing boards. If there are to be modifications to a standard product, such as cutting beveled butts, planing off residual surface circular saw marks, or controlling the mixture of acceptable widths (3"-8"), these too should be specified. Every instruction for modifying the shingles themselves should be written into the specifications or they may be overlooked.

The specifications and drawn details should describe special features important to the roof. Swept valleys, combed ridges, or wedged dormer cheek run-offs should each be detailed not only with the patterning of the shingles, but also with the placement of flashing or other unseen reinforcements. There are some modern products that appear to be useful. For example, paper-

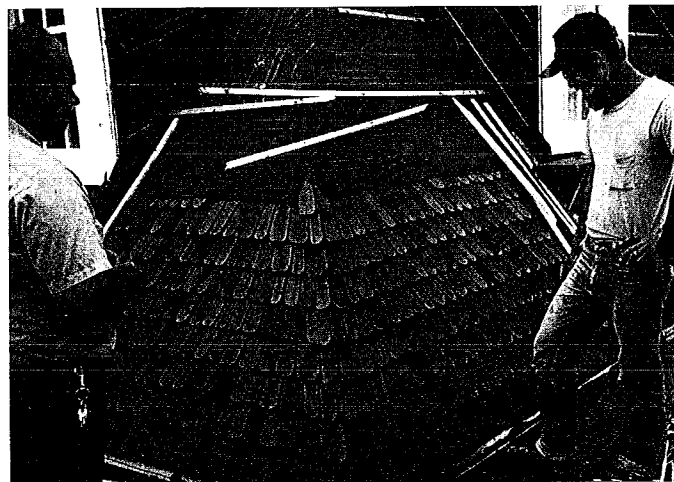
**Replacement Roofing for Appomattox Manor: City Point Unit of Petersburg National Battlefield, Hopewell, Virginia**



A. The later non-historic shingles were removed from Appomattox Manor (circa 1840 with later additions) and roofing paper was installed for temporary protection during the re-shingling.



B. These weathered historic 19th-century handsplit and dressed shingles were found in place under a later altered roof. Note the straight butt eave shingles under the curved butts of the historic dormer shingles.



D. The fanned hips (seen here), swept valleys, and projecting ridge combs were installed as part of the re-roofing project. Special features, when documented, should be reproduced when re-shingling historic roofs.

14. Original 19th-century handsplit and dressed wooden shingles 18" long, 3"-4" wide, and 5/8" thick were found in place on the Appomattox Manor at Hopewell, Virginia. The butts were curved and evidence of a red stain remained. The specifications and details were researched so that the appearance of the historic shingles and installation patterns could be matched in the re-shingling project. Photos: John Ingle.

**Excerpts from Specifications:**

**Type of wood to be used:** Western Red Cedar.

**Grade of wood and manufacturing process:** Number One, Tapersplit Shakes, 100% clear, 100% edge grain, 100% heartwood, no excessive grain sweeps, curvatures not to exceed 1/2" from level plain in length of shake; off grade (7% tolerance) material must *not* be used.

**Size of the shingle:** 18" long, 5/8" butt tapered to 1/4" head, 3"-4" wide, sawn curved butts, 5-1/2" exposure

**Surface finish and any applied coatings:** relatively smooth natural grain, no more than 1/8" variation in surface texture, butt thickness to be uniform throughout bundles. Site dipped with fire-rated chemicals tinted with red iron oxide for opaque color.

**Type of nails and flashing:** double hot dipped galvanized nails sized to penetrate sheathing totally; metal flashing to be 20 oz. lead-coated copper, or terne-coated stainless steel; additional flashing reinforcement to be aluminum foil type with fiber backing to use at hips, ridges, eaves, and valleys.

**Type of sheathing:** uninsulated attic, any deteriorated 3/4" sheathing boards, spaced 1/2"-3/4", to be replaced in kind.



C. The replacement shingles (see specifications above), matched the historic shingles and were of such high quality that little hand dressing was needed at the site. The building paper, a temporary protection, was removed as the shingles were installed on the sheathing boards.



E. In order to achieve a "Class B" fire-rating, the shingles were dipped in fire-retardant chemicals and allowed to dry prior to installation. Iron oxide was added to this chemical dip to stain the shingles to match the historic red color. These coatings will need periodic reapplication.

coated and reinforced metal-laminated flashing is easy to use and, in combination with other flashing, gives added protection over eaves and other vulnerable areas; adhesives give a stronger attachment at projecting roofing combs that could blow away in heavy wind storms. Clear or light-colored sealants may be less obvious than dark mastic often used in conjunction with flashing or repairs. These modern treatments should not be overlooked if they can prolong the life of the roof without changing its appearance.

### Roofing Practices to Avoid

Certain common roofing practices for modern installations should be avoided in re-roofing a historic building unless specifically approved in advance by the architect. These practices interfere with the proper drying of the shingles or result in a sloppy installation that will accelerate deterioration (see illus. 15). They include improper coverage and spacing of shingles, use of staples to hold shingles, inadequate ventilation, particularly for heavily insulated attics, use of heavy building felts as an underlayment, improper application of surface coatings causing stress in the wood surfaces, and use of inferior flashing that will fail while the shingles are still in good condition.

**Avoid skimpy shingle coverage and heavy building papers.** It has become a common modern practice to lay impregnated roofing felts under new wooden shingle roofs. The practice is especially prevalent in roofs that do not achieve a full triple layering of shingles. Historically, approximately one third of each single was exposed, thus making a three-ply or three-layered roof. This assured adequate coverage. Due to the expense of wooden shingles today, some roofers expose more of the shingle if the pitch of the roof allows, and compensate for less than three layers of shingles by using building felts interwoven at the top of each row of shingles. This absorptive material can hold moisture on the underside of the shingles and accelerate deterioration. If a shingle roof has proper coverage and proper flashing, such felts are unnecessary as a general rule.



15. These commercially available roofing products with rustic split faces are not appropriate for historic preservation projects. In addition to the inaccurate appearance, the irregular surfaces and often wide spaces between shingles will allow wind-driven moisture to penetrate up and under them. The excessively wide boards will tend to cup, curl and crack. Moss, lichens and debris will have a tendency to collect on these irregular surfaces, further deteriorating the roofing. Photo: Sharon C. Park.

However, the selective use of such felts or other reinforcements at ridges, hips and valleys does appear to be beneficial.

**Beware of heavily insulated attic rafters.** Historically, the longest lasting shingle roofs were generally the ones with the best roof ventilation. Roofs with shingling set directly on solid sheathing and where there is insulation packed tightly between the wooden rafters without adequate ventilation run the risk of condensation-related moisture damage to wooden roofing components. This is particularly true for air-conditioned structures. For that reason, if insulation must be used, it is best to provide ventilation channels between the rafters and the roof decking, to avoid heavy felt building papers, to consider the use of vapor barriers, and perhaps to raise the shingles slightly by using "sleepers" over the roof deck. This practice was popular in the 1920s in what the industry called a "Hollywood" installation, and examples of roofs lasting 60 years are partly due to this under-shingle ventilation (refer to illus. 9).

**Avoid staples and inferior flashing.** The common practice of using pneumatic staple guns to affix shingles can result in shooting staples through the shingles, in crushing the wood fibers, or in cracking the shingle. Instead, corrosion-resistant nails, generally with barked or deformed shanks long enough to extend about 3/4" into the roof decking, should be specified. Many good roofers have found that the pneumatic nail guns, fitted with the proper nails and set at the correct pressure with the nails just at the shingle surface, have worked well and reduced the stress on shingles from missed hammer blows. If red cedar is used, copper nails should not be specified because a chemical reaction between the wood and the copper will reduce the life of the roof. Hot-dipped, zinc-coated, aluminum, or stainless steel nails should be used. In addition, copper flashing and gutters generally should not be used with red cedar shingles as staining will occur, although there are some historic examples where very heavy gauge copper was used which outlasted the roof shingles. Heavier weight flashing (20 oz.) holds up better than lighter flashing, which may deteriorate faster than the shingles. Some metals may react with salts or chemicals used to treat the shingles. This should be kept in mind when writing specifications. Terne-coated stainless steel and lead-coated copper are generally the top of the line if copper is not appropriate.

**Avoid patching deteriorated roof lath or sheathing with plywood or composite materials.** Full size lumber may have to be custom-ordered to match the size and configuration of the original sheathing in order to provide an even surface for the new shingles. It is best to avoid plywood or other modern composition boards that may deteriorate or delaminate in the future if there is undetected moisture or leakage. If large quantities of shingle lath or sheathing must be removed and replaced, the work should be done in sections to avoid possible shifting or collapse of the roof structure.

**Avoid spray painting raw shingles on a roof after installation.** Rapidly drying solvent in the paint will tend to warp the exposed surface of the shingles. Instead, it is best to dip new shingles prior to installation to keep all of the wood fibers in the same tension. Once the entire shingle has been treated, however, later coats can be limited to the exposed surface.



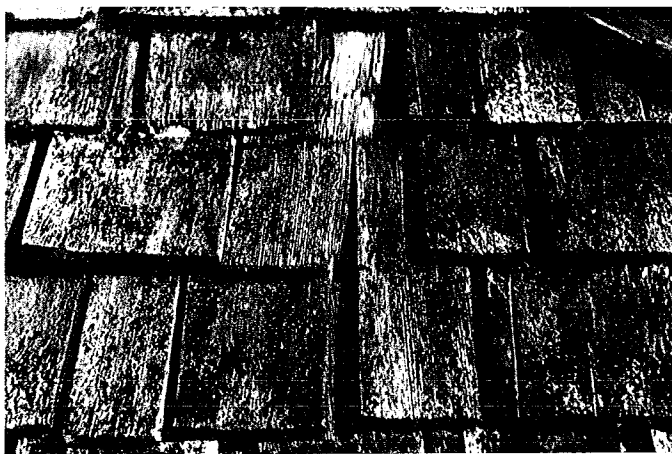
## Maintenance

The purpose of regular or routine maintenance is to extend the life of the roof. The roof must be kept clean and inspected for damage both to the shingles and to the flashing, sheathing, and gutters. If the roof is to be walked on, rubber soled shoes should be worn. If there is a simple ridge, a ladder can be hooked over the roof ridge to support and distribute the weight of the inspector.

Keeping the roof free of debris is important. This may involve only sweeping off pine needles, leaves and branches as needed. It may involve trimming overhanging branches. Other aspects of maintenance, such as removal of moss and lichen build-up, are more difficult. While they may impart a certain charm to roofs, these moisture-trapping organisms will rot the shingles and shorten the life of the roof. Buildups may need scraping and the residue removed with diluted bleaching solutions (chlorine), although caution should be used for surrounding materials and plants. Some roofers recommend power washing the roofs periodically to remove the dead wood cells and accumulated debris. While this makes the roof look relatively new, it can put a lot of water under shingles, and the high pressure may crack or otherwise damage them. The added water may also leach out applied coatings.

If the roof has been treated with a fungicide, stain, or revitalizing oil, it will need to be re-coated every few years (usually every 4-5). The manufacturer should be consulted as to the effective life of the coating. With the expense associated with installation of wood shingles, it is best to extend the life of the roof as long as possible. One practical method is to order enough shingles in the beginning to use for periodic repairs.

Periodic maintenance inspections of the roof may reveal loose or damaged shingles that can be selectively replaced before serious moisture damage occurs (see illus. 16). Keeping the wooden shingles in good condition and repairing the roof, flashing and guttering, as needed, can add years of life to the roof.



16. Routine maintenance is necessary to extend the life of the roof. On this roof, the shingles have not seriously eroded, but the presence of lichens and moss is becoming evident and there are a few cracked and missing shingles. The moss spores should be removed, missing shingles replaced, and small pieces of metal flashing slipped under cracked shingles to keep moisture from penetrating. Photo: Williamsport Preservation Training Center.

Cover Photo: 1907 view of a young couple's first home in a cedar stump with a shingled roof. Photo: Historical Society of Seattle and King County, Washington.

## Conclusion

A combination of careful research to determine the historic appearance of the roof, good specifications, and installation details designed to match the historic roof, and long-term maintenance, will make it possible to have not only a historically authentic roof, but a cost-effective one. It is important that professionals be part of the team from the beginning. A preservation architect should specify materials and construction techniques that will best preserve the roof's historic appearance. The shingle supplier must ensure that the best product is delivered and must stand behind the guarantee if the shipment is not correct. The roofer must be knowledgeable about traditional craft practices. Once the new shingle roof is in place, it must be properly maintained to give years of service.

## Acknowledgements

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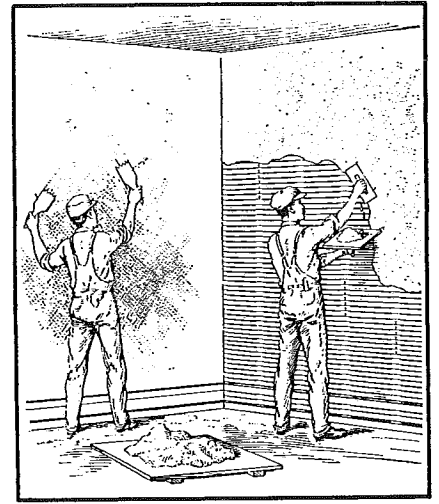
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# 21 PRESERVATION BRIEFS

## Repairing Historic Flat Plaster—Walls and Ceilings

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Plaster in a historic building is like a family album. The handwriting of the artisans, the taste of the original occupants, and the evolving styles of decoration are embodied in the fabric of the building. From modest farmhouses to great buildings, regardless of the ethnic origins of the occupants, plaster has traditionally been used to finish interior walls.

A versatile material, plaster could be applied over brick, stone, half-timber, or frame construction. It provided a durable surface that was easy to clean and that could be applied to flat or curved walls and ceilings.

Plaster could be treated in any number of ways: it could receive stenciling, decorative painting, wallpaper, or whitewash. This variety and the adaptability of the material to nearly any building size, shape, or configuration meant that plaster was the wall surface chosen for nearly all buildings until the 1930s or 40s (Fig. 1).

Historic plaster may first appear so fraught with problems that its total removal seems the only alternative. But there are practical and historical reasons for saving it. First, three-coat plaster is unmatched in strength

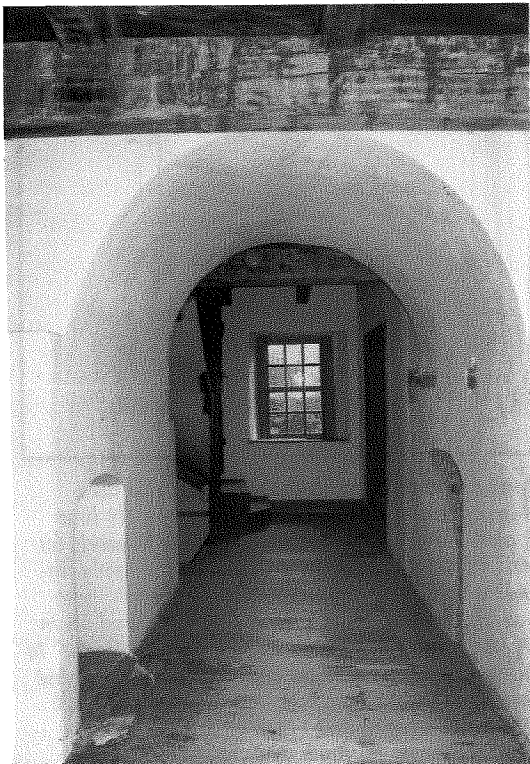


Fig. 1. Left: Schifferstadt, Frederick, Maryland, 1756. Right: First Christian Church, Eugene, Oregon, 1911. Although these two structures are separated in history by over 150 years and differences in size, ethnic origin, geography, construction techniques, and architectural character, their builders both used plaster as the interior surface coating for flat and curved walls. Photo left: Kay Weeks. Photo right: Kaye Ellen Simonson.

and durability. It resists fire and reduces sound transmission. Next, replacing plaster is expensive. A building owner needs to think carefully about the condition of the plaster that remains; plaster is often not as badly damaged as it first appears. Of more concern to preservationists, however, original lime and gypsum plaster is part of the building's historic fabric—its smooth-troweled or textured surfaces and subtle contours evoke the presence of America's earlier craftsmen. Plaster can also serve as a plain surface for irreplaceable decorative finishes. For both reasons, plaster walls and ceilings contribute to the historic character of the interior and should be left in place and repaired if at all possible (Fig. 2).

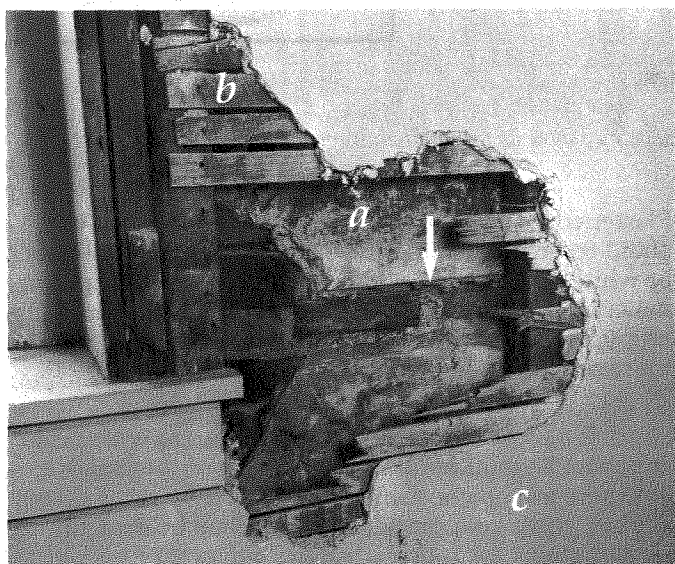


Fig. 2. A hole in the wall of a 1760s Custom House in Chestertown, Maryland illustrates the evolution of the room. (a) The original plaster was applied directly to an exterior masonry wall and the chairrail (missing here, see arrow) was in place before the wet plaster was applied to the wall. Sometime later when the interior was modified, the masonry was furred out. Machine-sawn wood lath (b) was nailed to the furring strips and (c) new three-coat plaster was applied. Photo: Maryland Historical Trust.

The approaches described in this Brief stress repairs using *wet* plaster, and traditional materials and techniques that will best assist the preservation of historic plaster walls and ceilings—and their appearance. Dry wall repairs are not included here, but have been written about extensively in other contexts. Finally, this Brief describes a replacement option when historic plaster cannot be repaired. Thus, a veneer plaster system is discussed rather than dry wall. Veneer systems include a coat or coats of *wet* plaster—although thinly applied—which can, to a greater extent, simulate traditional hand-troweled or textured finish coats. This system is generally better suited to historic preservation projects than dry wall.

To repair plaster, a building owner must often enlist the help of a plasterer. Plastering is a skilled craft, requiring years of training and special tools (Fig. 3). While minor repairs can be undertaken by building owners, most repairs will require the assistance of a plasterer.

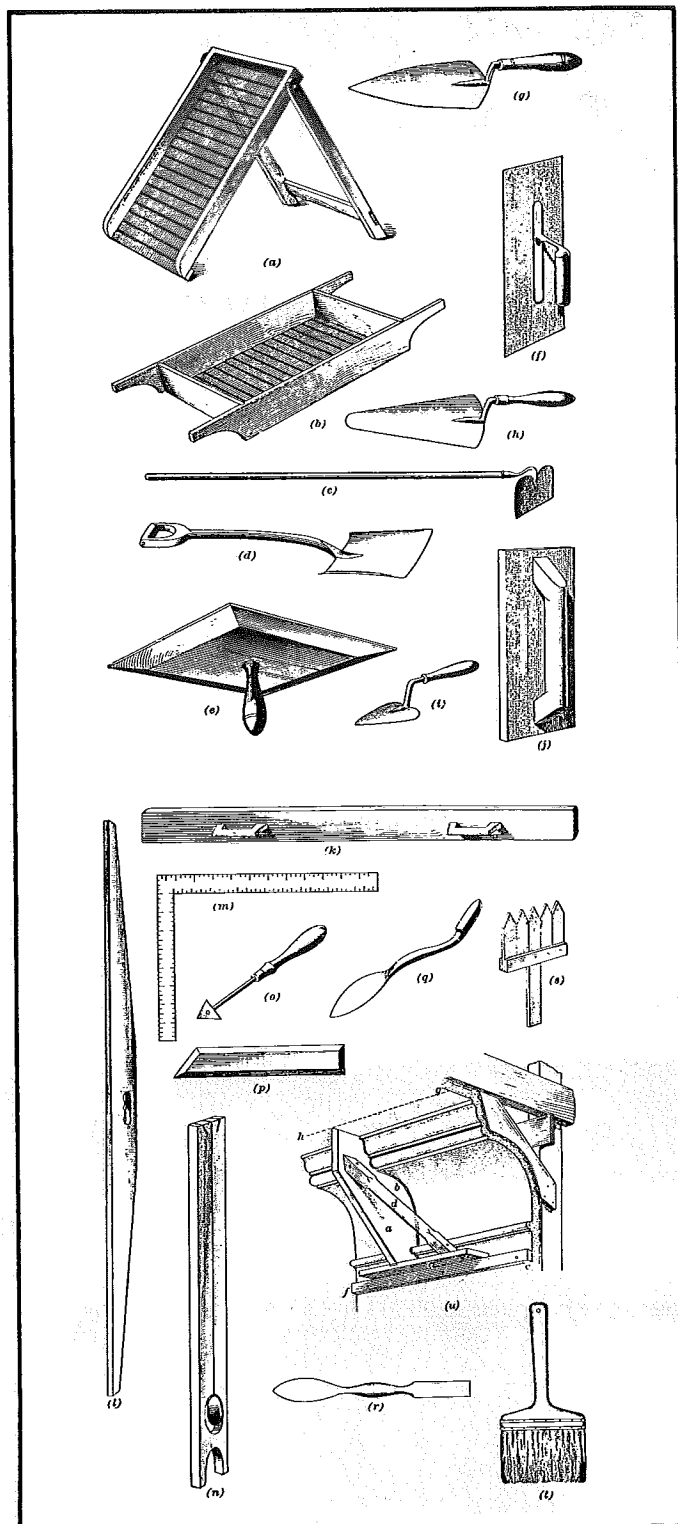


Fig. 3. Many of these traditional plastering tools are still used today: (a) screen to separate coarse sand from fine sand; (b) lime screen to remove unslaked particles of lime; (c) shovel; (d) hoe; (e) hawk to hold small amounts of plaster; (f) angle float to apply finishes to inside angles; (g), (h), (i) assorted trowels to apply base-coats and finish coat; (j) padded float to level off humps and fill in hollows caused by other tools; (k) a two-handled float or "darby" to float larger surfaces; (l) a simple straight edge; (m) a square to test the trueness of angles; (n) plumb to check verticality of plastered surfaces; (o), (p), (q), (r) jointing and mitering tools to pick out angles in decorative moldings; (s) comb made of sharpened lath pieces to scratch the basecoat of plaster; (t) brush to dampen plaster surfaces while they are worked smooth; (u) template made of wood and metal to cut a required outline for a fancy mold.



## Historical Background

Plasterers in North America have relied on two materials to create their handiwork—lime and gypsum. Until the end of the 19th century, plasterers used lime plaster. Lime plaster was made from four ingredients: lime, aggregate, fiber, and water. The lime came from ground-and-heated limestone or oyster shells; the aggregate from sand; and the fiber from cattle or hog hair. Manufacturing changes at the end of the 19th century made it possible to use gypsum as a plastering material. Gypsum and lime plasters were used in combination for the base and finish coats during the early part of the 20th century; gypsum was eventually favored because it set more rapidly and, initially, had a harder finish.

Not only did the basic plastering material change, but the method of application changed also. In early America, the windows, doors, and all other trim were installed before the plaster was applied to the wall (Fig. 4). Generally the woodwork was prime-painted before plastering. Obtaining a plumb, level wall, while working against built-up mouldings, must have been difficult. But sometime in the first half of the 19th century, builders began installing wooden plaster “grounds” around windows and doors and at the base of the wall. Installing these grounds so that they were level and plumb made the job much easier because the plasterer could work from a level, plumb, straight surface. Woodwork was then nailed to the “grounds” after the walls were plastered (Fig. 5). Evidence of plaster behind trim is often an aid to dating historic houses, or to discerning their physical evolution.



Fig. 4. The builders of this mid-18th century house installed the baseboard moulding first, then applied a mud and horse hair plaster (called *paling*) to the masonry wall. Lime was used for the finish plaster. Also shown are the hacking marks which prepared the wall for a subsequent layer of plaster. Photo: Kay Weeks.

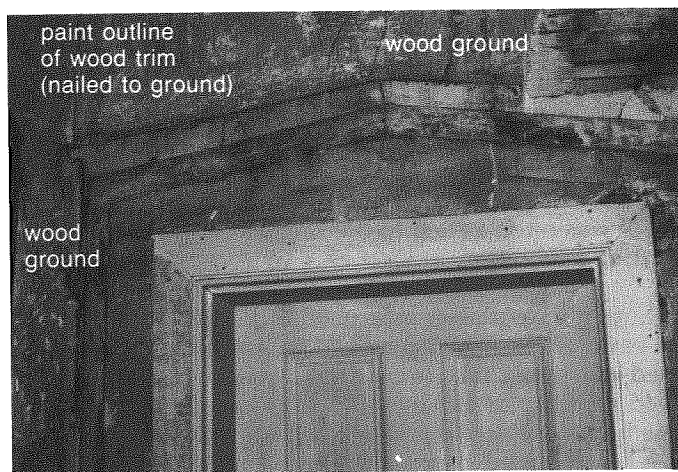


Fig. 5 (a). The photo above shows the use of wooden plaster “grounds” nailed to the wall studs of the mid-19th century Lockwood House in Harpers Ferry, West Virginia. This allowed the plasterer to work flush with the surface of the grounds. Afterwards, the carpenter could nail the finish woodwork to the ground, effectively hiding the joint between the plaster and the ground. The trim was painted after its installation, leaving a paint outline on the plaster. Fig. 5 (b). The photo below shows door trim and mouldings in place after the plastering was complete. Photos: Kaye Ellen Simonson.



### Lime Plaster

When building a house, plasterers traditionally mixed bags of quick lime with water to “hydrate” or “slake” the lime. As the lime absorbed the water, heat was given off. When the heat diminished, and the lime and water were thoroughly mixed, the lime putty that resulted was used to make plaster.

When lime putty, sand, water, and animal hair were mixed, the mixture provided the plasterer with “coarse stuff.” This mixture was applied in one or two layers to build up the wall thickness. But the best plaster was done with three coats. The first two coats made up the coarse stuff; they were the *scratch* coat and the *brown* coat. The finish plaster, called “setting stuff” contained a much higher proportion of lime putty, little aggregate, and no fiber, and gave the wall a smooth white surface finish.

Compared to the 3/8-inch-thick layers of the scratch and brown coats, the finish coat was a mere 1/8-inch thick. Additives were used for various finish qualities.



For example, fine white sand was mixed in for a "float finish." This finish was popular in the early 1900s. (If the plasterer raked the sand with a broom, the plaster wall would retain swirl marks or stipples.) Or marble dust was added to create a hard-finish white coat which could be smoothed and polished with a steel trowel. Finally, a little plaster of Paris, or "gauged stuff," was often added to the finish plaster to accelerate the setting time.

Although lime plaster was used in this country until the early 1900s, it had certain disadvantages. A plastered wall could take more than a year to dry; this delayed painting or papering. In addition, bagged quick lime had to be carefully protected from contact with air, or it became inert because it reacted with ambient moisture and carbon dioxide. Around 1900, gypsum began to be used as a plastering material.

### Gypsum Plaster

Gypsum begins to cure as soon as it is mixed with water. It sets in minutes and completely dries in two to three weeks. Historically, gypsum made a more rigid plaster and did not require a fibrous binder. However, it is difficult to tell the difference between lime and gypsum plaster once the plaster has cured.

Despite these desirable working characteristics, gypsum plaster was more vulnerable to water damage than lime. Lime plasters had often been applied directly to masonry walls (without lathing), forming a suction bond. They could survive occasional wind-driven moisture or water wicking up from the ground. Gypsum plaster needed protection from water. Furring strips had to be used against masonry walls to create a dead air space. This prevented moisture transfer.

In rehabilitation and restoration projects, one should rely on the plasterer's judgment about whether to use lime or gypsum plaster. In general, gypsum plaster is the material plasterers use today. Different types of aggregate may be specified by the architect such as clean river sand, perlite, pumice, or vermiculite; however, if historic finishes and textures are being replicated, sand should be used as the base-coat aggregate. Today, if fiber is required in a base coat, a special gypsum is available which includes wood fibers. Lime putty, mixed with about 35 percent gypsum (gauging plaster) to help it harden, is still used as the finish coat.

### Lath

Lath provided a means of holding the plaster in place. Wooden lath was nailed at right angles directly to the structural members of the buildings (the joists and studs), or it was fastened to non-structural spaced strips known as furring strips. Three types of lath can be found on historic buildings (Fig. 6).

**Wood Lath.** Wood lath is usually made up of narrow, thin strips of wood with spaces in between. The plasterer applies a slight pressure to push the wet plaster through the spaces. The plaster slumps down on the inside of the wall, forming plaster "keys." These keys hold the plaster in place.

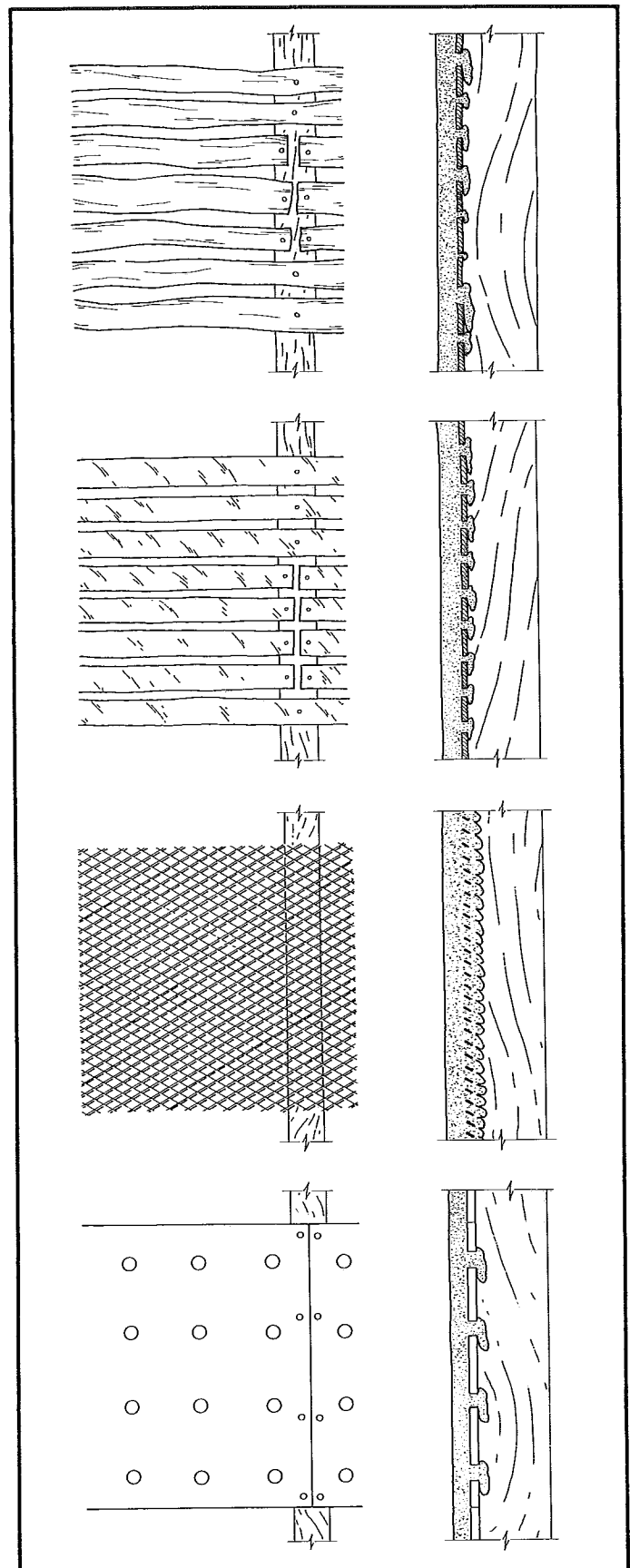


Fig. 6. Top to bottom: Hand-riven lath, machine-sawn wood lath, expanded metal (diamond mesh) lath, and perforated gypsum board lath. Profile views of their keying characteristics are shown to the right. For plaster repairs or replastering, galvanized metal lath is the most reliable in terms of longevity, stability, and proper keying. Drawing: Kaye Ellen Simonson.

**Metal Lath.** Metal lath, patented in England in 1797, began to be used in parts of the United States toward the end of the 19th century. The steel making up the metal lath contained many more spaces than wood lath had contained. These spaces increased the number of keys; metal lath was better able to hold plaster than wood lath had been.

**Rock Lath.** A third lath system commonly used was rock lath (also called plaster board or gypsum-board lath). In use as early as 1900, rock lath was made up of compressed gypsum covered by a paper facing. Some rock lath was textured or perforated to provide a key for wet plaster. A special paper with gypsum crystals in it provides the key for rock lath used today; when wet plaster is applied to the surface, a crystalline bond is achieved.

Rock lath was the most economical of the three lathing systems. Lathers or carpenters could prepare a room more quickly. By the late 1930s, rock lath was used almost exclusively in residential plastering.

## Common Plaster Problems

When plaster dries, it is a relatively rigid material which should last almost indefinitely. However, there are conditions that cause plaster to crack, effloresce, separate, or become detached from its lath framework (Fig. 7). These include:

- Structural Problems
- Poor Workmanship
- Improper Curing
- Moisture

### Structural Problems

**Overloading.** Stresses within a wall, or acting on the house as a whole, can create stress cracks. Appearing as diagonal lines in a wall, stress cracks usually start at a door or window frame, but they can appear anywhere in the wall, with seemingly random starting points.

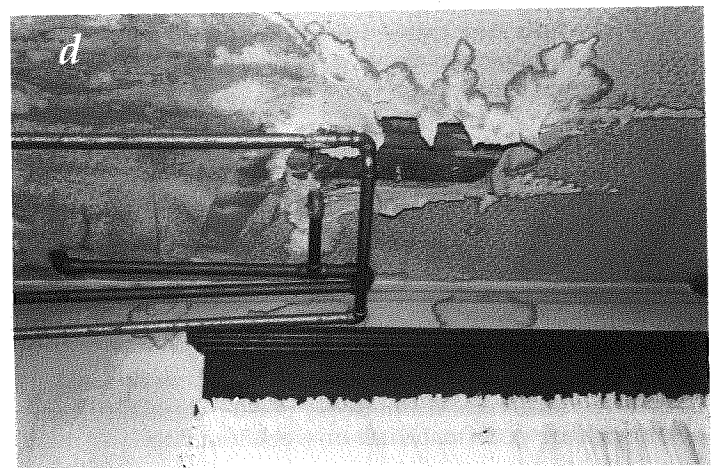
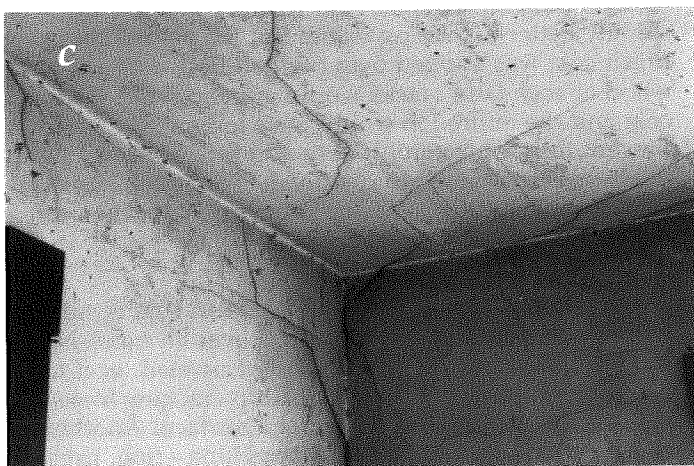
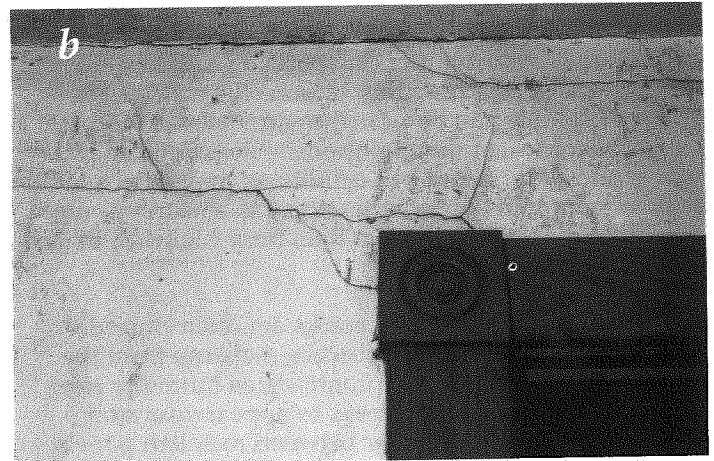


Fig. 7 (a) to (d). A series of photographs taken in different rooms of an early 20th century house in West Virginia reveal a variety of plaster wall surface problems, most of which can easily be remedied through sensitive repair: Hairline cracks (a) in an otherwise sound wall can be filled with joint compound or patched plaster. The wall can also be canvassed or wallpapered. Stress cracks (b) in plaster over a kitchen door frame can be repaired using fiberglass mesh tape and joint compound. Settlement cracks (c) in a bedroom can be similarly repaired. The dark crack at the juncture between walls, however, may be a structural crack and should be investigated for its underlying cause. Moisture damage (d) from leaking plumbing on the second floor has damaged both wallpaper and plaster in the dining room. After fixing the leaking pipes, the wall covering and rotted plaster will need to be replaced and any holes repaired. Photos: Kay Weeks.

Builders of now-historic houses had no codes to help them size the structural members of buildings. The weight of the roof, the second and third stories, the furniture, and the occupants could impose a heavy burden on beams, joists, and studs. Even when houses were built properly, later remodeling efforts may have cut in a doorway or window without adding a structural beam or "header" across the top of the opening. Occasionally, load-bearing members were simply too small to carry the loads above them. Deflection or wood "creep" (deflection that occurs over time) can create cracks in plaster.

Overloading and structural movement (especially when combined with rotting lath, rusted nails, or poor quality plaster) can cause plaster to detach from the lath. The plaster loses its key. When the mechanical bond with the lath is broken, plaster becomes loose or bowed. If repairs are not made, especially to ceilings, gravity will simply cause chunks of plaster to fall to the floor.

**Settlement/Vibration.** Cracks in walls can also result when houses settle. Houses built on clay soils are especially vulnerable. Many types of clay (such as montmorillonite) are highly expansive. In the dry season, water evaporates from the clay particles, causing them to contract. During the rainy season, the clay swells. Thus, a building can be riding on an unstable footing. Diagonal cracks running in opposite directions suggest that house settling and soil conditions may be at fault. Similar symptoms occur when there is a nearby source of vibration—blasting, a train line, busy highway, or repeated sonic booms.

**Lath movement.** Horizontal cracks are often caused by lath movement. Because it absorbs moisture from the air, wood lath expands and contracts as humidity rises and falls. This can cause cracks to appear year after year. Cracks can also appear between rock lath panels. A nail holding the edge of a piece of lath may rust or loosen, or structural movement in the wood framing behind the lath may cause a seam to open. Heavy loads in a storage area above a rock-lath ceiling can also cause ceiling cracks.

Errors in initial building construction such as improper bracing, poor corner construction, faulty framing of doors and windows, and undersized beams and floor joists eventually "telegraph" through to the plaster surface.

### Poor Workmanship

In addition to problems caused by movement or weakness in the structural framework, plaster durability can be affected by poor materials or workmanship.

**Poorly proportioned mix.** The proper proportioning and mixing of materials are vital to the quality of the plaster job. A bad mix can cause problems that appear years later in a plaster wall. Until recently, proportions of aggregate and lime were mixed on the job. A plasterer may have skimped on the amount of cementing material (lime or gypsum) because sand was the

cheaper material. Oversanding can cause the plaster to weaken or crumble (Fig. 8). Plaster made from a poorly proportioned mix may be more difficult to repair.



Fig. 8. Too much aggregate (sand) and not enough cementing material (lime or gypsum) in the base coat has made this plaster surface weak and crumbly. Besides losing its key with the lath, the layers are disintegrating. It will most likely need to be totally removed and replaced with all new plaster. Photo: Marylee MacDonald.

**Incompatible basecoats and finish coats.** Use of perlite as an aggregate also presented problems. Perlite is a lightweight aggregate used in the base coat instead of sand. It performs well in cold weather and has a slightly better insulating value. But if a smooth lime finish coat was applied over perlited base coats on wood or rock lath, cracks would appear in the finish coat and the entire job would have to be re-done. To prevent this, a plasterer had to add fine silica sand or finely crushed perlite to the finish coat to compensate for the dramatically differing shrinkage rates between the base coat and the finish coat.

**Improper plaster application.** The finish coat is subject to "chip cracking" if it was applied over an excessively dry base coat, or was insufficiently troweled, or if too little gauging plaster was used. Chip cracking looks very much like an alligatorated paint surface. Another common problem is called map cracking—fine, irregular cracks that occur when the finish coat has been applied to an oversanded base coat or a very thin base coat.

**Too much retardant.** Retarding agents are added to slow down the rate at which plaster sets, and thus inhibit hardening. They have traditionally included ammonia,

glue, gelatin, starch, molasses, or vegetable oil. If the plasterer has used too much retardant, however, a gypsum plaster will not set within a normal 20 to 30 minute time period. As a result, the surface becomes soft and powdery.

**Inadequate plaster thickness.** Plaster is applied in three coats over wood lath and metal lath—the scratch, brown, and finish coats. In three-coat work, the scratch coat and brown coat were sometimes applied on successive days to make up the required wall thickness. Using rock lath allowed the plasterer to apply one base coat and the finish coat—a two-coat job.

If a plasterer skimped on materials, the wall may not have sufficient plaster thickness to withstand the normal stresses within a building. The minimum total thickness for plaster on gypsum board (rock lath) is 1/2 inch. On metal lath the minimum thickness is 5/8 inch; and for wood lath it is about 3/4 to 7/8 inch. This minimum plaster thickness may affect the thickness of trim projecting from the wall's plane.

### Improper Curing

Proper temperature and air circulation during curing are key factors in a durable plaster job. The ideal temperature for plaster to cure is between 55–70 degrees Fahrenheit. However, historic houses were sometimes plastered before window sashes were put in. There was no way to control temperature and humidity.

**Dryouts, freezing, and sweat-outs.** When temperatures were too hot, the plaster would return to its original condition before it was mixed with water, that is, calcined gypsum. A plasterer would have to spray the wall with alum water to re-set the plaster. If freezing occurred before the plaster had set, the job would simply have to be re-done. If the windows were shut so that air could not circulate, the plaster was subject to sweat-out or rot. Since there is no cure for rotted plaster, the affected area had to be removed and replastered.

### Moisture

Plaster applied to a masonry wall is vulnerable to water damage if the wall is constantly wet. When salts from the masonry substrate come in contact with water, they migrate to the surface of the plaster, appearing as dry bubbles or efflorescence. The source of the moisture must be eliminated before replastering the damaged area.

**Sources of Water Damage.** Moisture problems occur for several reasons. Interior plumbing leaks in older houses are common. Roofs may leak, causing ceiling damage. Gutters and downspouts may also leak, pouring rain water next to the building foundation. In brick buildings, dampness at the foundation level can wick up into the above-grade walls. Another common source of moisture is splash-back. When there is a paved area next to a masonry building, rainwater splashing up from the paving can dampen masonry walls. In both cases water travels through the masonry and damages interior plaster. Coatings applied to the

interior are not effective over the long run. The moisture problem must be stopped on the outside of the wall.

## Repairing Historic Plaster

Many of the problems described above may not be easy to remedy. If major structural problems are found to be the source of the plaster problem, the structural problem should be corrected. Some repairs can be made by removing only small sections of plaster to gain access. Minor structural problems that will not endanger the building can generally be ignored. Cosmetic damages from minor building movement, holes, or bowed areas can be repaired without the need for wholesale demolition. However, it may be necessary to remove deteriorated plaster caused by rising damp in order for masonry walls to dry out. Repairs made to a wet base will fail again.

### Canvassing Uneven Wall Surfaces

Uneven wall surfaces, caused by previous patching or by partial wallpaper removal, are common in old houses. As long as the plaster is generally sound, cosmetically unattractive plaster walls can be “wallpapered” with strips of a canvas or fabric-like material. Historically, canvassing covered imperfections in the plaster and provided a stable base for decorative painting or wallpaper.

### Filling Cracks

Hairline cracks in wall and ceiling plaster are not a serious cause for concern as long as the underlying plaster is in good condition. They may be filled easily with a patching material (see **Patching Materials**, page 13). For cracks that re-open with seasonal humidity change, a slightly different method is used. First the crack is widened slightly with a sharp, pointed tool such as a crack widener or a triangular can opener. Then the crack is filled. For more persistent cracks, it may be necessary to bridge the crack with tape. In this instance, a fiberglass mesh tape is pressed into the patching material. After the first application of a quick-setting joint compound dries, a second coat is used to cover the tape, feathering it at the edges. A third coat is applied to even out the surface, followed by light sanding. The area is cleaned off with a damp sponge, then dried to remove any leftover plaster residue or dust.

When cracks are larger and due to structural movement, repairs need to be made to the structural system *before* repairing the plaster. Then, the plaster on each side of the crack should be removed to a width of about 6 inches down to the lath. The debris is cleaned out, and metal lath applied to the cleared area, leaving the existing wood lath in place. The metal lath usually prevents further cracking. The crack is patched with an appropriate plaster in three layers (i.e., basecoats and finish coat). If a crack seems to be expanding, a structural engineer should be consulted.



## Replacing Delaminated Areas of the Finish Coat

Sometimes the finish coat of plaster comes loose from the base coat (Fig. 9). In making this type of repair, the plasterer paints a liquid plaster-bonding agent onto the areas of base-coat plaster that will be replastered with a new lime finish coat. A homeowner wishing to repair small areas of delaminated finish coat can use the methods described in **Patching Materials**.

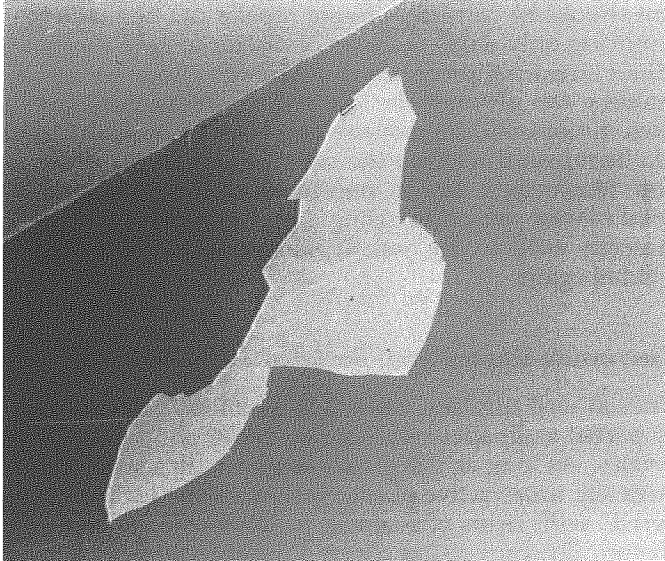


Fig. 9. The smooth-troweled lime finish coat has delaminated from the brown coat underneath. This is another repair that can be undertaken without further loss of the historic plaster. Photo: Marylee MacDonald.

## Patching Holes in Walls

For small holes (less than 4 inches in diameter) that involve loss of the brown and finish coats, the repair is made in two applications. First, a layer of basecoat plaster is troweled in place and scraped back below the level of the existing plaster. When the base coat has set but not dried, more plaster is applied to create a smooth, level surface. One-coat patching is not generally recommended by plasterers because it tends to produce concave surfaces that show up when the work is painted. Of course, if the lath only had one coat of plaster originally, then a one-coat patch is appropriate (Fig. 10).

For larger holes where all three coats of plaster are damaged or missing down to the wood lath, plasterers generally proceed along these lines. First, all the old plaster is cleaned out and any loose lath is re-nailed. Next, a water mist is sprayed on the old lath to keep it from twisting when the new, wet plaster is applied, or better still, a bonding agent is used. To provide more reliable keying and to strengthen the patch, expanded metal lath (diamond mesh) should be attached to the wood lath with tie wires or nailed over the wood lath with lath nails (Fig. 11). The plaster is then applied in three layers over the metal lath, lapping each new layer of plaster over the old plaster so that old and new are evenly joined. This stepping is recommended to produce a strong, invisible patch (Fig. 12). Also, if a patch is made in a plaster wall that is slightly wavy, the contour of the patch should be made to conform to the irregularities of the existing work. A flat patch will stand out from the rest of the wall.

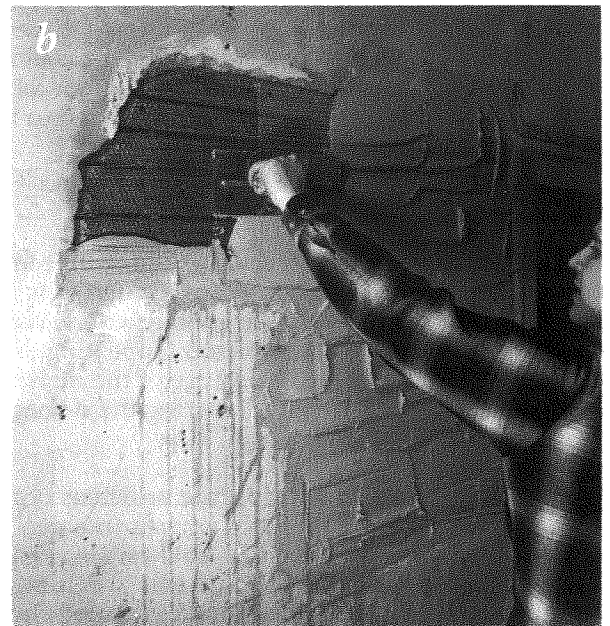


Fig. 10 (a) and (b). In this New Hampshire residence dating from the 1790s, the original plaster was a single coat of lime, sand, and horsehair applied over split lath. A one-coat repair, in this case, is appropriate. To the left: a flat sheet of galvanized expanded metal lath is placed over the patch area and an outline marked with a large soft lumber crayon. The metal lath is then cut to fit the hole and nailed to the lath. To the right: the edges of the original plaster and wood lath beneath have been thoroughly soaked with water. A steel trowel is used to apply the plaster in large, rough strokes. Finally, it will be scraped and smoothed off. Because only one coat of plaster is used, without a finish coat, a clean butt-joint is made with the original plaster. Photos: John Leeke.

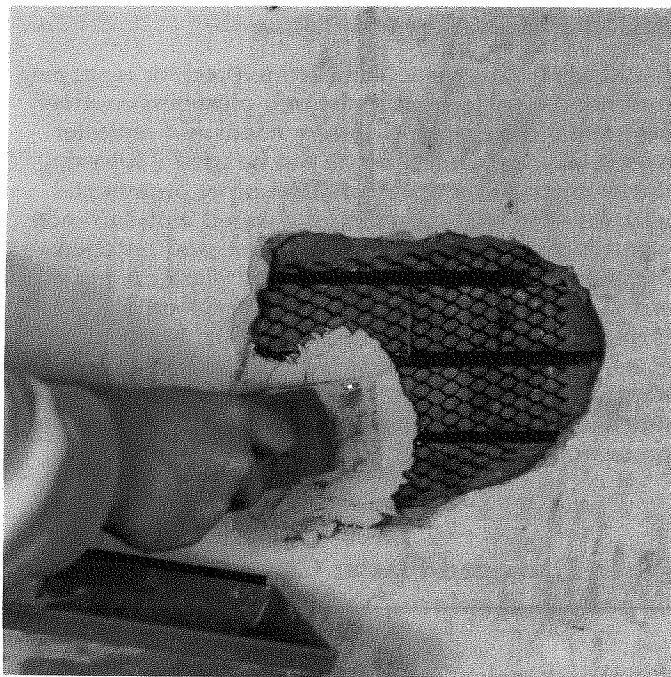


Fig. 11. Repairs are being made to the historic plaster in an early 20th century residence in Tennessee. A fairly sizeable hole in three-coat plaster extends to the wood lath. Expanded metal lath has been cut to fit the hole, then attached to the wood lath with a tie-wire. Two ready-mix gypsum base coats are in the process of being applied. After they set, the finish coat will be smooth-troweled gauged lime to match the existing wall. Photo: Walter Jowers.

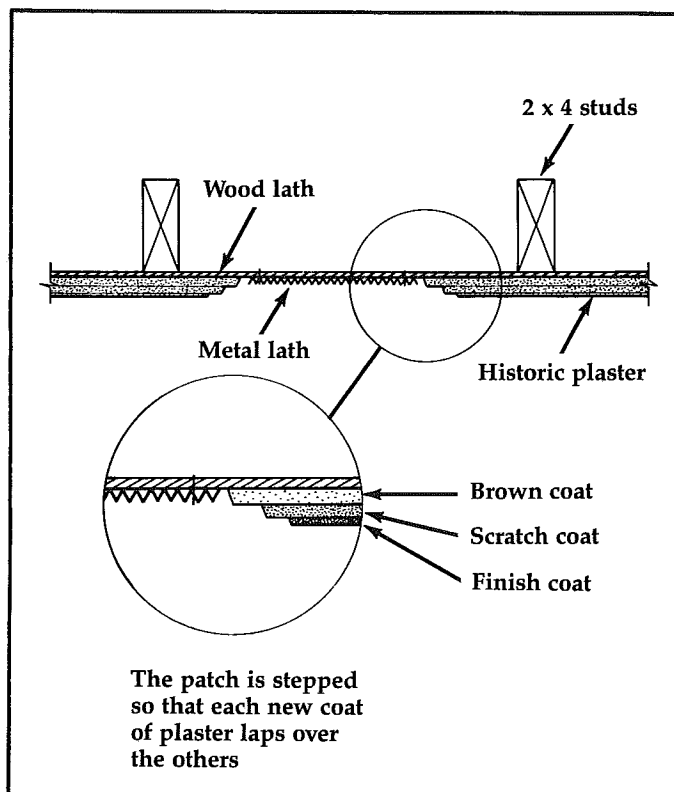


Fig. 12. This explains how a hole in historic plaster is repaired over the existing wood lath. First, metal lath is secured over the wood lath with a tie wire, then the new plaster is applied in three layers, "stepped" so that each new coat overlaps the old plaster to create a good adhesive bond. Drawing: Kaye Ellen Simonson.

## Patching Holes in Ceilings

Hairline cracks and holes may be unsightly, but when portions of the ceiling come loose, a more serious problem exists (Fig. 13). The keys holding the plaster to the ceiling have probably broken. First, the plaster around the loose plaster should be examined. Keys may have deteriorated because of a localized moisture problem, poor quality plaster, or structural overloading; yet, the surrounding system may be intact. If the areas surrounding the loose area are in reasonably good condition, the loose plaster can be reattached to the lath using flat-head wood screws and plaster washers (Fig. 14). To patch a hole in the ceiling plaster, metal lath is fastened over the wood lath; then the hole is filled with successive layers of plaster, as described above.



Fig. 13. This beaded ceiling in one of the bedrooms of the 1847 Lockwood House, Harpers Ferry, West Virginia, is missing portions of plaster due to broken keys. This is attributable, in part, to deterioration of the wood lath. Photo: Kaye Ellen Simonson.

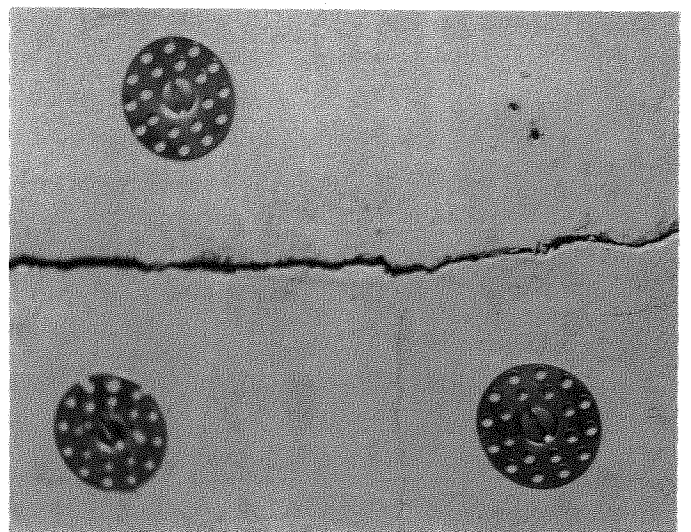


Fig. 14. In a late 18th century house in Massachusetts, flat-head wood screws and plaster washers were used to reattach loose ceiling plaster to the wood lath. After the crack is covered with fiberglass mesh tape, both the taped crack and the plaster washers will be skim-coated with a patching material. Photo: John Obed Curtis.

## Establishing New Plaster Keys

If the back of the ceiling lath is accessible (usually from the attic or after removing floor boards), small areas of bowed-out plaster can be pushed back against the lath. A padded piece of plywood and braces are used to secure the loose plaster. After dampening the old lath and coating the damaged area with a bonding agent, a fairly liquid plaster mix (with a glue size retardant added) is applied to the backs of the lath, and worked into the voids between the faces of the lath and the back of the plaster. While this first layer is still damp, plaster-soaked strips of jute scrim are laid across the backs of the lath and pressed firmly into the first layer as reinforcement. The original lath must be secure, otherwise the weight of the patching plaster may loosen it.

Loose, damaged plaster can also be re-keyed when the goal is to conserve decorative surfaces or wallpaper. Large areas of ceilings and walls can be saved. This method requires the assistance of a skilled conservator—it is not a repair technique used by most plasterers. The conservator injects an acrylic adhesive mixture through holes drilled in the face of the plaster (or through the lath from behind, when accessible). The loose plaster is held firm with plywood bracing until the adhesive bonding mixture sets. When complete, gaps between the plaster and lath are filled, and the loose plaster is secure (Fig. 15).

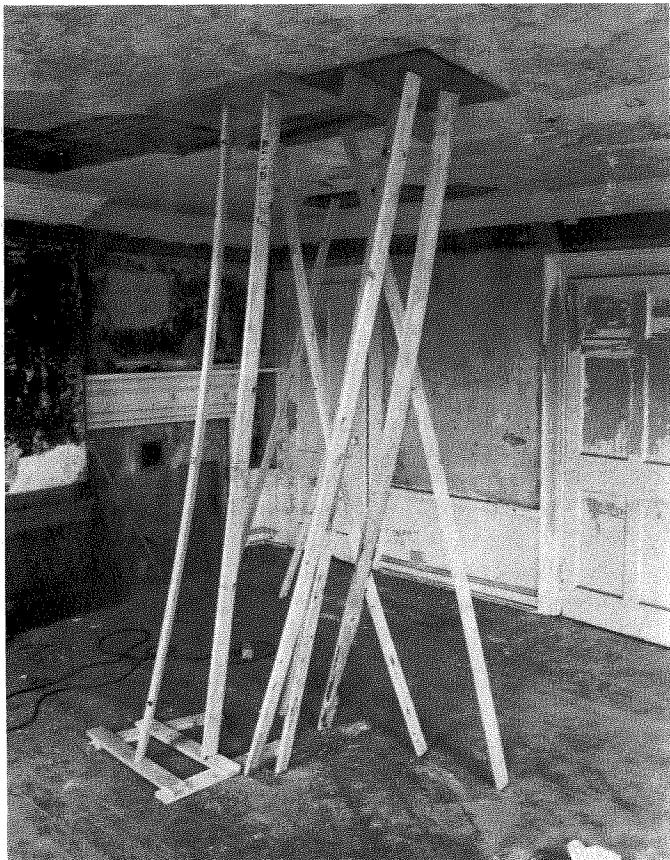


Fig. 15. When ceiling repairs are made with wet plaster or with an injected adhesive mixture, the old loose plaster must be supported with a plywood brace until re-keying is complete. Photo: John Leeke.

## Replastering Over the Old Ceiling

If a historic ceiling is too cracked to patch or is sagging (but not damaged from moisture), plasterers routinely keep the old ceiling and simply relath and replaster over it. This repair technique can be used if lowering the ceiling slightly does not affect other ornamental features. The existing ceiling is covered with 1x3-inch wood furring strips, one to each joist, and fastened completely through the old lath and plaster using a screw gun. Expanded metal lath or gypsum board lath is nailed over the furring strips. Finally, two or three coats are applied according to traditional methods. Replastering over the old ceiling saves time, creates much less dust than demolition, and gives added fire protection.

## When Damaged Plaster Cannot be Repaired—Replacement Options

Partial or complete removal may be necessary if plaster is badly damaged, particularly if the damage was caused by long-term moisture problems. Workers undertaking demolition should wear OSHA-approved masks because the plaster dust that flies into the air may contain decades of coal soot. Lead, from lead-based paint, is another danger. Long-sleeved clothing and head-and-eye protection should be worn. Asbestos, used in the mid-twentieth century as an insulating and fireproofing additive, may also be present and OSHA-recommended precautions should be taken. If plaster in adjacent rooms is still in good condition, walls should not be pounded—a small trowel or pry bar is worked behind the plaster carefully in order to pry loose pieces off the wall.

When the damaged plaster has been removed, the owner must decide whether to replaster over the existing lath or use a different system. This decision should be based in part on the thickness of the original plaster and the condition of the original lath. Economy and time are also valid considerations. It is important to ensure that the wood trim around the windows and doors will have the same “reveal” as before. (The “reveal” is the projection of the wood trim from the surface of the plastered wall). A lath and plaster system that will give this required depth should be selected.

## Replastering—Alternative Lath Systems for New Plaster

**Replastering old wood lath.** When plasterers work with old lath, each lath strip is re-nailed and the chunks of old plaster are cleaned out. Because the old lath is dry, it must be thoroughly soaked before applying the base coats of plaster, or it will warp and buckle; furthermore, because the water is drawn out, the plaster will fail to set properly. As noted earlier, if new metal lath is installed *over* old wood lath as the base for new plaster,



many of these problems can be avoided and the historic lath can be retained (Fig. 16). The ceiling should still be sprayed unless a vapor barrier is placed behind the metal lath.

**Replastering over new metal lath.** An alternative to reusing the old wood lath is to install a different lathing system. Galvanized metal lath is the most expensive, but also the most reliable in terms of longevity, stability, and proper keying. When lathing over open joists, the plasterer should cover the joists with kraft paper or a polyethylene vapor barrier. Three coats of wet plaster are applied consecutively to form a solid, monolithic unit with the lath. The scratch coat keys into the metal lath; the second, or brown, coat bonds to the scratch coat and builds the thickness; the third, or finish coat, consists of lime putty and gauging plaster.

**Replastering over new rock lath.** It is also possible to use rock lath as a plaster base. Plasterers may need to remove the existing wood lath to maintain the woodwork's reveal. Rock lath is a 16x36-inch, 1/2-inch thick, gypsum-core panel covered with absorbent paper with gypsum crystals in the paper. The crystals in the paper bond the wet plaster and anchor it securely. This type of lath requires two coats of new plaster—the brown coat and the finish coat. The gypsum lath itself takes the place of the first, or scratch, coat of plaster.

### Painting New Plaster

The key to a successful paint job is proper drying of the plaster. Historically, lime plasters were allowed to cure for at least a year before the walls were painted or papered. With modern ventilation, plaster cures in a shorter time; however, fresh gypsum plaster with a lime finish coat should still be perfectly dry before paint is applied—or the paint may peel. (Plasterers traditionally used the "match test" on new plaster. If a match would light by striking it on the new plaster surface, the plaster was considered dry.) Today it is best to allow new plaster to cure two to three weeks. A good alkaline-resistant primer, specifically formulated for new plaster, should then be used. A compatible latex or oil-based paint can be used for the final coat.

### A Modern Replacement System

**Veneer Plaster.** Using one of the traditional lath and plaster systems provides the highest quality plaster job. However, in some cases, budget and time considerations may lead the owner to consider a less expensive replacement alternative. Designed to reduce the cost of materials, a more recent lath and plaster system is less expensive than a two-or-three coat plaster job, but only slightly more expensive than drywall. This plaster system is called veneer plaster.



Fig. 16. In the restoration of a ca. 1830s house in Maine, split-board lath has been covered with expanded metal lath in preparation for new coats of plaster. This method permits the early lath to be saved while the metal lath, with its superior keying, serves as reinforcement. Photo: National Park Service files.



The system uses gypsum-core panels that are the same size as drywall (4x8 feet), and specially made for veneer plaster. They can be installed over furring channels to masonry walls or over old wood lath walls and ceilings. Known most commonly as "blueboard," the panels are covered with a special paper compatible with veneer plaster. Joints between the 4-foot wide sheets are taped with fiberglass mesh, which is bedded in the veneer plaster. After the tape is bedded, a thin, 1/16-inch coat of high-strength veneer plaster is applied to the entire wall surface. A second veneer layer can be used as the "finish" coat, or the veneer plaster can be covered with a gauged lime finish-coat—the same coat that covers ordinary plaster (Fig. 17).



*Fig. 17. This contemporary plasterer is mixing a lime finish coat in much the same way as America's earlier artisans. The ring consists of lime putty; the white powder inside is gauging plaster. After the mixture is blended, a steel trowel will be used to apply it. It should be noted that a traditional lime finish coat can be applied over a veneer plaster base coat to approximate the look of historic plaster walls and ceilings. Photo: Marylee MacDonald.*

Although extremely thin, a two-coat veneer plaster system has a 1,500 psi rating and is thus able to withstand structural movements in a building or surface abrasion. With either a veneer finish or a gauged lime-putty finish coat, the room will be ready for painting almost immediately. When complete, the troweled or textured wall surface looks more like traditional plaster than drywall.

The thin profile of the veneer system has an added benefit, especially for owners of uninsulated masonry buildings. Insulation can be installed between the pieces of furring channel used to attach blueboard to masonry walls. This can be done without having to furr out the window and door jambs. The insulation plus the veneer system will result in the same thickness as the original plaster. Occupants in the rooms will be more comfortable because they will not be losing heat to cold wall surfaces.

## Summary

The National Park Service recommends retaining historic plaster if at all possible. Plaster is a significant part of the "fabric" of the building. Much of the building's history is documented in the layers of paint and paper found covering old plaster. For buildings with decorative painting, conservation of historic flat plaster is even more important. Consultation with the National Park Service, with State Historic Preservation Officers, local preservation organizations, historic preservation consultants, or with the Association for Preservation Technology is recommended. Where plaster cannot be repaired or conserved using one of the approaches outlined in this Brief, documentation of the layers of wallpaper and paint should be undertaken before removing the historic plaster. This information may be needed to complete a restoration plan.

## Patching Materials

Plasterers generally use ready-mix base-coat plaster for patching, especially where large holes need to be filled. The ready-mix plaster contains gypsum and aggregate in proper proportions. The plasterer only needs to add water.

Another mix plasterers use to patch cracks or small holes, or for finish-coat repair, is a "high gauge" lime putty (50 percent lime; 50 percent gauging plaster). This material will produce a white, smooth patch. It is especially suitable for surface repairs.

Although property owners cannot duplicate the years of accumulated knowledge and craft skills of a professional plasterer, there are materials that can be used for do-it-yourself repairs. For example, fine cracks can be filled with an all-purpose drywall joint compound. For bridging larger cracks using fiberglass tape, a homeowner can use a "quick-setting" joint compound. This compound has a fast drying time—60, 90, or 120 minutes. Quick-setting joint compound dries because of a chemical reaction, not because of water evaporation. It shrinks less than all-purpose joint compound and has much the same workability as ready-mix base-coat

plaster. However, because quick-set joint compounds are hard to sand, they should only be used to bed tape or to fill large holes. All-purpose joint compound should be used as the final coat prior to sanding.

Homeowners may also want to try using a ready-mix perlited base-coat plaster for scratch and brown coat repair. The plaster can be hand-mixed in small quantities, but bagged ready-mix should be protected from ambient moisture. A "mill-mixed pre-gauged" lime finish coat plaster can also be used by homeowners. A base coat utilizing perlite or other lightweight aggregates should only be used for making small repairs (less than 4 ft. patches). For large-scale repairs and entire room re-plastering, see the precautions in Table 1 for using perlite.

Homeowners may see a material sold as "patching plaster" or "plaster of Paris" in hardware stores. This dry powder cannot be used by itself for plaster repairs. It must be combined with lime to create a successful patching mixture.

When using a lime finish coat for any repair, wait longer to paint, or use an alkaline-resistant primer.

**TABLE 1**  
**REPLASTERING**  
**Selected Plaster Bases/Compatible Basecoats and Finish Coats**

<i>Traditional Plaster Bases</i>	<i>Compatible Basecoats</i>	<i>Compatible Finish Coats</i>
OLD WOOD LATH	gypsum/sand plaster gypsum/perlite plaster <sup>2</sup>	lime putty/gauging plaster lime putty/gauging plaster
METAL LATH	gypsum/sand plaster (high strength) gypsum/perlite plaster <sup>2</sup>	lime putty/gauging plaster lime putty/gauging plaster
GYPSON (ROCK) LATH PANELS	gypsum/sand plaster gypsum/perlite plaster <sup>2</sup>	lime putty/gauging plaster lime putty/gauging plaster
UNGLAZED BRICK/CLAY TILE	gypsum/perlite plaster <sup>2</sup> (masonry type)	lime putty/gauging plaster
<i>Modern Plaster Base</i>	<i>Compatible Basecoat</i>	<i>Compatible Finish Coat</i>
GYPSON CORE VENEER PANELS (BLUE BOARD)	veneer plaster	veneer plaster or lime putty/gauging plaster

<sup>1</sup> On traditional bases (wood, metal, and rock lath), the thickness of base coat plaster is one of the most important elements of a good plaster job. Grounds should be set to obtain the following minimum plaster thicknesses: (1) Over rock lath—1/2" (2) Over brick, clay tile, or other masonry—5/8" (3) Over metal lath, measured from face of lath—5/8" (4) Over wood lath—7/8". In no case should the total plaster thickness be less than 1/2". The allowance for the finish coat is approximately 1/16" which requires the base coat to be 7/16" for 1/2" grounds. This is a *minimum* base coat thickness on rock lath. The standard for other masonry units and metal lath is 5/8" thick, including the finish. Certain types of construction or fire ratings may require an increase in plaster thickness (and/or an increase in the gypsum to aggregate ratio) but never a thinner application of plaster than recommended above. Job experience indicates that thin applications of plaster often evidence cracking where normal applications to standard grounds do not. This condition is a direct result of the inability of thin section areas to resist external forces as adequately as thicker, normal applications of plaster.

<sup>2</sup> Perlite is a lightweight aggregate often used in gypsum plaster in place of sand. It performs well in cold weather and has a slightly better insulating value than sand. In a construction with metal lath, perlite aggregate is not recommended in the basecoat except under a sand or "float" finish. When gypsum/perlite basecoats are used over any other base (i.e., wood, rock lath, brick) and the finish coat is to be a "white" finish coat (smooth-troweled gauged lime putty) it is necessary to add fine silica sand or perlite fines to the finish coat. This measure prevents cracking of the "white" finish coat due to differential shrinkage.

## Plaster Terms

**Scratch coat.** The first base coat put on wood or metal lath. The wet plaster is "scratched" with a scarifier or comb to provide a rough surface so the next layer of base coat will stick to it.

**Brown coat.** The brown coat is the second application of wet, base-coat plaster with wood lath or metal systems. With gypsum board lath (rock lath, plasterboard), it is the only base coat needed.

**Finish coat.** Pure lime, mixed with about 35 percent gauging plaster to help it harden, is used for the very thin surface finish of the plaster wall. Fine sand can be added for a sanded finish coat.

**Casing Bead.** Early casing bead was made of wood. In the 19th century, metal casing beads were sometimes used around fireplace projections, and door and window openings. Like a wood ground, they indicate the proper thickness for the plaster.

**Corner Bead.** Wire mesh with a rigid metal spline used on outside corners. Installing the corner bead plumb is important.

**Cornerite.** Wire mesh used on inside corners of adjoining walls and ceilings. It keeps corners from cracking.

**Ground.** Plasterers use metal or wood strips around the edges of doors and windows and at the bottom of walls. These grounds help keep the plaster the same thickness and provide a stopping edge for the plaster. Early plaster work, however, did not use grounds. On early buildings, the woodwork was installed and primed before plastering began. Some time in the early 19th century, a transition occurred, and plasterers applied their wall finish before woodwork was installed.

**Gypsum.** Once mined from large gypsum quarries near Paris (thus the name plaster of Paris), gypsum in its natural form is calcium sulfate. When calcined (or heated), one-and-a-half water molecules are driven off, leaving a hemi-hydrate of calcium sulfate. When mixed with water, it becomes calcium sulfate again. While gypsum was used in base-coat plaster from the 1890s on, it has always been used in finish coat and decorative plaster. For finish coats, gauging plaster was added to lime putty; it causes the lime to harden. Gypsum is also the ingredient in moulding plaster, a finer plaster used to create decorative mouldings in ornamental plasterwork.

**Lime.** Found in limestone formations or shell mounds, naturally occurring lime is calcium carbonate. When heated, it becomes calcium oxide. After water has been added, it becomes calcium hydroxide. This calcium hydroxide reacts with carbon dioxide in the air to recreate the original calcium carbonate.

**Screed.** Screeds are strips of plaster run vertically or horizontally on walls or ceilings. They are used to plumb and straighten uneven walls and level ceilings. Metal screeds are used to separate different types of plaster finishes or to separate lime and cement plasters.

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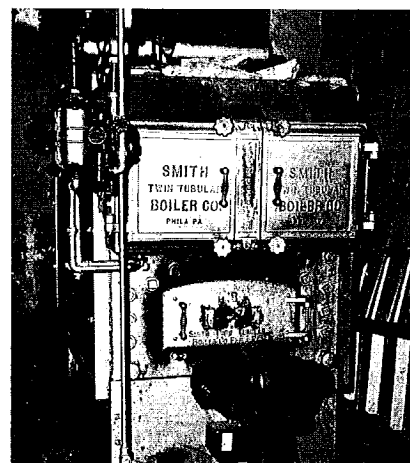
# 24 PRESERVATION BRIEFS

## Heating, Ventilating, and Cooling Historic Buildings: Problems and Recommended Approaches

Sharon C. Park, AIA



U.S. Department of the Interior  
National Park Service  
Cultural Resources  
Preservation Assistance



The need for modern mechanical systems is one of the most common reasons to undertake work on historic buildings. Such work includes upgrading older mechanical systems, improving the energy efficiency of existing buildings, installing new heating, ventilation or air conditioning (HVAC) systems, or—particularly for museums—installing a climate control system with humidification and dehumidification capabilities. Decisions to install new HVAC or climate control systems often result from concern for occupant health and comfort, the desire to make older buildings marketable, or the need to provide specialized environments for operating computers, storing artifacts, or displaying museum collections. Unfortunately, occupant comfort and concerns for the objects within the building are sometimes given greater consideration than the building itself. In too many cases, applying modern standards of interior climate comfort to historic buildings has proven detrimental to historic materials and decorative finishes.

This Preservation Brief underscores the importance of careful planning in order to balance the preservation objectives with interior climate needs of the building. It is not intended as a technical guide to calculate tonnage or to size piping or ductwork. Rather, this Brief identifies some of the problems associated with installing mechanical systems in historic buildings and recommends approaches to minimizing the physical and visual damage associated with installing and maintaining these new or upgraded systems.

Historic buildings are not easily adapted to house modern precision mechanical systems. Careful planning must be provided early on to ensure that decisions made during the design and installation phases of a new system are appropriate. Since new mechanical and other related systems, such as electrical and fire suppression, can use up to 10% of a building's square footage and 30%–40% of an overall rehabilitation budget, decisions must be made in a systematic and coordinated manner. The installation of inappropriate

mechanical systems may result in any or all of the following:

- large sections of historic materials are removed to install or house new systems.
- historic structural systems are weakened by carrying the weight of, and sustaining vibrations from, large equipment.
- moisture introduced into the building as part of a new system migrates into historic materials and causes damage, including biodegradation, freeze/thaw action, and surface staining.
- exterior cladding or interior finishes are stripped to install new vapor barriers and insulation.
- historic finishes, features, and spaces are altered by dropped ceilings and boxed chases or by poorly located grilles, registers, and equipment.
- systems that are too large or too small are installed before there is a clearly planned use or a new tenant.

For historic properties it is critical to understand what spaces, features, and finishes are historic in the building, what should be retained, and what the *realistic* heating, ventilating, and cooling needs are for the building, its occupants, and its contents. A systematic approach, involving preservation planning, preservation design, and a follow-up program of monitoring and maintenance, can ensure that new systems are successfully added—or existing systems are suitably upgraded—while preserving the historic integrity of the building.

No set formula exists for determining what type of mechanical system is best for a specific building. Each building and its needs must be evaluated separately. Some buildings will be so significant that every effort must be made to protect the historic materials and systems in place with minimal intrusion from new systems. Some buildings will have museum collections that need special climate control. In such cases, curatorial needs must be considered—but not to the ultimate detriment of the historic building resource. Other



buildings will be rehabilitated for commercial use. For them, a variety of systems might be acceptable, as long as significant spaces, features, and finishes are retained.

Most mechanical systems require upgrading or replacement within 15–30 years due to wear and tear or the availability of improved technology. Therefore, historic buildings should not be greatly altered or otherwise sacrificed in an effort to meet short-term systems objectives.

### History of Mechanical Systems

The history of mechanical systems in buildings involves a study of inventions and ingenuity as building owners, architects, and engineers devised ways to improve the interior climate of their buildings. Following are highlights in the evolution of heating, ventilating, and cooling systems in historic buildings.

**Eighteenth Century.** Early heating and ventilation in America relied upon common sense methods of *managing the environment* (see figure 1). Builders purposely sited houses to capture winter sun and prevailing summer cross breezes; they chose materials that could help protect the inhabitants from the elements, and took precautions against precipitation and damaging drainage patterns. The location and sizes of windows, doors, porches, and the floor plan itself often evolved to maximize ventilation. Heating was primarily from fireplaces or stoves and, therefore, was at the source of delivery. In 1744, Benjamin Franklin designed his “Pennsylvania stove” with a fresh air intake in order to maximize the heat radiated into the room and to minimize annoying smoke.

Thermal insulation was rudimentary—often wattle and daub, brick and wood nogging. The comfort level for occupants was low, but the relatively small difference between internal and external temperatures and relative humidity allowed building materials to expand and contract with the seasons.

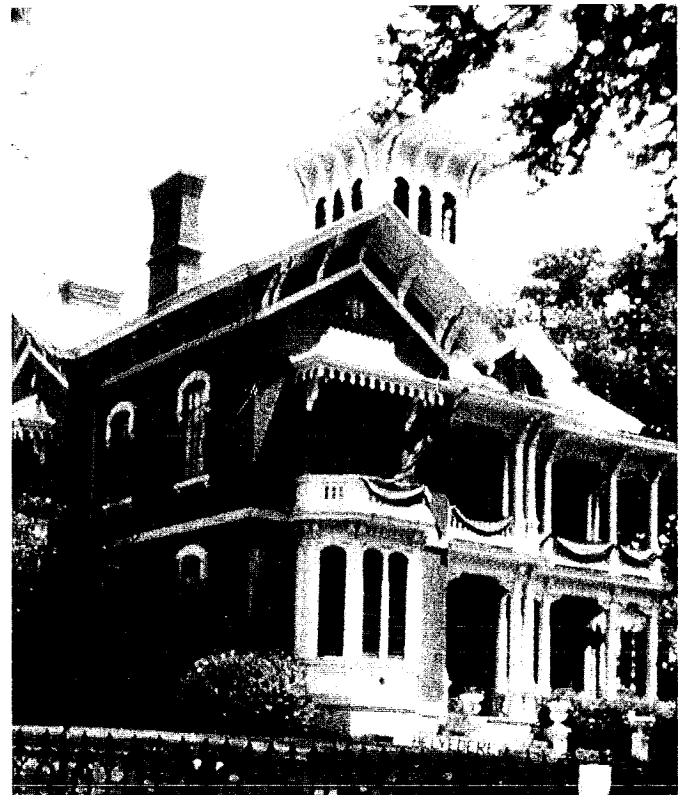
Regional styles and architectural features reflected regional climates. In warm, dry and sunny climates, thick adobe walls offered shelter from the sun and kept the inside temperatures cool. Verandas, courtyards, porches, and high ceilings also reduced the impact of the sun. Hot and humid climates called for elevated living floors, louvered grilles and shutters, balconies, and interior courtyards to help circulate air.

**Nineteenth Century.** The industrial revolution provided the technological means for *controlling the environment* for the first time (see figure 2). The dual developments of steam energy from coal and industrial mass production made possible early central heating systems with distribution of heated air or steam using metal ducts or pipes. Improvements were made to early wrought iron boilers and by late century, steam and low pressure hot water radiator systems were in common use, both in offices and residences. Some large institutional buildings heated air in furnaces and distributed it throughout the building in brick flues with a network of metal pipes delivering heated air to individual rooms. Residential designs of the period often used gravity hot air systems utilizing decorative floor and ceiling grilles.

Ventilation became more scientific and the introduc-



1. Eighteenth century and later vernacular architecture depended on the siting of the building, deciduous trees, cross ventilation, and the placement of windows and chimneys to maximize winter heating and natural summer cooling. Regional details, as seen in this Virginia house, include external chimneys and a separate summer kitchen to reduce fire risk and isolate heat in the summer. Photo: NPS Files.



2. Nineteenth century buildings continued to use architectural features such as porches, cupolas, and awnings to make the buildings more comfortable in summer, but heating was greatly improved by hot water or steam radiators. Photo: NPS Files

tion of fresh air into buildings became an important component of heating and cooling. Improved forced air ventilation became possible in mid-century with the introduction of power-driven fans. Architectural features such as porches, awnings, window and door transoms, large open-work iron roof trusses, roof monitors, cupolas, skylights and clerestory windows helped to dissipate heat and provide healthy ventilation.

Cavity wall construction, popular in masonry structures, improved the insulating qualities of a building and also provided a natural cavity for the dissipation of moisture produced on the interior of the building. In some buildings, cinder chips and broken masonry filler between structural iron beams and jack arch floor vaults provided thermal insulation as well as fire-proofing. Mineral wool and cork were new sources of lightweight insulation and were forerunners of contemporary batt and blanket insulation.

The technology of the age, however, was not sufficient to produce "tight" buildings. There was still only a moderate difference between internal and external temperatures. This was due, in part, to the limitations of early insulation, the almost exclusive use of single glazed windows, and the absence of air-tight construction. The presence of ventilating fans and the reliance on architectural features, such as operable windows, cupolas and transoms, allowed sufficient air movement to keep buildings well ventilated. Building materials could behave in a fairly traditional way, expanding and contracting with the seasons.

**Twentieth Century.** The twentieth century saw intensive development of new technologies and the notion of fully *integrating mechanical systems* (see figure 3). Oil and gas furnaces developed in the nineteenth century were improved and made more efficient, with electricity becoming the critical source of power for building systems in the latter half of the century. Forced air heating systems with ducts and registers became popular for all types of buildings and allowed architects to experiment with architectural forms free from mechanical encumbrances. In the 1920s large-scale theaters and auditoriums introduced central air conditioning, and by mid-century forced air systems which combined heating and air conditioning in the same ductwork set a new standard for comfort and convenience. The combination and coordination of a variety of systems came together in the post-World War II highrise buildings; complex heating and air conditioning plants, electric elevators, mechanical towers, ventilation fans, and full service electric lighting were integrated into the building's design.

The insulating qualities of building materials improved. Synthetic materials, such as spun fiberglass batt insulation, were fully developed by mid-century. Prototypes of insulated thermal glazing and integral storm window systems were promoted in construction journals. Caulking to seal out perimeter air around window and door openings became a standard construction detail.

The last quarter of the twentieth century has seen making HVAC systems more energy efficient and better integrated. The use of vapor barriers to control moisture migration, thermally efficient windows, caulking

and gaskets, compressed thin wall insulation, has become standard practice. New integrated systems now combine interior climate control with fire suppression, lighting, air filtration, temperature and humidity control, and security detection. Computers regulate the performance of these integrated systems based on the time of day, day of the week, occupancy, and outside ambient temperature.



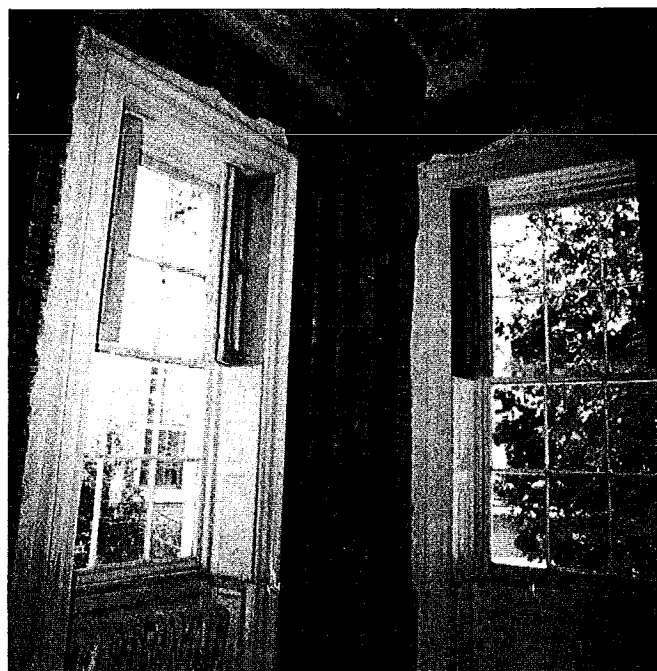
3. The circa 1928 Fox Theater in Detroit, designed by C. Howard Crane, was one of the earliest twentieth century buildings to provide air conditioning to its patrons. The early water-cooled system was recently restored. Commercial and highrise buildings of the twentieth century were able, mostly through electrical power, to provide sophisticated systems that integrated many building services. Photo: William Kessler and Associates, Architects.

### Climate Control and Preservation

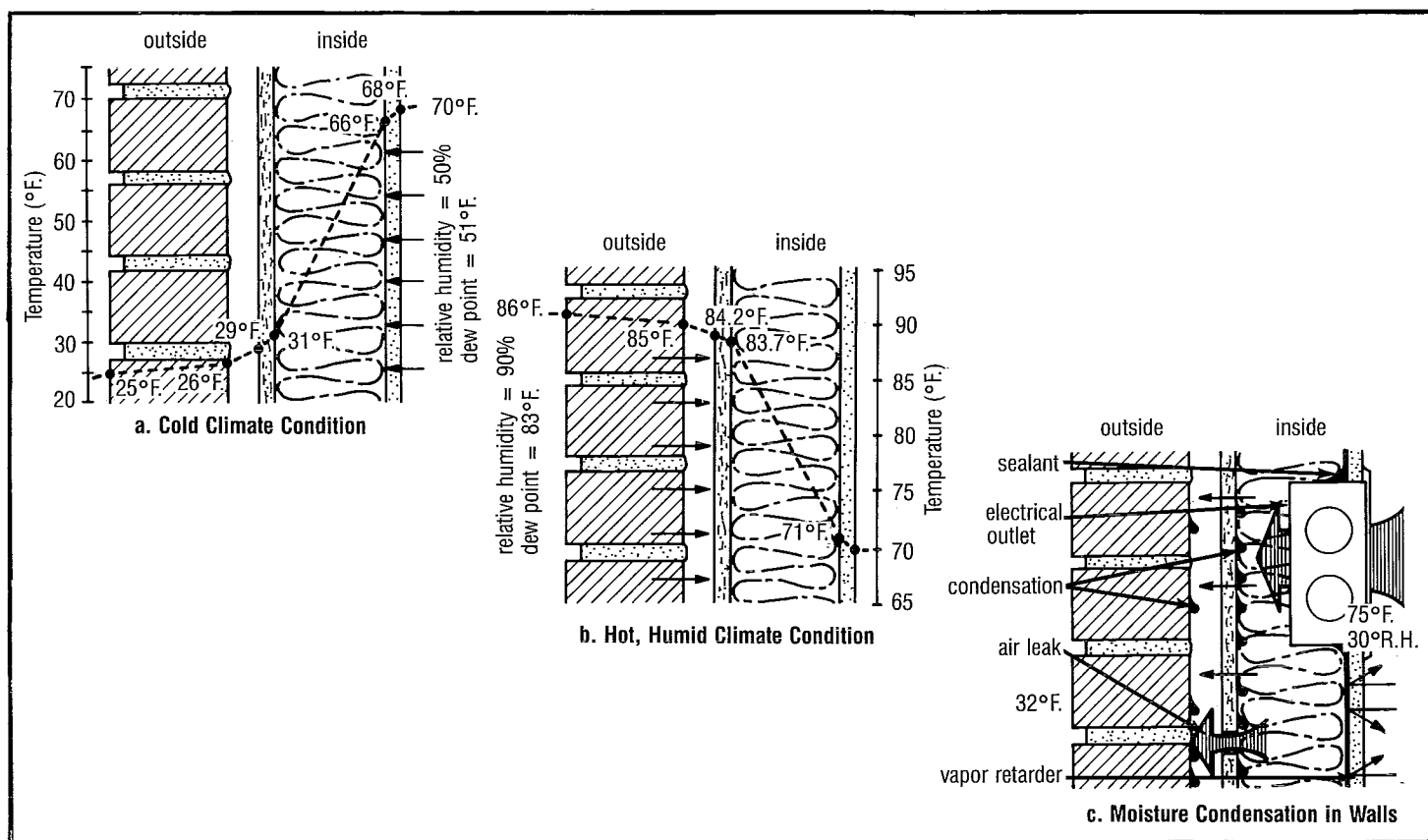
Although twentieth century mechanical systems technology has had a tremendous impact on making historic buildings comfortable, the introduction of these new systems in older buildings is not without problems. The attempt to meet and maintain modern climate control standards *may in fact be damaging to historic resources*. Modern systems are often over-designed to compensate for inherent inefficiencies of some historic buildings materials and plan layouts. Energy retrofit measures, such as installing exterior wall insulation and vapor barriers or the sealing of operable window and vents, ultimately affect the performance and can reduce the life of aging historic materials.

In general, the greater the differential between the interior and exterior temperature and humidity levels, the greater the potential for damage. As natural vapor pressure moves moisture from a warm area to a colder, dryer area, condensation will occur on or in building materials in the colder area (see figure 4). Too little humidity in winter, for example, can dry and crack historic wooden or painted surfaces. Too much humidity in winter causes moisture to collect on cold surfaces, such as windows, or to migrate into walls. As a result, this condensation deteriorates wooden or metal windows and causes rotting of walls and wooden structural elements, dampening insulation and holding moisture against exterior surfaces. Moisture migration through walls can cause the corrosion of metal anchors, angles, nails or wire lath, can blister and peel exterior paint, or can leave efflorescence and salt deposits on exterior masonry. In cold climates, freeze-thaw damage can result from excessive moisture in external walls.

To avoid these types of damage to a historic building, it is important to understand how building components work together as a system. Methods for controlling interior temperature and humidity and improving ventilation must be considered in any new or upgraded HVAC or climate control system. While certain energy retrofit measures will have a positive effect on the overall building, installing effective vapor barriers in historic walls is difficult and often results in destruction of significant historic materials (see figure 5).



5. The installation of vapor retarders in walls of historic buildings in an effort to contain interior moisture can cause serious damage to historic finishes as shown here. In this example, all the wall plaster and lath have been stripped in preparation for a vapor barrier prior to replastering. Controlling interior temperature and relative humidity can be more effective than adding insulation and vapor barriers to historic perimeter walls. Photo: Ernest A. Conrad, P.E.



4. Mechanical heating and cooling systems change the interior climate of a building. Moisture in the air will dissipate from the warmer area of a building to the colder area and can cause serious deterioration of historic materials. Condensation can form if the dew point occurs within the building wall, particularly one that has been insulated (see a and b). Even when vapor retarders are installed (c), any non-continuous areas will provide spaces for moisture to pass. Wall Section Drawings: NPS files

## Planning the New System

Climate control systems are generally classified according to the medium used to condition the temperature: air, water, or a combination of both (see overview on page 6). The complexity of choices facing a building owner or manager means that a *systematic approach* is critical in determining the most suitable system for a building, its contents, and its occupants. No matter which system is installed, a change in the interior climate will result. This physical change will in turn affect how the building materials perform. New registers, grilles, cabinets, or other accessories associated with the new mechanical system will also visually change the interior (and sometimes the exterior) appearance of the building. Regardless of the type or extent of a mechanical system, the owner of a historic building should know *before* a system is installed what it will look like and what problems can be anticipated during the life of that system. The potential harm to a building and costs to an owner of selecting the wrong mechanical system are very great.

The use of a building and its contents will largely determine the best type of mechanical system. The historic building materials and construction technology as well as the size and availability of secondary spaces within the historic structure will affect the choice of a system. It may be necessary to investigate a combination of systems. In each case, the needs of the user, the needs of the building, and the needs of a collection or equipment must be considered. It may not be necessary to have a comprehensive climate control system if climate-sensitive objects can be accommodated in special areas or climate-controlled display cases. It may not be necessary to have central air conditioning in a mild climate if natural ventilation systems can be improved through the use of operable windows, awnings, exhaust fans, and other "low-tech" means. Modern standards for climate control developed for new construction may not be achievable or desirable for historic buildings. *In each case, the lowest level of intervention needed to successfully accomplish the job should be selected.*

Before a system is chosen, the following planning steps are recommended:

1. **Determine the use of the building.** The proposed use of the building (museum, commercial, residential, retail) will influence the type of system that should be installed. The number of people and functions to be housed in a building will establish the level of comfort and service that must be provided. Avoid uses that require major modifications to significant architectural spaces. What is the intensity of use of the building: intermittent or constant use, special events or seasonal events? Will the use of the building require major new services such as restaurants, laundries, kitchens, locker rooms, or other areas that generate moisture that may exacerbate climate control within the historic space? In the context of historic preservation, uses that require radical reconfigurations of historic spaces are inappropriate for the building.

2. **Assemble a qualified team.** This team ideally should consist of a preservation architect, mechanical engineer, electrical engineer, structural engineer, and preservation consultants, each knowledgeable in codes and local requirements. If a special use (church, mu-

seum, art studio) or a collection is involved, a specialist familiar with the mechanical requirements of that building type or collection should also be hired.

Team members should be familiar with the needs of historic buildings and be able to balance complex factors: the preservation of the historic architecture (aesthetics and conservation), requirements imposed by mechanical systems (quantified heating and cooling loads), building codes (health and safety), tenant requirements (quality of comfort, ease of operation), access (maintenance and future replacement), and the overall cost to the owner.

3. **Undertake a condition assessment of the existing building and its systems.** What are the existing construction materials and mechanical systems? What condition are they in and are they reusable (see figure 6)? Where are existing chillers, boilers, air handlers, or cooling towers located? Look at the condition of all other services that may benefit from being integrated into a new system, such as electrical and fire suppression systems. Where can energy efficiency be improved to help downsize any new equipment added, and which of the historic features, e.g. shutters, awnings, skylights, can be reused (see figure 7)? Evaluate air infiltration through the exterior envelope; monitor the interior for temperature and humidity levels with hygrothermographs for at least a year. Identify building, site, or equipment deficiencies or the presence of asbestos that must be corrected prior to the installation or upgrading of mechanical systems.



6. A condition assessment during the planning stage would identify this round radiator in a small oval-shaped vestibule as a significant element of the historic heating system. In upgrading the mechanical system, the radiator should be retained. Photo: Michael C. Henry, P.E., AIA.



# Overview of HVAC Systems

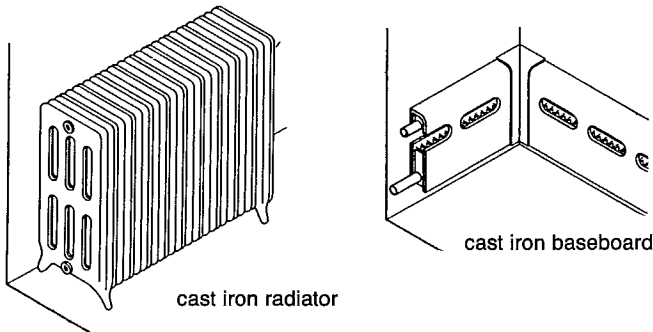
## WATER SYSTEMS: Hydronic radiators, Fan coil, or radiant pipes

Water systems are generally called *hydronic* and use a network of pipes to deliver water to hot water radiators, radiant pipes set in floors or fan coil cabinets which can give both heating and cooling. Boilers produce hot water or steam; chillers produce chilled water for use with fan coil units. Thermostats control the temperature by zone for radiators and radiant floors. Fan coil units have individual controls. Radiant floors provide quiet, even heat, but are not common.

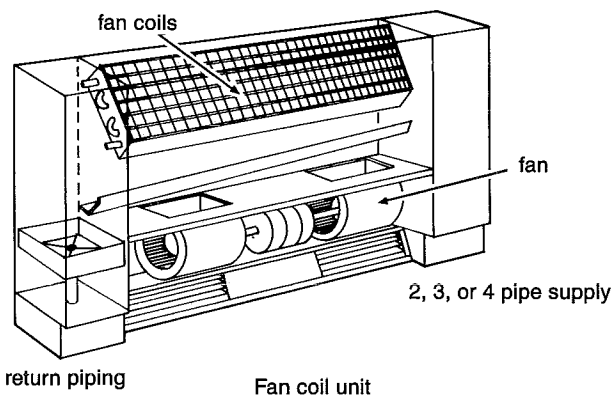
**Advantages:** Piped systems are generally easier to install in historic buildings because the pipes are smaller than ductwork.

**Disadvantages:** There is the risk, however, of hidden leaks in the wall or burst pipes in winter if boilers fail. Fan coil condensate pans can overflow if not properly maintained. Fan coils may be noisy.

**Hydronic Radiators:** Radiators or baseboard radiators are looped together and are usually set under windows or along perimeter walls. New boilers and circulating pumps can upgrade older systems. Most piping was cast iron although copper systems can be used if separately zoned. Modern cast iron baseboards and copper fin-tubes are available. Historic radiators can be reconditioned.



**Fan Coil Units:** Fan coil systems use terminal cabinets in each room serviced by 2, 3, or 4 pipes approximately 1-1/2" each in diameter. A fan blows air over the coils which are serviced by hot or chilled water. Each fan coil cabinet can be individually controlled. Four-pipe fan coils can provide both heating and cooling all year long. Most piping is steel. Non-cabinet units may be concealed in closets or custom cabinetry, such as benches, can be built.



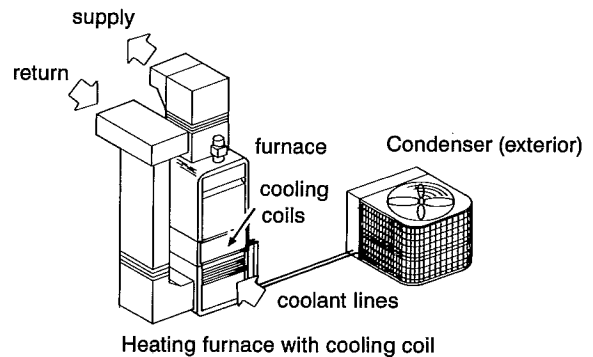
## CENTRAL AIR SYSTEMS

The basic heating, ventilation and air conditioning (HVAC) system is all-air, single zone fan driven designed for low, medium or high pressure distribution. The system is composed of compressor drives, chillers, condensers, and furnace depending on whether the air is heated, chilled or both. Condensers, generally air cooled, are located outside. The ducts are sheet metal or flexible plastic and can be insulated. Fresh air can be circulated. Registers can be designed for ceilings, floors and walls. The system is controlled by thermostats; one per zone.

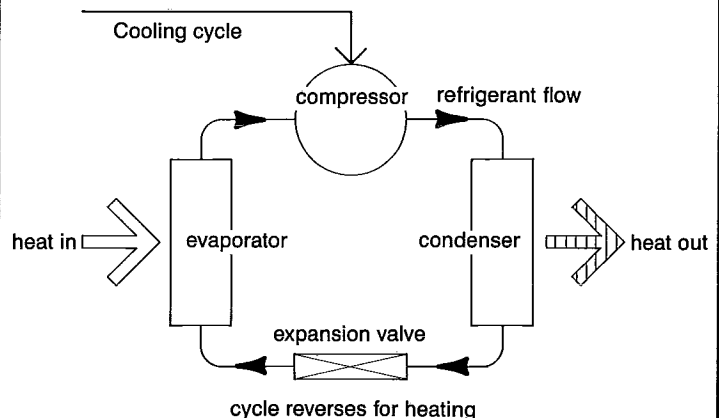
**Advantages:** Ducted systems offer a high level of control of interior temperature, humidity, and filtration. Zoned units can be relatively small and well concealed.

**Disadvantages:** The damage from installing a ducted system without adequate space can be serious for a historic building. Systems need constant balancing and can be noisy.

**Basic HVAC:** Most residential or small commercial systems will consist of a basic furnace with a cooling coil set in the unit and a refrigerant compressor or condenser located outside the building. Heating and cooling ductwork is usually shared. If sophisticated humidification and dehumidification is added to the basic HVAC system, a full climate control system results. This can often double the size of the equipment.



**Basic Heat Pump/Air System:** The heat pump is a basic HVAC system as described above except for the method of generating hot and cold air. The system operates on the basic refrigeration cycle where latent heat is extracted from the ambient air and is used to evaporate refrigerant vapor under pressure. Functions of the condenser and evaporator switch when heating is needed. Heat pumps, somewhat less efficient in cold climates, can be fitted with electric resistance coil.



## COMBINED AIR AND WATER SYSTEMS

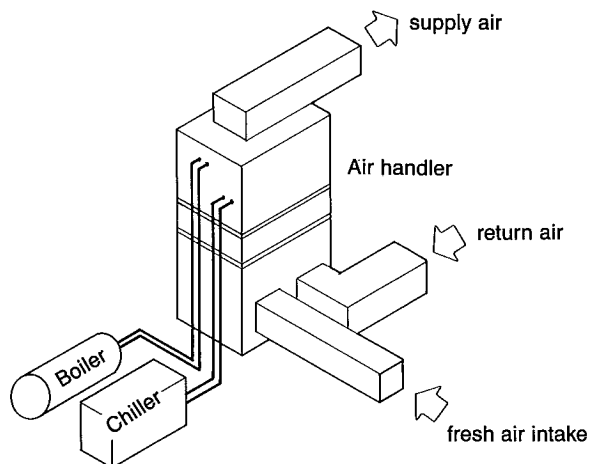
These systems are popular for restoration work because they combine the ease of installation for the piped system with the performance and control of the ducted system. Smaller air handling units, not unlike fan coils, may be located throughout a building with service from a central boiler and chiller. In many cases the water is delivered from a central plant which services a complex of buildings.

This system overcomes the disadvantages of a central ducted system where there is not adequate horizontal or vertical runs for the ductwork. The equipment, being smaller, may also be quieter and cause less vibration. If only one air handler is being utilized for the building, it is possible to house all the equipment in a vault outside the building and send only conditioned air into the structure.

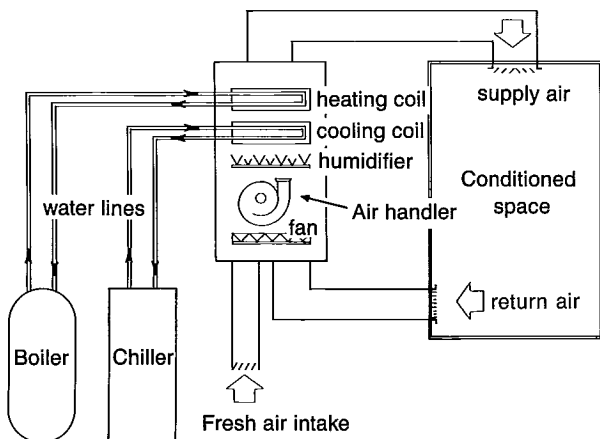
**Advantages:** flexibility for installation using greater piping runs with shorter ducted runs; Air handlers can fit into small spaces.

**Disadvantages:** piping areas may have undetected leaks; air handlers may be noisy.

### Water-serviced Air Handlers:



### Typical Systems Layout:



## OTHER SYSTEM COMPONENTS

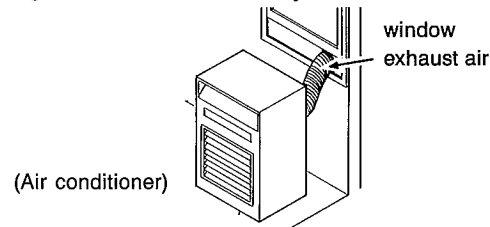
Non-systems components should not be overlooked if they can make a building more comfortable without causing damage to the historic resource or its collection.

**Advantages:** components may provide acceptable levels of comfort without the need for an entire system.

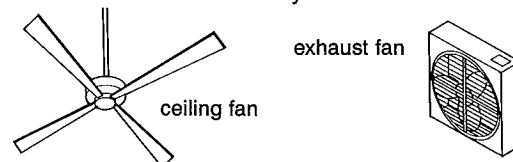
**Disadvantages:** Spot heating, cooling and fluctuations in humidity may harm sensitive collections or furnishings. If an integrated system is desirable, components may provide only a temporary solution.

### Portable Air Conditioning:

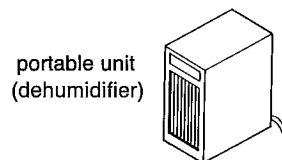
Most individual air conditioners are set in windows or through exterior walls which can be visually as well as physically damaging to historic buildings. Newer portable air conditioners are available which sit in a room and exhaust directly to the exterior through a small slot created by a raised window sash.



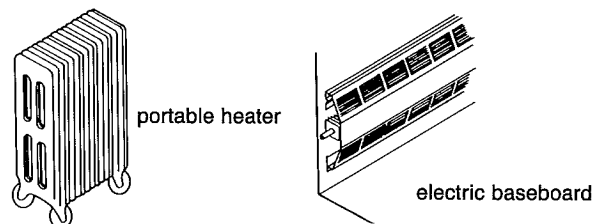
**Fans:** Fans should be considered in most properties to improve ventilation. Fans can be located in attics, at the top of stairs, or in individual rooms. In moderate climates, fans may eliminate the need to install central air systems.



**Dehumidifiers:** For houses without central air handling systems, a dehumidifier can resolve problems in humid climates. Seasonal use of dehumidifiers can remove moisture from damp basements and reduce fungal growth.



**Heaters:** Portable radiant heaters, such as those with water and glycol, may provide temporary heat in buildings used infrequently or during systems breakdowns. Care should be taken not to create a fire hazard with improperly wired units.



4. **Prioritize architecturally significant spaces, finishes, and features to be preserved.** Significant architectural spaces, finishes and features should be identified and evaluated at the outset to ensure their preservation. This includes significant existing mechanical systems or elements such as hot water radiators, decorative grilles, elaborate switchplates, and non-mechanical architectural features such as cupolas, transoms, or porches. Identify non-significant spaces where mechanical equipment can be placed and secondary spaces where equipment and distribution runs on both a horizontal and vertical basis can be located. Appropriate secondary spaces for housing equipment might include attics, basements, penthouses, mezzanines, false ceiling or floor cavities, vertical chases, stair towers, closets, or exterior below-grade vaults (see figure 8).

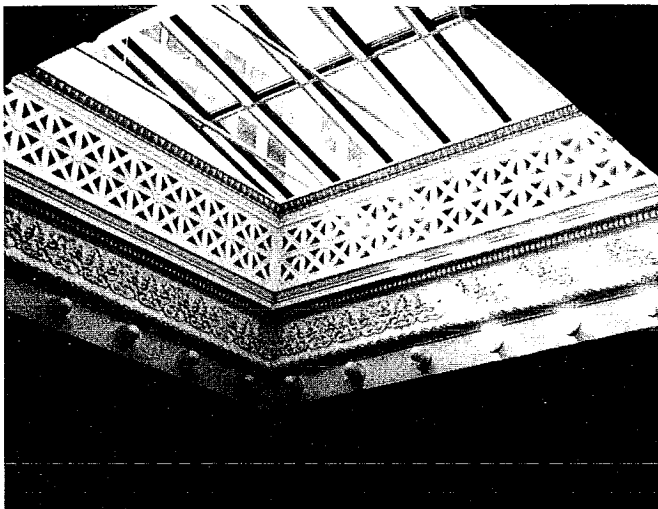
5. **Become familiar with local building and fire codes.** Owners or their representatives should meet early and often with local officials. Legal requirements should be checked; for example, can existing ductwork be reused or modified with dampers? Is asbestos abatement required? What are the energy, fire, and safety codes and standards in place, and how can they be met while maintaining the historic character of the building? How are fire separation walls and rated mechanical systems to be handled between multiple tenants? Is there a requirement for fresh air intake for stair towers that will affect the exterior appearance of the building? Many of the health, energy, and safety code requirements will influence decisions made for mechanical equipment for climate control. It is important to know what they are before the design phase begins.

6. **Evaluate options for the type and size of systems.** A matrix or feasibility studies should be developed to balance the benefits and drawbacks of various systems. Factors to consider include heating and/or cooling, fuel type, distribution system, control devices, generating equipment and accessories such as filtration, and humidification. What are the initial installation costs, projected fuel costs, long-term maintenance, and life-cycle

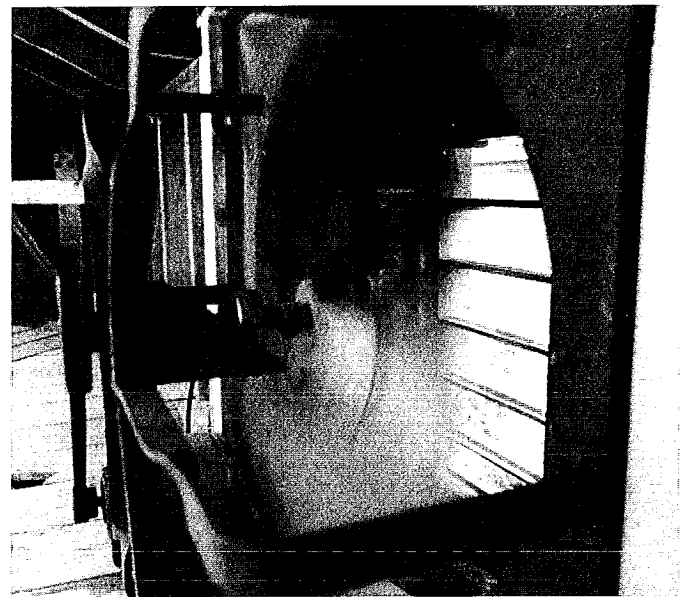
costs of these components and systems? Are parts of an existing system being reused and upgraded? The benefits of added ventilation should not be overlooked (see figure 9). What are the trade-offs between one large central system and multiple smaller systems? Should there be a forced air ducted system, a 2-pipe fan coil system, or a combined water and air system? What space is available for the equipment and distribution system? Assess the fire-risk levels of various fuels. Understand the advantages and disadvantages of the various types of mechanical systems available. *Then evaluate each of these systems in light of the preservation objectives established during the design phase of planning.*



8. In considering options for new systems, existing spaces should be evaluated for their ability to house new equipment. This sketch shows several areas where new mechanical equipment could be located to avoid damaging significant spaces. Sketch: NPS files



7. Operable skylights and grilles that can be adapted for return air should be identified as part of the planning phase for new or upgraded mechanical systems. Photo: Dianne Pierce, NPS files.



9. Improving ventilation through traditional means should not be overlooked in planning new or upgraded HVAC systems. In mild climates, good exhaust fans can often eliminate the need for air conditioning or can reduce equipment size by reducing cooling loads. Photo: Ernest A. Conrad, P.E.

## Designing the new system

In designing a system, it is important to anticipate how it will be installed, how damage to historic materials can be minimized, and how visible the new mechanical system will be within the restored or rehabilitated spaces (see figure 10 a-f). Mechanical equipment space needs are often overwhelming; in some cases, it may be advantageous to look for locations outside of the building, including ground vaults, to house some of the equipment but only if there is no adverse impact to the historic landscape or adjacent archeological resources. Various means for reducing the heating and cooling loads (and thereby the size of the equipment) should be investigated. This might mean reducing slightly the comfort levels of the interior, increasing the number of climate control zones, or improving the energy efficiency of the building.

The following activities are suggested during the design phase of the new system:

**1. Establish specific criteria for the new or upgraded mechanical system.** New systems should be *installed with a minimum of damage* to the resource and should be *visually compatible with the architecture* of the building. They should be installed in a way that is *easy to service, maintain, and upgrade* in the future. There should be *safety and back-up monitors in place* if buildings have collections, computer rooms, storage vaults or special conditions that need monitoring. The new systems *should work within the structural limits* of the historic building. They should produce *no undue vibration, no undue noise, no dust or mold, and no excess moisture* that could damage the historic building materials. If any equipment is to be located outside of the building, there should be *no impact to the historic appearance of building or site*, and there should be *no impact on archeological resources*.

**2. Prioritize the requirements for the new climate control system.** The use of the building will determine the level of interior comfort and climate control. Sometimes, various temperature zones may safely be created within a historic building. This zoned approach may be appropriate for buildings with specialized collections storage, for buildings with mixed uses, or for large buildings with different external exposures, occupancy patterns, and delivery schedules for controlled air. Special archives, storage vaults or computer rooms may need a completely different climate control from the rest of the building. Determine temperature and humidity levels for occupants and collections and ventilation requirements between differing zones. Establish if the system is to run 24 hours a day or only during operating or business hours. Determine what controls are optimum (manual, computer, preset automatic, or other). The size and location of the equipment to handle these different situations will ultimately affect the design of the overall system as well.

**3. Minimize the impact of the new HVAC on the existing architecture.** Design criteria for the new system should be based on the type of architecture of the historic resource. Consideration should be given as to whether or not the delivery system is visible or hidden. Utilitarian and industrial spaces may be capable of

accepting a more visible and functional system. More formal, ornate spaces which may be part of an interpretive program may require a less visible or disguised system. A ducted system should be installed without ripping into or boxing out large sections of floors, walls, or ceilings. A wet pipe system should be installed so that hidden leaks will not damage important decorative finishes. In each case, not only the type of system (air, water, combination), but its distribution (duct, pipe) and delivery appearance (grilles, cabinets, or registers) must be evaluated. It may be necessary to use a combination of different systems in order to preserve the historic building. Existing chases should be reused whenever possible.

**4. Balance quantitative requirements and preservation objectives.** The ideal system may not be achievable for each historic resource due to cost, space limitations, code requirements, or other factors beyond the owner's control. However, significant historic spaces, finishes, and features can be preserved in almost every case, even given these limitations. For example, if some ceiling areas must be slightly lowered to accommodate ductwork or piping, these should be in secondary areas away from decorative ceilings or tall windows. If modern fan coil terminal units are to be visible in historic spaces, consideration should be given to custom designing the cabinets or to using smaller units in more locations to diminish their impact. If grilles and registers are to be located in significant spaces, they should be designed to work within the geometry or placement of decorative elements. All new elements, such as ducts, registers, pipe-runs, and mechanical equipment should be installed in a reversible manner to be removed in the future without further damage to the building (see fig 11).

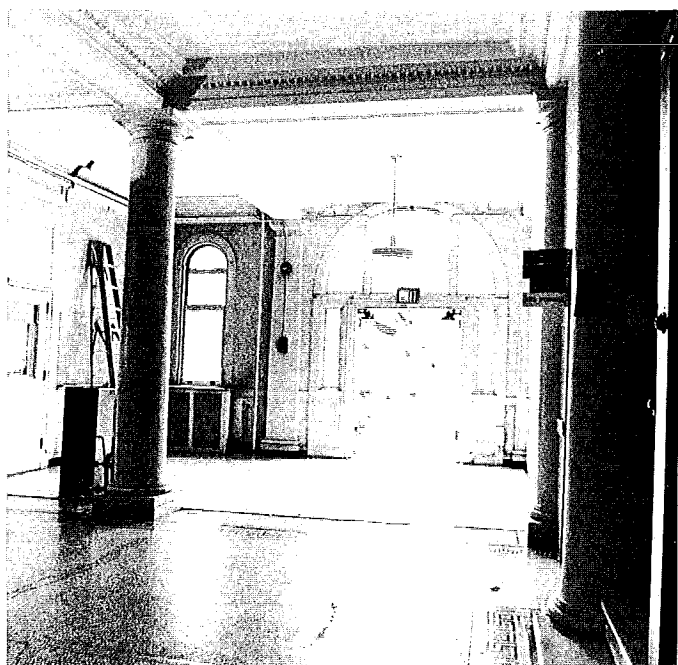
## Systems Performance and Maintenance

Once the system is installed, it will require routine maintenance and balancing to ensure that the proper performance levels are achieved. In some cases, extremely sophisticated, computerized systems have been developed to control interior climates, but these still need monitoring by trained staff. If collection exhibits and archival storage are important to the resource, the climate control system will require constant monitoring and tuning. Back-up systems are also needed to prevent damage when the main system is not working. The owner, manager, or chief of maintenance should be aware of all aspects of the new climate control system and have a plan of action before it is installed.

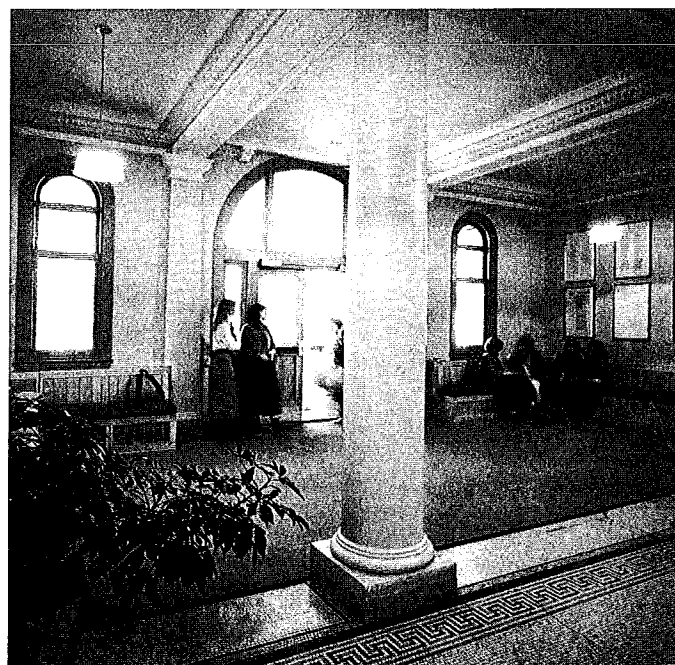
Regular training sessions on operating, monitoring, and maintaining the new system should be held for both curatorial and building maintenance staff. If there are curatorial reasons to maintain constant temperature or humidity levels, only individuals thoroughly trained in how the HVAC systems operates should be able to adjust thermostats. Ill-informed and haphazard attempts to adjust comfort levels, or to save energy over weekends and holidays, can cause great damage.



10. The following photographs illustrate recent preservation projects where careful planning and design retained the historic character of the resources.

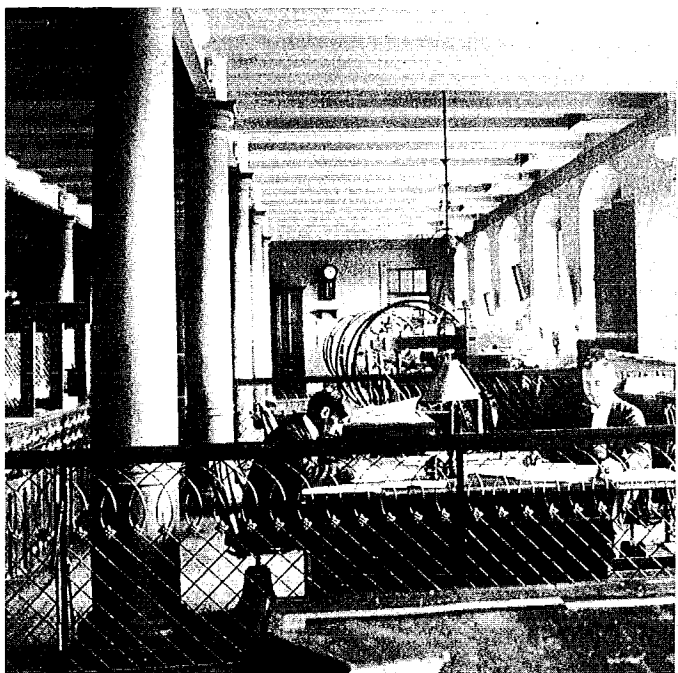


before



after

a. Before and after of a circa 1900 school entrance. The radiators have been replaced with a two-pipe fan coil system built into bench seats. The ceiling was preserved and no exposed elements were required to add air conditioning. Piping runs are under the benches and there was no damage to the masonry walls. Photos: Notter Finegold + Alexander Inc. and Lautman Photography, Washington.



historic

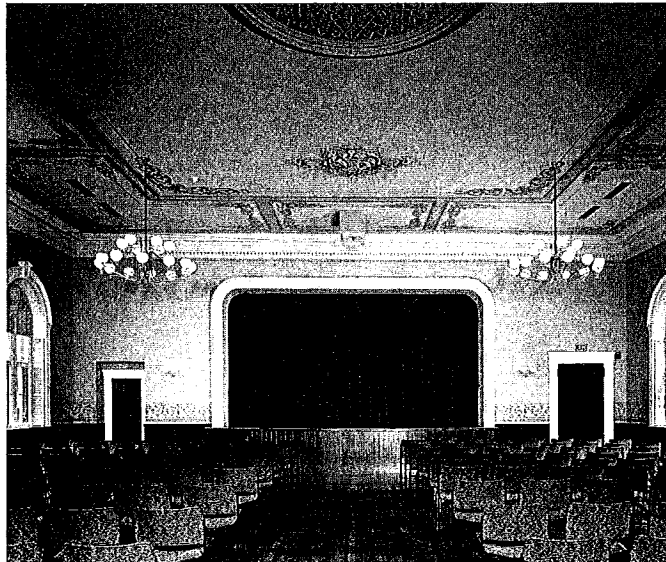


after

d. Auditors Buildings, Washington, D.C. This upper floor workspace had been modified over the years with dropped ceilings and partitions. In the recent restoration, the open plan workspace was restored, the false ceiling was removed, and the fireproof construction was exposed. A variable air volume (VAV) system using round double shell exposed ductwork is in keeping with the industrial character of the architectural space. Photo: Kenneth Wyner Photography, courtesy of Notter Finegold + Alexander Inc. Before view provided by Notter Finegold + Alexander/Mariani.



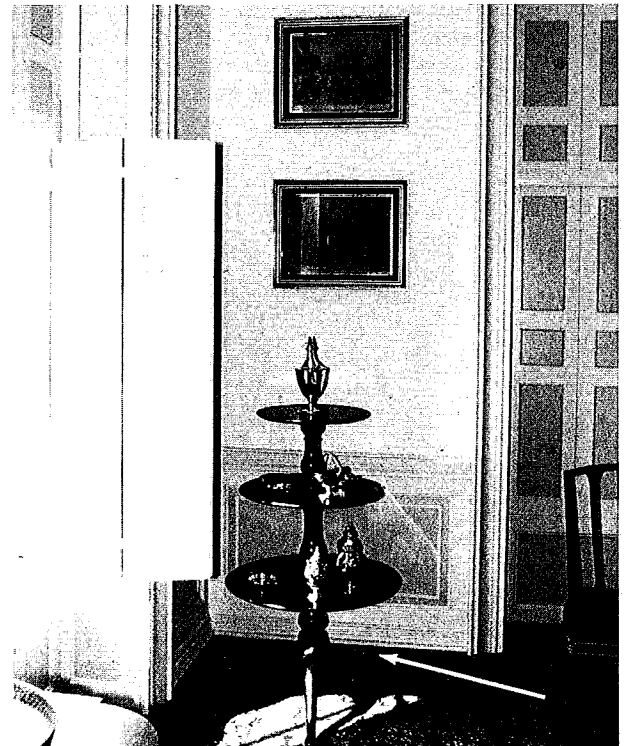
b. Central air conditioning was installed in the corridors of this circa 1900 school building by adding an air handler over the entrance from a vestibule. Custom-designed slot registers provide linear diffusers without detracting from the architecture of the space. Photo: Lautman Photography courtesy of Notter Finegold + Alexander Inc.



c. Town Hall, Andover, MA. The upstairs auditorium was restored and new mechanical systems were installed. Perimeter baseboard radiation provides heat and air handlers, located in the attic space provide air conditioning. The cast iron ceiling grille was adapted for return air and the supply registers were installed in a symmetrical and regular manner to minimize impact on the historic ceiling. Photo: David Hewitt/Anne Garrison for Ann Beha Associates.



d. Conference room, Auditors Building, Washington, D.C. The historic steam radiators were retained for heating. The cast iron ceiling register was retained as a decorative element, but made inoperable to meet fire codes. Photo: Kenneth Wyner Photography courtesy of Notter Finegold + Alexander Inc.



e. Homewood, Baltimore, MD. This elegant circa 1806 residence is now a house museum. The registers for the forced air ducted system seen behind the table legs, are grained to blend with the historic baseboards. The HVAC system uses a water/air system where chilled water and steam heat are converted to conditioned air. Photo: Courtesy Homewood Museum, Johns Hopkins University.

## HVAC Do's and Don'ts

### DO's:

- Use shutters, operable windows, porches, curtains, awnings, shade trees and other historically appropriate non-mechanical features of historic buildings to reduce the heating and cooling loads. Consider adding sensitively designed storm windows to existing historic windows.
- Retain or upgrade existing mechanical systems whenever possible: for example, reuse radiator systems with new boilers, upgrade ventilation within the building, install proper thermostats or humidistats.
- Improve energy efficiency of existing buildings by installing insulation in attics and basements. Add insulation and vapor barriers to exterior walls *only* when it can be done without further damage to the resource.
- In major spaces, retain decorative elements of the historic system whenever possible. This includes switchplates, grilles and radiators. Be creative in adapting these features to work within the new or upgraded system.
- Use space in existing chases, closets or shafts for new distribution systems.
- Design climate control systems that are compatible with the architecture of the building: hidden system for formal spaces, more exposed systems possible in industrial or secondary spaces. In formal areas, avoid standard commercial registers and use custom slot registers or other less intrusive grilles.
- Size the system to work within the physical constraints of the building. Use multi-zoned smaller units in conjunction with existing vertical shafts, such as stacked closets, or consider locating equipment in vaults underground, if possible.
- Provide adequate ventilation to the mechanical rooms as well as to the entire building. Selectively install air intake grilles in less visible basement, attic, or rear areas.
- Maintain appropriate temperature and humidity levels to meet requirements without accelerating the deterioration of the historic building materials. Set up regular monitoring schedules.
- Design the system for maintenance access and for future systems replacement.
- For highly significant buildings, install safety monitors and backup features, such as double pans, moisture detectors, lined chases, and battery packs to avoid or detect leaks and other damage from system failures.

- Have a regular maintenance program to extend equipment life and to ensure proper performance.
- Train staff to monitor the operation of equipment and to act knowledgeably in emergencies or breakdowns.
- Have an emergency plan for both the building and any curatorial collections in case of serious malfunctions or breakdowns.

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### DON'TS:

- Don't install a new system if you don't need it.
- Don't switch to a new type of system (e.g. forced air) unless there is sufficient space for the new system or an appropriate place to put it.
- Don't over-design a new system. Don't add air conditioning or climate control if they are not absolutely necessary.
- Don't cut exterior historic building walls to add through-wall heating and air conditioning units. These are visually disfiguring, they destroy historic fabric, and condensation runoff from such units can further damage historic materials.
- Don't damage historic finishes, mask historic features, or alter historic spaces when installing new systems.
- Don't drop ceilings or bulkheads across window openings.
- Don't remove repairable historic windows or replace them with inappropriately designed thermal windows.
- Don't seal operable windows, unless part of a museum where air pollutants and dust are being controlled.
- Don't place condensers, solar panels, chimney stacks, vents or other equipment on visible portions of roofs or at significant locations on the site.
- Don't overload the building structure with the weight of new equipment, particularly in the attic.
- Don't place stress on historic building materials through the vibrations of the new equipment.
- Don't allow condensation on windows or within walls to rot or spall adjacent historic building materials.

Maintenance staff should learn how to operate, monitor, and maintain the mechanical equipment. They must know where the maintenance manuals are kept. Routine maintenance schedules must be developed for changing and cleaning filters, vents, and condensate pans to control fungus, mold, and other organisms that are dangerous to health. Such growths can harm both inhabitants and equipment. (In piped systems, for example, molds in condensate pans can block drainage lines and cause an overflow to leak onto finished surfaces). Maintenance staff should also be able to monitor the appropriate gauges, dials, and thermographs. Staff must be trained to intervene in emergencies, to know where the master controls are, and whom to call in an emergency. As new personnel are hired, they will also require maintenance training.

In addition to regular cyclical maintenance, thorough inspections should be undertaken from time to time to evaluate the continued performance of the climate control system. As the system ages, parts are likely to fail, and signs of trouble may appear. Inadequately ventilated areas may smell musty. Wall surfaces may show staining, wet patches, bubbling or other signs of moisture damage. Routine tests for air quality, humidity, and temperature should indicate if the system is performing properly. If there is damage as a result of the new system, it should be repaired immediately and then closely monitored to ensure complete repair.

Equipment must be accessible for maintenance and should be visible for easy inspection. Moreover, since mechanical systems last only 15–30 years, the system itself must be “reversible.” That is, the system must be installed in such a way that later removal will not damage the building. In addition to servicing, the back-up monitors that signal malfunctioning equipment must be routinely checked, adjusted, and maintained. Checklists should be developed to ensure that all aspects of routine maintenance are completed and that data is reported to the building manager.

## Conclusion

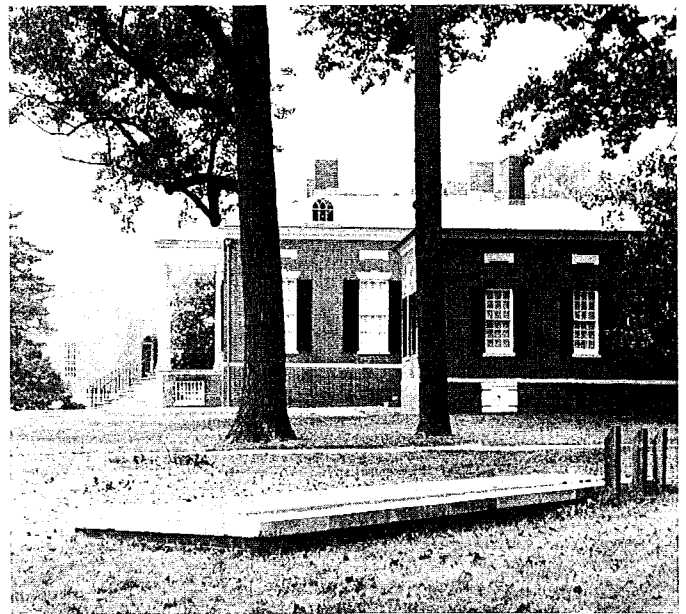
The successful integration of new systems in historic buildings can be challenging. Meeting modern HVAC requirements for human comfort or installing controlled climates for museum collections or for the operation of complex computer equipment can result in both visual and physical damage to historic resources. Owners of historic buildings must be aware that the final result will involve balancing multiple needs; no perfect heating, ventilating, and air conditioning system exists. In undertaking changes to historic buildings, it is best to have the advice and input of trained professionals who can:

- assess the condition of the historic building,
- evaluate the significant elements that should be preserved or reused,
- prioritize the preservation objectives,
- understand the impact of new interior climate conditions on historic materials,
- integrate preservation with mechanical and code requirements,
- maximize the advantages of various new or upgraded mechanical systems,
- understand the visual and physical impact of various installations,
- identify maintenance and monitoring requirements for new or upgraded systems, and
- plan for the future removal or replacement of the system.

Too often the presumed climate needs of the occupants or collections can be detrimental to the long-term preservation of the building. With a careful balance between the preservation needs of the building and the interior temperature and humidity needs of the occupants, a successful project can result.



a



b

11. During the restoration of this 1806 National Historic Landmark (photo a), a new climate control system was installed. The architects removed all the earlier mechanical equipment from the house and installed new equipment in a 30' × 40' concrete vault located underground 150 feet from the house itself (photo b). Only conditioned air is blown into the house reusing much of the circa 1930s ductwork. Photos: Thomas C. Jester.



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## Acknowledgements

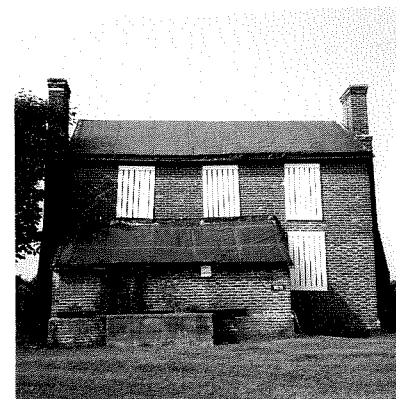
The author gratefully acknowledges the invaluable assistance of Michael C. Henry, P.E., AIA, in the development and technical editing of this Preservation Brief. Technical review was also provided by Ernest A. Conrad, P.E. Thanks is also given to staff members of the National Park Service Cultural Resources Programs, including Tom Keohan and Catherine Colby, Rocky Mountain Region; Michael Crowe, Western Region; Mark Chavez, Midwest Region; Randall J. Biallas, AIA, Chief, Park Historic Architecture Division, and George A. Thorsen, Historical Architect, Denver Service Center. Special thanks is also given to Michael J. Auer of Technical Preservation Services for his editorial assistance in preparing this paper and Tim Buehner for his assistance with the illustrations.

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# 31 PRESERVATION BRIEFS

## Mothballing Historic Buildings

Sharon C. Park, AIA



U.S. Department of the Interior  
National Park Service  
Cultural Resources  
Heritage Preservation Services

When all means of finding a productive use for a historic building have been exhausted or when funds are not currently available to put a deteriorating structure into a useable condition, it may be necessary to close up the building temporarily to protect it from the weather as well as to secure it from vandalism. This process, known as mothballing, can be a necessary and effective means of protecting the building while planning the property's future, or raising money for a preservation, rehabilitation or restoration project. If a vacant property has been declared unsafe by building officials, stabilization and mothballing may be the only way to protect it from demolition.

This Preservation Brief focuses on the steps needed to "deactivate" a property for an extended period of time. The project team will usually consist of an architect, historian, preservation specialist, sometimes a structural engineer, and

a contractor. Mothballing should not be done without careful planning to ensure that needed physical repairs are made prior to securing the building. The steps discussed in this Brief can protect buildings for periods of up to ten years; long-term success will also depend on continued, although somewhat limited, monitoring and maintenance. For all but the simplest projects, hiring a team of preservation specialists is recommended to assess the specific needs of the structure and to develop an effective mothballing program.

A vacant historic building cannot survive indefinitely in a boarded-up condition, and so even marginal interim uses where there is regular activity and monitoring, such as a caretaker residence or non-flammable storage, are generally preferable to mothballing. In a few limited cases when the vacant building is in good condition and in a location where it can be watched and checked regularly, closing and locking

the door, setting heat levels at just above freezing, and securing the windows may provide sufficient protection for a period of a few years. But if long-term mothballing is the only remaining option, it must be done properly (see fig. 1 & 2). This will require stabilization of the exterior, properly designed security protection, generally some form of interior ventilation - either through mechanical or natural air exchange systems - and continued maintenance and surveillance monitoring.

Comprehensive mothballing programs are generally expensive and may cost 10% or more of a modest rehabilitation budget. However, the money spent on well-planned protective measures will seem small when amortized over the life of the resource. Regardless of the location and condition of the property or the funding available, the following 9 steps are involved in properly mothballing a building:



*Figure 1. Proper mothballing treatment: This building has been successfully mothballed for 10 years because the roof and walls were repaired and structurally stabilized, ventilation louvers were added, and the property is maintained. Photo: Charles E. Fisher, NPS.*



Figure 2. Improper treatment: Boarding up without adequate ventilation, lack of maintenance, and neglect of this property have accelerated deterioration. Photo; NPS file.

#### Documentation

1. Document the architectural and historical significance of the building.
2. Prepare a condition assessment of the building.

#### Stabilization

3. Structurally stabilize the building, based on a professional condition assessment.
4. Exterminate or control pests, including termites and rodents.
5. Protect the exterior from moisture penetration.

#### Mothballing

6. Secure the building and its component features to reduce vandalism or break-ins.
7. Provide adequate ventilation to the interior.
8. Secure or modify utilities and mechanical systems.
9. Develop and implement a maintenance and monitoring plan for protection.

These steps will be discussed in sequence below. Documentation and stabilization are critical components of the process and should not be skipped over. Mothballing measures should not result in permanent damage, and so each treatment should be weighed in terms of its reversibility and its overall benefit.

### Documentation

Documenting the historical significance and physical condition of the property will provide information necessary for setting priorities and allocating funds. The project team should be cautious when first entering the structure if it has been vacant or is deteriorated. It may be advisable to shore temporarily areas appearing

to be structurally unsound until the condition of the structure can be fully assessed (see fig. 3). If pigeon or bat droppings, friable asbestos or other health hazards are present, precautions must be taken to wear the appropriate safety equipment when first inspecting the building. Consideration should be given to hiring a firm specializing in hazardous waste removal if these highly toxic elements are found in the building.

**Documenting and recording the building.** Documenting a building's history is important because evidence of its true age and architectural significance may not be readily evident. The owner should check with the State Historic Preservation Office or local preservation commission for assistance in researching the building. If the building has never been researched for listing in the National Register of Historic Places or other historic registers, then, at a minimum, the following should be determined:

- The overall historical significance of the property and dates of construction;
- the chronology of alterations or additions and their approximate dates; and,
- types of building materials, construction techniques, and any unusual detailing or regional variations of craftsmanship.

Old photographs can be helpful in identifying early or original features that might be hidden under modern materials. On a walk-through, the architect, historian, or preservation specialist should identify the architecturally significant elements of the building, both inside and out (see fig.4).



Figure 3. Buildings seriously damaged by storms or deterioration may need to be braced before architectural evaluations can be made. Jethro Coffin House. Photo: John Milner Architects.



*Figure 4. Documenting the building's history, preparing schematic plans, and assessing the condition of the building will provide necessary information on which to set priorities for stabilization and repair prior to securing the building. Photo: Frederick Lindstrom, HABS.*

By understanding the history of the resource, significant elements, even though deteriorated, may be spared the trash pile. For that reason alone, any materials removed from the building or site as part of the stabilization effort should be carefully scrutinized and, if appearing historic, should be photographed, tagged with a number, inventoried, and safely stored, preferably in the building, for later retrieval (see fig. 5).

A site plan and schematic building floor plans can be used to note important information for use when the building is eventually preserved, restored, or rehabilitated. Each room should be given a number and notations added to the plans regarding the removal of important features to storage or recording physical treatments undertaken as part of the stabilization or repair.

Because a mothballing project may extend over a long period of time, with many different people involved, clear records should be kept and a building file established. Copies of all important data, plans, photographs, and lists of consultants or contractors who have worked on the property should be added to the file as the job progresses.



*Figure 5. Loose or detached elements should be identified, tagged and stored, preferably on site. Photo: NPS files.*

Recording all actions taken on the building will be helpful in the future.

The project coordinator should keep the building file updated and give duplicate copies to the owner. A list of emergency numbers, including the number of the key holder, should be kept at the entrance to the building or on a security gate, in a transparent vinyl sleeve.

**Preparing a condition assessment of the building.** A condition assessment can provide the owner with an accurate overview of the current condition of the property. If the building is deteriorated or if there are significant interior architectural elements that will need special protection during the mothballing years, undertaking a condition assessment is highly recommended, but it need not be exhaustive.

A modified condition assessment, prepared by an architect or preservation specialist, and in some case a structural engineer, will help set priorities for repairs necessary to stabilize the property for both the short and long-term. It will evaluate the age and condition of the following major elements: foundations; structural systems; exterior materials; roofs and gutters; exterior porches and steps; interior finishes; staircases; plumbing, electrical, mechanical systems; special features such as chimneys; and site drainage.

To record existing conditions of the building and site, it will be necessary to clean debris from the building and to remove unwanted or overgrown vegetation to expose foundations. The interior should be emptied of its furnishing (unless provisions are made for mothballing these as well), all debris removed, and the interior swept with a broom. Building materials too deteriorated to repair, or which have come detached, such as moldings, balusters, and decorative plaster, and which can be used to guide later preservation work, should be tagged, labeled and saved.

Photographs or a videotape of the exterior and all interior spaces of the resource will provide an invaluable record of "as is" conditions. If a videotape is made, oral commentary can be provided on the significance of each space and architectural feature. If 35mm photographic prints or slides are made, they should be numbered, dated, and appropriately identified. Photographs should be cross-referenced with the room numbers on the schematic plans. A systematic method for photographing should be developed; for example, photograph each wall in a room and then take a corner shot to get floor and ceiling portions in the picture. Photograph any unusual details as well as examples of each window and door type.

For historic buildings, the great advantage of a condition assessment is that architectural features, both on the exterior as well as the interior, can be rated on a scale of their importance to the integrity and significance of the building. Those features of the highest priority should receive preference when repairs or protection measures are outlined as part of the mothballing process. Potential problems with protecting these features should be identified so that appropriate interim solutions can be selected. For example, if a building has always been heated and if murals, decorative plaster walls, or examples of patterned wall paper are identified as highly significant, then special care should be taken to regulate the interior climate and to monitor it adequately during the

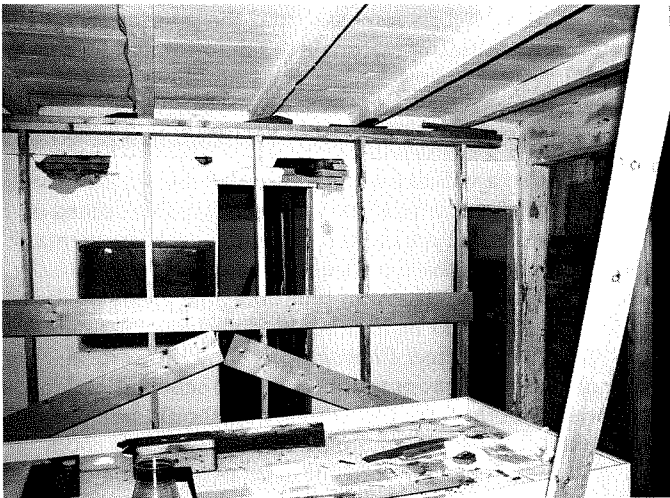


mothballing years. This might require retaining electrical service to provide minimal heat in winter, fan exhaust in summer, and humidity controls for the interior.

## Stabilization

Stabilization as part of a mothballing project involves correcting deficiencies to slow down the deterioration of the building while it is vacant. Weakened structural members that might fail altogether in the forthcoming years must be braced or reinforced; insects and other pests removed and discouraged from returning; and the building protected from moisture damage both by weatherizing the exterior envelope and by handling water run-off on the site. Even if a modified use or caretaker services can eventually be found for the building, the following steps should be addressed.

**Structurally stabilizing the building.** While bracing may have been required to make the building temporarily safe for inspection, the condition assessment may reveal areas of hidden structural damage. Roofs, foundations, walls, interior framing, porches and dormers all have structural components that may need added reinforcement. Structural stabilization by a qualified contractor should be done under the direction of a structural engineer or a preservation specialist to ensure that the added weight of the reinforcement can be sustained by the building and that the new members do not harm historic finishes (see fig. 6). Any major vertical post added during the stabilization should be properly supported and, if necessary, taken to the ground and underpinned.



*Figure 6. Interior bracing which will last the duration of the mothballing will protect weakened structural members. Jethro Coffin House. Photo: John Milner Architects.*

If the building is in a northern climate, then the roof framing must be able to hold substantial snow loads. Bracing the roof at the ridge and mid-points should be considered if sagging is apparent. Likewise, interior framing around stair openings or under long ceiling spans should be investigated. Underpinning or bracing structural piers weakened by poor drainage patterns may be a good precaution as well. Damage caused by insects, moisture, or from other causes should be repaired or reinforced and, if possible, the source of the damage removed. If features such as porches and dormers are so severely deteriorated

that they must be removed, they should be documented, photographed, and portions salvaged for storage prior to removal.

If the building is in a southern or humid climate and termites or other insects are a particular problem, the foundation and floor framing should be inspected to ensure that there are no major structural weaknesses. This can usually be done by observation from the crawl space or basement. For those structures where this is not possible, it may be advisable to lift selective floor boards to expose the floor framing. If there is evidence of pest damage, particularly termites, active colonies should be treated and the structural members reinforced or replaced, if necessary.

**Controlling pests.** Pests can be numerous and include squirrels, raccoons, bats, mice, rats, snakes, termites, moths, beetles, ants, bees and wasps, pigeons, and other birds. Termites, beetles, and carpenter ants destroy wood. Mice, too, gnaw wood as well as plaster, insulation, and electrical wires. Pigeon and bat droppings not only damage wood finishes but create a serious and sometimes deadly health hazard.

If the property is infested with animals or insects, it is important to get them out and to seal off their access to the building. If necessary, exterminate and remove any nests or hatching colonies. Chimney flues may be closed off with exterior grade plywood caps, properly ventilated, or protected with framed wire screens. Existing vents, grills, and louvers in attics and crawl spaces should be screened with bug mesh or heavy duty wire, depending on the type of pest being controlled. It may be advantageous to have damp or infected wood treated with insecticides (as permitted by each state) or preservatives, such as borate, to slow the rate of deterioration during the time that the building is not in use.

### **Securing the exterior envelope from moisture penetration.**

It is important to protect the exterior envelope from moisture penetration before securing the building. Leaks from deteriorated or damaged roofing, from around windows and doors, or through deteriorated materials, as well as ground moisture from improper site run-off or rising damp at foundations, can cause long-term damage to interior finishes and structural systems. Any serious deficiencies on the exterior, identified in the condition assessment, should be addressed.

To the greatest extent possible, these weatherization efforts should not harm historic materials. The project budget may not allow deteriorated features to be fully repaired or replaced in-kind. Non-historic or modern materials may be used to cover historic surfaces temporarily, but these treatments should not destroy valuable evidence necessary for future preservation work. Temporary modifications should be as visually compatible as possible with the historic building.

Roofs are often the most vulnerable elements on the building exterior and yet in some ways they are the easiest element to stabilize for the long term, if done correctly. "Quick fix" solutions, such as tar patches on slate roofs, should be avoided as they will generally fail within a year or so and may accelerate damage by trapping moisture. They are difficult to undo later when more permanent repairs are undertaken. Use of a tarpaulin over a leaking roof should be thought of only as a very temporary



*Figure 7. Non-historic materials are appropriate for mothballing projects when they are used to protect historic evidence remaining for future preservation. This lightweight aluminum channel frame and roofing covers the historic wooden shingle roof. Galvanized mesh panels secure the window openings from intrusion by raccoons and other unwanted guests. Photo: Williamsport Preservation Training Center, NPS.*



*Figure 8. Appropriate mortar mixes should be used when masonry repairs are undertaken. In this case, a soft lime based mortar is used as an infill between the brick and wooden elements. When full repairs are made during the restoration phase, this soft mortar can easily be removed and missing bricks replaced.*

emergency repair because it is often blown off by the wind in a subsequent storm.

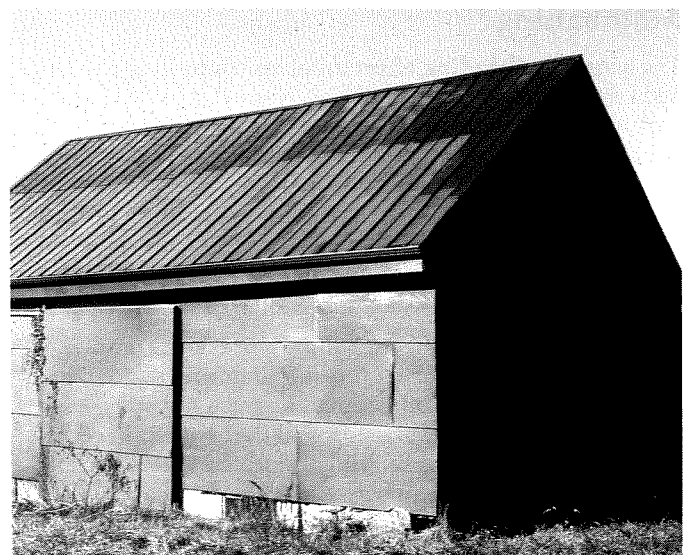
If the existing historic roof needs moderate repairs to make it last an additional ten years, then these repairs should be undertaken as a first priority. Replacing cracked or missing shingles and tiles, securing loose flashing, and reanchoring gutters and downspouts can often be done by a local roofing contractor. If the roof is in poor condition, but the historic materials and configuration are important, a new temporary roof, such as a lightweight aluminum channel system over the existing, might be considered (see fig. 7). If the roofing is so deteriorated that it must be replaced and a lightweight aluminum system is not affordable, various inexpensive options might be considered. These include covering the existing deteriorated roof with galvanized corrugated metal roofing panels, or 90 lb. rolled roofing, or a rubberized membrane (refer back to cover photo). These alternatives should leave as much of the historic sheathing and roofing in place as evidence for later preservation treatments.

For masonry repairs, appropriate preservation approaches are essential. For example, if repointing deteriorated brick chimneys or walls is necessary to prevent serious moisture penetration while the building is mothballed, the mortar should match the historic mortar in composition, color, and tooling. The use of hard portland cement mortars or vapor-impermeable waterproof coatings are not appropriate solutions as they can cause extensive damage and are not reversible treatments (see fig. 8).

For wood siding that is deteriorated, repairs necessary to keep out moisture should be made; repainting is generally warranted. Cracks around windows and doors can be beneficial in providing ventilation to the interior and so should only be caulked if needed to keep out bugs and moisture. For very deteriorated wall surfaces on wooden frame structures, it may be necessary to sheathe in plywood panels, but care should be taken to minimize installation damage by planning the location of the nailing or screw

patterns or by installing panels over a frame of battens (see fig. 9). Generally, however, it is better to repair deteriorated features than to cover them over.

Foundation damage may occur if water does not drain away from the building. Run-off from gutters and downspouts should be directed far away from the foundation wall by using long flexible extender pipes equal in length to twice the depth of the basement or crawl space. If underground drains are susceptible to clogging, it is recommended that the downspouts be disconnected from the drain boot and attached to flexible piping. If gutters and downspouts are in bad condition, replace them with inexpensive aluminum units.



*Figure 9. Severely deteriorated wooden siding on a farm building has been covered over with painted plywood panels as a temporary measure to eliminate moisture penetration to the interior. Foundation vents and loose floor boards allow air to circulate inside.*

If there are no significant landscape or exposed archeological elements around the foundation, consideration should be given to regrading the site if there is a documented drainage problem (see fig. 10). If building up the grade, use a fiber mesh membrane to separate the new soil from the old and slope the new soil 6 to 8 feet (200 cm-266 cm) away from the foundation making sure not to cover up the dampcourse layer or come into contact with skirting boards. To keep vegetation under control, put down a layer of 6 mil black polyethylene sheeting or fiber mesh matting covered with a 2"-4" (5-10 cm.) of washed gravel. If the building suffers a serious rising damp problem, it may be advisable to eliminate the plastic sheeting to avoid trapping ground moisture against foundations.



Figure 10. Regrading around the Booker Tenement at Colonial Williamsburg has protected the masonry foundation wall from excessive damp. This building has been successfully mothballed for over 10 years. Note the attic and basement vents, the temporary stairs, and the informative sign interpreting the history of this building.

## Mothballing

The actual mothballing effort involves controlling the long-term deterioration of the building while it is unoccupied as well as finding methods to protect it from sudden loss by fire or vandalism. This requires securing the building from unwanted entry, providing adequate ventilation to the interior, and shutting down or modifying existing utilities. Once the building is de-activated or secured, the long-term success will depend on periodic maintenance and surveillance monitoring.

**Securing the building from vandals, break-ins, and natural disasters.** Securing the building from sudden loss is a critical aspect of mothballing. Because historic buildings are irreplaceable, it is vital that vulnerable entry points are sealed. If the building is located where fire and security service is available then it is highly recommended that some form of monitoring or alarm devices be used.

To protect decorative features, such as mantels, lighting fixtures, copper downspouts, iron roof cresting, or stained glass windows from theft or vandalism, it may be advisable to temporarily remove them to a more secure location if they cannot be adequately protected within the structure.

Mothballed buildings are usually boarded up, particularly on the first floor and basement, to protect fragile glass windows from breaking and to reinforce entry points (see fig. 11). Infill materials for closing door and window openings include plywood, corrugated panels, metal grates, chain fencing, metal grills, and cinder or cement blocks (see fig. 12). The method of installation should not result in the destruction of the opening and all associated sash, doors, and frames should be protected or stored for future reuse.



Figure 11. Urban buildings often need additional protection from unwanted entry and graffiti. This commercial building uses painted plywood panels to cover expansive glass storefronts and chain link fencing is applied on top of the panels. The upper windows on the street sides have been covered and painted to resemble 19th century sash. Photo: Thomas Jester, NPS.

Generally exterior doors are reinforced and provided with strong locks, but if weak historic doors would be damaged or disfigured by adding reinforcement or new locks, they may be removed temporarily and replaced with secure modern doors (see fig. 13). Alternatively, security gates in a new metal frame can be installed within existing door openings, much like a storm door, leaving the historic door in place. If plywood panels are installed over door openings, they should be screwed in place, as opposed to nailed, to avoid crowbar damage each time the panel is removed. This also reduces pounding vibrations from hammers and eliminates new nail holes each time the panel is replaced.

For windows, the most common security feature is the closure of the openings; this may be achieved with wooden or pre-formed panels or, as needed, with metal sheets or concrete blocks. Plywood panels, properly installed to protect wooden frames and properly ventilated, are the preferred treatment from a preservation standpoint.

There are a number of ways to set insert plywood panels into windows openings to avoid damage to frame and sash (see fig. 14). One common method is to bring the upper and lower sash of a double hung unit to the mid-point of the opening and then to install pre-cut plywood panels using long carriage bolts anchored into horizontal wooden bracing, or strong backs, on the inside face of the window. Another means is to build new wooden blocking frames set into deeply recessed openings, for example in an industrial mill or warehouse, and then to affix the plywood panel to

the blocking frame. If sash must be removed prior to installing panels, they should be labeled and stored safely within the building.

Plywood panels are usually 1/2"-3/4" (1.25-1.875 cm.) thick and made of exterior grade stock, such as CDX, or



Figure 12. First floor openings have been filled with cinderblocks and doors, window sash and frames have been removed for safe keeping. Note the security light over the windows and the use of a security metal door with heavy duty locks. Photo: H. Ward Jandl, NPS.



Figure 13. If historic doors would be damaged by adding extra locks, they should be removed and stored and new security doors added. At this lighthouse, the historic door has been replaced with a new door (seen both inside and outside) with an inset vent and new deadbolt locks. The heavy historic hinges have not been damaged. Photo: Williamsport Preservation Training Center, NPS.

marine grade plywood. They should be painted to protect them from delamination and to provide a neater appearance. These panels may be painted to resemble operable windows or treated decoratively (see fig. 15). With extra attention to detail, the plywood panels can be

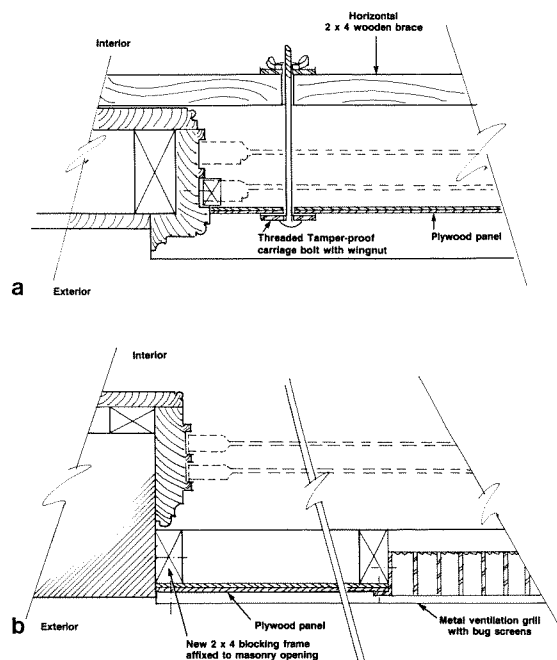


Figure 14. A: Plan detail showing plywood security panel anchored with carriage bolts through to the inside horizontal bracing, or strong backs. B: Plan detail showing section of plywood window panel attached to a new pressure treated wood frame set within the masonry opening. Ventilation should be included whenever possible or necessary.

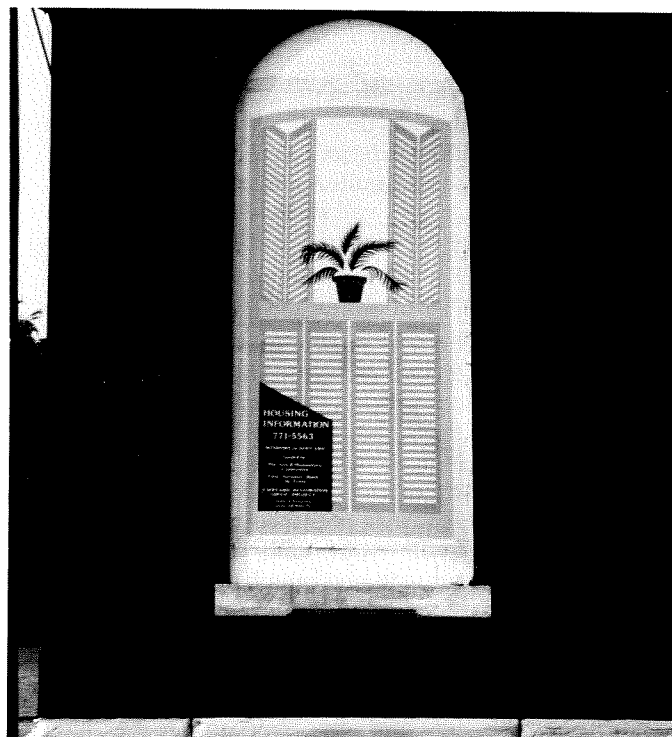


Figure 15. Painting trompe l'oeil scenes on plywood panels is a neighborhood friendly device. In addition, the small sign at the bottom left corner gives information for contacting the organization responsible for the care of the mothballed building. Photo: Lee H. Nelson, FAIA.



trimmed out with muntin strips to give a shadow line simulating multi-lite windows. This level of detail is a good indication that the building is protected and valued by the owner and the community.

If the building has shutters, simply close the shutters and secure them from the interior (see fig. 16). If the building had shutters historically, but they are missing, it may be appropriate to install new shutters, even in a modern material, and secure them in the closed position. Louvered shutters will help with interior ventilation if the sash are propped open behind the shutters.



Figure 16. Historic louvered shutters make excellent security closures with passive ventilation.

There is some benefit from keeping windows unboarded if security is not a problem. The building will appear to be occupied, and the natural air leakage around the windows will assist in ventilating the interior. The presence of natural light will also help when periodic inspections are made. Rigid polycarbonate clear storm glazing panels may be placed on the window exterior to protect against glass breakage. Because the sun's ultraviolet rays can cause fading of floor finishes and wall surfaces, filtering pull shades or inexpensive curtains may be options for reducing this type of deterioration for significant interiors. Some acrylic sheeting comes with built-in ultraviolet filters.

Securing the building from catastrophic destruction from fire, lightning, or arson will require additional security devices. Lightning rods properly grounded should be a first consideration if the building is in an area susceptible to lightning storms. A high security fence should also be installed if the property cannot be monitored closely. These interventions do not require a power source for operation. Since many buildings will not maintain electrical power, there are some devices available using battery packs, such as intrusion alarms, security lighting, and smoke detectors which through audible horn alarms can alert nearby neighbors. These battery packs must be replaced every 3 months to 2 years, depending on type and usage. In combination with a cellular phone, they can also provide some level of direct communication with police and fire departments.

If at all possible, new temporary electric service should be provided to the building (see fig. 17). Generally a telephone

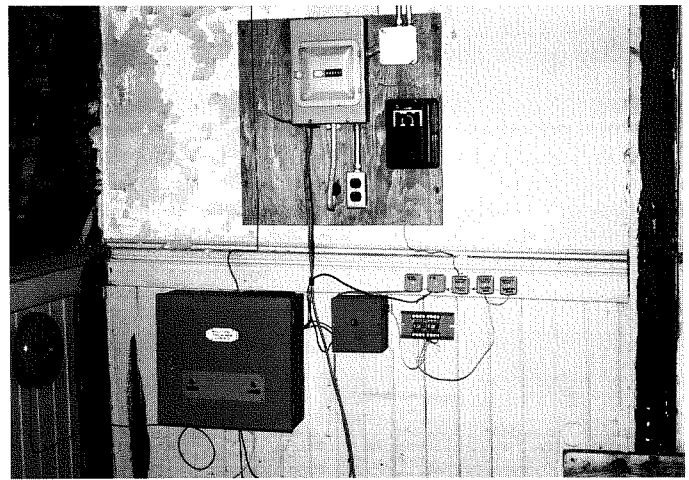


Figure 17. Security systems are very important for mothballed buildings if they are located where fire and security services are available. A temporary electric service with battery back-up has been installed in this building. Intrusion alarms and ionization smoke/fire detectors are wired directly to the nearby security service.

line is needed as well. A hard wired security system for intrusion and a combination rate-of-rise and smoke detector can send an immediate signal for help directly to the fire department and security service. Depending on whether or not heat will be maintained in the building, the security system should be designed accordingly. Some systems cannot work below 32°F (0°C). Exterior lighting set on a timer, photo electric sensor, or a motion/infrared detection device provides additional security.

**Providing adequate ventilation to the interior.** Once the exterior has been made weathertight and secure, it is essential to provide adequate air exchange throughout the building. Without adequate air exchange, humidity may rise to unsafe levels, and mold, rot, and insect infestation are likely to thrive (see fig. 18). The needs of each historic resource must be individually evaluated because there are so many variables that affect the performance of each interior space once the building has been secured. A

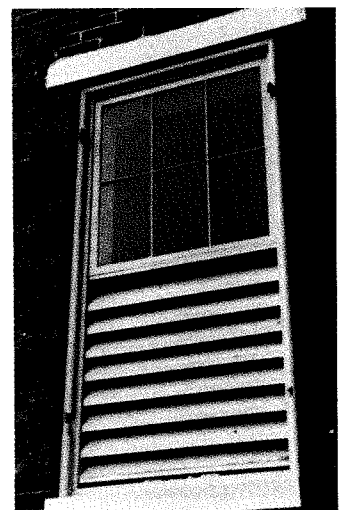
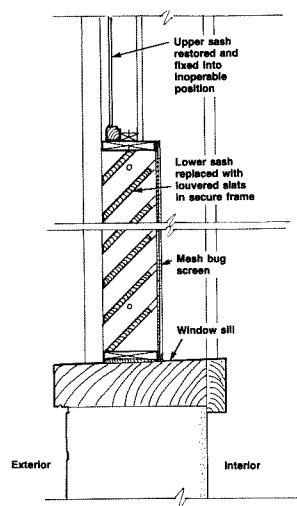


Figure 18. Heavy duty wooden slated lowers were custom fabricated to replace the deteriorated lower sash. The upper sash were rebuilt to retain the historic appearance and to allow light into this vacant historic building. Refer back to Fig. 1 for a view of the building. Photo: Charles E. Fisher, NPS. Drawing by Thomas Vitanza.

mechanical engineer or a specialist in interior climates should be consulted, particularly for buildings with intact and significant interiors. In some circumstances, providing heat during the winter, even at a minimal 45° F (7°C), and utilizing forced-fan ventilation in summer will be recommended and will require retaining electrical service. For masonry buildings it is often helpful to keep the interior temperature above the spring dew point to avoid damaging condensation. In most buildings it is the need for summer ventilation that outweighs the winter requirements.

Many old buildings are inherently leaky due to loose-fitting windows and floorboards and the lack of insulation. The level of air exchange needed for each building, however, will vary according to geographic location, the building's construction, and its general size and configuration.

There are four critical climate zones when looking at the type and amount of interior ventilation needed for a closed up building: hot and dry (southwestern states); cold and damp (Pacific northwest and northeastern states); temperate and humid (Mid-Atlantic states, coastal areas); and hot and humid (southern states and the tropics). (See fig. 19 for a chart outlining guidance on ventilation.)

Once closed up, a building interior will still be affected by the temperature and humidity of the exterior. Without proper ventilation, moisture from condensation may occur and cause damage by wetting plaster, peeling paint,

staining woodwork, warping floors, and in some cases even causing freeze thaw damage to plaster. If moist conditions persist in a property, structural damage can result from rot or returning insects attracted to moist conditions. Poorly mothballed masonry buildings, particularly in damp and humid zones have been so damaged on the interior with just one year of unventilated closure that none of the interior finishes were salvageable when the buildings were rehabilitated.

The absolute minimum air exchange for most mothballed buildings consists of one to four air exchanges every hour; one or two air exchanges per hour in winter and often twice that amount in summer. Even this minimal exchange may foster mold and mildew in damp climates, and so monitoring the property during the stabilization period and after the building has been secured will provide useful information on the effectiveness of the ventilation solution.

There is no exact science for how much ventilation should be provided for each building. There are, however, some general rules of thumb. Buildings, such as adobe structures, located in hot and arid climates may need no additional ventilation if they have been well weatherized and no moisture is penetrating the interior. Also frame buildings with natural cracks and fissures for air infiltration may have a natural air exchange rate of 3 or 4 per hour, and so in arid as well as temperate climates may need no additional ventilation once secured. The most difficult

VENTILATION GUIDANCE CHART							
CLIMATE	AIR EXCHANGES		VENTILATION				
Temperature and Humidity	Winter air exchange per hour	Summer air exchange per hour	Frame Buildings passive louvering		Masonry Buildings passive louvering		Masonry Buildings fan combination
			% of openings louvered		% of openings louvered		one fan + % louvered
			winter	summer	winter	summer	summer
<b>hot and dry</b> Southwestern areas	less than 1	less than 1	N/A	N/A	N/A	N/A	N/A
<b>cold and damp</b> Northeastern & Pacific northwestern areas	1	2-3	5%	10%	10%	30%	20%
<b>temperate/humid</b> Mid-Atlantic & coastal areas	2	3-4	10%	20%	20%	40%	30%
<b>hot and humid</b> Southern states & tropical areas	3	4 or more	20%	30%	40% or more	80%	40% or more

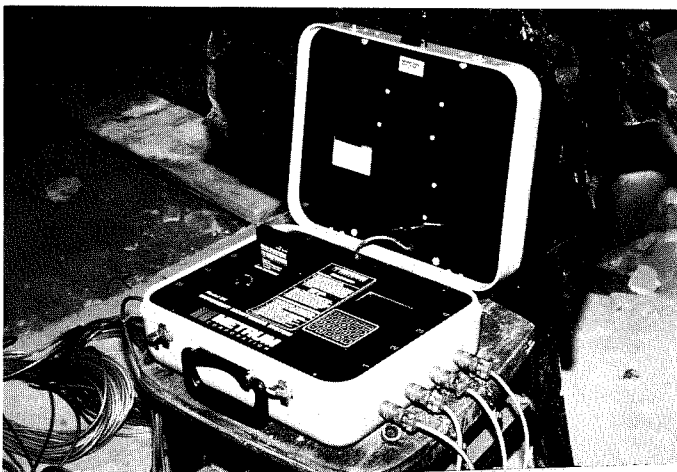
Figure 19. This is a general guide for the amount of louvering which might be expected for a medium size residential structure with an average amount of windows, attic, and crawl space ventilation. There is currently research being done on effective air exchanges, but each project should be evaluated individually. It will be noticed from the chart that summer louvering requirements can be reduced with the use of an exhaust fan. Masonry buildings need more ventilation than frame buildings. Chart prepared by Sharon C. Park, AIA and Ernest A. Conrad, PE.

buildings to adequately ventilate without resorting to extensive louvering and/or mechanical exhaust fan systems are masonry buildings in humid climates. Even with basement and attic vent grills, a masonry building may not have more than one air exchange an hour. This is generally unacceptable for summer conditions. For these buildings, almost every window opening will need to be fitted out with some type of passive, louvered ventilation.

Depending on the size, plan configuration, and ceiling heights of a building, it is often necessary to have louvered opening equivalent to 5%-10% of the square footage of each floor. For example, in a humid climate, a typical 20'x30' (6.1m x 9.1m) brick residence with 600 sq. ft. (55.5 sq.m) of floor space and a typical number of windows, may need 30-60 sq. ft. (2.75sq.m-5.5 sq. m) of louvered openings per floor. With each window measuring 3'x5' (.9m x 1.5 m) or 15 sq. ft. (1.3 sq.m), the equivalent of 2 to 4 windows per floor may need full window louvers.

Small pre-formed louvers set into a plywood panel or small slit-type registers at the base of inset panels generally cannot provide enough ventilation in most moist climates to offset condensation, but this approach is certainly better than no louvers at all. Louvers should be located to give cross ventilation, interior doors should be fixed ajar at least 4" (10cm) to allow air to circulate, and hatches to the attic should be left open.

Monitoring devices which can record internal temperature and humidity levels can be invaluable in determining if the internal climate is remaining stable. These units can be powered by portable battery packs or can be wired into electric service with data downloaded into laptop computers periodically (see fig. 20). This can also give long-term information throughout the mothballing years. If it is determined that there are inadequate air exchanges to keep interior moisture levels under control, additional passive ventilation can be increased, or, if there is electric service, mechanical exhaust fans can be installed. One fan in a small to medium sized building can reduce the amount of louvering substantially.

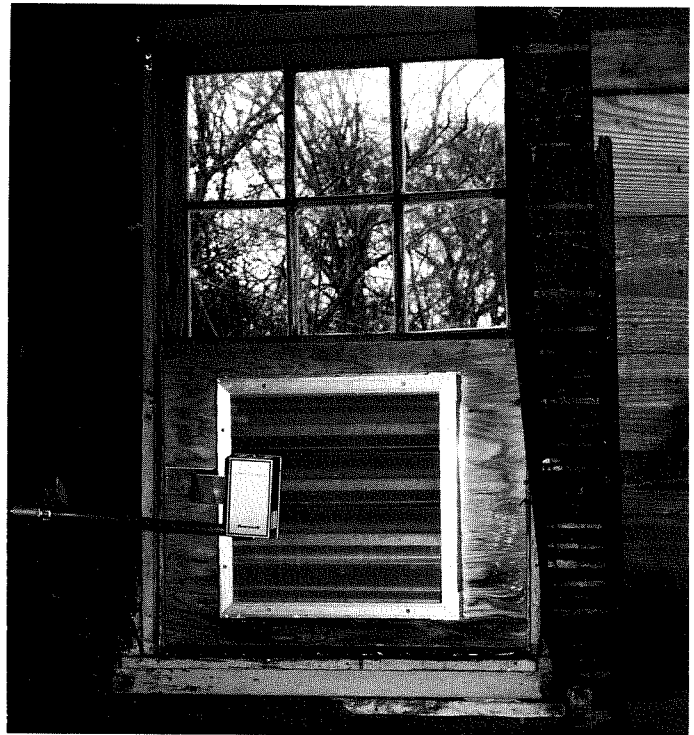


*Figure 20. Portable monitors used to record temperature and humidity conditions in historic buildings during mothballing can help identify ventilation needs. This data can be downloaded directly into a lap top computer on site. These monitors are especially helpful over the long term for buildings with significant historic interiors or which are remaining furnished. If interiors are remaining damp or humid, additional ventilation should be added or the source of moisture controlled.*

If electric fans are used, study the environmental conditions of each property and determine if the fans should be controlled by thermostats or automatic timers. Humidistats, designed for enclosed climate control systems, generally are difficult to adapt for open mothballing conditions. How the system will draw in or exhaust air is also important. It may be determined that it is best to bring dry air in from the attic or upper levels and force it out through lower basement windows (see fig. 21). If the basement is damp, it may be best to zone it from the rest of the building and exhaust its air separately. Additionally, less humid day air is preferred over damper night air, and this can be controlled with a timer switch mounted to the fan.

The type of ventilation should not undermine the security of the building. The most secure installations use custom-made grills well anchored to the window frame, often set in plywood security panels. Some vents are formed using heavy millwork louvers set into existing window openings (refer back to fig.18). For buildings where security is not a primary issue, where the interior is modest, and where there has been no heat for a long time, it may be possible to use lightweight galvanized metal grills in the window openings (refer back to fig.7). A cost effective grill can be made from the expanded metal mesh lath used by plasterers and installed so that the mesh fins shed rainwater to the exterior.

**Securing mechanical systems and utilities.** At the outset, it is important to determine which utilities and services, such as electrical or telephone lines, are kept and which are cut off. As long as these services will not constitute a fire



*Figure 21. This electric thermostat/humidistat mounted in the attic vent controls a modified ducted air/fan system. The unit uses temporary exposed sheet metal ducts to pull air through the building and exhaust it out of the basement. For over ten years this fan system in combination with 18" x 18" preformed louvers in selective windows has kept the interior dry and with good air exchanges.*

hazard, it is advisable to retain those which will help protect the property. Since the electrical needs will be limited in a vacant building, it is best to install a new temporary electric line and panel (100 amp) so that all the wiring is new and exposed. This will be much safer for the building, and allows easy access for reading the meter (see fig. 22).

Most heating systems are shut down in long term mothballing. For furnaces fueled by oil, there are two choices for dealing with the tank. Either it must be filled to the top with oil to eliminate condensation or it should be drained. If it remains empty for more than a year, it will likely rust and not be reusable. Most tanks are drained if a newer type of system is envisioned when the building is put back into service. Gas systems with open flames should be turned off unless there is regular maintenance and frequent surveillance of the property. Gas lines are shut off by the utility company.

If a hot water radiator system is retained for low levels of heat, it generally must be modified to be a self-contained system and the water supply is capped at the meter. This



Figure 22. All systems except temporary electric have been shut off at this residence which has been mothballed over 20 years. An electric meter and 100 amp panel box have been set on a plywood panel at the front of the building. It is used for interior lighting and various alarm systems. The building, however, is showing signs of moisture problems with efflorescent stains on the masonry indicating the need for gutter maintenance and additional ventilation for the interior. The vegetation on the walls, although picturesque, traps moisture and is damaging to the masonry. Photo: H. Ward Jandl, NPS.

recirculating system protects the property from extensive damage from burst pipes. Water is replaced with a water/glycol mix and the reserve tank must also be filled with this mixture. This keeps the modified system from freezing, if there is a power failure. If water service is cut off, pipes should be drained. Sewerage systems will require special care as sewer gas is explosive. Either the traps must be filled with glycol or the sewer line should be capped off at the building line.

**Developing a maintenance and monitoring plan.** While every effort may have been made to stabilize the property and to slow the deterioration of materials, natural disasters, storms, undetected leaks, and unwanted intrusion can still occur. A regular schedule for surveillance, maintenance, and monitoring should be established: (See fig. 23 for maintenance chart).

MAINTENANCE CHART	
<b>periodic</b>	
<input type="checkbox"/>	regular drive by surveillance
<input type="checkbox"/>	check attic during storms if possible
<b>monthly walk arounds</b>	
<input type="checkbox"/>	check entrances
<input type="checkbox"/>	check window panes for breakage
<input type="checkbox"/>	mowing as required
<input type="checkbox"/>	check for graffiti or vandalism
<b>enter every 3 months to air out</b>	
<input type="checkbox"/>	check for musty air
<input type="checkbox"/>	check for moisture damage
<input type="checkbox"/>	check battery packs and monitoring equipment
<input type="checkbox"/>	check light bulbs
<input type="checkbox"/>	check for evidence of pest intrusion
<b>every 6 months; spring and fall</b>	
<input type="checkbox"/>	site clean-up; pruning and trimming
<input type="checkbox"/>	gutter and downspout check
<input type="checkbox"/>	check crawlspace for pests
<input type="checkbox"/>	clean out storm drains
<b>every 12 months</b>	
<input type="checkbox"/>	maintenance contract inspections for equipment/utilities
<input type="checkbox"/>	check roof for loose or missing shingles
<input type="checkbox"/>	termite and pest inspection/treatment
<input type="checkbox"/>	exterior materials spot repair and touch up painting
<input type="checkbox"/>	remove bird droppings or other stains from exterior
<input type="checkbox"/>	check and update building file

Figure 23. Maintenance Chart. Many of the tasks on the maintenance chart can be done by volunteer help or service contracts. Regular visits to the site will help detect intrusion, storm damage, or poor water drainage.



The fire and police departments should be notified that the property will be vacant. A walk-through visit to familiarize these officials with the building's location, construction materials, and overall plan may be invaluable if they are called on in the future.

The optimum schedule for surveillance visits to the property will depend on the location of the property and the number of people who can assist with these activities. The more frequent the visits to check the property, the sooner that water leaks or break-ins will be noticed. Also, the more frequently the building is entered, the better the air exchange. By keeping the site clear and the building in good repair, the community will know that the building has not been abandoned (see fig. 24). The involvement of neighbors and community groups in caring for the property can ensure its protection from a variety of catastrophic circumstances.

The owner may utilize volunteers and service companies to undertake the work outlined in the maintenance chart.

Service companies on a maintenance contract can provide yard, maintenance, and inspection services, and their reports or itemized bills reflecting work undertaken should be added to update the building file.



Figure 24. Once mothballed, a property must still be monitored and maintained. The openings in this historic barn has been modified with a combination of wood louvers and metal mesh panels which require little maintenance. The grounds are regularly mowed, even inside the chain link security fence. Photo: Williamsport Preservation Training Center, NPS.

## Components of a Mothballing Project

**Document:** Brearley House, New Jersey; 2½ story center hall plan house contains a high degree of integrity of circa 1761 materials and significant early 19th century additions. Deterioration was attributable to leaking roof, unstable masonry at gables and chimneys, deteriorating attic windows, poor site drainage, and partially detached gutters. Mothballing efforts are required for approximately 7-10 years.

**Stabilize:** Remove bat droppings from attic using great caution. Secure historic chimneys and gable ends with plywood panels. Do not take historic chimneys down. Reroof with asphalt shingles and reattach or add new gutters and downspouts. Add extenders to downspouts. Add bug screens to any ventilation areas. Add soil around foundation and slope to gain positive drain; do not excavate as this will disturb archeological evidence.

**Mothball:** Install security fence around the property. Secure doors and windows with plywood panels (½" exterior grade). Install preformed metal grills in basement and attic openings. Add surface mounted wiring for ionization smoke and fire detection with direct wire to police and fire departments. Shut off heat and drain pipes. Add window exhaust fan set on a thermostatic control. Provide for periodic monitoring and maintenance of the property.

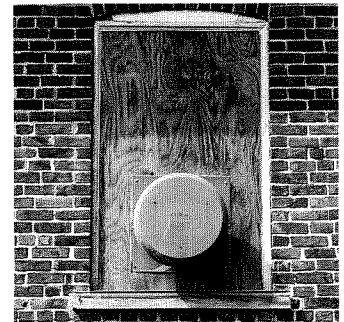
Figure 25. Above is a summary of the tasks that were necessary in order to protect this significant property while restoration funds are raised. Photographs: Michael Mills; Ford Farewell Mills Gatsch Architects.



a. A view showing the exterior of the house in its mothballed condition.



b. Plywood panels stabilize the chimneys. Note the gable vents.



c. The exhaust fan has tamper-proof housing.

# MOTHBALLING CHECKLIST

<b>Mothballing Checklist</b> In reviewing mothballing plans, the following checklist may help to ensure that work items are not inadvertently omitted.	Yes	No	Date of action or comment.
<i>Moisture</i> <ul style="list-style-type: none"> <li>• Is the roof watertight?</li> <li>• Do the gutters retain their proper pitch and are they clean?</li> <li>• Are downspout joints intact?</li> <li>• Are drains unobstructed?</li> <li>• Are windows and doors and their frames in good condition?</li> <li>• Are masonry walls in good condition to seal out moisture?</li> <li>• Is wood siding in good condition?</li> <li>• Is site properly graded for water run-off?</li> <li>• Is vegetation cleared from around the building foundation to avoid trapping moisture?</li> </ul>			
<i>Pests</i> <ul style="list-style-type: none"> <li>• Have nests/pests been removed from the building's interior and eaves?</li> <li>• Are adequate screens in place to guard against pests?</li> <li>• Has the building been inspected and treated for termites, carpenter ants, and rodents?</li> <li>• If toxic droppings from bats and pigeons are present, has a special company been brought in for its disposal?</li> </ul>			
<i>Housekeeping</i> <ul style="list-style-type: none"> <li>• Have the following been removed from the interior: trash, hazardous materials such as inflammable liquids, poisons, and paints and canned goods that could freeze and burst?</li> <li>• Is the interior broom-clean?</li> <li>• Have furnishings been removed to a safe location?</li> <li>• If furnishings are remaining in the building, are they properly protected from dust, pests, ultraviolet light, and other potentially harmful problems?</li> <li>• Have significant architectural elements that have become detached from the building been labeled and stored in a safe place?</li> <li>• Is there a building file?</li> </ul>			
<i>Security</i> <ul style="list-style-type: none"> <li>• Have fire and police departments been notified that the building will be mothballed?</li> <li>• Are smoke and fire detectors in working order?</li> <li>• Are the exterior doors and windows securely fastened?</li> <li>• Are plans in place to monitor the building on a regular basis?</li> <li>• Are the keys to the building in a secure but accessible location?</li> <li>• Are the grounds being kept from becoming overgrown?</li> </ul>			
<i>Utilities</i> <ul style="list-style-type: none"> <li>• Have utility companies disconnected/shut off or fully inspected water, gas, and electric lines?</li> <li>• If the building will not remain heated, have water pipes been drained and glycol added?</li> <li>• If the electricity is to be left on, is the wiring in safe condition?</li> </ul>			
<i>Ventilation</i> <ul style="list-style-type: none"> <li>• Have steps been taken to ensure proper ventilation of the building?</li> <li>• Have interior doors been left open for ventilation purposes?</li> <li>• Has the secured building been checked within the last 3 months for interior dampness or excessive humidity?</li> </ul>			

Figure 26.. MOTHBALL CHECKLIST. This checklist will give the building owner or manager a handy reference guide to items that should be addressed when mothballing a historic building. Prepared by H. Ward Jandl, NPS.

## Conclusion

Providing temporary protection and stabilization for vacant historic buildings can arrest deterioration and buy the owner valuable time to raise money for preservation or to find a compatible use for the property. A well planned mothballing project involves documenting the history and condition of the building, stabilizing the structure to slow down its deterioration, and finally mothballing the structure to secure it (See fig. 25). The three highest priorities for the building while it is mothballed are 1) to protect the building from sudden loss, 2) to weatherize and maintain the property to stop moisture penetration, and 3) to control the humidity levels inside once the building has been secured. See Mothballing Checklist Figure 26.

While issues regarding mothballing may seem simple, the variables and intricacies of possible solutions make the decision-making process very important. Each building must be individually evaluated prior to mothballing. In addition, a variety of professional services as well as volunteer assistance are needed for careful planning and repair, sensitively designed protection measures, follow-up security surveillance, and cyclical maintenance (see fig. 27).

In planning for the future of the building, complete and systematic records must be kept and generous funds allocated for mothballing. This will ensure that the historic property will be in stable condition for its eventual preservation, rehabilitation, or restoration.

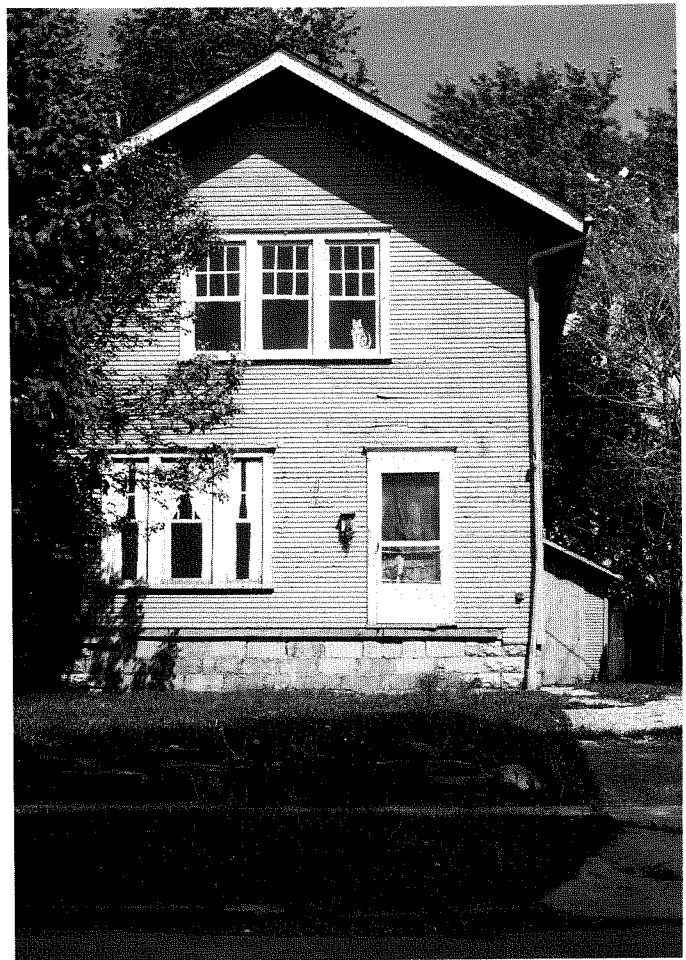


Figure 27. This residential building blends into its neighborhood even though all the windows have been covered over and the front steps are missing. The grounds are maintained and the special attention to decoratively painting the window panels shows that the property is being well cared for until it can be rehabilitated. Photo: Ohio Historical Society.

## Acknowledgements

This publication has been prepared pursuant to the National Historic Preservation Act of 1966, as amended, which directs the Secretary of the Interior to develop and make available information concerning historic properties. Comments on the usefulness of this publication may be directed to H. Ward Jandl, Deputy Chief, Preservation Assistance Division, National Park Service, P.O. Box 37127, Washington, D.C. 20013-7127. This publication is not copyrighted and can be reproduced without penalty. Normal procedures for credit to the author and the National Park Service are appreciated.

The author, Sharon C. Park, Senior Historical Architect, Preservation Assistance Division, National Park Service, would like to acknowledge the assistance of the following individuals in the preparation and review of this publication. H. Ward Jandl served as the technical editor and assisted with producing this Preservation Brief. In addition the following persons have provided invaluable information and illustrations: Ernest A. Conrad, PE; Doug Hicks, NPS Williamsport Preservation Training Center; Thomas C. Taylor, Colonial Williamsburg; Karen Gordon, Seattle Urban Conservation Office; Kevin B. Stoops, Seattle Department of Parks and Recreation; Michael Mills, AIA; Christine Henry, architect, Mary Beth Hirsch, Ohio Historical Society. Thanks also to Preservation Assistance Division staff members Michael J. Auer, Anne E. Grimmer, Kay D. Weeks, Timothy A. Buehner, and Jean Travers, and to the numerous staff members of the NPS Regional offices who submitted comments.

All photographs and drawings are by the author unless otherwise noted.

Cover photograph: Mothballing of this historic house involved a new membrane roof covering over the historic roof and slatted window covers for security and ventilation. Photo: Williamsport Preservation Training Center, NPS.

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## Further Reading

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Nelson, Lee H. *Preservation Briefs 17. Architectural character-Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character*. Washington, DC: Government Printing Office, 1988.

Solon, Thomas E. "Security Panels for the Foster-Armstrong House." *Association for Preservation Technology Bulletin*. Vol XVI no. 3 & 4, 1984. (note the design of the panels, but be aware that additional louvering may be needed on other projects).

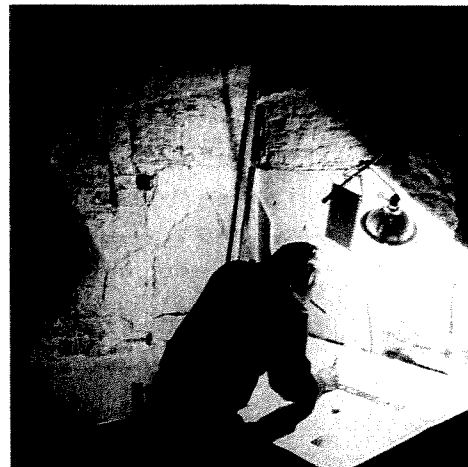
# 35 PRESERVATION BRIEFS

## Understanding Old Buildings: The Process of Architectural Investigation

Travis C. McDonald, Jr.



U.S. Department of the Interior  
National Park Service  
Cultural Resources  
Preservation Assistance



If you have ever felt a sense of excitement and mystery going inside an old building—whether occupied or vacant—it is probably because its materials and features resonate with the spirit of past people and events. Yet excitement about the unknown is heightened when a historic structure is examined architecturally, and its evolution over time emerges with increasing clarity to reveal the lives of its occupants. Architectural investigation is the critical first step in planning an appropriate treatment—understanding how a building has changed over time and assessing levels of deterioration.

Whether as a home owner making sympathetic repairs, a craftsman or contractor replacing damaged or missing features, or a conservator reconstituting wood or restoring decorative finishes, some type of investigative skill was used to recognize and solve an architectural question or explain a difficult aspect of the work itself.

To date, very little has been written for the layman on the subject of architectural investigation. This Preservation Brief thus addresses the often complex investigative process in broad, easy-to-understand terminology. The logical sequence of planning, investigation and analysis presented in this Brief is applicable to all buildings, geographic locations, periods, and construction types. It is neither a "how to" nor an exhaustive study on techniques or methodologies; rather, it serves to underscore the need for meticulous planning prior to work on our irreplaceable cultural resources.

### Determining the Purpose of Investigation

Both the purpose and scope of investigation need to be determined before formulating a particular approach. For example, investigation strictly for research purposes could produce information for an architectural survey or for an historic designation application at the local, state or national level.

Within the framework of *The Secretary of the Interior's Standards for the Treatment of Historic Properties*, investigation is crucial for "identifying, retaining, and preserving the form and detailing of those architectural materials and features that are important in defining the

historic character" of a property, whether for repair or replacement. A rehabilitation project, for instance, might require an investigation to determine the historic configuration of interior spaces prior to partitioning a room to meet a compatible new use. Investigation for preservation work can entail more detailed information about an entire building, such as determining the physical sequence of construction to aid in interpretation. Investigation for a restoration project must be even more comprehensive in order to re-capture the exact form, features, finishes, and detailing of every component of the building.

Whether investigation will be undertaken by professionals—architects, conservators, historians—or by interested homeowners, the process is essentially comprised of a preliminary four-step procedure: historical research, documentation, inventory, and stabilization.

**Historical Research.** Primary historical research of an old building generally encompasses written, visual and oral resources that can provide valuable site-specific information. Written resources usually include letters, legal transactions, account books, insurance policies, institutional papers, and diaries. Visual resources consist of drawings, maps, plats, paintings and photographs. Oral resources are people's remembrances of the past. Secondary resources, comprised of research or history already compiled and written about a subject, are also important for providing a broad contextual setting for a project.

Historical research should be conducted well in advance of physical investigation. This allows time for important written, visual, and oral information to be located, transcribed, organized, studied and used for planning the actual work.

A thorough scholarly study of a building's history provides a responsible framework for the physical investigation; in fact, the importance of the link between written historical research and structural investigation cannot be overestimated. For example, the historical research of a building through deed records may merely determine the sequence of owners. This, in turn, aids the investigation of the building by establishing a chronology and identifying the changes each occupant made to the building. A letter







Figure 4. An inventory of animal nests found within hidden spaces of a structure may yield unexpected evidence, such as information about food, decorative arts, and cultural or social traditions of every day life. Typical items of paper, fabric and wood are important artifacts which are generally not found during archeology digs in the ground. photo: Tom Graves, Jr., courtesy Jefferson's Poplar Forest.

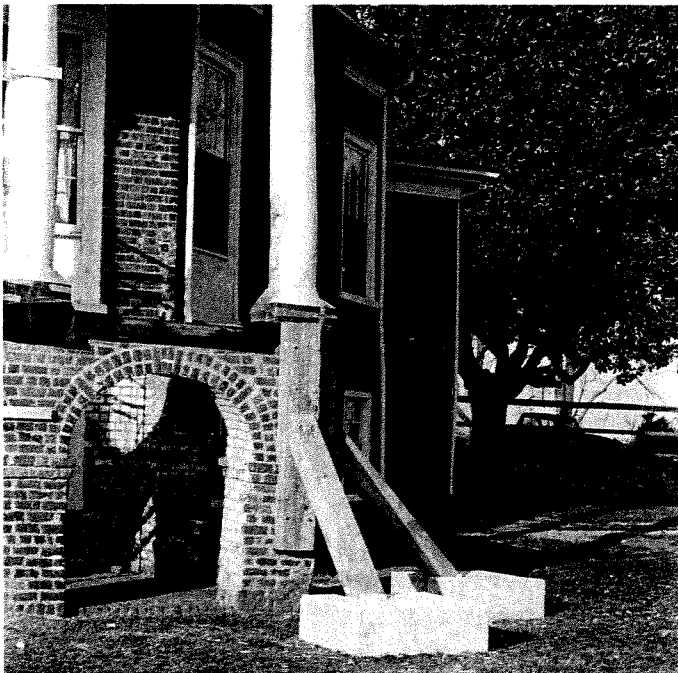


Figure 5. Investigation frequently identifies urgent needs of stabilization. Priority must be given to issues of safety and structural integrity. Supplemental support, such as temporary shoring, may be required to prevent collapse and should be reviewed by a structural engineer.

structure against intruding insects, animals and vandals.

An old building may require temporary remedial work on exterior surfaces such as reversible caulking or an impermanent, distinguishable mortar. Or if paint analysis is contemplated in the future, deteriorated paint can be protected without heavy scraping by applying a recognizable "memory" layer over all the historic layers. Stabilization adds to the cost of any project, but human safety and the protection of historical evidence are well worth the extra money.

## Investigators and Investigative Skills

**General and Specialized Skills.** The essential skill needed for any level of investigation is the ability to observe closely and to analyze. These qualities are ideally combined with a hands-on familiarity of historic buildings—and an open mind! Next, whether acquired in a university or in a practical setting, an investigator should have a good general knowledge of history, building design history and, most important, understand both construction and finish technologies.

But it is not enough to know architectural style and building technology from a national viewpoint; the investigator needs to understand regional and local differences as well. While investigative skills are transferable between regions and chronological periods, investigators must be familiar with the peculiarities of any given building type and geographical area.

Architectural survey and comparative fieldwork provides a crucial database for studying regional variations in historic buildings. For example, construction practices can reflect shared experiences of widely diverse backgrounds and traditions within a small geographical area. Contemporary construction practice in an urban area might vary dramatically from that of rural areas in the same region. Neighbors or builders within the same geographical area



Figure 6. An investigator must have the skill and ability to closely observe and analyze the materials with a broad understanding of historic construction practices and technologies. Through the collection of samples and analysis of materials, investigative questions are either answered, refined, or formulated.

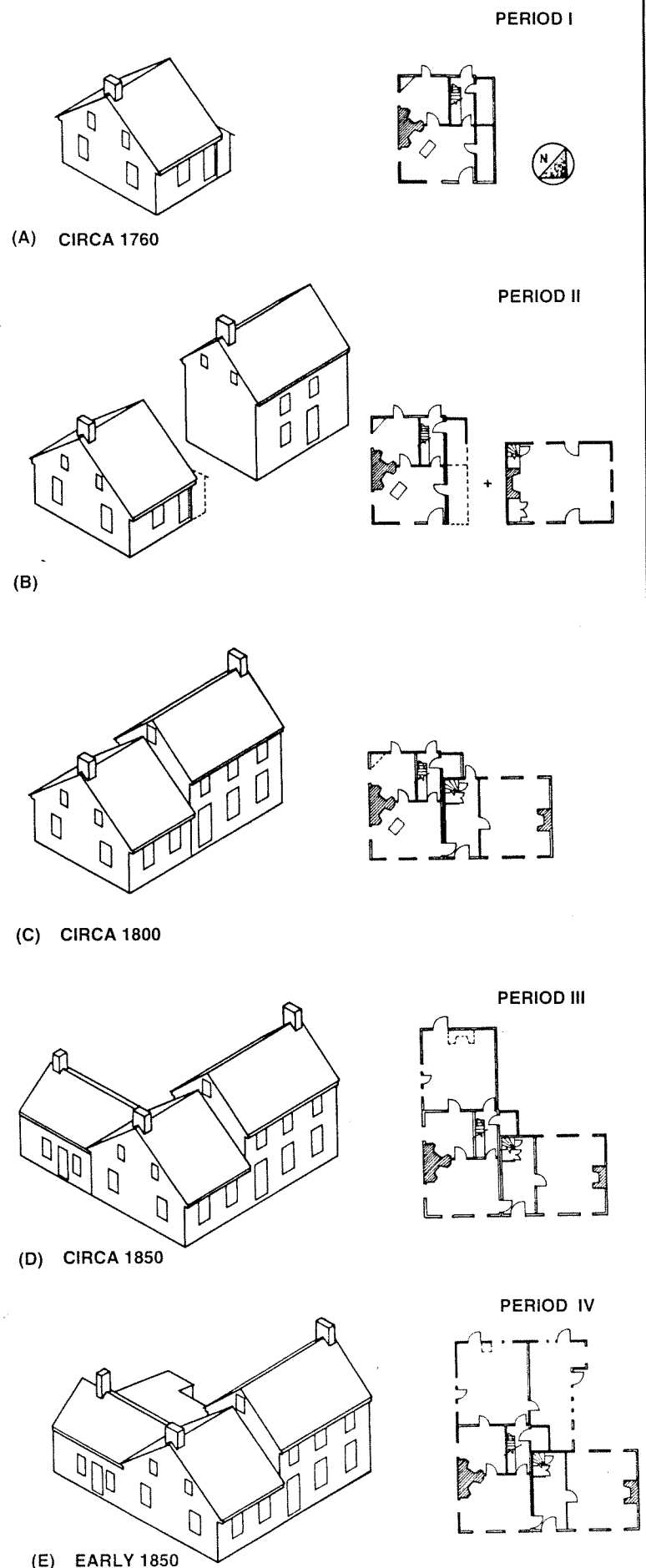
## Showing the Evolution of an 18th Century Farmhouse

Most structures evolve over time. Houses, perhaps more than other building types, are often subjected to a full range of change that reflects a wide variety of solutions for creating new living space or eliminating outmoded spaces. Architectural changes to historic houses can be studied through the close physical examination of construction and decorative details. Tracing the history of alterations over time is tantamount to "excavating" the structure, somewhat like an archeological investigation. By peeling back its layers of occupation and assembling plan changes, a sequence of consecutive solutions or transformations can be developed that reveals people's ongoing desires for new and improved living conditions.

The example of a Sussex County, Delaware, house--from ca. 1790 to the early 1900s--illustrates how complicated the pattern of change over time can become in outlining an individual house history. The Hunter Farm House was built in the 18th century as a double-cell, double-pile, half-passage plan (a). Two bays across the front and two stories tall, the house possessed back-to-back corner fireplaces with fully paneled fireplace walls in the front and back rooms. A stair in the rear passage provided access to the second floor. A one-story, two-room shed that was attached to the gable wall farthest from the fireplace was accessed by a low door leading from the front room.

During the course of its history, the house was altered at least three times. The five-part illustration shows the house's transformation from an open plan to a Georgian plan and the subsequent addition and re-arrangement of service rooms for cooking and storage. The first remodelling occurred in the early nineteenth century when the lean-to shed was removed, and a two-story, single-pile, two-bay house was moved up and attached to the northwest gable of the existing building (b). (The newly attached building had originally been furnished with opposing doors and windows on the front and back facades, a fireplace on the southeast gable, and double windows on the opposite end.) When the second building was joined to the first, the fireplace in the newer building was relocated to the opposite gable; the front door in the older house moved to a more central position; and a center-hall plan created with a roughly symmetrical front elevation (c). A subsequent alteration later in the nineteenth century included the addition of a one-story rear service ell (d). Finally, in the early 1900s, the one-story service wing was increased. During this last remodeling, the large kitchen hearth was demolished and replaced with a stove and new brick flue (e).

*Sidebar: Bernard L. Herman and Gabrielle M. Lanier, University of Delaware. Drawings by: Center for Historic Architecture and Engineering, University of Delaware.*



Finally, even beyond regional and local variation, an investigator needs to understand that each building has its own unique history of construction and change over time. Form, features, materials and detailing often varied according to the tastes and finances of both builder and supplier; construction quality and design were also inconsistent, as they are today.

Architectural investigation often includes the related fields of landscape and archeological investigation. Landscape survey or analysis by horticulturists and landscape architects identify pre-existing features or plantings or those designed as separate or complementary parts of the site. Both above and below-ground archeology contribute information about missing or altered buildings, construction techniques, evidence of lifestyle and material culture, and about the evolution of the historic landscape itself.

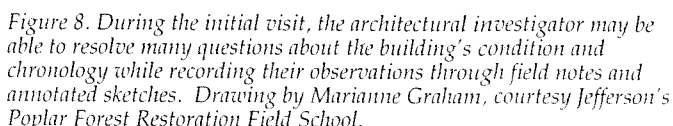
**Original Construction and Later Changes.** Research prior to investigation may have indicated the architect, builder or a building's date of construction. In the absence of such information, architectural histories and field guides to architectural style can help identify a structure's age through its form and style.

The architectural investigation usually determines original construction details, the chronology of later alterations, and the physical condition of a structure. Most structures over fifty years old have been altered, even if only by natural forces. People living in a house or using a building for any length of time leave some physical record of their time there, however subtle.

Changes to architectural form over time are generally attributable to material durability, improvement in convenience systems, and aesthetics. First, the durability of building materials is affected by weathering, temperature and humidity, by disasters such as storms, floods or fire, or by air pollution from automobiles and industry. Second, changes in architectural form have always been made for convenience's sake—fueled by technological innovations—as people embrace better lighting, plumbing, heating, sanitation, and communication. People alter living spaces to meet changing family needs. Finally, people make changes to architectural form, features, and detailing to conform to current taste and style.

Architectural investigation can range from a simple one hour walk-through to a month long or even multi-year project—and varies from looking at surfaces to professional sub-surface examination and laboratory work.

All projects should begin with the simplest, non-destructive processes and proceed as necessary. The sequence of investigation starts with reconnaissance and progresses to surface examination and mapping, sub-surface non-destructive testing, and various degrees of sub-surface destructive testing.





## Looking More Closely at Historic Building Materials and Features

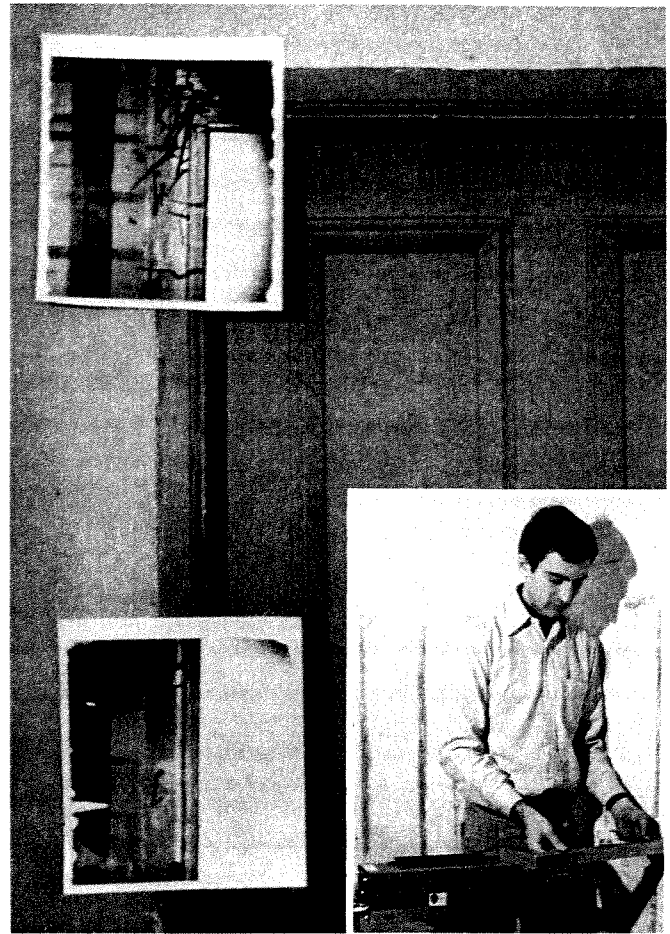
*Although brick or wood frame buildings are the most common in this country, similar sets of characteristics and questions can be established for examining log, adobe, steel, or any other material.*



*Figure A. Careful examination of the masonry reveals different periods of construction and repair through the composition and detailing of bricks and mortar. Depending upon location, open vertical joints may indicate the location of nailing blocks for decorative trim or weeps for drainage. These open joints at the building's cornice show evidence of an earlier wooden entablature extending down two courses below the present trim. The paint ghosts below the lowest blocks confirms the entablature's existence and provides clues to its size and finish.*

**Masonry.** Studying historic brickwork can provide important information about methods of production and construction. For example, the color, size, shape and texture of brick reveals whether it was hand molded and traditionally fired in a clamp with hardwoods, or whether it was machine molded and fired in a kiln using modern fuels. Similarly, the principal component part of masonry mortar, the lime or cement, reveals whether it was produced in a traditional or modern manner. Certain questions need to be asked during investigation. Is the mortar made with a natural or a Portland cement? If a natural cement, did it come from an oyster shell or a limestone source? Is it hydrated or hydraulic? As a construction unit, brick and mortar further reveal something about the time, place and human variables of construction, such as the type of bond, special brick shapes, decorative uses of glazed or rubbed brick, coatings and finishes, and different joints, striking and tooling. Does the bond conform with neighboring or regional buildings of the same period? Does the pattern of "make up" bricks in a Flemish Bond indicate the number of different bricklayers? What is the method of attaching wood trim to the masonry? The same types of questions related to production and construction characteristics can be applied to all types of masonry work, including stone, concrete, terra cotta, adobe and coquina construction. A complete survey undertaken during "surface mapping" can outline the materials and construction practices for the

various periods of a structure, distinguishing the original work as well as the additions, alterations, and replacements.



*Figure B. Without damaging or altering historic fabric, X-ray images of wood connections provide internal views of construction materials and techniques. These x-ray images show nails being used to form the connections of a door opening in a wood stud wall covered with plaster and cut wooden lath. A single technician can operate the portable equipment and develop the film on site for immediate analysis. photos: NPS North Atlantic Cultural Resource Center, Building Conservation Branch.*

**Wood.** Buildings constructed with wood have a very different set of characteristics, requiring a different line of questioning. Is the wooden structural system log, timber frame, or balloon frame construction? Evidence seen on the wood surface indicates whether production was by ax, adze, pit saw, mill saw (sash or circular), or band saw. What are the varying dimensions of the lumber used? Finished parts can be sawn, gouged, carved, or planed (by hand or by machine). Were they fastened by notching, mortise and tenon, pegs, or nailing? If nails were used, were they wrought by hand, machine cut with wrought heads, entirely machine cut, or machine wire nails? For much of the nineteenth century the manufacture of nails underwent a series of changes and improvements that are dateable, allowing nails to be used as a tool in establishing periods of construction and alteration. Regardless of region or era, the method of framing, joining and finishing a wooden structure will divulge something about the original construction, its alterations, and the practices of its builders. Finally, does some of the wood

appear to be re-used or re-cycled? Re-used and reproduction materials used in early restoration projects have confused many investigators. When no identification record was kept, it can be a problem distinguishing between materials original to the house and later replacement materials.

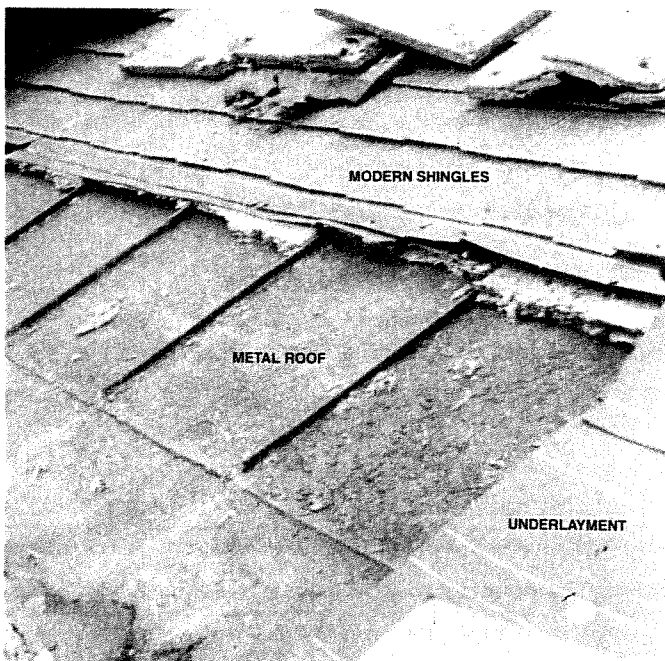


Figure C. In many cases, new materials or coverings are placed directly over existing exterior features, preserving the original materials underneath. Here, the removal of a modern shingle roof and its underlayment revealed an historic standing seam metal roof. photo: courtesy, Phillips and Opperman, P.A.

**Roofs.** Exterior features are especially prone to alteration due to weathering and lack of maintenance. Even in the best preserved structures, the exterior often consists of replaced or repaired roofing parts. Roof coverings typically last no more than fifty years. Are several generations of roof coverings still in place? Can the layers be identified? If earlier coverings were removed, the sheathing boards frequently provide clues to the type of covering as well as missing roof features. Dormers, cupolas, finials, cresting, weathervanes, gutters, lightning rods, skylights, balustrades, parapets and platforms come and go as taste, function and maintenance dictate. The roof pitch itself can be a clue to stylistic dating and is unlikely to change unless the entire roof has been rebuilt. Chimneys might hold clues to original roof pitch, flashings, and roof feature attachments. Is it possible to look down a chimney and count the number of flues? This practice has occasionally turned up a missing fireplace. In many parts of the country, nineteenth-century roof coverings evolved from wooden shingles or slate shingles, to metal shingles, to sheet metal, and still later in the twentieth century, to asphaltic or asbestos shingles. Clay tiles can be found covering roofs in seventeenth and eighteenth-century settlements of the east coast as well as western and southwestern Spanish settlements from the same period. Beyond the mid-nineteenth century, and into the twentieth, the range and choice of roof coverings greatly expanded.

**Floors.** In addition to production and construction clues, floors reveal other information about the interior, such as circulation patterns, furniture placement, the use of carpets, floor cloths, and applied floor finishes. Is there a pattern of tack holes? Tacks or tack holes often indicate the position and even the type of a floor covering. A thorough understanding of the seasonal uses of floor coverings and the technological history of their manufacture provide the background for identifying this type of evidence.

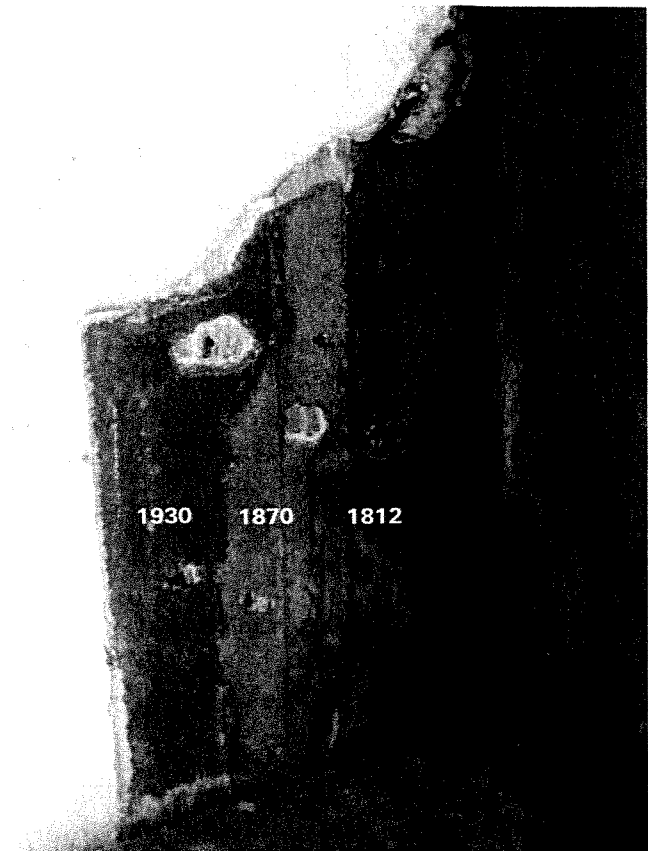
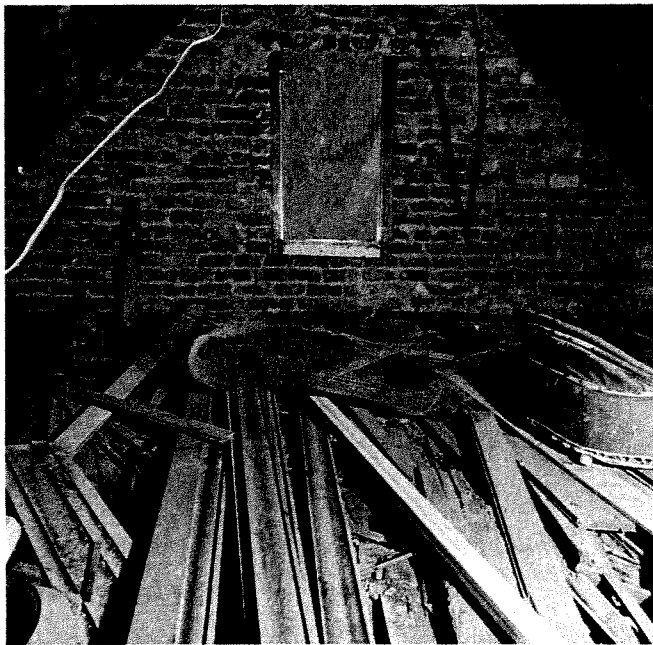


Figure D. Building styles change over time as moldings and trims are added and removed. The ghosts of the previous woodwork are often left behind and preserved under the new trim. This photograph shows distinct profiles of architectural trim from three successive periods. photo: courtesy, Valentine Museum, Richmond, Virginia.

**Walls.** Walls and their associated trim, both outside and inside, hold many clues to the building's construction and changes made over time. The overall style of moldings, trim and finishes, and their hierarchical relationship, can help explain original construction as well as room usage and social interaction between rooms. Holes, scars, patches, nails, nail holes, screws and other hardware indicate former attachments. Are there "ghosts," or shadow outlines of missing features, or trim attachments such as bases, chair rails, door and window casings, entablatures, cornices, mantels and shelves? Ghosts can be formed by paint, plaster, stucco, wear, weathering or dirt. Interior walls from the eighteenth and early nineteenth-century were traditionally plastered after grounds or finished trim was in place, leaving an absence of plaster on the wall behind them. Evidence of attachments on window casings can also be helpful in understanding certain interior changes. Other clues to look for include

the installation of re-used material brought into a house or moved about within a house; worker's or occupant's graffiti, especially on the back of trim; and hidden finishes or wallpaper stuck in crevices or underneath pieces of trim. Stylistic upgrading often resulted in the re-use of outdated trim for blocking or shims. Unexpected discoveries are particularly rewarding. Investigators frequently tell stories about clues that were uncovered from architectural fragments carried off by rats and later found, or left by workers in attics, between walls and under floors.

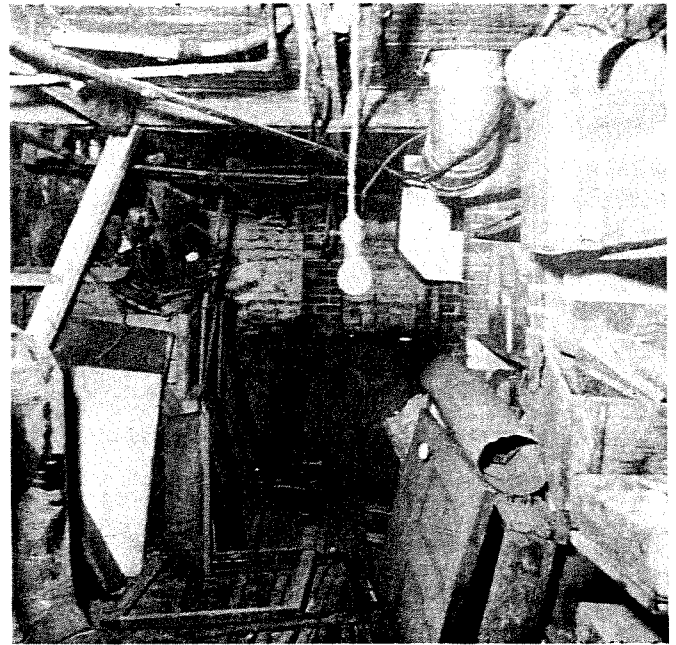


*Figure E. Discarded items are routinely stored within attics, then forgotten, only to be discovered during a later investigation. Seemingly worthless clutter and debris may help answer many questions. A thorough inventory should be performed before evaluating any object's usefulness.*

**Attics and Basements.** Attics and basements have been known as collection points for out-of-date, out-of-style and cast-off pieces such as mechanical systems, furnishings, family records and architectural fragments. These and other out-of-the-way places of a structure provide an excellent opportunity for non-destructive investigation. Not only are these areas where structural and framing members might be exposed to view, they are also areas which may have escaped the frequent alteration campaigns that occur in the more lived-in parts of a building. If a building has been raised or lowered in height, evidence of change would be found in the attic as well as on the exterior. Evidence of additions might also be detected in both the attic and the basement. Attics frequently provide a "top-side" view at the ceiling below, revealing its material, manner of production and method of attachment. A "bottom-side" view of the roof sheathing or roof covering can be seen from the attic as well.

Basements generally relate more to human service functions in earlier buildings and to mechanical services in more recent eras. For example, a cellar of an urban

1812 house disclosed the following information during an investigation: first period bell system, identification of a servant's hall, hidden fireplace, displacement of the service stairs, identification of a servants' quarters, an 1850s furnace system, 1850s gas and plumbing systems, relocation of the kitchen in 1870, early use of 1890s concrete floor slabs and finally, twentieth century utility systems. While the earliest era had been established as the interpretation period, evidence from all periods was documented in order to understand and interpret how the house evolved or changed over time.



*Figure F. Outdated fixtures and systems are frequently abandoned in place when more modern units are installed. Examining and documenting their existence can provide a technological reference to the history and use of many rooms or structures. photo: NPS Preservation Assistance Division Files.*

**Mechanical, Electrical, Plumbing and Other Systems.** Systems of utility and convenience bear close scrutiny during investigation. All historic buildings inhabited and used by people reveal some association, at the very minimum, with the necessities of lighting, climate control, water, food preparation, and waste removal. Later installations in a building may include communication, hygiene, food storage, security, and lightning protection systems. Other systems, such as transportation, are related to more specific functions of commercial or public structures. Although research into the social uses of rooms and their furnishings has borne many new studies, parallel research into how people actually carried out the most mundane tasks of everyday life has been fairly neglected. Utility and convenience systems are most prone to alteration and upgrading and, at the same time, less apt to be preserved, documented or re-used. Understanding the history or use of a building, and the history of systems technology can help predict the physical evidence that might be found, and what it will look like after it is found.

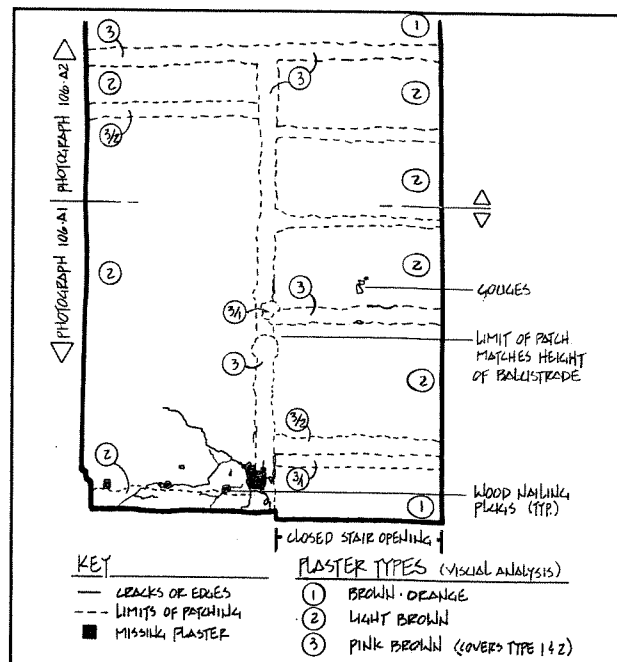


Figure 9. Raking light is used to show irregularities on flat surfaces. Patches, repairs, and alterations can then be mapped by the shadows or ghosts they cast. In this case, the pattern of patched plaster suggested the removal shelves and a balustrade handrail from the wall. Historical research and plaster analysis confirmed the findings and the sequence of change.

**Reconnaissance.** An initial reconnaissance trip through a structure—or visual overview—provides the most limited type of investigation. But experienced investigators accustomed to observation and analysis can resolve many questions in a two-to-four hour preliminary site visit. They may be able to determine the consistency of the building's original form and details as well as major changes made over time.

**Surface Mapping.** The first step in a thorough, systematic investigation is the examination of all surfaces. Surface investigation is sometimes called "surface mapping" since it entails a minute look at all the exterior and interior surfaces. The fourfold purpose of surface mapping is to observe every visible detail of design and construction; develop questions related to evidence and possible alterations; note structural or environmental problems; and help develop plans for any further investigation. Following investigation, a set of documentary drawings and photographs is prepared which record or "map" the evidence.

While relying upon senses of sight and touch, the most useful tool for examining surfaces is a high-powered, portable light used for illuminating dark spaces as well as for enhancing surface subtleties. Raking light at an angle on a flat surface is one of the most effective means of seeing evidence of attachments, repairs or alterations.

**Non-Destructive Testing.** The next level of investigation consists of probing beneath surfaces using non-destructive methods. Questions derived from the surface mapping examination and analysis will help determine which areas to probe. Investigators have perfected a number of tools and techniques which provide minimal damage to historic fabric. These include x-rays to penetrate surfaces in order to see nail types and joining details; boroscopes, fiber optics and small auto mechanic or dentists' mirrors to look inside of tight spaces; and ultra violet or infra-red lights to observe differences in materials and finishes. The most advanced

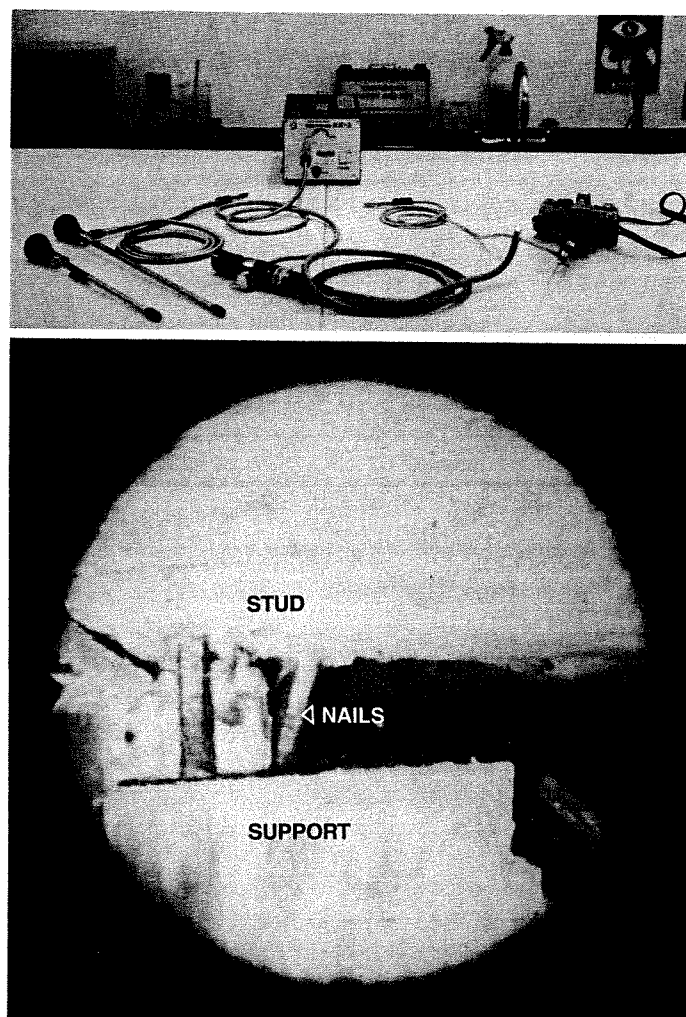


Figure 10. Top: A boroscope is a fiber-optic tube which can provide views into the framing connections of a wall through an existing crack or hole. Bottom: Once the image is oriented, the investigator can see an open joint between the wood stud and its nailed lateral support. photos: NPS North Atlantic Cultural Resource Center, Building Conservation Branch.



technology combines the boroscope with video cameras using fiber optic illumination. In addition to the more common use of infra-red photography, similar non-destructive techniques used in archeological investigations include remote sensing and ground-penetrating radar.

Small material samples of wood, plaster, mortar, or paint can also be taken for laboratory analysis at this stage of investigation. For instance, a surface examination of a plaster wall using a raking light may show clear evidence of patching which corresponds to a shelf design. Were the shelves original or a later addition? A small sample of plaster from the patched area is analyzed in the laboratory and matches plaster already dated to a third period of construction. A probe further reveals an absence of first period plaster on the wall underneath. The investigator might conclude from this evidence that the shelves were an original feature and that the plaster fill dates their removal and patching to a third period of construction.

**Destructive Testing.** Most investigations require nothing more than historical research, surface examination and non-destructive testing. In very rare instances the investigation may require a sub-surface examination and the removal of fabric. Destructive testing should be carried out by a professional only after historical research and surface mapping have been fully accomplished and *only after* non-destructive testing has failed to produce the necessary information. Owners should be aware that the work is a form of demolition in which the physical record may be destroyed. Sub-surface examination begins with the most accessible spaces, such as retrofitted service and mechanical chases; loose or previously altered trim, ceilings or floor boards; and pieces of trim or hardware which can be easily removed and replaced.

Non-destructive testing techniques do not damage historic

fabric. If non-destructive techniques are not sufficient to resolve important questions, small "windows" can be opened in surface fabric at predetermined locations to see beneath the surface. This type of subsurface testing and removal is sometimes called "architectural archeology" because of its similarity to the more well-known process of trenching in archeology. The analogy is apt because both forms of archeology use a method of destructive investigation.

Photographs, video and drawings should record the before, during and after evidence when the removal of historic fabric is necessary. The selection and sequence of material to be removed requires careful study so that original extant fabric remains *in situ* if possible. If removed, original fabric should be carefully put back or labelled and stored. At least one documentary patch of each historic finish should be retained *in situ* for future research. Treatment and interpretation, no matter how accurate, are usually not final; treatment tends to be cyclical, like history, and documentation must be left for future generations, both on the wall and in the files.

**Laboratory Analysis.** Laboratory analysis plays a scientific role in the more intuitive process of architectural investigation. One of the most commonly known laboratory procedures used in architectural investigation is that of historic paint analysis. The chronology and stratigraphy of applied layers can establish appropriate colors, finishes, designs or wall coverings. When conducted simultaneously with architectural investigation, the stratigraphy of finishes, like that of stratigraphic soils in archeology, helps determine the sequence of construction or alterations in a building. Preliminary findings from *in situ* examinations of painted finishes on walls or trim are common, but more accurate results come from extensive

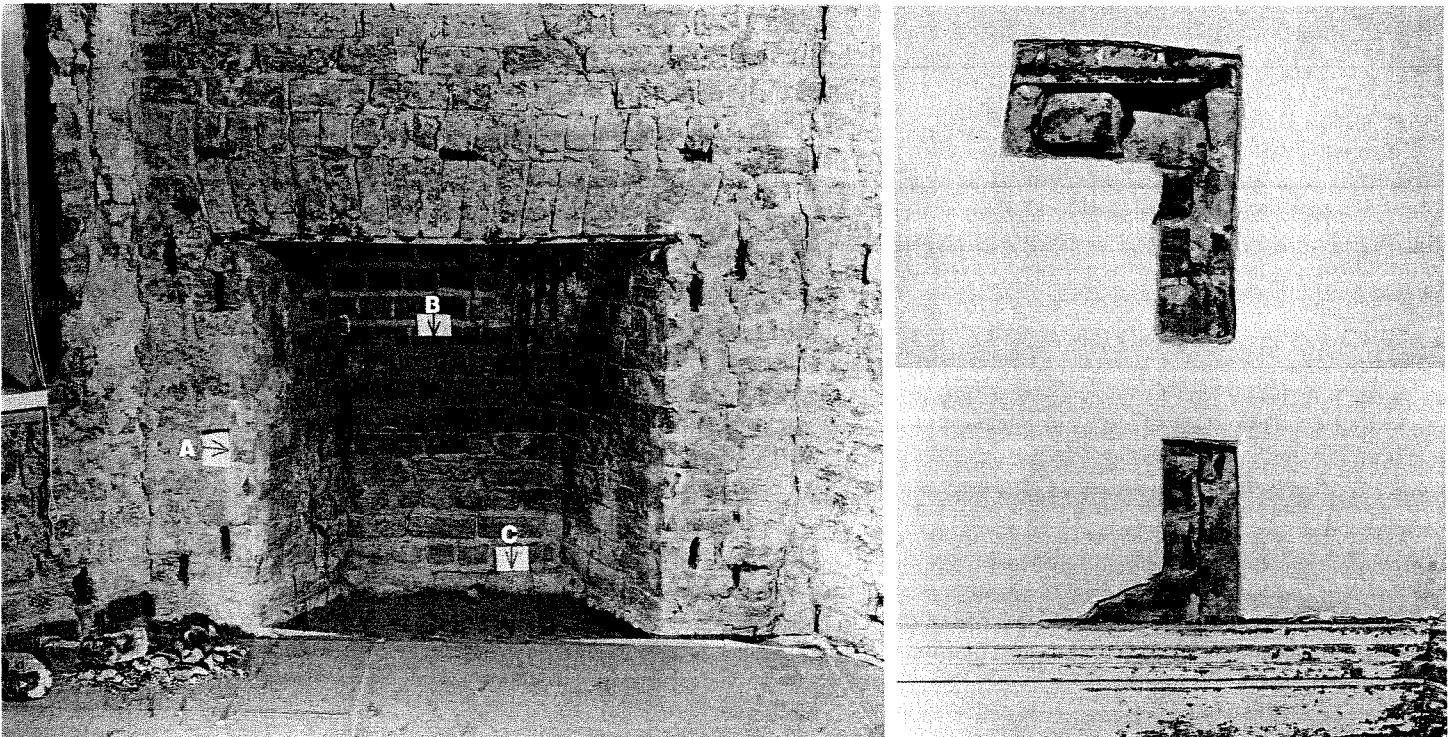


Figure 11. The physical evidence of cracks and patches seen during surface mapping suggested an abandoned fireplace. Right: Exploratory testing was used to verify its location. Left: Museum restoration required more detailed probing to discover the original detailing. Plaster and brick were carefully documented and removed to determine the fireplace's type, size, and decoration. The rectangular slots held wooden nailing blocks supporting the mantel and surround. A indicates the inside edge of the surround; B points to the ghost from an iron fireback and C shows the original floor level of the hearth.

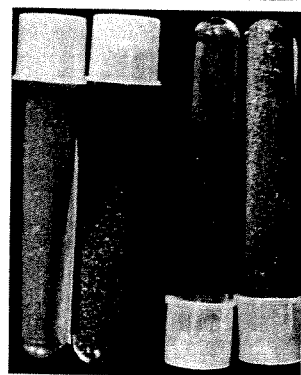


Figure 12. During a thorough investigation, the mortar sample is viewed under a microscope using various lighting to find the presence of coatings or additives. It is then ground and washed in an acid bath to separate and free the sand and fibers. After further cleaning, these fines are stored and used for comparison in matching or dating repairs and alterations. photos: NPS North Atlantic Cultural Resource Center, Building Conservation Branch.

sampling and microscopic laboratory work using chemical analysis and standardized color notations. Consultants without the proper knowledge have been known to cause far more harm than good.

Mortar and plaster analysis often provide a basis for dating construction with minimal intervention. Relatively small samples of the lime-based materials can be chemically separated into their component parts of sands and fines, which are then visually compared to equivalent parts of known or dated samples. A more thorough scientific approach may be used to accurately profile and compare samples of other materials through elemental analysis. Two similar methods in common use are Neutron Activation and Energy Dispersive Spectroscopy (EDS). Neutron Activation identifies the sample's trace elements by monitoring their response to neutron bombardment. EDS measures the response to electron bombardment through

the use of an electron microscope. In both tests, the gathered information is plotted and matched with the reactions of known elements. The results provide a quantitative and qualitative profile of the sample's elemental components for use in further comparisons.

Dendrochronology presents a minimally destructive process for dating wooden members. Also called tree ring dating, this process relies on the comparative wet and dry growth seasons of trees as seen in their rings via a core sample. This technique has two limitations: a very extensive data base must be compiled for climatic conditions over a long span of years and matched with corresponding tree ring samples; and the core samples can only be taken from timber which still has a bark edge. Simple identification of wood species during an investigation can be determined from small samples sent to a forest products laboratory.

### After Architectural Investigation: Weighing the Evidence

Evidence, questions, and hypotheses must be continually evaluated during investigation. Like a detective constructing a case, an investigator must sort out information to get at "the facts." Yet, are the "facts" conclusive at any time?

Observations made during the surface mapping may identify random features. These features begin to form patterns; then, sets of patterns, perhaps representing alterations from multiple eras, begin to appear. If the right questions are not asked, the evidence can remain hidden. Hypotheses are formed, questioned, tested, re-formed and either rejected or substantiated. This process is repeated as more "facts" are uncovered and questions asked. Eventually the evidence seems conclusive. These conclusions, in turn, may lead to re-examination, more historical research, and the advice of specialized consultants. At some point, treatment generally follows based on the collective, educated conclusions of an entire professional team.

### Keeping a Responsible Record for Future Investigators

The evidence collected during investigation, and any conclusions which can be drawn from it, should be documented in a written report. The complexity of a project dictates the complexity of the resulting record. It may be wise to maintain a report in an expandable format if long or extensive work is expected—additional evidence will undoubtedly need to be incorporated that alters previous conclusions. Reports tend to range from annotated photographs in loose-leaf binders to full-length bound "books."

Putting findings and conclusions in an accessible form helps those who are planning treatment. For example, a rehabilitation project may require documentation to satisfy grant funding or tax credit program requirements; preservation and restoration projects always need careful documentation to guide the work. After work, the investigation report and notes on the treatment itself are made into a permanent file record. Whether or not work is

being planned, the architectural investigation report will always be of value to future researchers or owners of the building.

The most common professional document is called an *Historic Structure Report*. This invaluable tool for preservation typically contains historical as well as physical information. Sections include a history of the building, an architectural description of the original structure and changes made over time, the results of all investigations, a record of current conditions or problems, of past repairs and treatments, and recommendations for current and future action. They are seldom definitive; thus, research is a continuing process.

## Conclusion

Architectural investigation plays a critical role in making responsible decisions about treating and interpreting historic buildings. A successful project to research, inventory, document, and ultimately treat and interpret a building is directly linked to the knowledge and skills of architectural investigators and other historic preservation specialists. The expressed goal of historic preservation is to protect and preserve materials and features that convey the significant history of a place. Careful architectural investigation—together with historical research—provides a firm foundation for this goal.

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## Cover Photo:

*An historical architect analyzes and records his investigative findings while on site. photo: courtesy Valentine Museum.*

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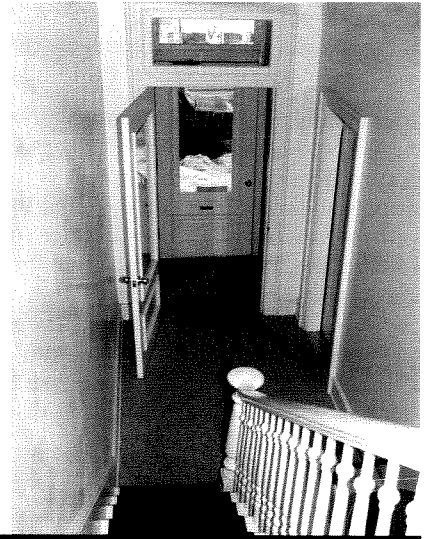
# 37 PRESERVATION BRIEFS

## Appropriate Methods for Reducing Lead-Paint Hazards in Historic Housing

Sharon C. Park, FAIA, and Douglas C. Hicks



National Park Service  
U.S. Department of the Interior  
Heritage Preservation Services



Lead-based paint, a toxic material, was widely used in North America on both the exteriors and interiors of buildings until well into the second half of the twentieth century. If a “historic” place is broadly defined in terms of time as having attained an age of fifty years, this means that almost every historic house contains some lead-based paint. In its deteriorated form, it produces paint chips and lead-laden dust particles that are a known health hazard to both children and adults. Children are particularly at risk when they ingest lead paint dust through direct hand-to-mouth contact and from toys or pacifiers. They are also at risk when they chew lead-painted surfaces in accessible locations. In addition to its presence in houses, leaded paint

chips, lead dust, or lead-contaminated soil in play areas can elevate a child’s blood lead level to a degree that measures to reduce and control the hazard should be undertaken (see Action Level Chart, page 6)

The premise of this Preservation Brief is that historic housing can be made lead-safe for children without removing significant decorative features and finishes, or architectural trimwork that may contribute to the building’s historic character (see fig. 1). *Historic housing*—encompassing private dwellings and all types of rental units—is necessarily the focus of this Brief because federal and state laws primarily address the hazards of lead and



Before



After

Figure 1. A large-scale historic rehabilitation project incorporated sensitive lead-hazard reduction measures. Interior walls and woodwork were cleaned, repaired, and repainted and compatible new floor coverings added. The total project was economically sound and undertaken in a careful manner that preserved the building’s historic character. Photos: Landmarks Design Associates.



lead-based paint in housing and day-care centers to protect the health of children under six years of age. Rarely are there mandated requirements for the removal of lead-based paint from non-residential buildings.

Ideally, most owners and managers should understand the health hazards created by lead-based paint and voluntarily control these hazards to protect young children. A stricter approach has been taken by some state and federal funding programs which have compliance requirements for identifying the problem, notifying tenants, and, in some cases, remedying lead hazards in housing (see Legislation Sidebar, pg.15). With new rules being written, and new products and approaches being developed, it is often difficult to find systematic and balanced methodologies for dealing with lead-based paint in historic properties.

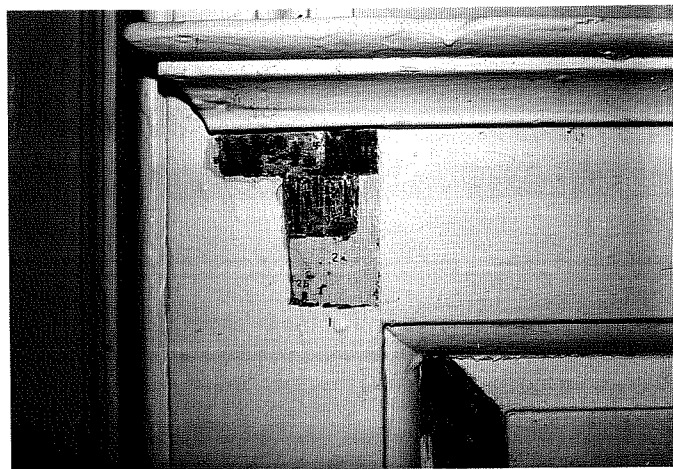
This Preservation Brief is intended to serve as an introduction to the complex issue of historic lead-based paint and its management. It explains how to plan and implement lead-hazard control measures to strike a balance between preserving a historic building's significant materials and features and protecting human health and safety, as well as the environment. It is not meant to be a "how-to guide" for undertaking the work. Such a short-cut approach could easily result in creating a greater health risk, if proper precautions were not taken. Home renovators and construction workers should be aware that serious health problems can be caused by coming into contact with lead. For this reason, there are also laws to protect workers on the job site (see Worker Safety Sidebar, pg. 4). Controlling the amount of waste containing lead-based paint residue will also reduce the impact on the environment. All of these considerations must be weighed against the goal of providing housing that is safe for children.

## Lead in Historic Paints

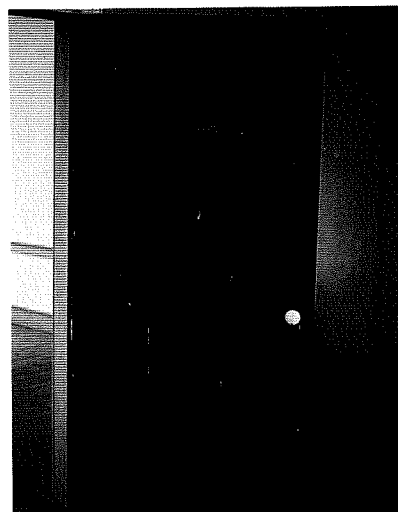
Lead compounds were an important component of many historic paints. Lead, in the forms of lead carbonate and lead oxides, had excellent adhesion, drying, and covering abilities. White lead, linseed oil, and inorganic pigments were the basic components for paint in the 18th, 19th, and early 20th centuries. Lead-based paint was used extensively on wooden exteriors and interior trimwork, window sash, window frames, baseboards, wainscoting, doors, frames, and high gloss wall surfaces such as those found in kitchens and bathrooms. Almost all painted metals were primed with red lead or painted with lead-based paints. Even milk (casein) and water-based paints (distemper and calcimines) could contain some lead, usually in the form of hiding agents or pigments. Varnishes sometimes contained lead. Lead compounds were also used as driers in paint and window glazing putty.

In 1978, the use of lead-based paint in residential housing was banned by the federal government. Because the hazards have been known for some time, many lead components of paint were replaced by titanium and other less toxic elements earlier in the 20th century. Since houses are periodically repainted, the most recent layer of paint will most likely *not* contain lead, but the older layers underneath probably will. Therefore, the only way to accurately determine the amount of lead present in older paint is to have it analyzed.

It is important that owners of historic properties be aware that layers of older paint can reveal a great deal about the history of a building and that paint chronology is often used to date alterations or to document decorative period colors (see figs. 2, 3). Highly significant decorative finishes, such as graining, marbling, stenciling, polychrome decoration, and murals should be evaluated by a painting conservator to develop the appropriate preservation treatment that will stabilize the paint and eliminate the need to remove it. If such finishes must be removed in the process of controlling lead hazards, then research, paint analysis, and documentation are advisable as a record for future research and treatment.



*Figure 2. The paint chronology of this mantel, seen in the exposed paint layers in the left corner, proved it had been relocated from another room of the house. To remove a significant feature's paint history and the evidence of its original sequence of color by stripping off all the paint is inappropriate — and unnecessary — as part of a lead hazard reduction project. Careful surface preparation and repainting with lead-free top coats is recommended. Photo: NPS Files.*



*Figure 3. Significant architectural features and their finishes should not be removed during a project incorporating lead hazard controls. If the decorative stenciling above, or hand grained doors below, or painted murals need repair, then a paint conservator should be consulted. Once loose paint is consolidated or otherwise stabilized, a clear finish or other reversible clear protective surface or coating can be added to areas subject to impact or abrasion. Photos: NPS Files.*

## Planning for Lead Hazard Reduction in Historic Housing

Typical health department guidelines call for removing as much of the surfaces that contain lead-based paint as possible. *This results in extensive loss or modification of architectural features and finishes and is not appropriate for most historic properties* (see fig. 4). A great number of federally-assisted housing programs are moving away from this approach as too expensive and too dangerous to the immediate work environment. A preferred approach, consistent with *The Secretary of the Interior's Standards for the Treatment of Historic Properties*, calls for removing, controlling, or managing the hazards rather than wholesale—or even partial—removal of the historic features and finishes (fig. 5). This is generally achieved through careful cleaning and treatment of deteriorating paint, friction surfaces, surfaces accessible to young children, and lead in soil (see figs. 6, 7). Lead-based paint that it not causing a hazard is thus permitted to remain, and, in consequence, the amount of historic finishes, features and trimwork removed from a property is minimized.

Because the hazard of lead poisoning is tied to the risk of ingesting lead, careful planning can help to determine how

much risk is present and how best to allocate available financial resources. An owner, with professional assistance, can protect a historic resource and make it lead-safe using this three-step planning process:

- I. Identify the historical significance of the building and architectural character of its features and finishes;
  - II. Undertake a risk assessment of interior and exterior surfaces to determine the hazards from lead and lead-based paint; and,
  - III. Evaluate the options for lead hazard control in the context of historic preservation standards.
- I. Identify the historical significance of the building and architectural character of its features and finishes**

The historical significance, integrity, and architectural character of the building always need to be assessed before work is undertaken that might adversely affect them. An owner may need to enlist the help of a preservation architect, building conservator or historian. The State Historic Preservation Office (SHPO) may be able to provide a list of knowledgeable preservation professionals who could assist with this evaluation.



**Before**



**After**

Figure 4. The typical method for abating lead-based paint through substrate removal is not consistent with the Standards for Rehabilitation. In this project, all the historic trim, base panels, and the transom were removed. While the unit is lead-safe, its character has been severely altered. Figure 5 shows a similar, but successful, balance of historic preservation and lead hazard control work. Photo: NPS Files.



**Before**



**After**

Figure 5. When historic interiors are rehabilitated, it is possible to remove the offending substance, such as deteriorated paint, without removing the features. In this case, the walls were repaired, and the trim and base panels were stripped of paint to a sound substrate, then repainted. Photos: Landmarks Design Associates.

## Worker Safety

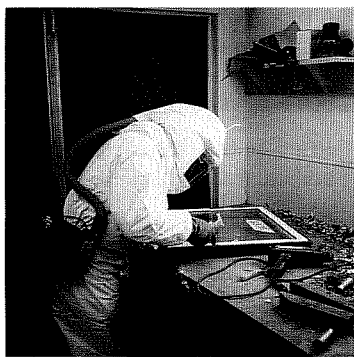
Current worker safety standards were established by OSHA's 29 CFR Part 1926, Lead Exposure in Construction; Interim Final Rule, which became effective June 3, 1993. These standards base levels of worker protection on exposure to airborne lead dust. They are primarily targeted to persons working within the construction industry, but apply to any workers who are exposed to lead dust for

longer than a specific amount of time and duration. The Interim Final Rule establishes an action level of 30 micrograms of lead dust per cubic meter of air ( $30 \mu\text{g}/\text{m}^3$ ) based on an eight hour, time-weighted average, as the level at which employers must initiate compliance activities; and it also establishes  $50 \mu\text{g}/\text{m}^3$  of lead dust as the permitted exposure level (PEL) for workers.

The standard identifies responsibilities before, during, and after the actual abatement activity necessary to protect the worker. Before the project begins, it requires an exposure assessment, a written compliance plan, initial medical surveillance, and training. The exposure assessment determines whether a worker may be exposed to lead. OSHA has identified a number of work tasks expected to produce dust levels between 50 and  $500 \mu\text{g}/\text{m}^3$  of air, including manual demolition, manual scraping, manual sanding, heat gun applications, general cleanup, and power tool use when the power tool is equipped with a dust collection system. It is an OSHA requirement that, at a minimum, a HEPA filtered half-face respirator with a protection factor of 10 be used for these operations. Initial blood lead level (BLL) base lines are established for each worker. Actual dust levels are monitored by air sampling of representative work activities, generally by an industrial hygienist or an environmental monitoring firm. Protective equipment is determined by the dust level. For all workers exposed at, or above, the action level for over 30 days in a 12-month period, BLLs are tested on a regular basis of every 2 months for the first 6 months and every 6 months thereafter. After completing a project, maintenance, medical surveillance, and recordkeeping responsibilities continue.

HEPA vacuums, HEPA respirators, and HEPA filters, which substantially reduce exposure to lead dust, are available through laboratory safety and supply catalogs and vendors.

Copies of 29 CFR Part 1926, Lead Exposure in Construction: Interim Final Rule, are available from the Department of Labor, Occupational Safety and Health Administration, or may be found in any library with a current edition of the Code of Federal Regulation (CFR).



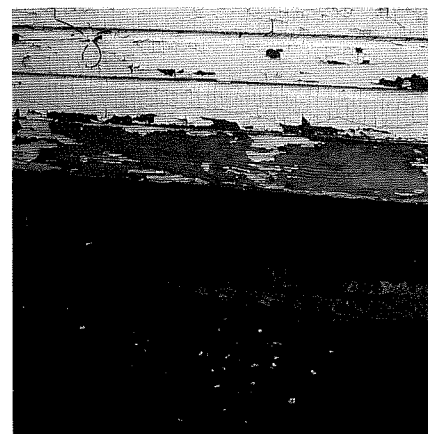
*Low-level heat guns can be used to remove lead-based paint from significant historic windows and trimwork, but a worker exposed to lead dust over an extended period of time must be protected from the hazards created during the process of paint removal. Photo: Williamsport Preservation Training Center.*

Features and finishes of a historic building that exhibit distinctive characteristics of an architectural style; represent work by specialized craftsmen; or possess high artistic value should be identified so they can be protected and preserved during treatment. When it is absolutely necessary to remove a significant architectural feature or finish—as noted in the first two priorities listed below—it should be replaced with a new feature and finish that matches in design, detail, color, texture, and, in most cases, material.

*Figure 6. Deteriorating operable windows often contribute to lead dust in a house. Peeling paint and small particles from abraded surfaces collect in window troughs or sills and are then carried inside by air currents, settling on floors. When the lead dust mixes with regular house dust, it can easily be ingested by a child through hand to mouth contact. In homes with small children, floors and other surfaces should be kept as clean as possible to avoid lead contamination.*



*Figure 7. Chalking exterior paint can cause dangerous lead levels in soil around a house. Lead levels are usually highest in the one foot wide area adjacent to the building foundation. In these cases, the existing soil should be replaced with new soil or sod. This is particularly important if children and small pets play in contaminated areas, then inadvertently track the dirt inside.*

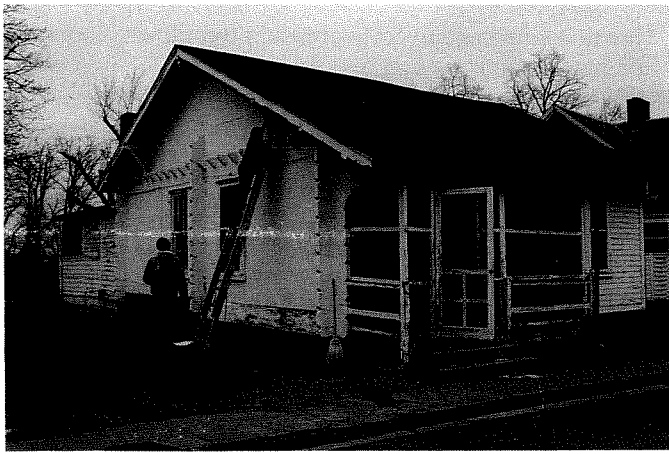


Finally, features and finishes that characterize simple, vernacular buildings should be retained and preserved; in the process of removing hazards, there are usually reasonable options for their protection. Wholesale removal of historic trim, and other seemingly less important historic material, undermines a building's overall character and integrity and, thus, is never recommended.

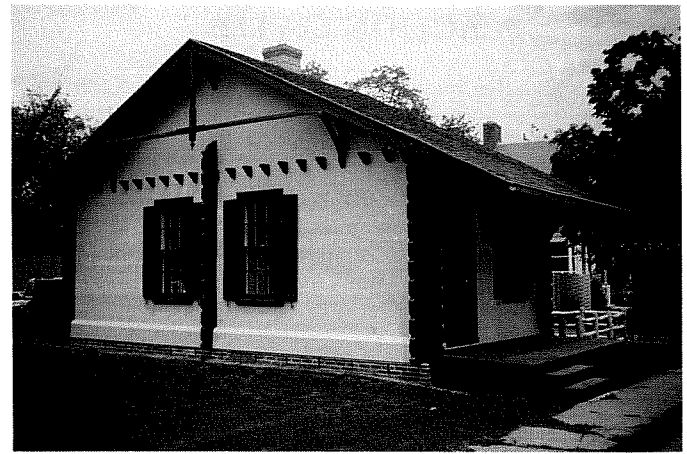
For each historic property, features will vary in significance. As part of a survey of each historic property (see figure 8), a list of priorities should be made, in this order:

- Highly significant features and finishes that should always be protected and preserved;
- Significant features and finishes that should be carefully repaired or, if necessary, replaced in-kind or to match all visual qualities; and
- Non-significant or altered areas where removal, rigid enclosure, or replacement could occur.

This hierarchy gives an owner a working guide for making decisions about appropriate methods of removing lead paint.



**Before**



**After**

Figure 8. A survey of the property will help establish priorities for treatment based on its historical significance and physical condition. In this 1878 plank house, the original interlocking planks, corner details, projecting rafter tails, and original windows were considered highly significant features and were carefully stripped of failing paint using chemical poultices and HEPA sanding, then repainted. The less significant, but character-defining, painted porch flooring was replaced in new, but matching material. The non-historic porch screening was removed entirely. Photo before: Bryan Blundell; Photo after: Deborah Birch.

## II. Undertake a risk assessment of interior and exterior surfaces to determine hazards from lead and lead-based paint.

While it can be assumed that most historic housing contains lead-based paint, it cannot be assumed that it is causing a health risk and should be removed. The purpose of a risk assessment is to determine, through testing and evaluation, where hazards from lead warrant remedial action (see fig. 9). Testing by a specialist can be done on paint, soil, or lead dust either on-site or in a laboratory using methods such as x-ray fluorescence (XRF) analyzers, chemicals, dust wipe tests, and atomic absorption spectroscopy. Risk assessments can be fairly low cost investigations of the location, condition, and severity of lead hazards found in house dust, soil, water, and deteriorating paint. Risk assessments will also address other sources of lead from hobbies, crockery, water, and the parents' work environment. A public health office should be able to provide names of certified risk assessors, paint

inspectors, and testing laboratories. These services are critical when owners are seeking to implement measures to reduce suspected lead hazards in housing, day-care centers, or when extensive rehabilitations are planned.

The risk assessment should record:

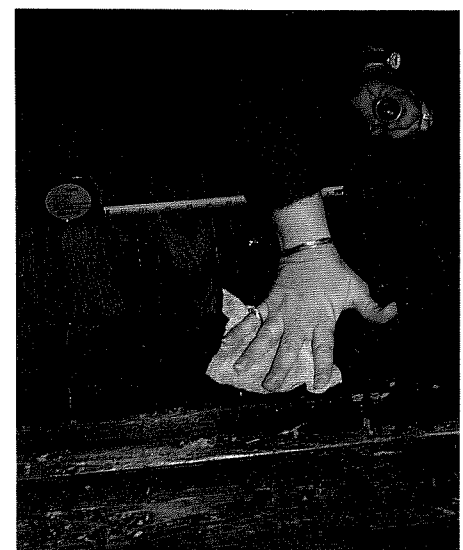
- the paint's location
- the paint's condition
- lead content of paint and soil
- the type of surface (friction; accessible to children for chewing; impact)
- how much lead dust is actively present
- how the family uses and cares for the house
- the age of the occupants who might come into contact with lead paint.



**a**



**b**



**c**

Figure 9. A variety of testing methods are used to establish how much lead is in paint and where this paint is located: a home test kit (a) is a good screening device to determine if lead is present, but it should not be relied upon exclusively; an X-ray Fluorescence machine or scanner (b), used by a licensed professional, determines, without disturbing the surface, if lead is present in underlying layers of paint; and a dust wipe test (c), sent to a laboratory for processing, can be used as either a clearance test, once work is completed, or as a monitoring device to determine if lead dust is present on surfaces. Paint chips can also be sent to a laboratory for analysis to determine the exact amount of lead by weight in a sample.



## ACTION LEVELS

Check with a Regional Environmental Protection Agency (EPA) office or appropriate state authorities if you have questions about applicable action levels that may change over time.

*Blood Lead Levels* are generally established from drawn blood and not from a finger stick test that may be unreliable. Units are measured in micrograms per deciliter ( $\mu\text{g}/\text{dL}$ ) and reflect the Centers for Disease Control (CDC) Standards in effect in 2006.

Children:	<10 $\mu\text{g}/\text{dL}$ normal; no action needed 10-14 $\mu\text{g}/\text{dL}$ ; slight concern; look for lead source 15-19 $\mu\text{g}/\text{dL}$ ; mild concern; counseling; medical monitoring 20-44 $\mu\text{g}/\text{dL}$ ; moderate-high concern; must find/reduce lead source >45 $\mu\text{g}/\text{dL}$ ; very serious; hospitalization and removal of lead source
Adults:	25 $\mu\text{g}/\text{dL}$ ; level of concern; find source of lead >50 $\mu\text{g}/\text{dL}$ ; Occupational Safety and Health Administration (OSHA) Standard for medical removal from the worksite.

*Lead in paint:* Paint with lead levels greater than or equal to 1.0 milligrams per square centimeter, or more that 0.5% by weight is considered lead-based paint.

Lead dust wipes should be below the following:  
Floors; 40  $\mu\text{g}/\text{ft}^2$   
Window sills; 250  $\mu\text{g}/\text{ft}^2$   
Window troughs; 400  $\mu\text{g}/\text{ft}^2$

*Lead in soil:* measured in parts per million (ppm)  
Hazardous conditions:  
Play area residential soil; 400 ppm  
Soil in remaining yard areas; 1200 ppm

It is important from a health standpoint that future tenants, painters, and construction workers know that lead-based paint is present, even under treated surfaces, in order to take precautions when work is undertaken in areas that will generate lead dust. Whenever mitigation work is completed, it is important to have a clearance test using the *dust wipe method* to ensure that lead-laden dust generated during the work does not remain at levels above those established by the Environmental Protection Agency (EPA) and the Department of Housing and Urban Development (HUD) (see Action Levels Chart, above). A building file should be maintained and updated whenever any additional lead hazard control work is completed.

Hazards should be removed, mitigated, or managed in the order of their health threat, as identified in a risk assessment (with 1. the greatest risk and 8. the least dangerous):

1. Peeling, chipping, flaking, and chewed interior lead-based paint and surfaces
2. Lead dust on interior surfaces
3. High lead in soil levels around the house and in play areas (check state requirements)

4. Deteriorated exterior painted surfaces and features
5. Friction surfaces subject to abrasion (windows, doors, painted floors)
6. Accessible, chewable surfaces (sills, rails) if small children are present
7. Impact surfaces (baseboards and door jambs)
8. Other interior surfaces showing age or deterioration (walls and ceilings)

### III. Evaluate options for hazard control in the context of historic preservation standards.

*The Secretary of the Interior's Standards for the Treatment of Historic Properties*—established principles used to evaluate work that may impact the integrity and significance of National Register properties—can help guide suitable health control methods. The *preservation standards* call for the protection of historic materials and historic character of buildings through stabilization, conservation, maintenance, and repair. The *rehabilitation standards* call for the repair of historic materials with replacement of a character-defining feature appropriate only when its deterioration or damage is so extensive that repair is infeasible. From a preservation standpoint, selecting a hazard control method that removes *only* the deteriorating paint, or that involves some degree of repair, is always preferable to the total replacement of a historic feature.

By tying the remedial work to the areas of risk, it is possible to limit the amount of intrusive work on delicate or aging features of a building without jeopardizing the health and safety of the occupants. To make historic housing lead-safe, the gentlest method possible should be used to remove the offending substance—lead-laden dust, visible paint chips, lead in soil, or extensively deteriorated paint. Overly aggressive abatement may damage or destroy much more historic material than is necessary to remove lead paint, such as abrading historic surfaces. Another reason for targeting paint removal is to limit the amount of lead dust on the work site. This, in turn, helps avoid expensive worker protection, cleanup, and disposal of larger amounts of hazardous waste.

Whenever extensive amounts of lead must be removed from a property, or when methods of removing toxic substances will impact the environment, it is extremely important that the owner be aware of the issues surrounding worker safety, environmental controls, and proper disposal (see fig. 10, 11). Appropriate architectural, engineering and environmental professionals should be consulted when lead hazard projects are complex.

Following are brief explanations of the two approaches for controlling lead hazards, once they have been identified as a risk. These controls are recommended by the Department of Housing and Urban Development in *Guidelines for the Evaluation and Control of Lead-Paint Hazards in Housing*, and are summarized here to focus on the special considerations for historic housing:

**Interim Controls:** Short-term solutions include thorough dust removal; thorough washdown and clean-up of exposed surfaces; paint film stabilization and repainting; covering of lead-contaminated soil; and making tenants aware of lead hazards. Interim controls require ongoing maintenance and evaluation.



Figure 10. The choice of paint removal method will trigger various environmental controls and worker protection. The chemical poultice-type paint remover uses a paper backing that keeps the lead waste contained for proper disposal. The worker is adequately protected by a suit and gloves; for this work a respirator was not required. Local laws required containment and neutralization of any after-wash water run off. Photo: NPS Files.

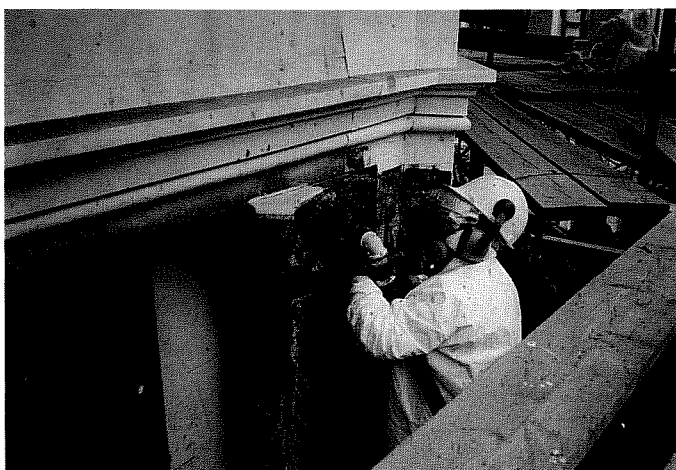


Figure 11. New methods are being developed or adapted to safely remove lead-based paint from various substrates. On this cast iron building undergoing rehabilitation for apartment units, multiple layers of lead-based paint were removed with pneumatic needle guns with vacuum attachments. Paint chips and waste containing lead-based paint were placed in 55 gallon drums for transport to a special waste site, and the workers were fully protected. The cleaned metal was primed and repainted. Photo: Building Conservation Associates, Inc.

**Hazard Abatement:** Long-term solutions are defined as having an expected life of 20 years or more, and involve permanent removal of hazardous paint through chemicals, heat guns or controlled sanding/abrasive methods; permanent removal of deteriorated painted features through replacement; the removal or permanent covering of contaminated soil; and the use of enclosures (such as drywall) to isolate painted surfaces. The use of specialized elastomeric encapsulant paints and coatings can be considered as permanent containment of lead-based paint if they receive a 20-year manufacturer's warranty or are approved by a certified risk assessor. One should be aware of their advantages and drawbacks for use in historic housing.

Within the context of the historic preservation standards, the most appropriate method will always be the least invasive. More invasive approaches are considered only under the special circumstances outlined in the three-step

process. An inverted triangle (see fig. 12) shows the greatest number of residential projects fall well within the "interim controls" section. Most housing can be made safe for children using these sensitive treatments, particularly if no renovation work is anticipated. Next, where owners may have less control over the care and upkeep of housing and rental units, more aggressive means of removing hazards may be needed. Finally, large-scale projects to rehabilitate housing or convert non-residential buildings to housing may successfully incorporate "hazard abatement" as a part of the overall work.

## Appropriate Methods for Controlling Lead Hazards

In selecting appropriate methods for controlling lead hazards, it is important to refer to Step I. of the survey where architecturally significant features and finishes are identified and need to be preserved. Work activities will vary according to hazard abatement needs; for example, while an interim control would be used to stabilize paint on most trimwork, an accessible window sill might need to be stripped prior to repainting. Since paint on a window sill is usually not a significant finish, such work would be appropriate. Other appropriate methods for controlling lead hazards are summarized in the accompanying chart (see fig. 13).

The method selected for removing or controlling the hazards has a direct bearing on the type of worker protection as well as the type of disposal needed, if waste is determined to be hazardous (see fig. 14). Following are

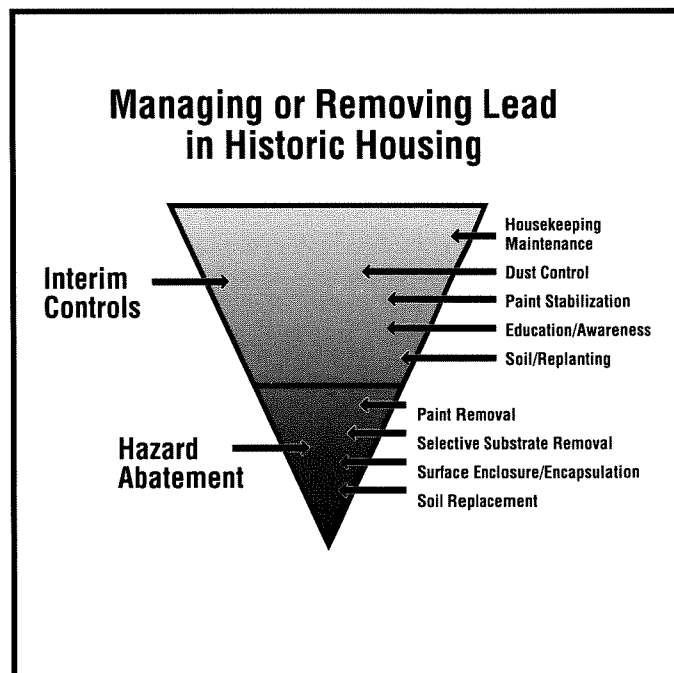


Figure 12. An inverted triangle makes the point that most of the nation's housing can be made lead-safe using interim control methods, such as dust control, paint stabilization, and good housekeeping. Shaded from light to dark, the lighter interim controls will generally not harm the historic materials. The darker, more aggressive controls, can be implemented with rehabilitation projects where paint removal, selective replacement of deteriorated elements, and encapsulation or enclosure are incorporated into other work.

## MANAGING OR REMOVING LEAD-BASED PAINT IN HISTORIC BUILDINGS

Interim solutions, the preferred approach, include a combination of the following:

General maintenance	Dust control	Paint stabilization	Soil treatment	Tenant education
<p>Repair deteriorated materials;</p> <p>Control leaks;</p> <p>Maintain exterior roofs, siding, etc. to keep moisture out of building;</p> <p>Perform emergency repairs quickly if lead-based paint is exposed;</p> <p>Maintain building file with lead test data and reports, receipts or invoices on completed lead mitigation work.</p>	<p>Damp mop floor; wet broom sweep porches and steps;</p> <p>Damp dust window sills and window troughs;</p> <p>Washdown painted surfaces periodically (use tri-sodium phosphate or equivalent, if necessary);</p> <p>Clean or vacuum carpets regularly (use HEPA vacuum if lead dust returns);</p> <p>Undertake periodic inspection with annual dust wipe tests.</p>	<p>Wet-sand loose paint and repaint;</p> <p>Keep topcoats of paint in good condition;</p> <p>Selectively remove paint from friction &amp; chewable surfaces (sills) and repaint;</p> <p>Use good quality latex, latex acrylic or oil/ alkyd paints compatible with existing paint;</p> <p>Consider more durable encapsulating paints and wall lining systems if necessary.</p>	<p>Add bark mulch, sod or topsoil to bare dirt areas with high lead levels;</p> <p>Discourage children from playing in these areas by providing sand box or other safe areas;</p> <p>Do not plant vegetable garden in areas with lead in soil;</p> <p>Be careful that pets do not track contaminated soil inside house.</p>	<p>Notify tenants and workers as to the location of lead-based paint;</p> <p>Instruct tenants to keep property clean;</p> <p>Instruct tenants to notify owner or manager when repairs are necessary;</p> <p>Provide tenants with health department pamphlets on the hazards of lead-based paint.</p>

Hazard abatement removes the hazard - not necessarily all the paint or the feature, and may include:

Paint removal	Paint Encapsulation Enclosure	Replace deteriorated elements	Soil treatment	Compliance
<p>Remove deteriorated paint or paint on friction, chewable, or impact surfaces to sound layer, repaint;</p> <p>Consider using the gentlest means possible to remove paint to avoid damage to substrate: wet sanding, low level heat guns, chemical strippers, or HEPA sanding;</p> <p>Send easily removable items (shutters, doors) off-site for paint stripping, then reinstall and paint.</p>	<p>Consider encapsulating paints with 20 years warranty to seal-in older paint; or use in combination with wall liners to stabilize plaster wall surfaces prior to repainting;</p> <p>Seal lead-based painted surfaces behind rigid enclosures, such as drywall, or use luan or plywood with new coverings over previously painted floors;</p> <p>Use rubber stair treads on painted steps.</p>	<p>Remove, only when necessary, seriously deteriorated painted elements such as windows, doors, and trimwork. Replace with new elements that match the historic in appearance, detailing, and materials, when possible;</p> <p>Replace component element of a friction surface (parting bead or stops of windows) or of impact surfaces (shoe moldings) with new elements.</p>	<p>Remove contaminated soil around foundation to a depth of 3" and replace with new soil and appropriate planting material or paving;</p> <p>If site is highly contaminated from other lead sources (smelter, sandblasted water tank) consult an environmental specialist as well as a landscape architect;</p> <p>Do not alter a significant historic landscape</p>	<p>Be aware of all federal, state and local laws regarding lead-based paint abatement, environmental controls and worker safety;</p> <p>Dispose of all hazardous waste according to applicable laws;</p> <p>Be aware that methods to remove lead-based paint can cause differing amounts of lead dust which can be dangerous to workers and residents.</p>

Figure 13. This chart indicates the wide variety of treatments that can be used to control or eliminate lead-based paint hazards. For historic buildings, the least invasive method should be used to control the hazards identified during a risk assessment and are shown in the lighter shaded portion of the chart. The darker portions show the more invasive hazard control methods which must be carefully implemented to ensure that whenever possible, historic materials are protected. The total abatement of all surfaces is not recommended for historic buildings because it can damage historic materials and destroy the evidence of early paint colors and layering. Prepared by Sharon C. Park, AIA.

## IMPACT OF VARIOUS PAINT REMOVAL/ABATEMENT TECHNIQUES

REMOVAL METHOD	IMPACT ON MATERIALS	LEAD DUST GENERATED	IMPACT ON WORKER	IMPACT ON ENVIRONMENT
Wet scraping; wet sanding; repainting	Low: Gentle to substrate; feather edges to obtain smooth paint surface	Low: Misting surfaces reduces lead dust	Low: No special protection for respiration, but wash before eating, drinking, etc.	Low-medium: Debris often general waste; check disposal requirements
Heat gun; paint removal w/ scrapers < 450°F	Low: Gentle to substrate	Medium: Flicking softened paint does create airborne lead dust	Medium: Respirator w/HEPA filters usually required	Medium: Lead-paint sludge is hazardous waste
Chemical stripping on-site; use liquid or poultice; avoid methylene chloride	Low to Medium: Avoid damage to wood texture/grain with long dwell time	Low: Chemicals are moist and reduce lead dust	Low: For lead dust; for volatile chemicals may require solvent filter mask	Medium: Lead residue hazardous; off/rinse must be filtered or contained
Controlled HEPA sanding; primarily for wooden surfaces; sander uses HEPA vacuum shroud	Low to Medium: Avoid gouging wooden surfaces; good for feathering edges	Medium to High: Worker must know how to use equipment	Medium to High: Requires respirator with HEPA filter and possibly containment of area	Medium to High: Paint debris is hazardous and must be contained in drums for disposal
Dry Abrasives on cast iron; CO <sub>2</sub> , walnut shells, needle gun removal; can use vacuum shrouds	Low to Medium: Substrate must be durable and in good condition; not for soft or porous materials	Generally High: Large volume of paint chips fall freely unless there is a vacuum shroud	High; Generally requires full suiting, respirators and containment, even if vacuum shroud used	Medium to High: Increased volume of hazardous waste if abrasive is added to lead debris
Chemical stripping off-site; cold tank reduces ungluing caused by hot tank	Medium to High: Elements can be damaged during removal or in tank	Usually low: Take care when removing elements to minimize lead-laden dust	Low: Take care when washing up to remove dust; wash clothes separately	Low to Medium: Stripping contractor responsible for disposal
Feature or substrate removal and replacement	High: Loss of feature is irretrievable; Avoid wholesale removal of significant elements	Usually low: Worker exposure can be high if element hazardous due to high amounts of lead-based paint	Usually low: Varies with lead dust generated; use air monitors and wet mist area	Varies: Must do a TCLP leach test to determine if debris can go to landfill or is hazardous waste

Figure 14. This chart shows how the impact of lead hazard control work can impact a property. The paint or hazard removal methods, shaded from light to dark, are listed from low to medium to high impact on historic materials. Each method will generate varying amounts of lead dust and hazardous materials; the impact on workers and the environment will thus vary accordingly. This information gives a general overview and is not a substitute for careful air monitoring and compliance with worker protection as established by OSHA regulations, and the proper handling/disposal of hazardous waste. Prepared by Sharon C. Park, AIA.



examples of appropriate methods to use to control lead hazards within an historic preservation context.

**Historic Interiors (deteriorating paint and chewed surfaces).** Whenever lead-based paint (or lead-free paint covering older painted surfaces) begins to peel, chip, craze, or otherwise comes loose, it should be removed to a sound substrate and the surface repainted. If children are present and there is evidence of painted surfaces that have been chewed, such as a window sill, then these surfaces should be stripped to bare wood and repainted. The removal of peeling, flaking, chalking, and deteriorating paint may be of a small scale and undertaken by the owner, or may be extensive enough to require a paint contractor. In either case, care must be taken to avoid spreading lead dust throughout the dwelling unit. If the paint failure is extensive and the dwelling unit requires more permanent hazard removal, then an abatement contractor should be considered. Many states are now requiring that this work be undertaken by specially trained and certified workers.

If an owner undertakes interim controls, it would be advisable to receive specialized training in handling lead-based paint. Such training emphasizes isolating the area, putting plastic sheeting down to catch debris, turning off mechanical systems, taping registers closed, and taking precautions to clean up prior to handling food. Work clothes should be washed separately from regular family laundry. The preferred method for removing flaking paint is the wet sanding of surfaces because it is gentle to the substrate and controls lead dust. The key to reducing lead hazards while stabilizing flaking paint is to keep the surfaces slightly damp to avoid ingesting lead dust. Wet sanding uses special flexible sanding blocks or papers that can be rinsed in water or used along with a bottle mister. This method will generally not create enough debris to constitute hazardous waste (see fig. 15).

Other methods for selectively removing more deteriorated paint in historic housing include controlled sanding, using low-temperature heat guns, or chemical strippers. Standard safety precautions and appropriate worker protection should be used. Methods to *avoid* include uncontrolled dry abrasive methods, high heat removal (lead vaporizes at 1100° F), uncontrolled water blasting, and some chemicals considered carcinogenic (methylene chloride). When possible and practicable, painted elements, such as

radiators, doors, shutters, or other easily removable items, can be taken to an off site location for paint removal.

In most cases, when interior surfaces are repainted, good quality interior latex or oil/alkyd paints may be used. The paint and primer system must be compatible with the substrate, as well as any remaining, well-bonded, paint.

Encapsulant paints and coatings, developed to contain lead-based paint, rely on an adhesive bonding of the new paint through the layers of the existing paint. The advantages of these special paint coatings is that they allow the historic substrate to remain in-place; reduce the amount of existing paint removed; can generally be applied without extensive worker protection; and are a durable finish. (They cannot, however, be used on friction surfaces.) The drawbacks include their ability to obscure carved details, unless thinly applied in several applications, and difficulty in future removal. If a specialized paint, such as an elastomeric encapsulant paint, is considered, the manufacturer should be contacted for specific instructions for its application. Unless these specialized paint systems are warranted for 20 years, they are considered as less permanent interim controls.

**Lead-dust on interior finishes.** Maintaining and washing painted surfaces is one of the most effective measures to prevent lead poisoning. Houses kept in a clean condition, with paint film intact and topcoated with lead-free paint or varnish, may not even pose a health risk. Dust wipe tests, which are sent to a laboratory for processing, can identify the level of lead dust present on floors, window sills, and window troughs. If lead dust is above acceptable levels, then specially modified maintenance procedures can be undertaken to reduce it. All paints deteriorate over time, so maintenance must be ongoing to control fine lead dust. The periodic washing of surfaces with a surfactant, such as tri-sodium phosphate (TSP) or its equivalent, loosens dirt and removes lead dust prior to a water rinse and touch-up painting, if necessary. This interim treatment can be extremely beneficial in controlling lead dust that is posing a hazard (see fig. 16).

**Soil/landscape.** Soil around building foundations may contain a high level of lead from years of chalking and peeling exterior paint. This dirt can be brought indoors on shoes or by pets and small children if they play outside a house. Lead in the soil is generally found in a narrow band



Figure 15. Wet sanding of interior surfaces will keep dust levels down, reduce the need for workers' protection, and provide a sound surface for repainting. Priming and repainting with oil/alkyd, latex or latex acrylic should be undertaken according to manufacturers' instructions.

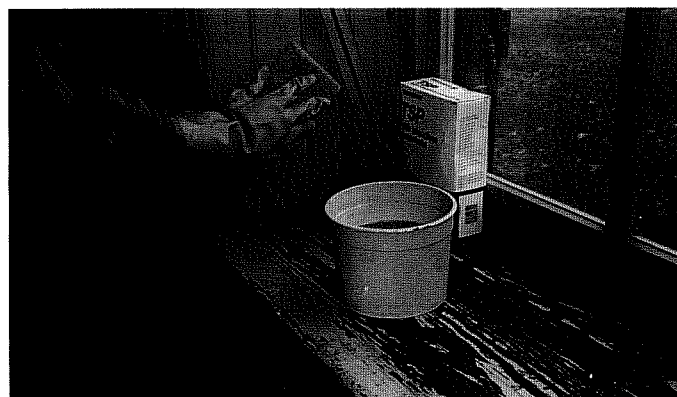
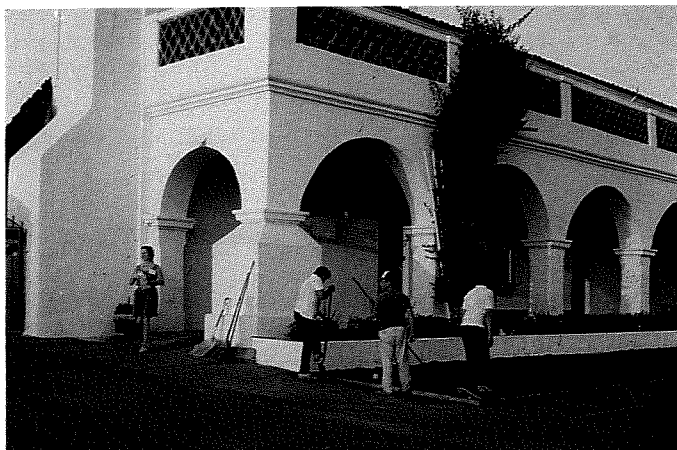


Figure 16. Washing windows and cleaning debris from window wells on a periodic basis can substantially reduce lead dust. Using water and tri-sodium phosphate (TSP or equivalent) will remove loose paint, and, after rinsing, the surface can be repainted with latex, oil/alkyd, or latex acrylic paints.

directly adjacent to the foundation. If the bare soil tests high in lead (see Action Levels Chart, pg. 6), it should be replaced to a depth of several inches or covered with new sod or plantings. Care should be taken to protect historic plantings on the building site and, in particular, historic landscapes, while mitigation work is underway (see fig. 17). If an area has become contaminated due to a variety of environmental conditions (for example, a smelter nearby or water tanks that have been sandblasted in the past), then an environmental specialist as well as a landscape preservation architect should be consulted on appropriate site protection and remedial treatments. It is inappropriate to place hard surfaces, such as concrete or macadam, over historically designed landscaped areas, which is often the recommendation of typical abatement guidelines.



*Figure 17. When historic sites are found to contain high levels of lead in bare soil — particularly around foundations — it is important to reduce the hazard without destroying significant landscapes. In many cases, contaminated soil can be removed from the foundation area and appropriate plantings or ground covers replanted in new soil. Photo: Charles A. Birnbaum, ASLA.*

**Deteriorating paint on exteriors.** Deteriorating exterior paint will settle onto window ledges and be blown into the dwelling, and will also contaminate soil at the foundation, as previously discussed. Painted exteriors may include wall surfaces, porches, roof trim and brackets, cornices, dormers, and window surrounds. Most exteriors need repainting every 5-10 years due to the cumulative effect of sun, wind, and rain or lack of maintenance. Methods of paint removal that do not abrade or damage the exterior materials should be evaluated. Because there is often more than one material (for example, painted brick and galvanized roof ornaments), the types of paint removal or paint stabilization systems need to be compatible with each material (see fig. 18). If paint has failed down to the substrate, it should be removed using either controlled sanding/scraping, controlled light abrasives for cast iron and durable metals, chemicals, or low heat. If chemicals are used, it may be necessary to have the contractor contain, filter, or otherwise treat any residue or rinse water. Environmental regulations must be checked prior to work, particularly if a large amount of lead waste will be generated or public water systems affected.

A cost analysis may show that, in the long run, repair and maintenance of historic materials or in-kind replacement can be cost effective. Due to the physical condition and location of wood siding, together with the cost of paint removal, a decision may be made to remove and replace



*Figure 18. As part of an urban housing grant program, the exterior of this row house was successfully made lead-safe and met the Secretary of the Interior's Standards for Rehabilitation. The exterior was washed, then repainted with exterior grade alkyd paint. The decorative roof brackets and cornice were repainted; not removed or covered as is often recommended in typical abatement guidelines. The previously altered, deteriorated window sash were replaced with new sash and jamb liners set within the historic frames. Photos: Deborah Birch.*

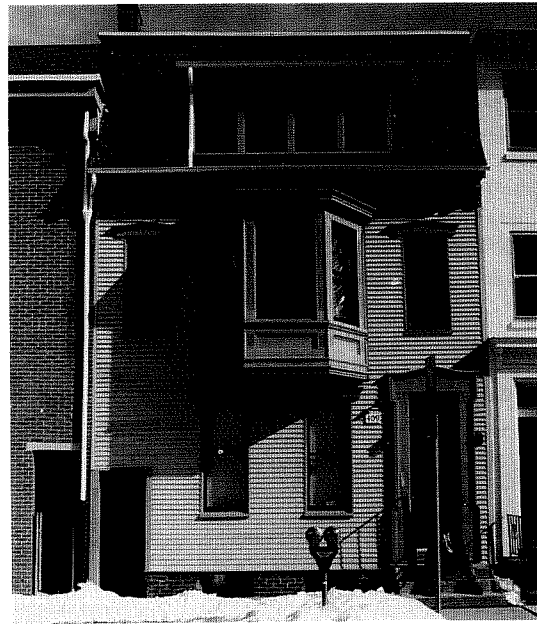
these materials on some historic frame buildings. If the repair or replacement of historic cladding on a primary elevation is being undertaken, such replacement materials should match the historic cladding in material, size, configuration, and detail (see fig. 19). The use of an artificial siding or aluminum coil stock panning systems over wooden trimwork or sills and lintels (as recommended in some abatement guidelines) is not appropriate, particularly on principal facades of historic buildings because they change the profile appearance of the exterior trimwork and may damage historic materials and detailing during installation. Unless the siding is too deteriorated to warrant repair and the cost is too prohibitive to use matching replacement materials (i.e., wood for wood), substitute materials are not recommended.

The use of specialized encapsulant paint coatings on exteriors—in particular, moist or humid climates, and, to some extent, cold climates—is discouraged because such coatings may serve to impede the movement of moisture that naturally migrates through other paints or mask leaks that may be causing substrate decay. Thus, a carefully applied exterior paint system (either oil/alkyd or latex) with periodic repainting can be very effective.

**Friction Surfaces.** Interior features with surfaces that—functionally—rub together such as windows and doors, or are subject to human wear and tear, such as floor and steps, are known as friction surfaces. It is unclear how much lead dust is created when friction surfaces that contain lead-based paint, but are top-coated with lead-free paint, rub together because much of the earlier paint may have worn away. For example, if lead dust levels around windows or on painted floors are consistently above acceptable levels, treating nearby friction surfaces should be considered. If surfaces, such as operable windows, operable doors, painted porch decks, painted floors and painted steps appear to be generating lead dust, they should be controlled through isolating or removing the lead-based paint. Window and door edges can be stripped or planed, or the units stripped on or off site to remove paint prior to repainting. Simple wooden stops and parting beads for windows, which often split upon removal, can be replaced.



**Before**



**After**

Figure 19. In many cases, exterior wood siding can be repaired, selectively replaced, and repainted, as illustrated in this successful residential rehabilitation. Deteriorating wood siding was removed from the foundation to the top of the first floor windows and replaced with matching wood siding. The entire building was repainted. Photos: Crispus Attucks Community Development Corporation.



Figure 20. Operable windows have friction surfaces between the sash and the frames, which can be a source of fine lead dust. In this case, the deteriorated sash was replaced, but the historic frame remains in place, successfully isolated from the sash with a simple vinyl jamb liner that is part of the new sash operation.

If window sash are severely deteriorated, it is possible to replace them; and vinyl jamb liners can effectively isolate remaining painted window jambs (see fig. 20). When windows are being treated within rehabilitation projects, their repair and upgrading are always recommended. In the event that part or all of a window needs to be replaced, the new work should match in size, configuration, detail, and, whenever possible, material.

Painted floors often present a difficult problem because walking on them abrades the surface, releasing small particles of lead-based paint. It is difficult to remove lead dust between the cracks in previously painted strip flooring even after sanding and vacuuming using special High Efficiency Particulate Air (HEPA) filters to control the lead dust. If painted floors are not highly significant in material, design, or craftsmanship, and they cannot be adequately cleaned and refinished, then replacing or covering them with new flooring may be considered. Stair treads can be easily fitted with rubber or vinyl covers (see fig. 21).

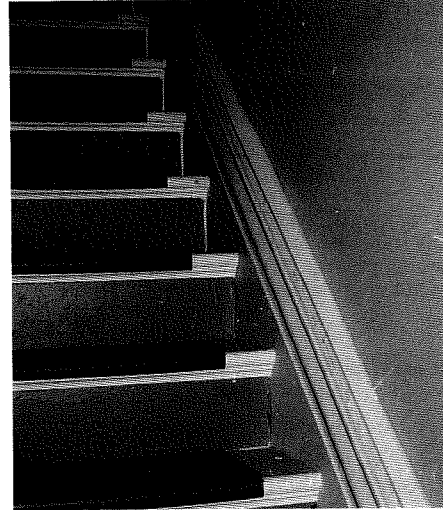


Figure 21. Painted stairs and floors can cause a problem because lead dust settles between the wooden boards. In this case, the steps were sanded, repainted, and covered with rubber stair treads. The floors could not be effectively cleaned and sealed so they were isolated with a new subflooring, and a washable tile finish installed.

**Accessible, projecting, mouthable surfaces.** Accessible, chewable surfaces that can be mouthed by small children need not be removed entirely, as some health guidelines recommend. These accessible surfaces are listed as projecting surfaces within a child's reach, including window sills, banister railings, chair rails, and door edges. In many cases, the projecting edges can have all paint removed using wet sanding, a heat gun or chemical strippers, prior to repainting the feature (see fig. 22). If the homeowner feels that there is no evidence of unsupervised mouthing of surfaces, a regular paint may be adequate once painted surfaces have been stabilized. An encapsulant paint that adhesively bonds existing paint layers onto the substrate extends durability. While encapsulant paint systems are difficult to remove from a surface in the future, they permit retention of the historic feature itself. If encapsulant paint is used on molded or decorative woodwork, it should be applied in several thin coats to prevent the architectural detail from being obscured by the heavy paint (see fig 23).



Figure 22. Research has shown that some small children will chew on projecting window sills while teething. As part of a lead hazard control project, the edge of the sill can be stripped to bare wood or an encapsulating paint applied. In this case, a new window sill was installed as part of a window upgrade that retained the historic trim and frame.

Figure 23. Stair banisters and railings are considered mouthable surfaces. In this case, the old paint was wet sanded to a sound layer. Special encapsulant paints were then applied in three thin layers to avoid obscuring the woodwork's fine detailing. It should be noted that many encapsulant paints are now treated with a bitter agent to discourage mouth contact. Photo: Landmarks Design Associates.



**Impact Surfaces.** Painted surfaces near doorways and along corridors tend to become chipped and scraped simply because of their location. This is particularly true of baseboards, which were designed to protect wall surfaces, and also for doorjambs. Owners should avoid hitting painted impact surfaces with vacuums, brooms, baby carriages, or wheeled toys. Adding new shoe moldings can give greater protection to some baseboards. In most cases, stabilizing loose paint and repainting with a high quality interior paint will provide a durable surface. Clear panels or shields can be installed at narrow doorways, if abrasion continues, or these areas can be stripped of paint and repainted. Features in poor condition may need to be replaced with new, matching materials (see fig. 24).

**Other surfaces showing age or deterioration/ walls and ceilings.** Many flat wall surfaces and ceilings were not painted with lead-based paint, so will need to be tested for its presence prior to any treatment. Flat surfaces that contain deteriorating lead-based paint should be repaired following the responsible approach previously cited (i.e., removing loose paint to a sound substrate, then repairing damaged plaster using a skim coat or wet plaster repair (see fig. 25). Drywall is used *only* when deterioration is too great to warrant plaster repair. If walls and ceilings have a high lead content, and extensive paint removal is not feasible, there are systems available that use elastomeric paints with special fabric liners to stabilize older, though intact, wall surfaces.

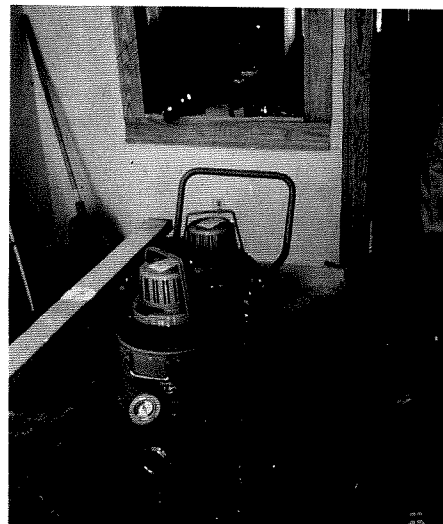
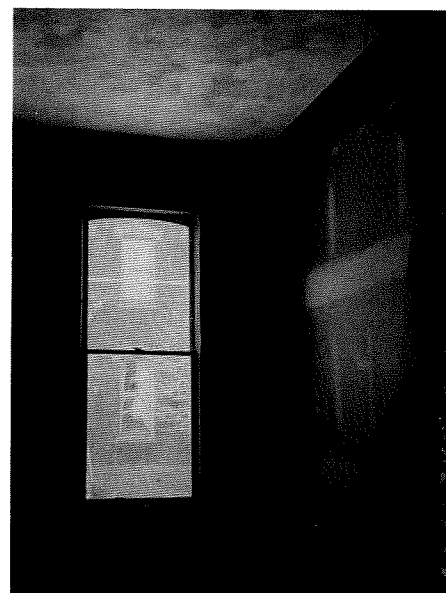


Figure 24. Historic baseboards are often bumped by brooms and vacuum cleaners, causing lead-based paint chips to fall on the floor. Shoe moldings can be added or replaced to increase protection to the baseboard itself. In this case, because the condition of the interior warranted substantial repair, simple historic board trim was replaced with new matching trim. Note the HEPA filter vacuum in the foreground. Photo: NPS file.

Figure 25. In some cases, skim coating deteriorated plaster and repainting is adequate. If the plaster is seriously damaged or failing, drywall may be considered so long as the molding and window reveal relationships are retained. In this case, plaster between the windows was repaired and repainted and the side wall plaster was replaced with drywall. Photo: Landmarks Design Associates.



If a new drywall surface needs to be applied, care should be taken that the historic relationship of wall to trim is not lost. Also, if there are significant features, such as crown moldings or ceiling medallions, they should always be retained and repaired (see fig. 26).



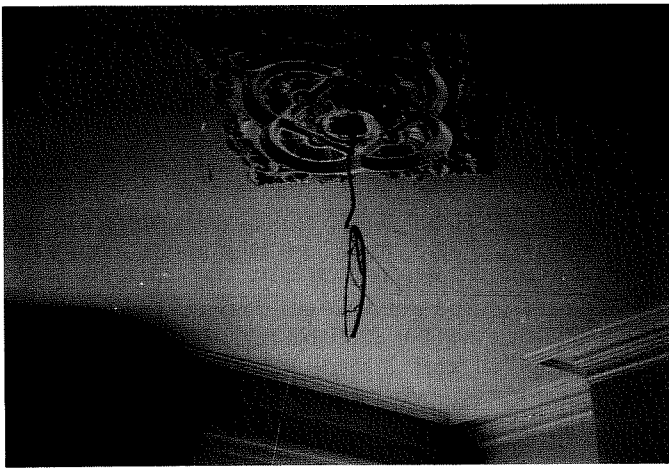


Figure 26. Deteriorated ceiling plaster was removed and a new drywall ceiling installed. The historic ceiling medallion was preserved, and the plaster cornices repaired in place. Photo: Landmarks Design Associates.

## Maintenance after Hazard Control Treatment

Following treatment, particularly where interim controls have been used, ongoing maintenance and re-evaluation become critical. In urban areas, even fully lead-safe houses can be re-contaminated within a year from lead or dirt outside the immediate property. Thus, housing interiors must be kept clean, once lead hazard control measures have been implemented. Dust levels should be kept down by wet sweeping porch steps and entrances on a regular basis. Vacuum cleaning and dusting should be repeated inside on a weekly basis or even more often. Vinyl, tile, and wood floor surfaces should be similarly damp mopped. Damp washing of window troughs and sills to remove new dust should be encouraged several times a year, particularly in the spring and fall when windows will be open. Carpets and area rugs should be steam cleaned or washed periodically if they appear to hold outside dirt.

Housing should be inspected frequently for signs of deterioration by both owner and occupant. Tenants need to be made aware of the location of lead-based paint under lead-free top coats and instructed to contact the owners or property managers when the paint film becomes disturbed (see figure 27). Any leaks, peeling paint, or evidence of

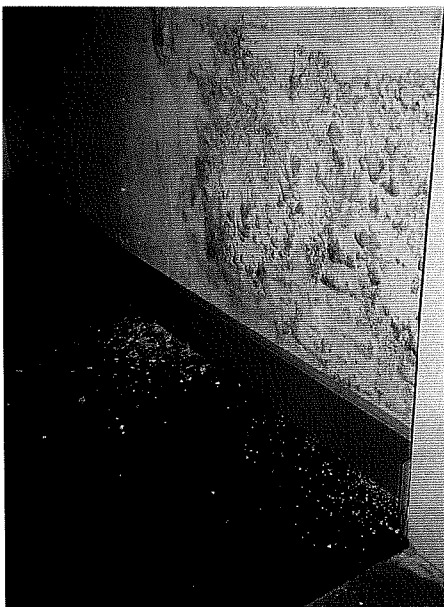


Figure 27. Wall leaks can cause historic surfaces to deteriorate, thereby exposing underlayers of lead-based paint. If painted surfaces show signs of deterioration, they should be repaired as soon as possible.

conditions that may generate lead-dust should be identified and corrected immediately. Occupants must be notified prior to any major dust-producing project. Dry sanding, burning, compressed air cleaning or blasting should not be used. Repairs, repainting, or remodeling activities that have the potential of raising significant amounts of lead dust should be undertaken in ways that isolate the area, reduce lead-laden dust as much as possible, and protect the occupants.

Yearly dust wipe tests are recommended to ensure that dust levels remain below actionable levels. Houses or dwelling units that fail the dust-wipe test should be thoroughly re-cleaned with TSP, or its equivalent, washed down, wet vacuumed and followed by HEPA vacuuming, if necessary, until a clearance dust wipe test shows the area to be under actionable levels (see Action Levels chart). Spaces that are thoroughly cleaned and maintained in good condition are not a health risk (see fig. 28).

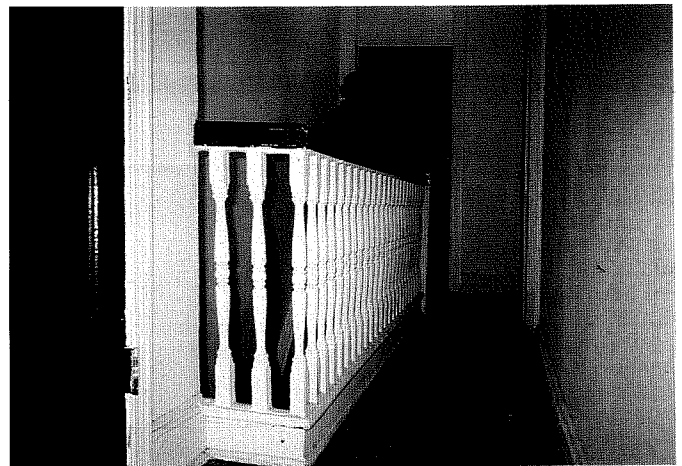


Figure 28. This recently completed housing, which is now lead-safe, could become re-contaminated from lead if safe conditions are not maintained. Damp mopping floor surfaces and regular dusting to keep the house clean will ensure its continuing safety.

## Conclusion

The three-step planning process outlined in this Brief provides owners and managers of historic housing with responsible methods for protecting historic paint layers and architectural elements, such as windows, trimwork, and decorative finishes. Exposed decorative finishes, such as painted murals or grained doors can be stabilized by a paint conservator without destroying their significance.

Reducing and controlling lead hazards can be successfully accomplished without destroying the character-defining features and finishes of historic buildings. Federal and state laws generally support the reasonable control of lead-based paint hazards through a variety of treatments, ranging from modified maintenance to selective substrate removal. The key to protecting children, workers, and the environment is to be informed about the hazards of lead, to control exposure to lead dust and lead in soil, and to follow existing regulations. In all cases, methods that control lead hazards should be selected that minimize the impact to historic resources while ensuring that housing is lead-safe for children.

## LEAD-BASED PAINT LEGISLATION

*Federal Legislation:* **Title X (Ten) Residential Lead-Based Paint Hazard Reductions Act of 1992.** Title X is part of Housing and Urban Development (HUD) Housing and Community Development Act of 1992 (Public Law 102-550). Title X calls for the reduction of lead in housing that is *federally supported* and outlines the federal responsibility towards its own residential units and the need for disclosure of lead in residences, even private residences, prior to sale.

**Interim Final Regulations of Lead in Construction Standards (29 CFR 1926.62).** Issued by the Department of Labor, Occupational Safety and Health Administration (OSHA), these regulations address worker safety, training, and protective measures. It is based in part on environmental air sampling to determine the amount of lead dust generated by various activities.

**Lead: Identification of Dangerous Levels of Lead; Final Rule (Environmental Protection Agency (EPA) 40 CFR Part 745).** This regulation supports the efforts of Title X to reduce and prevent lead poisoning in children under the age of six. This rule issues uniform national standards for lead paint hazards. EPA Regional Offices can provide guidance on the appropriate regulatory agency for states within their region. See [www.epa.gov/lead](http://www.epa.gov/lead).

*State Laws:* States generally have the authority to regulate the removal and transportation of lead-based paint and the generated waste for disposal through the appropriate state environmental and public health agencies. Most states have requirements for mitigation in the case of a lead-poisoned child, or for protection

of children, or for oversight to ensure the safe handling and disposal of lead waste. When undertaking a lead-based paint reduction program, it is important to determine which laws are in place that may affect your project. Call the appropriate officials.

*Local Ordinances:* Check with local health departments, Poison Control Centers, and offices of housing and community development to determine if there are laws that require compliance with building owners. Some cities have their own rules, so check with your local authorities to see which laws apply to you or for assistance in finding firms licensed to handle lead-based paint projects.

*Owner's Responsibility:* Owners are ultimately responsible for ensuring that hazardous waste is properly disposed of when generated on site. Owners should check with the state or local authorities to determine requirements for proceeding with abatement or management of lead-based paint in either commercial or residential projects. Owners should establish that the contractor is responsible for the safety of the crew and that all applicable laws are followed, and that transporters and disposers of hazardous waste have liability insurance as a protection for the owner. If an interim treatment is being used to reduce lead hazards, the owner should notify the contractor that lead-based paint is present and that it is the contractor's responsibility to follow appropriate work practices to protect workers and complete a thorough clean-up to ensure that lead-laden dust is not present after the work is completed.

## Glossary of Terms

**Deteriorated Lead-Based Paint:** Paint known to contain lead that shows signs of peeling, chipping, chalking, blistering, alligatoring or otherwise separating from its substrate.

**Dust Removal:** The process of removing dust to avoid creating a greater problem of spreading lead particles, usually through wet or damp collection or through the use of special HEPA vacuums.

**Hazard Abatement:** Long-term measures to remove the hazards of lead-based paint through selective paint stripping of deteriorated areas, or, in some cases, replacement of deteriorated features.

**Hazard Control:** Measures to reduce lead hazards to make housing safe for young children. Can be accomplished with interim (short-term) or hazard abatement (long-term) controls.

**Interim Control:** Short-term methods to remove lead dust, stabilize deteriorating surfaces, and repaint sur-

faces. Maintenance can ensure that housing remains lead-safe.

**Lead-based Paint:** Any existing paint, varnish, shellac, or other coating that is in excess of 1.0 mg/cm<sup>2</sup> as measured by an XRF detector or greater than 0.5% by weight from laboratory analysis (5,000 ppm, 5,000 ug/g, or 5,000 mg/kg). For new products, the Consumer Safety Act notes 0.06% as the maximum amount of lead allowed in paint.

**Lead-safe:** The act of making a property safe from contamination by lead-based paint, lead-dust, and lead in soil generally through short and long-term methods to remove it, or to isolate it from small children.

**Risk Assessment:** An on-site investigation to determine the presence and condition of lead-based paint, including limited test samples, and an evaluation of the age, condition, housekeeping practices, and uses of a residence.

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*Photographs courtesy of the authors unless identified.*

*Front cover:*  
Most residences painted prior to 1978 will contain some lead-based paint. It was widely used on exterior woodwork, siding, and windows as well as interior finishes. This apartment stairhall retains its historic character after a successful rehabilitation project that included work to control lead-based paint hazards. Photo: Crispus Attucks Community Development Corporation.

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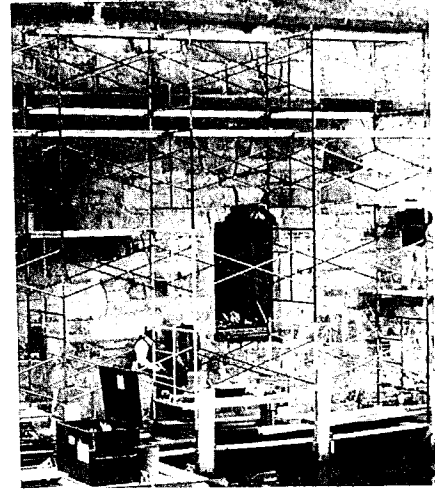
# 39 PRESERVATION BRIEFS

## Holding the Line: Controlling Unwanted Moisture in Historic Buildings

Sharon C. Park, AIA



U.S. Department of the Interior  
National Park Service  
Cultural Resources  
Heritage Preservation Services



Uncontrolled moisture is the most prevalent cause of deterioration in older and historic buildings. It leads to erosion, corrosion, rot, and ultimately the destruction of materials, finishes, and eventually structural components. Ever-present in our environment, moisture can be *controlled* to provide the differing *levels* of moisture necessary for human comfort as well as the longevity of historic building materials, furnishings, and museum collections. The challenge to building owners and preservation professionals alike is to understand the patterns of moisture movement in order to better manage it — not to eliminate it. There is never a single answer to a moisture problem. Diagnosis and treatment will always differ depending on where the building is located, climatic and soil conditions, ground water effects, and local traditions in building construction.

### Remedial Actions within an Historic Preservation Context

In this Brief, advice about controlling the sources of unwanted moisture is provided within a preservation context based on philosophical principles contained in the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. Following the Standards means significant materials and features that contribute to the historic character of the building should be preserved, not damaged during remedial treatment (see fig.1). It also means that physical treatments should be reversible, whenever possible. The majority of treatments for moisture management in this Brief stress preservation maintenance for materials, effective drainage of troublesome ground moisture, and improved interior ventilation.

The Brief encourages a systematic approach for evaluating moisture problems which, in some cases, can be undertaken by a building owner. Because the source of moisture can be elusive, it may be necessary to consult with historic preservation professionals prior to starting work that would affect historic materials. Architects, engineers, conservators, preservation contractors, and staff of State Historic Preservation Offices (SHPOs) can provide such advice.

Regardless of who does the work, however, these are the principles that should guide treatment decisions:

- Avoid remedial treatments without prior careful diagnosis.
- Undertake treatments that protect the historical significance of the resource.
- Address issues of ground-related moisture and rain runoff thoroughly.
- Manage existing moisture conditions before introducing humidified / dehumidified mechanical systems.
- Implement a program of ongoing monitoring and maintenance once moisture is controlled or managed.
- Be aware of significant landscape and archeological resources in areas to be excavated.

Finally, mitigating the effects of catastrophic moisture, such as floods, requires a different approach and will not be addressed fully in this Brief.



Fig. 1. Moisture problems, if not properly corrected, will increase damage to historic buildings. This waterproof coating trapped moisture from the leaking roof, causing portions of the masonry parapet to fail. Photo: NPS Files.



## How and Where to Look for Damaging Moisture

Finding, treating, and managing the sources of damaging moisture requires a systematic approach that takes time, patience, and a thorough examination of all aspects of the problem—including a series of variable conditions (See this page). Moisture problems may be a direct result of one of these factors or may be attributable to a combination of interdependent variables.

### Factors Contributing to Moisture Problems

A variety of simultaneously existing conditions contribute to moisture problems in old buildings. For recurring moisture problems, it may be necessary for the owner or preservation professional to address many, if not all, of the following variables:

- Types of building materials and construction systems
- Type and condition of roof and site drainage systems and their rates of discharge
- Type of soil, moisture content, and surface / subsurface water flow adjacent to building
- Building usage and moisture generated by occupancy
- Condition and absorption rates of materials
- Type, operation, and condition of heating, ventilating, cooling, humidification/ dehumidification, and plumbing systems
- Daily and seasonal changes in sun, prevailing winds, rain, temperature, and relative humidity (inside and outside), as well as seasonal or tidal variations in groundwater levels
- Unusual site conditions or irregularities of construction
- Conditions in affected wall cavities, temperature and relative humidity, and dewpoints
- Amount of air infiltration present in a building
- Adjacent landscape and planting materials

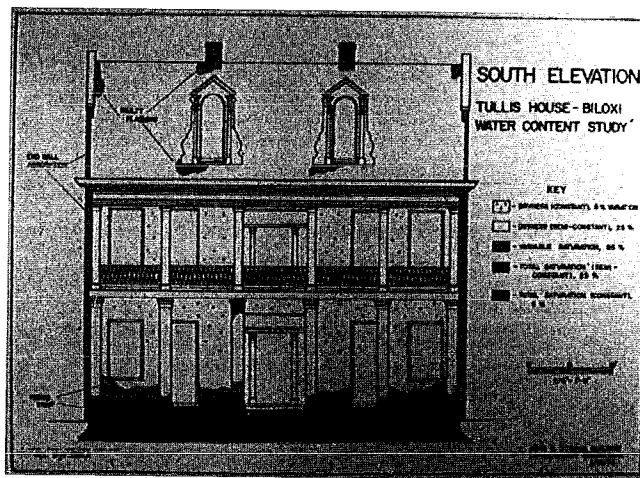


Fig. 2. Historic buildings plagued by dampness problems will benefit from systematic documentation to set a baseline against which moisture changes can be measured. Exterior areas with higher moisture levels may have algae growth or discoloration stains. Drawing: John H. Stubbs.

Diagnosing and treating the cause of moisture problems requires looking at both the localized decay, as well as understanding the performance of the entire building and site. Moisture is notorious for traveling far from the source, and moisture movement within concealed areas of the building construction make accurate diagnosis of the source and path difficult. Obvious deficiencies, such as broken pipes, clogged gutters, or cracked walls that contribute to moisture damage, should always be corrected promptly.

For more complicated problems, it may take several months or up to four seasons of monitoring and evaluation to complete a full diagnosis. Rushing to a solution without adequate documentation can often result in the unnecessary removal of historic materials—and worse—the creation of long-term problems associated with an increase, rather than a decrease, in the unwanted moisture.

### Looking for Signs

Identifying the type of moisture damage and discovering its source or sources usually involves the human senses of sight, smell, hearing, touch, and taste combined with intuition. Some of the more common signs of visible as well as hidden moisture damage (see fig. 2, 3) include:

- Presence of standing water, mold, fungus, or mildew
- Wet stains, eroding surfaces, or efflorescence (salt deposits) on interior and exterior surfaces
- Flaking paint and plaster, peeling wallpaper, or moisture blisters on finished surfaces
- Dank, musty smells in areas of high humidity or poorly ventilated spaces
- Rust and corrosion stains on metal elements, such as anchorage systems and protruding roof nails in the attic
- Cupped, warped, cracked, or rotted wood
- Spalled, cracked masonry or eroded mortar joints
- Faulty roofs and gutters including missing roofing slates, tiles, or shingles and poor condition of flashing or gutters
- Condensation on window and wall surfaces
- Ice dams in gutters, on roofs, or moisture in attics

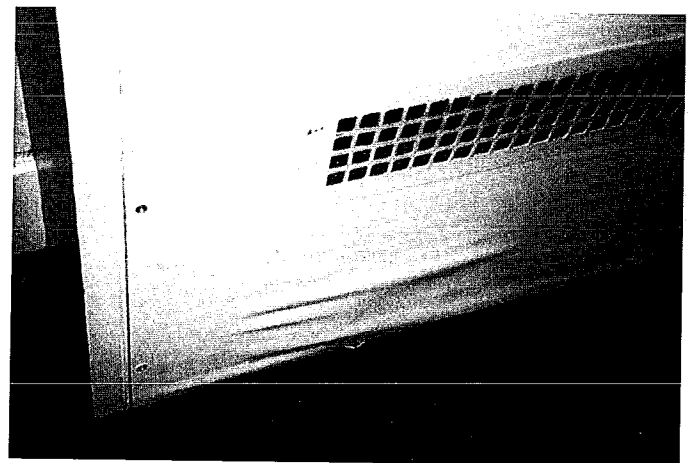


Fig. 3. The deterioration of this wooden cover was a sign that water was leaking from the fan coil unit behind. Photo: author.

## Uncovering and Analyzing Moisture Problems

Moisture comes from a variety of external sources. Most problems begin as a result of the weather in the form of rain or snow, from high ambient relative humidity, or from high water tables. But some of the most troublesome moisture damage in older buildings may be from internal sources, such as leaking plumbing pipes, components of heating, cooling, and climate control systems, as well as sources related to use or occupancy of the building. In some cases, moisture damage may be the result of poorly designed original details, such as projecting outriggers in rustic structures that are vulnerable to rotting, and may require special treatment.

The five most common sources of unwanted moisture include:

- Above grade exterior moisture entering the building
- Below grade ground moisture entering the building
- Leaking plumbing pipes and mechanical equipment
- Interior moisture from household use and climate control systems
- Water used in maintenance and construction materials.

**Above grade exterior moisture** generally results from weather related moisture entering through deteriorating materials as a result of deferred maintenance, structural settlement cracks, or damage from high winds or storms (see fig. 4). Such sources as faulty roofs, cracks in walls, and open joints around window and door openings can be corrected through either repair or limited replacement. Due to their age, historic buildings are notoriously “drafty,” allowing rain, wind, and damp air to enter through missing mortar joints; around cracks in windows, doors, and wood siding; and into uninsulated attics. In some cases, excessively absorbent materials, such as soft sandstone, become saturated from rain or gutter overflows, and can allow moisture to dampen interior surfaces. Vines or other vegetative materials allowed to grow directly on building

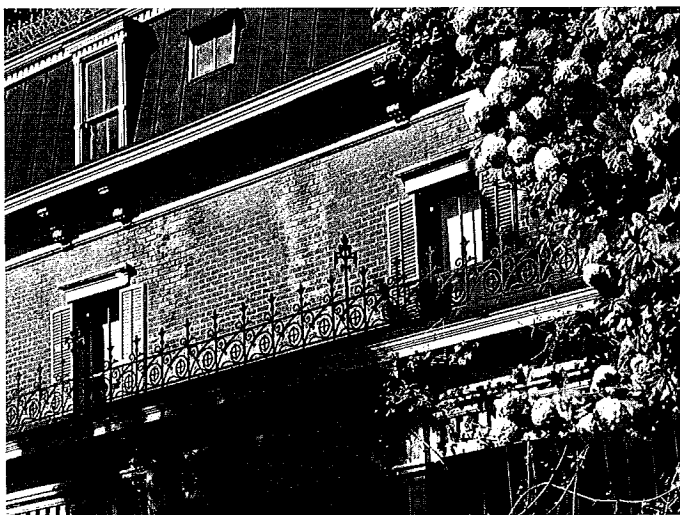


Fig. 4. Deferred maintenance often leads to blocked gutters and downspouts. This cracked gutter system allowed moisture to penetrate the upper exterior wall, erode mortar joints, and rot fascia boards. Photo: NPS files.

materials without trellis or other framework can cause damage from roots eroding mortar joints and foundations as well as dampness being held against surfaces. In most cases, keeping vegetation off buildings, repairing damaged materials, replacing flashings, rehangng gutters, repairing downspouts, repointing mortar, caulking perimeter joints around windows and doors, and repainting surfaces can alleviate most sources of unwanted exterior moisture from entering a building above grade.

**Below grade ground moisture** is a major source of unwanted moisture for historic and older buildings. *Proper handling of surface rain run-off is one of the most important measures of controlling unwanted ground moisture.* Rain water is often referred to as “bulk moisture” in areas that receive significant annual rainfalls or infrequent, but heavy, precipitation. For example, a heavy rain of 2” per hour can produce 200 gallons of water from downspout discharge alone for a house during a one hour period. When soil is saturated at the base of the building, the moisture will wet footings and crawl spaces or find its way through cracks in foundation walls and enter into basements (see fig. 5). Moisture in saturated basement or foundation walls—also exacerbated by high water tables—will generally rise up within a wall and eventually cause deterioration of the masonry and adjacent wooden structural elements.

Builders traditionally left a working area, known as a builder’s trench, around the exterior of a foundation wall. These trenches have been known to increase moisture problems if the infill soil is less than fully compacted or includes rubble backfill, which, in some cases, may act as a reservoir holding damp materials against masonry walls. Broken subsurface pipes or downspout drainage can leak into the builder’s trench and dampen walls some distance from the source. Any subsurface penetration of the foundation wall for sewer, water, or other piping also can act as a direct conduit of ground moisture unless these holes are well sealed. A frequently unsuspected, but serious, modern source of ground moisture is a landscape irrigation system set too close to the building. Incorrect placement of sprinkler heads can add a tremendous amount of moisture at the foundation level and on wall surfaces.

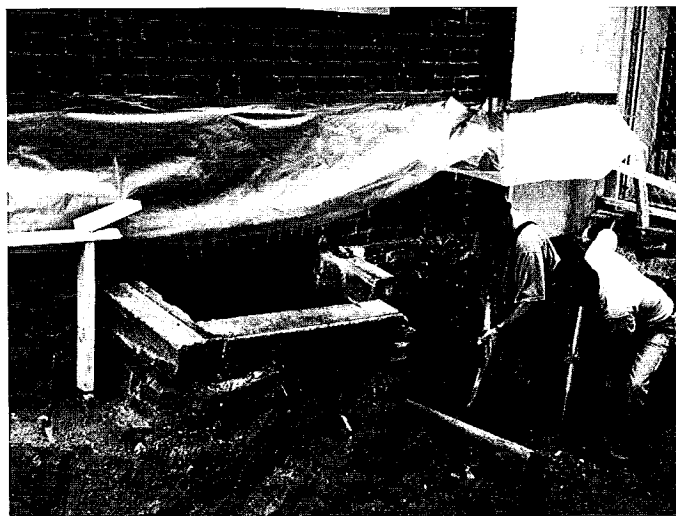


Fig. 5. Excavating this foundation revealed that the downspout pipe had corroded at the “u-trap” and was leaking moisture into the soil. Openings around the horizontal water supply line and cracks in the wall allowed moisture to penetrate the basement in multiple locations. Photo: author.

The ground, and subsequently the building, will stay much drier by 1) re-directing rain water away from the foundation through sloping grades, 2) capturing and disposing downspout water well away from the building, 3) developing a controlled ground gutter or effective drainage for buildings historically without gutters and downspouts, and 4) reducing splash-back of moisture onto foundation walls. The excavation of foundations and the use of dampproof coatings and footing drains should only be used after the measures of reducing ground moisture listed above have been implemented.

**Leaking plumbing pipes and mechanical equipment** can cause immediate or long-term damage to historic building interiors. Routine maintenance, repair, or, if necessary, replacement of older plumbing and mechanical equipment are common solutions. Older water and sewer pipes are subject to corrosion over time. Slow leaks at plumbing joints hidden within walls and ceilings can ultimately rot floor boards, stain ceiling plaster, and lead to decay of structural members. Frozen pipes that crack can damage interior finishes (see fig. 6). In addition to leaking plumbing pipes, old radiators in some historic buildings have been replaced with water-supplied fan coil units which tend to leak. These heating and cooling units, as well as central air equipment, have overflow and condensation pans that require cyclical maintenance to avoid mold and mildew growth and corrosion blockage of drainage channels. Uninsulated forced-air sheet metal ductwork and cold water pipes in walls and ceilings often allow condensation to form on the cold metal, which then drips and causes bubbling plaster and peeling paint. Careful design and vigilant maintenance, as well as repair and insulating pipes or ductwork, will generally rid the building of these common sources of moisture.



Fig. 6. Uninsulated plumbing pipes close to the exterior wall froze and cracked, wetting this ornamental plaster ceiling before the water supply line could be shut off. As a result, limited portions of the ceiling needed reattaching. Photo: author.

**Interior moisture** from building use and modern humidified heating and cooling systems can create serious problems. In northern U.S. climates, heated buildings will have winter-time relative humidity levels ranging from 10%-35% Relative Humidity (RH). A house with four occupants generates between 10 and 16 pounds of water a day (approximately 1 – 2 gallons) from human residents. Moisture from food preparation, showering, or laundry use will produce condensation on windows in winter climates.

When one area or floor of a building is air-conditioned and another area is not, there is the chance for condensation to occur between the two areas. Most periodic condensation does not create a long-term problem.

Humidified climate control systems are generally a major problem in museums housed within historic buildings. They produce between 35%-55% RH on average which, as a vapor, will seek to dissipate and equalize with adjacent spaces (see fig. 7). Moisture can form on single-glazed windows in winter with exterior temperatures below 30 F and interior temperatures at 70 F with as little as 35% RH. Frequent condensation on interior window surfaces is an indication that moisture is migrating into exterior walls, which can cause long-term damage to historic materials. Materials and wall systems around climate controlled areas may need to be made of moisture resistant finishes in order to handle the additional moisture in the air. Moist interior conditions in hot and humid climates will generate mold and fungal growth. Unvented mechanical equipment, such as gas stoves, driers, and kerosene heaters, generate large quantities of moisture. It is important to provide adequate ventilation and find a balance between interior temperature, relative humidity, and airflow to avoid interior moisture that can damage historic buildings.

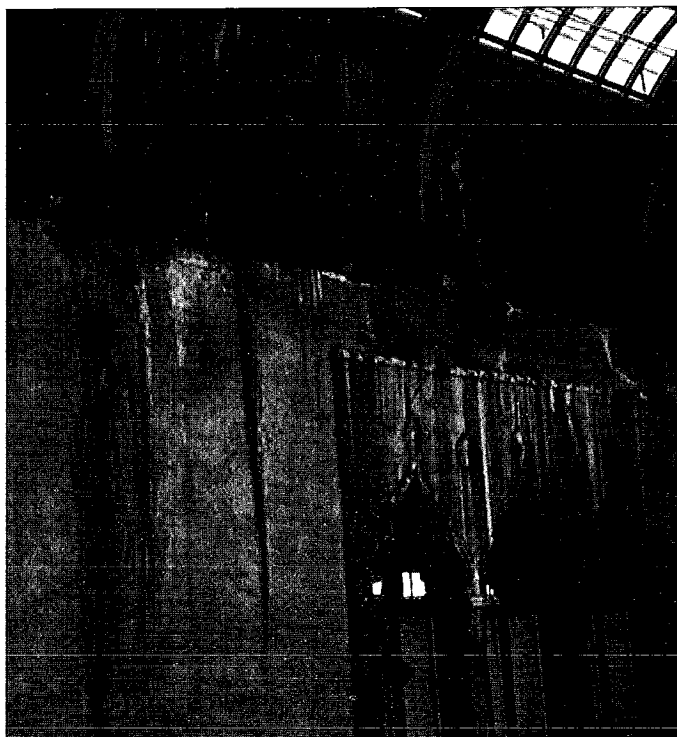


Fig. 7. Condensation dripping from the large overhead courtyard skylight was damaging the masonry in this museum. A new skylight with thermal glazing was installed, replacing the deteriorated single-glazed unit. A new climate control system monitors interior temperature and humidity. Photo: © Isabella Stewart Gardner Museum, Boston.

**Moisture from maintenance and construction materials** can cause damage to adjacent historic materials. Careless use of liquids to wash floors can lead to water seepage through cracks and dislodge adhesives or cup and curl materials. High-pressure power washing of exterior walls and roofing materials can force water into construction joints where it can dislodge mortar, lift roofing tiles, and saturate frame walls and masonry. Replastered or newly

plastered interior walls or the construction of new additions attached to historic buildings may hold moisture for months; new plaster, mortar, or concrete should be fully cured before they are painted or finished. The use of materials in projects that have been damaged by moisture prior to installation or have too high a moisture content may cause concealed damage (see fig. 8).

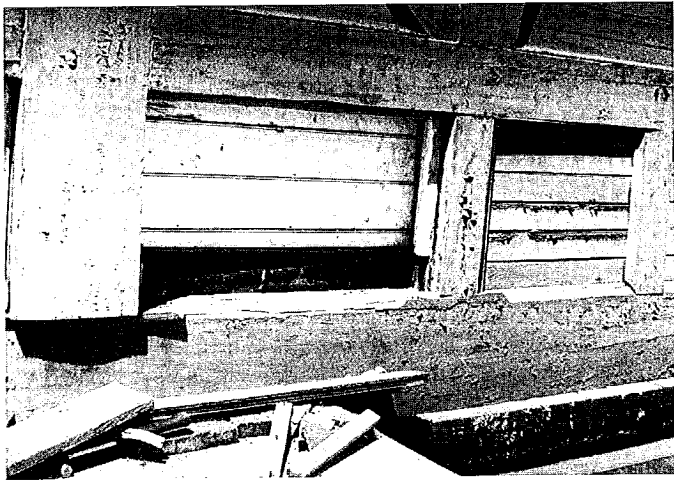


Fig. 8. Damaging moisture conditions can occur during construction. Peeling paint on this newly rehabilitated frame wall was attributed to wall insulation that had become wet during the project and was not discovered. Photo: NPS Files.

## Transport or Movement of Moisture

Knowing the five most common sources of moisture that cause damage to building materials is the first step in diagnosing moisture problems. But it is also important to understand the basic mechanisms that affect moisture movement in buildings. Moisture transport, or movement, occurs in two states: liquid and vapor. It is directly related to pressure differentials. For example, water in a gaseous or vapor state, as warm moist air, will move from its high pressure area to a lower pressure area where the air is cooler and drier. Liquid water will move as a result of differences in hydrostatic pressure or wind pressure. *It is the pressure differentials that drive the rate of moisture migration in either state.* Because the building materials themselves resist this moisture movement, the rate of movement will depend on two factors: the permeability of the materials when affected by vapor and the absorption rates of materials in contact with liquid.

The mechanics, or physics, of moisture movement is complex, but if the driving force is difference in pressure, then an approach to reducing moisture movement and its damage is to reduce the difference in pressure, not to increase it. That is why the treatments discussed in this Brief will look at *managing moisture by draining bulk moisture and ventilating vapor moisture* before setting up new barriers with impermeable coatings or over-pressurized new climate control systems that threaten aging building materials and archaic construction systems.

Three forms of moisture transport are particularly important to understand in regards to historic buildings — *infiltration, capillary action, and vapor diffusion* — remembering, at the same time, that the subject is infinitely complex and, thus, one of continuing scientific study (see

fig. 9). Buildings were traditionally designed to deal with the movement of air. For example, cupolas and roof lanterns allowed hot air to rise and provided a natural draft to pull air through buildings. Cavity walls in both frame and masonry buildings were constructed to allow moisture to dissipate in the air space between external and internal walls. Radiators were placed in front of windows to keep cold surfaces warm, thereby reducing condensation on these surfaces. Many of these features, however, have been altered over time in an effort to modernize appearances, improve energy efficiency, or accommodate changes in use. The change in use will also affect moisture movement, particularly in commercial and industrial buildings with modern mechanical systems. Therefore, the way a building handles air and moisture today may be different from that intended by the original builder or architect, and poorly conceived changes may be partially responsible for chronic moisture conditions.

Moisture moves into and through materials as both a visible liquid (capillary action) and as a gaseous vapor (infiltration and vapor diffusion). Moisture from leaks, saturation, rising damp, and condensation can lead to the deterioration of materials and cause an unhealthy environment. Moisture in its solid form, ice, can also cause damage from frozen, cracked water pipes, or split gutter seams or spalled masonry from freeze-thaw action. Moisture from melting ice dams, leaks, and condensation often can travel great distances down walls and along construction surfaces, pipes, or conduits. The amount of moisture and how it deteriorates materials is dependent upon complex forces and variables that must be considered for each situation.

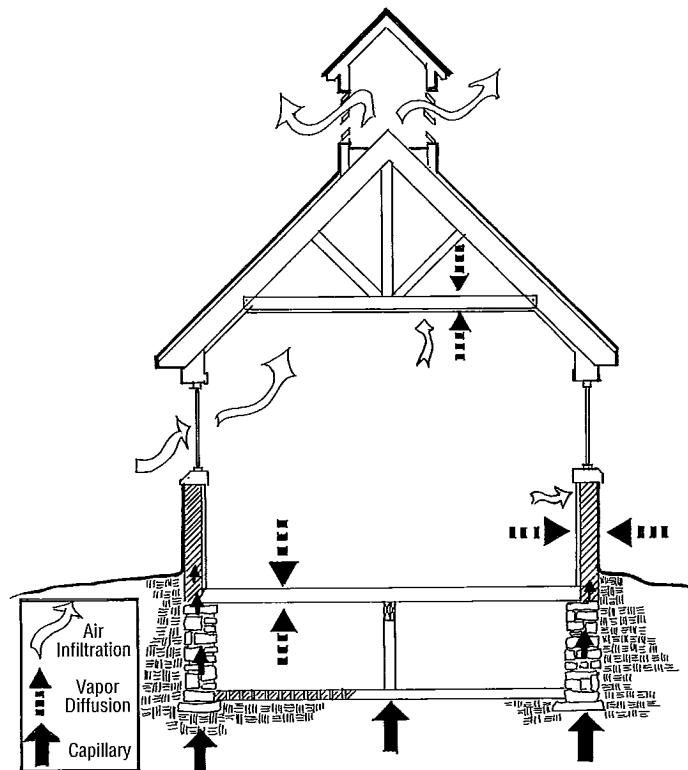


Fig. 9. The dynamic forces that move air and moisture through a building are important to understand particularly when selecting a treatment to correct a moisture problem. Air infiltration, capillary action, and vapor diffusion all affect the wetting and drying of materials. Drawing: NPS Files.



Determining the way moisture is handled by the building is further complicated because each building and site is unique. Water damage from blocked gutters and downspouts can saturate materials on the outside, and high levels of interior moisture can saturate interior materials. Difficult cases may call for technical evaluation by consultants specializing in moisture monitoring and diagnostic evaluation. In other words, it may take a team to effectively evaluate a situation and determine a proper approach to controlling moisture damage in old buildings.

**Infiltration** is created by wind, temperature gradients (hot air rising), ventilation fan action, and the stack or chimney effect that draws air up into tall vertical spaces. Infiltration as a dynamic force does not actually move liquid water, but is the vehicle by which dampness, as a component of air, finds its way into building materials. Older buildings have a natural air exchange, generally from 1 to 4 changes per hour, which, in turn, may help control moisture by diluting moisture within a building. The tighter the building construction, however, the lower will be the infiltration rate and the natural circulation of air. In the process of infiltration, however, moisture that has entered the building and saturated materials can be drawn in and out of materials, thereby adding to the dampness in the air (see fig. 10). Inadequate air circulation where there is excessive moisture (i.e., in a damp basement), accelerates the deterioration of historic materials. To reduce the unwanted moisture that accompanies infiltration, it is best to incorporate maintenance and repair treatments to close joints and weatherstrip windows, while providing controlled air exchanges elsewhere. The worst approach is to seal the building so completely, while limiting fresh air intake, that the building cannot breathe.



Fig. 10. Infiltration of damp air can occur around loose-fitting or deteriorated window sash and through cracks or open joints in building exteriors. Photo: Ann Brooks Prueher.

**Capillary action** occurs when moisture in saturated porous building materials, such as masonry, wicks up or travels vertically as it evaporates to the surface. In capillary attraction, liquid in the material is attracted to the solid surface of the pore structure causing it to rise vertically; thus, it is often called "rising damp," particularly when found in conjunction with ground moisture. It should not, however, be confused with moisture that laterally penetrates a foundation wall through cracks and settles in the basement. Not easily controlled, most rising damp comes from high water tables or a constant source under the footing. In cases of damp masonry walls with capillary action, there is usually a whitish stain or horizontal tide mark of efflorescence that seasonally fluctuates about 1-3 feet above grade where the excess moisture evaporates from the wall (see fig. 11). This tide mark is full of salt crystals, that have been drawn from the ground and building materials along with the water, making the masonry even more sensitive to additional moisture absorption from the surrounding air. Capillary migration of moisture may occur in any material with a pore structure where there is a constant or recurring source of moisture.

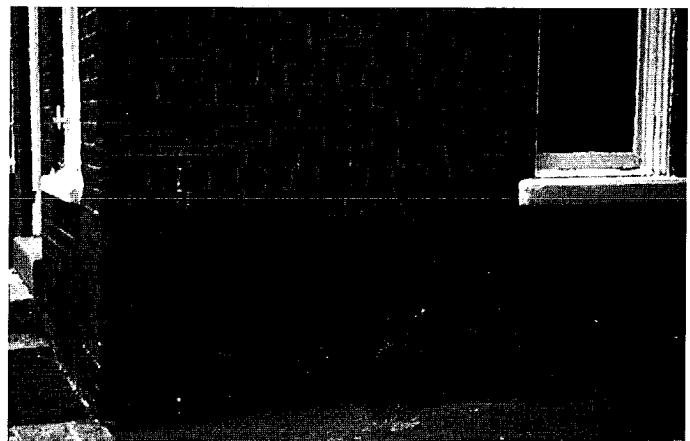


Fig. 11. Capillary rise of moisture in masonry is often accompanied with a horizontal tide-mark line several feet above the grade, as seen here. Removing or redirecting as much ground moisture as possible usually helps reduce moisture within a wall. Photo: NPS Files.

The best approach for dealing with capillary rise in building materials is to reduce the amount of water in contact with historic materials. If that is not possible due to chronically high water tables, it may be necessary to introduce a horizontal damp-proof barrier, such as slate course or a lead or plastic sheet, to stop the vertical rise of moisture. Moisture should not be sealed into the wall with a waterproof coating, such as cement parging or vinyl wall coverings, applied to the inside of damp walls. This will only increase the pressure differential as a vertical barrier and force the capillary action, and its destruction of materials, higher up the wall.

**Vapor diffusion** is the natural movement of pressurized moisture vapor through porous materials. It is most readily apparent as humidified interior air moves out through walls to a cooler exterior. In a hot and humid climate, the reverse will happen as moist hot air moves into cooler, dryer, air-conditioned, interiors. The movement of the moisture vapor is not a serious problem until the dewpoint temperature is reached and the vapor changes into liquid moisture known as *condensation*. This can occur within a wall or on interior surfaces. Vapor diffusion will be more of

a problem for a frame structure with several layers of infill materials within the frame cavity than a dense masonry structure. Condensation as a result of vapor migration usually takes place on a surface or film, such as paint, where there is a change in permeability.

The installation of climate control systems in historic buildings (mostly museums) that have *not* been properly designed or regulated and that force pressurized damp air to diffuse into perimeter walls is an ongoing concern. These newer systems take constant monitoring and back-up warning systems to avoid moisture damage.

Long-term and undetected condensation or high moisture content can cause serious structural damage as well as an unhealthy environment, heavy with mold and mildew spores. Reducing the interior/exterior pressure differential and the difference between interior and exterior temperature and relative humidity helps control unwanted vapor diffusion. This can sometimes be achieved by reducing interior relative humidity. In some instances, using vapor barriers, such as heavy plastic sheeting laid over damp crawl spaces, can have remarkable success in stopping vapor diffusion from damp ground into buildings. Yet, knowledgeable experts in the field differ regarding the appropriateness of vapor barriers and when and where to use them, as well as the best way to handle natural diffusion in insulated walls.

Adding insulation to historic buildings, particularly in walls of wooden frame structures, has been a standard modern weatherization treatment, but it can have a disastrous effect on historic buildings. The process of installing the insulation destroys historic siding or plaster, and it is very difficult to establish a tight vapor barrier. While insulation has the benefit of increasing the efficiency of heating and cooling by containing temperature controlled air, it does not eliminate surfaces on which damaging moisture can condense. For insulated residential frame structures, the most obvious sign of a moisture

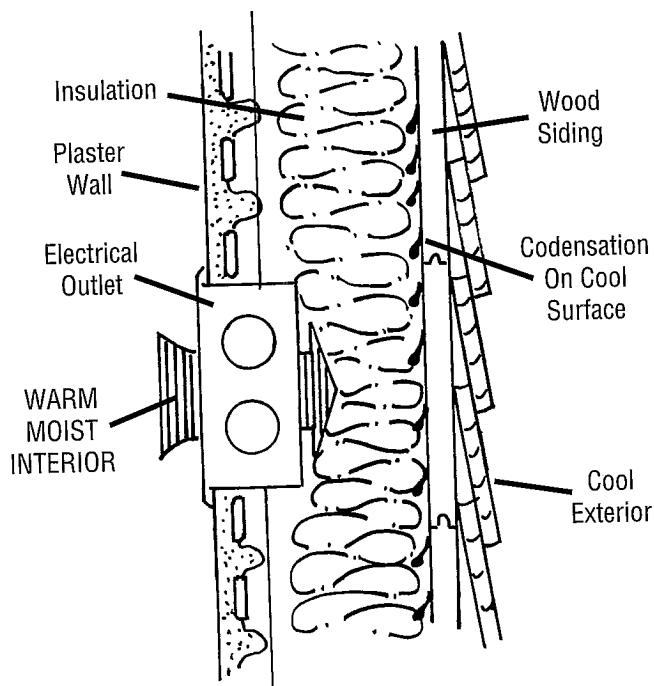


Fig. 12. Vapor diffusion can result in damp air migrating into absorbent materials and condensing on colder surfaces, thereby wetting insulation, damaging electrical conduits, and causing deterioration of the wooden framing. Drawing: NPS Files.

diffusion problem is peeling paint on wooden siding, even after careful surface preparation and repainting. Vapor impermeable barriers such as plastic sheeting, or more accurately, *vapor retarders*, in cold and moderate climates generally help slow vapor diffusion where it is not wanted.

In regions where *humidified* climate control systems are installed into insulated frame buildings, it is important to stop *interstitial*, or in-wall, dewpoint condensation. This is very difficult because humidified air can penetrate breaches in the vapor barrier, particularly around electrical outlets (see fig. 12). Improperly or incompletely installed retrofit vapor barriers will cause extensive damage to the building, just in the installation process, and will allow trapped condensation to wet the insulation and sheathing boards, corrode metal elements such as wiring cables and metal anchors, and blister paint finishes. Providing a tight wall vapor barrier, as well as a ventilated cavity behind wooden clapboards or siding appears to help insulated frame walls, if the interior relative humidity can be adjusted or monitored to avoid condensation. Correct placement of vapor retarders within building construction will vary by region, building construction, and type of climate control system.

## Surveying and Diagnosing Moisture Damage: Key Questions to Ask

It is important for the building to be surveyed first and the evidence and location of suspected moisture damage systematically recorded before undertaking any major work to correct the problem. This will give a baseline from which relative changes in condition can be noted.

When materials become wet, there are specific physical changes that can be detected and noted in a record book or on survey sheets. Every time there is a heavy rain, snow storm, water in the basement, or mechanical systems failure, the owner or consultant should note and record the way moisture is moving, its appearance, and what variables might contribute to the cause. *Standing outside to observe a building in the rain may answer many questions and help trace the movement of water into the building.* Evidence of deteriorating materials that cover more serious moisture damage should also be noted, even if it is not immediately clear what is causing the damage. (For example, water stains on the ceiling may be from leaking pipes, blocked fan coil drainage pans above, or from moisture which has penetrated around a poorly sloped window sill above.) Don't jump to conclusions, but use a systematic approach to help establish an educated theory — or hypothesis — of what is causing the moisture problem or what areas need further investigation.

*Surveying moisture damage must be systematic so that relative changes can be noted.* Tools for investigating can be as simple as a notebook, sketch plans, binoculars, camera, aluminum foil, smoke pencil, and flashlight. The systematic approach involves looking at buildings from the top down and from the outside to the inside. Photographs, floor plans, site plan, and exterior elevations — even roughly sketched — should be used to indicate all evidence of damp or damaged materials, with notations for musty or poorly ventilated areas. Information might be needed on the absorption and permeability characteristics of the building materials and soils. Exterior drainage patterns should be noted and these base plans referred to on a regular basis in different seasons and in differing types of weather (see fig. 13).

## Glossary:

**Air flow/infiltration:** The movement that carries moist air into and through materials. Air flow depends on the difference between indoor and outdoor pressures, wind speed and direction as well as the permeability of materials.

**Bulk water:** The large quantity of moisture from roof and ground run-off that can enter into a building either above grade or below grade.

**Capillary action:** The force that moves moisture through the pore structure of materials. Generally referred to as rising damp, moisture at or below the foundation level will rise vertically in a wall to a height at which the rate of evaporation balances the rate at which it can be drawn up by capillary forces.

**Condensation:** The physical process by which water vapor is transformed into a liquid when the relative humidity of the air reaches 100% and the excess water vapor forms, generally as droplets, on the colder adjacent surface.

**Convection:** Heat transfer through the atmosphere by a difference in force or air pressure is one type of air transport. Sometimes referred to as the "stack effect," hotter less dense air will rise, colder dense air will fall creating movement of air within a building.

**Dewpoint:** The temperature at which water vapor condenses when the air is cooled at a constant pressure and constant moisture content.

**Diffusion:** The movement of water vapor through a material. Diffusion depends on vapor pressure, temperature, relative humidity, and the permeability of a material.

**Evaporation:** The transformation of liquid into a vapor, generally as a result of rise of temperature, is the opposite of condensation. Moisture in damp soil, such as in a crawl space, can evaporate into the air, raise the relative humidity in that space, and enter the building as a vapor.

**Ground moisture:** The saturated moisture in the ground as a result of surface run-off and naturally occurring water tables. Ground moisture can penetrate through cracks and holes in foundation walls or can migrate up from moisture under the foundation base.

**Monitoring instrumentation:** These devices are generally used for long term diagnostic analysis of a problem, or to measure the performance of a treatment, or to measure changes of conditions or environment. In-wall probes or sensors are often attached to data-loggers which can be down-loaded into computers.

**Permeability:** A characteristic of porosity of a material generally listed as the rate of diffusion of a pressurized gas through a material. The pore structure of some materials allows them to absorb or adsorb more moisture than other materials. Limestones are generally more permeable than granites.

**Relative humidity (RH):** Dampness in the air is measured as the percent of water vapor in the air at a specific temperature relative to the amount of water vapor that can be held in a vapor form at that specific temperature.

**Survey instrumentation:** technical instrumentation that is used on-site to provide quick readings of specific physical conditions. Generally these are hand-held survey instruments, such as moisture, temperature and relative humidity readers, dewpoint sensors, and fiber optic boroscopes.

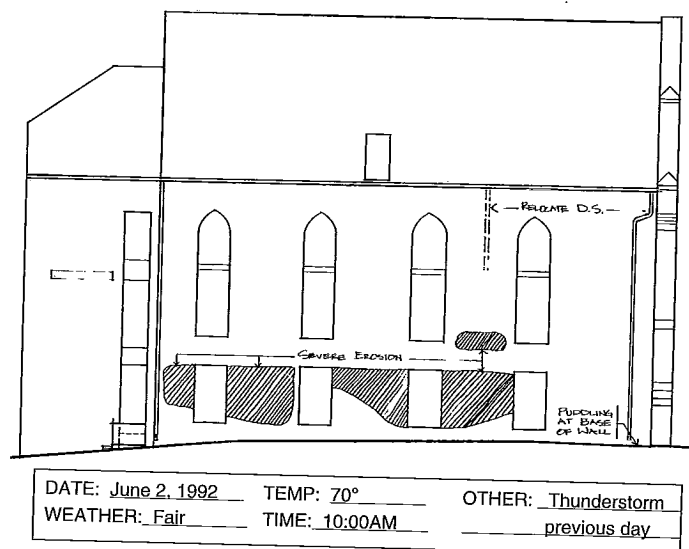


Fig. 13. Using sketch plans and elevation drawings to record the moisture damage along with the date, time, and weather conditions will show how moisture is affecting buildings over time. Drawing: Courtesy, Quinn Evans Architects.

It is best to start with one method of periodic documentation and to use this same method each time. Because moisture is affected by gravity, many surveys start with the roof and guttering systems and work down through the exterior walls. Any obvious areas of water penetration, damaged surfaces, or staining should be noted. Any recurring damp or stain patterns, both exterior and interior, should also be noted with a commentary on the temperature, weather, and any other facts that may be relevant (driving rains, saturated soil, high interior humidity, recent washing of the building, presence of a lawn watering system, etc.).

The interior should be recorded as well, beginning with the attic and working down to the basement and crawl space. It may be necessary to remove damaged materials selectively in order to trace the path of moisture or to pinpoint a source, such as a leaking pipe in the ceiling. The use of a basic resistance moisture meter, available in many hardware stores, can identify moisture contents of materials and show, over time, if wall surfaces are drying or becoming damper (see fig. 14). A smoke pencil can chart air infiltration around windows or draft patterns in interior spaces. For a quick test to determine if a damp basement is caused by saturated walls or is a result of condensation, tape a piece of foil onto a masonry surface and check it after a day or two; if moisture has developed behind the foil, then it is coming from the masonry. If condensation is on the surface of the foil, then moisture is from the air.

Comparing current conditions with previous conditions, historic drawings, photographs, or known alterations may also assist in the final diagnosis. A chronological record, showing improvement or deterioration, should be backed up with photographs or notations as to the changing size, condition, or features of the deterioration and how these changes have been affected by variables of temperature and rainfall. If a condition can be related in time to a particular event, such as efflorescence developing on a chimney after the building is no longer heated, it may be possible to isolate a cause, develop a hypothesis, and then test the hypothesis (by adding some temporary heat), before applying a remedial treatment.



Fig. 14. Using instruments in this damp-check kit can help determine the relative change in wet conditions over time. This involves readings of air temperature, computing dewpoint temperatures, and tracking the moisture content of materials to indicate if they are drying properly. Photo: Dell Corporation.

If the owner or consultant has access to moisture survey and monitoring equipment such as resistance moisture meters, dewpoint indicators, salt detectors, infrared thermography systems, psychrometer, fiber-optic boroscopes, and miniaturized video cameras, additional quantified data can be incorporated into the survey (see fig. 15). If it is necessary to track the wetting and drying of walls over a period of time, deep probes set into walls and in the soil with connector cables to computerized data loggers or the use of long-term recording of hygrothermographs may require a trained specialist. Miniaturized fiber-optic video cameras can record the condition of subsurface drain lines without excavation (see fig. 16). It should be noted, however, that instrumentation, while extremely useful, cannot take the place of careful personal observation and analysis. Relying on instrumentation alone rarely will give the owner the information needed to fully diagnose a moisture problem.

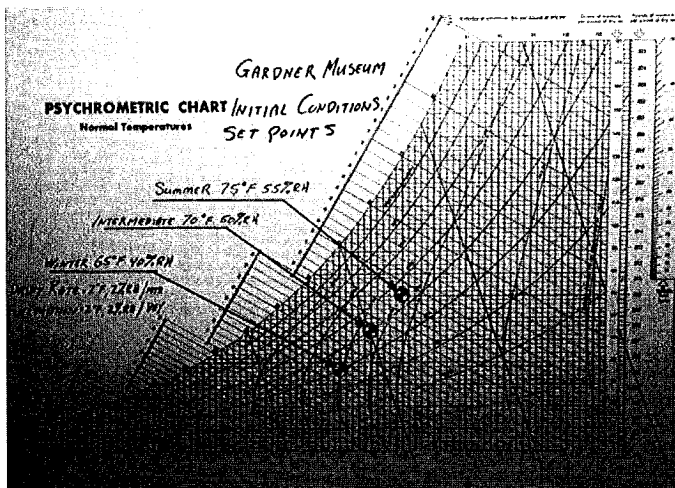


Fig. 15. Psychrometric charts quantify the amount of relative humidity a building can tolerate before dewpoint condensation occurs. This is important when the range of temperature and humidity are critical to both collections management and historic building preservation. Chart: Landmark Facilities Group.



Fig. 16. Contractors specializing in building diagnostics often have video cameras or fiber optic equipment that allow the viewing of inaccessible areas. This is particularly helpful in chimney flues or subsurface drains, as shown here. In the past, these areas would need to be excavated for visual inspection. Photo: author.

To avoid jumping to a quick—potentially erroneous—conclusion, a series of questions should be asked first. This will help establish a theory or hypothesis that can be tested to increase the chances that a remedial treatment will control or manage existing moisture.

**How is water draining around building and site?** What is the effectiveness of gutters and downspouts? Are the slopes or grading around foundations adequate? What are the locations of subsurface features such as wells, cisterns, or drainage fields? Are there subsurface drainage pipes (or drainage boots) attached to the downspouts and are they in good working condition? Does the soil retain moisture or allow it to drain freely? Where is the water table? Are there window wells holding rain water? What is the flow rate of area drains around the site (can be tested with a hose for several minutes)? Is the storm piping out to the street sufficient for heavy rains, or does water chronically back up on the site? Has adjacent new construction affected site drainage or water table levels?

**How does water/moisture appear to be entering the building?** Have all five primary sources of moisture been evaluated? What is the condition of construction materials and are there any obvious areas of deterioration? Did this building have a builder's trench around the foundation that could be holding water against the exterior walls? Are the interior bearing walls as well as the exterior walls showing evidence of rising damp? Is there evidence of hydrostatic pressure under the basement floor such as water percolating up through cracks? Has there been moisture damage from an ice dam in the last several months? Is damage localized, on one side of the building only, or over a large area?

**What are the principal moisture dynamics?** Is the moisture condition from liquid or vapor sources? Is the attic moisture a result of vapor diffusion as damp air comes up through the cavity walls from the crawl space or is it from a leaking roof? Is the exterior wall moisture from rising damp with a tide mark or are there uneven spots of dampness from foundation splash back, or other ground



moisture conditions? Is there adequate air exchange in the building, particularly in damp areas, such as the basement? Has the height of the water table been established by inserting a long pipe into the ground in order to record the water levels?

**How is the interior climate handling moisture?** Are there areas in the building that do not appear to be ventilating well and where mold is growing? Are there historic features that once helped the building control air and moisture that can be reactivated, such as operable skylights or windows? Could dewpoint condensation be occurring behind surfaces, since there is often condensation on the windows? Does the building feel unusually damp or smell in an unusual way that suggest the need for further study? Is there evidence of termites, carpenter ants, or other pests attracted to moist conditions? Is a dehumidifier keeping the air dry or is it, in fact, creating a cycle where it is actually drawing moisture through the foundation wall?

**Does the moisture problem appear to be intermittent, chronic, or tied to specific events?** Are damp conditions occurring within two hours of a heavy rain or is there a delayed reaction? Does rust on most nail heads in the attic indicate a condensation problem? What are the wet patterns that appear on a building wall during and after a rain storm? Is it localized or in large areas? Can these rain patterns be tied to gutter over-flows, faulty flashing, or saturation of absorbent materials? Is a repaired area holding up well over time or is there evidence that moisture is returning? Do moisture meter readings of wall cavities indicate they are wet, suggesting leaks or condensation in the wall?

Once a hypothesis of the source or sources of the moisture has been developed from observation and recording of data, it is often useful to prove or disprove this hypothesis with interim treatments, and, if necessary, the additional use of instrumentation to verify conditions. For damp basements, test solutions can help determine the cause. For example, surface moisture in low spots should be redirected away from the foundation wall with regrading to determine if basement dampness improves. If there is still a problem, determine if subsurface downspout collection pipes or cast iron boots are not functioning properly. The above grade downspouts can be disconnected and attached to long, flexible extender pipes and redirected away from the foundation (see fig. 17). If, after a heavy rain or a simulation using a hose, there is no improvement, look for additional ground moisture sources such as high water tables, hidden cisterns, or leaking water service lines as a cause of moisture in the basement. New data will lead to a new hypothesis that should be tested and verified. *The process of elimination can be frustrating, but is required if a systematic method of diagnosis is to be successful.*

## Selecting an Appropriate Level of Treatment

The treatments in chart format at the back of this publication are divided into levels based on the degree of moisture problems. Level I covers preservation maintenance; Level II focuses on repair using historically compatible materials and essentially mitigating damaging moisture conditions; and Level III discusses replacement and alteration of materials that permit continued use in a chronically moist environment. It is important to begin



Fig. 17. In testing a theory for the cause of basement wetness, the owner used long black extender pipes to direct roof run-off away from the foundation. This test established that the owner did not need expensive waterproofing of the foundation, but a better drainage system. Photo: Baird M. Smith.

with Level I and work through to a manageable treatment as part of the control of moisture problems. Buildings in serious decay will require treatments in Level II, and difficult or unusual site conditions may require more aggressive treatments in Level III. Caution should always be exercised when selecting a treatment. The treatments listed are a guide and not intended to be recommendations for specific projects as the key is always proper diagnosis.

Start with the repair of any obvious deficiencies using sound preservation maintenance. If moisture cannot be managed by maintenance alone, it is important to reduce it by mitigating problems *before* deteriorated historic materials are replaced (see fig. 18). Treatments should not remove materials that can be preserved; should not involve extensive excavation unless there is a documented need; and should not include coating buildings with waterproof sealers that can exacerbate an existing problem. Some alteration to historic materials, structural systems, mechanical systems, windows, or finishes may be needed when excessive site moisture cannot be controlled by drainage systems, or in areas prone to floods. These changes, however, should, be sensitive to preserving those materials, features, and finishes that convey the historic character of the building and site.

## Ongoing Care

Once the building has been repaired and the larger moisture issues addressed, it is important to keep a record of additional evidence of moisture problems and to *protect the historic or old building through proper cyclical maintenance* (see fig. 19). In some cases, particularly in museum environments, it is critical to monitor areas vulnerable to moisture damage. In a number of historic buildings, in-wall moisture monitors are used to ensure that the moisture purposely generated to keep relative humidity at ranges appropriate to a museum collection does not migrate into walls and cause deterioration. The potential problem with all systems is the failure of controls, valves, and panels over time. Back-up systems, warning devices, properly trained staff and an emergency plan will help control damage if there is a system failure.

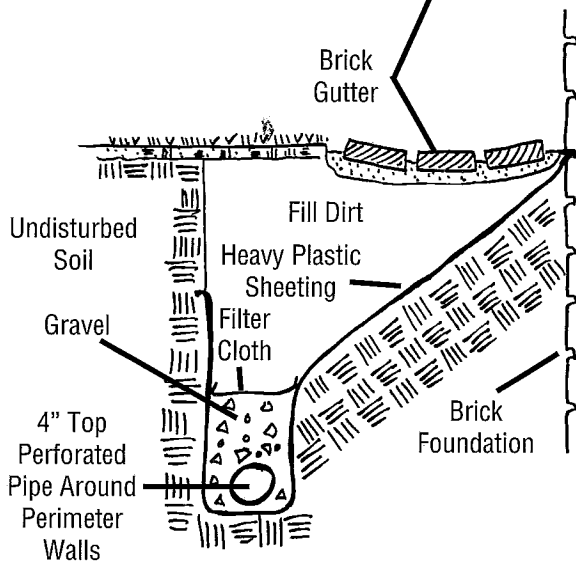
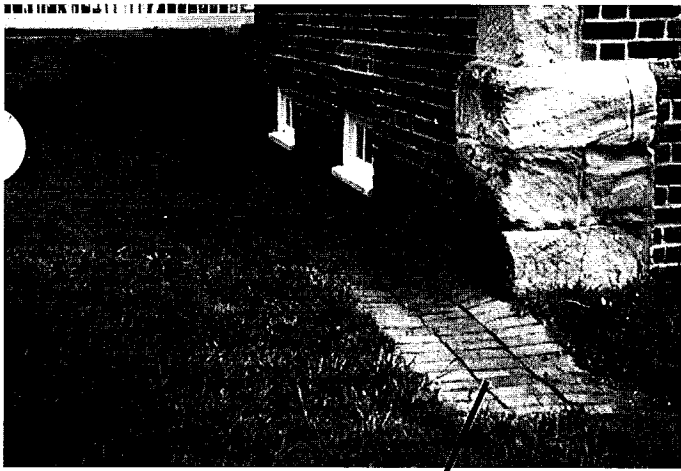


Fig. 18. This detail drawing shows a sub-surface perimeter drain in conjunction with a historic brick ground gutter system to help control roof run-off moisture from entering the historic foundation. Detail: Courtesy, Gunston Hall Plantation. Photo: Elizabeth Sasser.



Fig. 19. Maintaining gutters and downspouts in good operable condition, repairing exteriors to keep water out, redirecting damaging moisture away from foundations and controlling interior moisture and condensation are all important when holding the line on moisture deterioration. Photo: Nebraska State Historical Society.

Ongoing maintenance and vigilance to situations that could potentially cause moisture damage must become a routine part of the everyday life of a building. The owner or staff responsible for the upkeep of the building should inspect the property weekly and note any leaks, mustiness, or blocked drains. Again, observing the building during a rain will test whether ground and gutter drainage are working well.

For some buildings a back-up power system may be necessary to keep sump pumps working during storms when electrical power may be lost. For mechanical equipment rooms, condensation pans, basement floors, and laundry areas where early detection of water is important, there are alarms that sound when their sensors come into contact with moisture.

## Conclusion

Moisture in old and historic buildings, though difficult to evaluate, can be systematically studied and the appropriate protective measures taken. Much of the documentation and evaluation is based on common sense combined with an understanding of historic building materials, construction technology, and the basics of moisture and air movement. Variables can be evaluated step by step and situations creating direct or secondary moisture damage can generally be corrected. The majority of moisture problems can be mitigated with maintenance, repair, control of ground and roof moisture, and improved ventilation. For more complex situations, however, a thorough diagnosis and an understanding of how the building handles moisture at present, can lead to a treatment that solves the problem without damaging the historic resource.

It is usually advantageous to eliminate one potential source of moisture at a time. Simultaneous treatments may set up a new dynamic in the building with its own set of moisture problems. Implementing changes sequentially will allow the owner or preservation professional to track the success of each treatment.

Moisture problems can be intimidating to a building owner who has diligently tried to control them. Keeping a record of evidence of moisture damage, results of diagnostic tests, and remedial treatments, is beneficial to a building's long-term care. The more complete a survey and evaluation, the greater the success in controlling unwanted moisture now and in the future.

Holding the line on unwanted moisture in buildings will be successful if 1) there is constant concern for signs of problems and 2) there is ongoing physical care provided by those who understand the building, site, mechanical systems, and the previous efforts to deal with moisture. For properties with major or difficult-to-diagnose problems, a team approach is often most effective. The owner working with properly trained staff, contractors and consultants can monitor, select, and implement treatments within a preservation context in order to manage moisture and to protect the historic resource.

## MOISTURE: LEVEL I PRESERVATION MAINTENANCE

*Exterior: Apply cyclical maintenance procedures to eliminate rain and moisture infiltration.*

**Roofing/ guttering:** Make weather-tight and operational; inspect and clean gutters as necessary depending on number of nearby trees, but at least twice a year; inspect roofing at least once a year, preferably spring; replace missing or damaged roofing shingles, slates, or tiles; repair flashing; repair or replace cracked downspouts.

**Walls:** Repair damaged surface materials; repoint masonry with appropriately formulated mortar; prime and repaint wooden, metal, or masonry elements or surfaces; remove efflorescence from masonry with non-metallic bristle brushes.

**Window and door openings:** Eliminate cracks or open joints; caulk or repoint around openings or steps; repair or reset weatherstripping; check flashing; repaint, as necessary.

*Ground: Apply regular maintenance procedures to eliminate standing water and vegetative threats to building/site.*

**Grade:** Eliminate low spots around building foundations; clean out existing downspout boots twice a year or add extension to leaders to carry moisture away from foundation; do a hose test to verify that surface drains are functioning; reduce moisture used to clean steps and walks; eliminate the use of chlorides to melt ice which can increase freeze/thaw spalling of masonry; check operation of irrigation systems, hose bib leaks, and clearance of air conditioning condensate drain outlets.

**Crawl space:** Check crawl space for animal infestation, termites, ponding moisture, or high moisture content; check foundation grilles for adequate ventilation; seasonally close grilles when appropriate — in winter, if not needed, or in summer if hot humid air is diffusing into air conditioned space.

**Foliage:** Keep foliage and vines off buildings; trim overhanging trees to keep debris from gutters and limbs from rubbing against building; remove moisture retaining elements, such as firewood, from foundations.

*Basements and foundations: Increase ventilation and maintain surfaces to avoid moisture.*

**Equipment:** Check dehumidifiers, sump pump, vent fans, and water detection or alarm systems for proper maintenance as required; check battery back-up twice a year.

**Piping/ductwork:** Check for condensation on pipes and insulate/seal joints, if necessary.

*Interior: Maintain equipment to reduce leaks and interior moisture.*

**Plumbing pipes:** Add insulation to plumbing or radiator pipes located in areas subject to freezing, such as along outside walls, in attics, or in unheated basements.

**Mechanical equipment:** Check condensation pans and drain lines to keep clear; insulate and seal joints in exposed metal ductwork to avoid drawing in moist air.

**Cleaning:** Routinely dust and clean surfaces to reduce the amount of water or moist chemicals used to clean building; caulk around tile floor and wall connections; and maintain floor grouts in good condition.

**Ventilation:** Reduce household-produced moisture, if a problem, by increasing ventilation; vent clothes driers to the outside; install and always use exhaust fans in restrooms, bathrooms, showers, and kitchens, when in use.



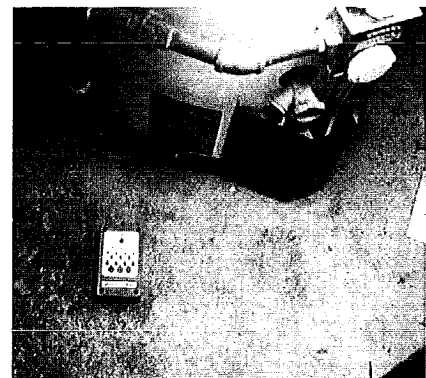
A. Inspecting the overall building on at least an annual basis will identify areas needing maintenance. A bucket lift is helpful for large buildings. Photo: author.



B. Repair exterior surfaces, paint, and recaulk as needed. Photo: Williamsport Preservation Training Center (WPTC), NPS.



C. Cleaning out gutters and downspouts should be done at least twice a year. Photo: WPTC, NPS.



D. Protect the building from damage by maintaining equipment and using alarms, like this floor water sensor. Photo: Dell Corporation.

## MOISTURE: LEVEL II REPAIR AND CORRECTIVE ACTION

**Exterior:** Repair features that have been damaged. Replace an extensively deteriorated feature with a new feature that matches in design, color, texture, and where possible, materials.

**Roofing:** Repair roofing, parapets and overhangs that have allowed moisture to enter; add ice and water shield membrane to lower 3-4 feet or roofing in cold climates to limit damage from ice dams; increase attic ventilation, if heat and humidity build-up is a problem. Make gutters slope @ 1/8" to the foot. Use professional handbooks to size gutters and reposition, if necessary and appropriate to historic architecture. Add ventilated chimney caps to unused chimneys that collect rain water.

**Walls:** Repair spalled masonry, terra cotta, etc. by selectively installing new masonry units to match; replace rotted clapboards too close to grade and adjust grade or clapboards to achieve adequate clearance; protect or cover open window wells.

**Ground:** Correct serious ground water problems; capture and dispose of downspout water away from foundation; and control vapor diffusion of crawlspace moisture.

**Grade:** Re-establish positive sloping of grade; try to obtain 6" of fall in the first 10' surrounding building foundation; for buildings without gutter systems, regrade and install a positive subsurface collection system with gravel, or waterproof sheeting and perimeter drains; adjust pitch or slope of eave line grade drains or French drains to reduce splash back onto foundation walls; add subsurface drainage boots or extension pipes to take existing downspout water away from building foundation to the greatest extent feasible.

**Crawl space:** Add polyethylene vapor barrier (heavy construction grade or Mylar) to exposed dirt in crawlspace if monitoring indicates it is needed and there is no rising damp; add ventilation grilles for additional cross ventilation, if determined advisable.

**Foundations and Basements:** Correct existing high moisture levels, if other means of controlling ground moisture are inadequate.

**Mechanical devices:** Add interior perimeter drains and sump pump; add dehumidifiers for seasonal control of humidity in confined, unventilated space (but don't create a problem with pulling dampness out of walls); add ventilator fans to improve air flow, but don't use both the dehumidifier and ventilator fan at the same time.

**Walls:** Remove commentates coatings, if holding rising damp in walls; coat walls with vapor permeable lime based rendering plaster, if damp walls need a sacrificial coating to protect mortar from erosion; add termite shields, if evidence of termites and dampness cannot be controlled.

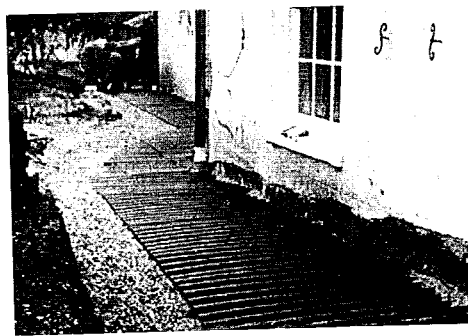
**Framing:** Reinforce existing floor framing weakened by moisture by adding lolly column support and reinforcing joist ends with sistered or parallel supports. Add a vapor impermeable shield, preferably non-ferrous metal, under wood joists coming into contact with moist masonry.

**Interior:** Eliminate areas where moisture is leaking or causing a problem.

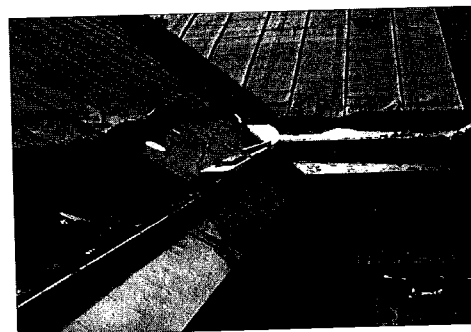
**Plumbing:** Replace older pipes and fixtures subject to leaking or overflowing; insulate water pipes subject to condensation.

**Ventilation:** Add exhaust fans and whole house fans to increase air flow through buildings, if areas are damp or need more ventilation to control mold and mildew.

**Climate:** Adjust temperature and relative humidity to manage interior humidity; Correct areas of improperly balanced pressure for HVAC systems that may be causing a moisture problem.



A. Mitigate poor drainage with gravel, filter cloth, or the use of subsurface drainage mats under finished paving. Photo: Larry D. Dermody.



B. Repair roofs and add ice and water shields at eaves and under valleys in cold climates. Photo: Larry D. Dermody.



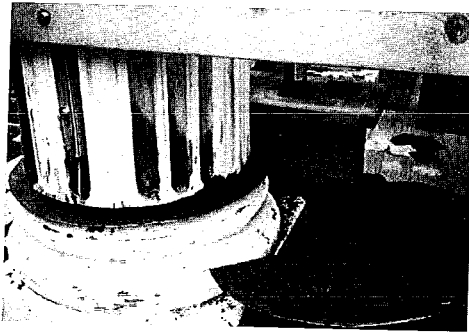
C. Develop new drainage systems for roof run-off that remove moisture from the base of the building. Photo: WPTC, NPS.



D. Install ventilating fans when additional air circulation will improve damp conditions in buildings or reduce cooling loads. Photo: Ernest A. Conrad, P. E.



## MOISTURE: LEVEL III REPLACEMENT / ALTERATIONS — —



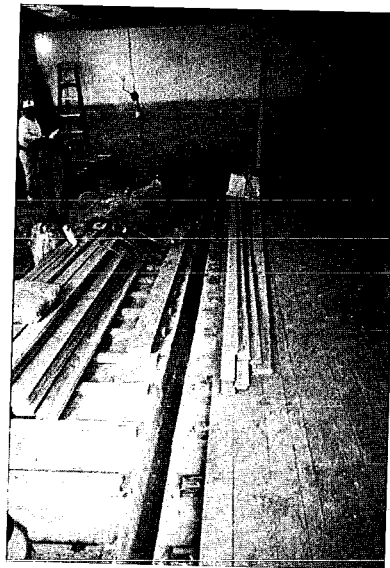
A. This lead sheet was installed at the base of the replacement column to stop rising damp. Photo: Bryan Blundell.



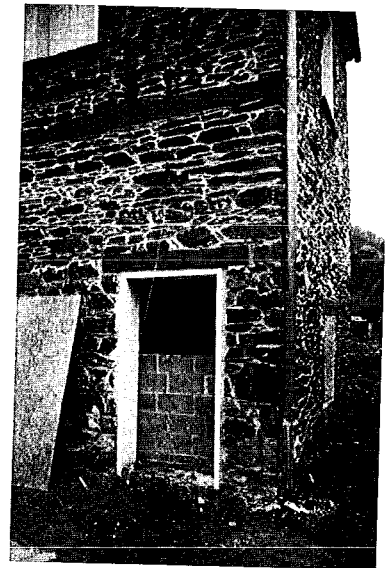
B. Wood sills set on grade were replaced with concrete pier foundation and new wooden sill plates. Changes were not visible on the exterior (see C). Photo: WPTC, NPS.



C. The new ground gutter gravel base helps drainage around the concrete foundation (see B above) which is not visible behind the replaced wooden wall shingles. Photo: WPTC, NPS.



D. In a flood plain, rotted joists were replaced with a concrete slab and sleepers designed to drain water. Spaced flooring allowed drainage and room for damp wood to swell without buckling. Harper's Ferry Center, NPS.



E. Mechanical systems on the lower level were placed on platforms above the flood line. Harper's Ferry Center, NPS.

**Exterior:** Undertake exterior rehabilitation work that follows professional repair practices — i.e., replace a deteriorated feature with a new feature to match the existing in design, color, texture, and when possible, materials. In some limited situations, non-historic materials may be necessary in unusually wet areas.

**Roofs:** Add ventilator fans to exhaust roofs but avoid large projecting features whose designs might negatively affect the appearance of the historic roof. When replacing roofs, correct conditions that have caused moisture problems, but keep the overall appearance of the roof; for example, ventilate under wooden shingles, or detail standing seams to avoid buckling and cracking. Be attentive to provide extra protection for internal or built-in gutters by using the best quality materials, flashing, and vapor impermeable connection details.

**Walls:** If insulation and vapor barriers are added to frame walls, consider maintaining a ventilation channel behind the exterior cladding to avoid peeling and blistering paint occurrences.

**Windows:** Consider removable exterior storm windows, but allow operation of windows for periodic ventilation of cavity between exterior storm and historic sash. For stained glass windows using protective glazing, use only ventilated storms to avoid condensation as well as heat build-up.

**Ground:** Control excessive ground moisture. This may require extensive excavations, new drainage systems, and the use of substitute materials. These may include concrete or new sustainable recycled materials for wood in damp areas when they do not impact the historic appearance of the building.

**Grade:** Excavate and install water collection systems to assist with positive run-off of low lying or difficult areas of moisture drainage; use drainage mats under finished grade to improve run-off control; consider the use of column plinth blocks or bases that are ventilated or constructed of non-absorbent substitute materials in chronically damp areas. Replace improperly sloped walks; repair non-functioning catch basins and site drains; repair settled areas around steps and other features at grade.

## — — FOR CHRONICALLY DAMP CONDITIONS

**Foundations:** Improve performance of foundation walls with damp-proof treatments to stop infiltration or damp course layers to stop rising damp. Some substitute materials may need to be selectively integrated into new features.

**Walls:** excavate, repoint masonry walls, add footing drains, and waterproof exterior subsurface walls; replace wood sill plates and deteriorated structural foundations with new materials, such as pressure treated wood, to withstand chronic moisture conditions; materials may change, but overall appearance should remain similar. Add dampcourse layer to stop rising damp; avoid chemical injections as these are rarely totally effective, are not reversible, and are often visually intrusive.

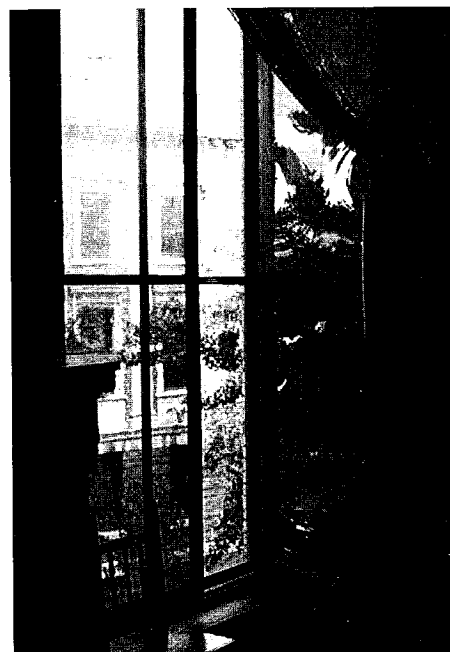
**Interior:** Control the amount of moisture and condensation on the interiors of historic buildings. Most designs for new HVAC systems will be undertaken by mechanical engineers, but systems should be selected that are appropriate to the resource and intended use.

**Windows, skylights:** Add double and triple glazing, where necessary to control condensation. Avoid new metal sashes or use thermal breaks where prone to heavy condensation.

**Mechanical systems:** Design new systems to reduce stress on building exterior. This might require insulating and tightening up the building exterior, but provisions must be made for adequate air flow. A new zoned system, with appropriate transition insulation, may be effective in areas with differing climatic needs.

**Control devices/Interior spaces:** If new climate control systems are added design back-up controls and monitoring systems to protect from interior moisture damage.

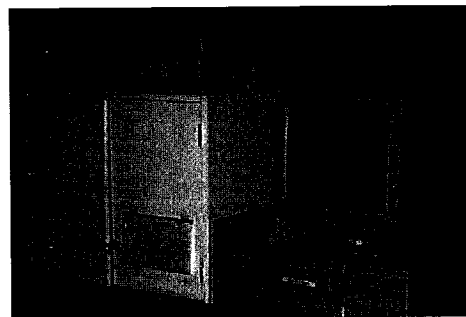
**Walls:** If partition walls sit on floors that periodically flood, consider spacers or isolation membranes behind baseboards to stop moisture from wicking up through absorbent materials.



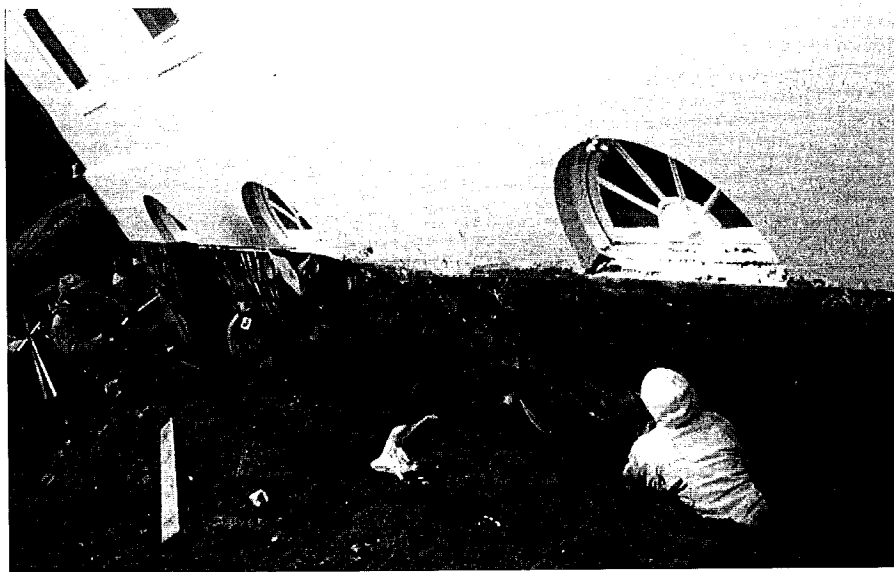
F. Triple glazed windows replaced the originals to control condensation. Photo: © Isabella Stewart Gardner Museum, Boston.



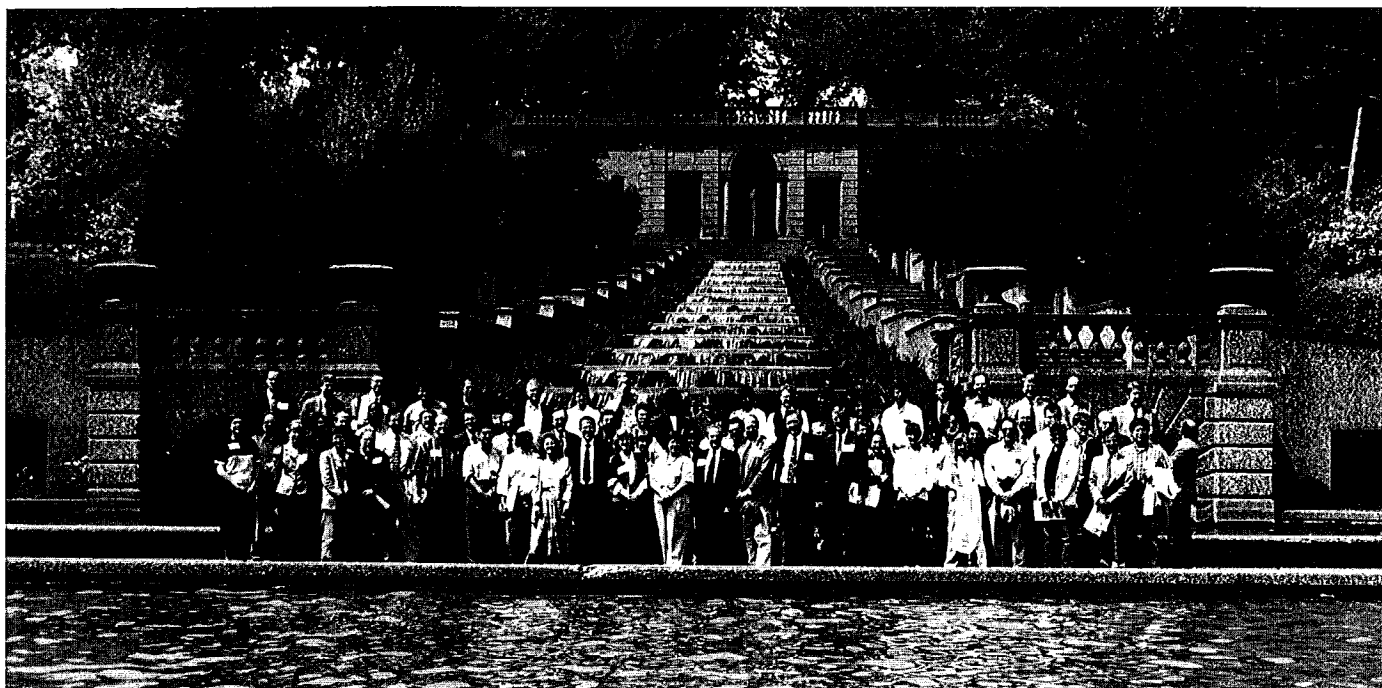
G. New sensors which monitor temperature and relative humidity are located throughout this museum and tied to a computer that controls the climate control system. Photo: © Isabella Stewart Gardner Museum, Boston.



H. New computers tie a variety of monitoring and security features into a comprehensive system which provides warning and backup alerts when any of the system components are not functioning properly. Photo: © Isabella Stewart Gardner Museum, Boston.



I. Critically damp foundation walls were protected with a layer of bentonite clay to reduce moisture penetration. This work was in combination with new downspouts that were connected to drainage boots that deposited captures roof run-off away from the foundation. Photo: Courtesy, Larry D. Dermody and the National Trust for Historic Preservation.



Back Cover: The Diagnosing Moisture in Historic Building Symposium held in Washington, DC, May, 1996, brought together practitioners in the field of historic preservation to discuss the issues contained in this Preservation Brief. Attendees are standing in front of the cascading fountains at Meridian Hill Park, a National Historic Landmark. Photo: Eric Avner.

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This publication has been prepared pursuant to the National Historic Preservation Act, as amended, which directs the Secretary of the Interior to develop and make available information concerning historic properties. Comments about this publication should be directed to de Teel Patterson Tiller, Acting Manager, Heritage Preservation Services Program, National Park Service, P.O. Box 37127, Washington, DC 20013-7127. This publication is not copyrighted and can be reproduced without penalty. Copyright photographs included in this publication may not be used to illustrate publications other than as a reference to this Preservation Brief, without permission of the owners. Normal procedures for credit to the authors and the National Park Service are appreciated.

Cover Photo: *Masonry repointing in a wet environment.*  
Photo: Williamsport Preservation Training Center, NPS.

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# 47 PRESERVATION BRIEFS

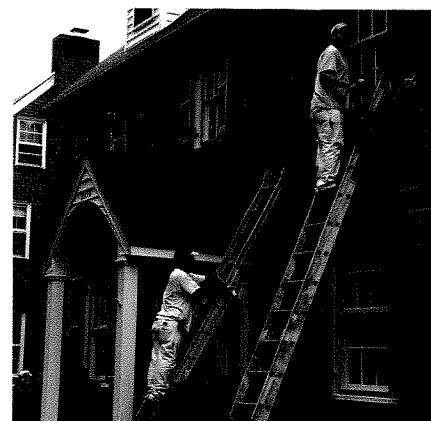
## Maintaining the Exteriors of Small and Medium Size Historic Buildings

Sharon C. Park, FAIA



National Park Service  
U.S. Department of the Interior

Heritage Preservation Services



Preservation is defined as “the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property. Work, including preliminary measures to protect and stabilize the property, generally focuses upon the *ongoing maintenance and repair* of historic materials and features rather than extensive replacement and new construction.”<sup>1</sup>

Maintenance helps preserve the integrity of historic structures. If existing materials are regularly maintained and deterioration is significantly reduced or prevented, the integrity of materials and workmanship of the building is protected. Proper maintenance is the most cost effective method of extending the life of a building. As soon as a building is constructed, restored, or rehabilitated, physical care is needed to slow the natural process of deterioration. An older building has already experienced years of normal weathering and may have suffered from neglect or inappropriate work as well.

Decay is inevitable but deterioration can accelerate when the building envelope is not maintained on a regular basis. Surfaces and parts that were seamlessly joined when the building was constructed may gradually become loose or disconnected; materials that were once sound begin to show signs of weathering. If maintenance is deferred, a typical response is to rush in to fix what has been ignored, creating additional problems. Work done on a crisis level can favor inappropriate treatments that alter or damage historic material.

There are rewards for undertaking certain repetitive tasks consistently according to a set schedule. Routine and preventive care of building materials is the most effective way of slowing the natural process of deterioration. The survival of historic buildings in good condition is primarily due to regular upkeep and the preservation of historic materials.

Well-maintained properties tend to suffer less damage from storms, high winds, and even small earthquakes. Keeping the roof sound, armatures and attachments such

as shutters tightened and secured, and having joints and connections functioning well, strengthens the ability of older buildings to withstand natural occurrences.

Over time, the cost of maintenance is substantially less than the replacement of deteriorated historic features and involves considerably less disruption. Stopping decay before it is widespread helps keep the scale and complexity of work manageable for the owner.

This *Preservation Brief* is designed for those responsible for the care of small and medium size historic buildings, including owners, property administrators, in-house maintenance staff, volunteers, architects, and maintenance contractors. The Brief discusses the benefits of regular inspections, monitoring, and seasonal maintenance work; provides general guidance on maintenance treatments for historic building exteriors; and emphasizes the importance of keeping a written record of completed work.

### Getting Started

Understanding how building materials and construction details function will help avoid treatments that are made in an attempt to simplify maintenance but which may also result in long-term damage. It is enticing to read about “maintenance free” products and systems, particularly waterproof sealers, rubberized paints, and synthetic siding, but there is no such thing as maintenance free when it comes to caring for historic buildings. Some approaches that initially seem to reduce maintenance requirements may over time actually accelerate deterioration.

Exterior building components, such as roofs, walls, openings, projections, and foundations, were often constructed with a variety of functional features, such as overhangs, trim pieces, drip edges, ventilated cavities, and painted surfaces, to protect against water infiltration, ultraviolet deterioration, air infiltration, and

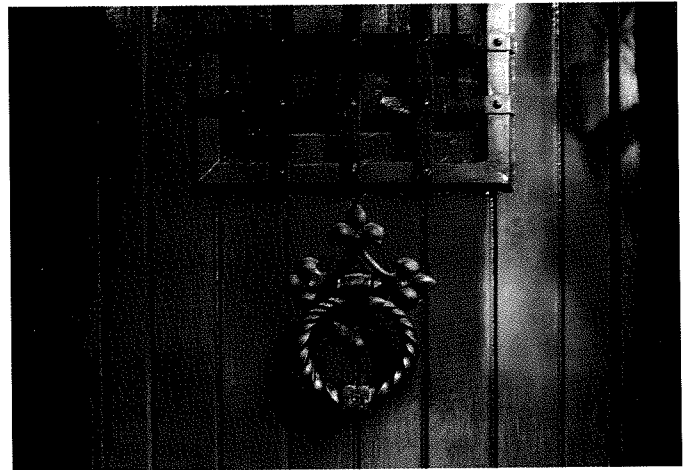
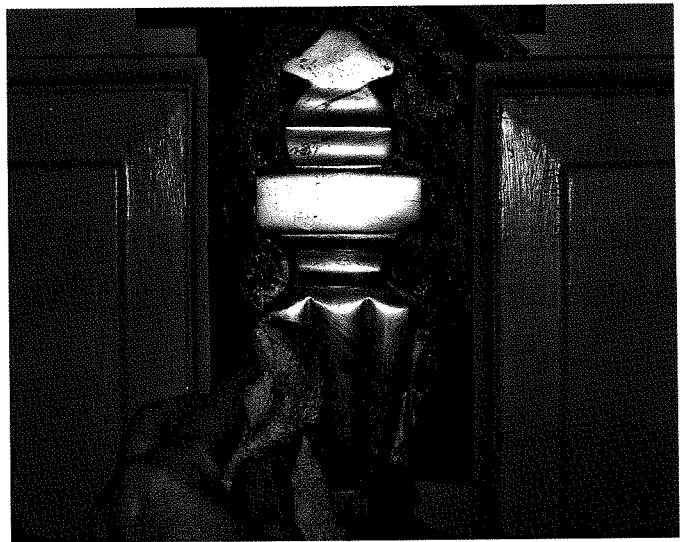


*Figure 1. Maintenance involves selecting the proper treatment and protecting adjacent surfaces. Using painter's tape to mask around a brass doorknocker protects the painted door surface from damage when polishing with chemical compounds. On the other hand, hardware with a patinated finish was not intended to be polished and should simply be cleaned with a damp cloth.*

## Cautions During Maintenance Work

All maintenance work requires attention to safety of the workers and protection of the historic structure. Examples include the following:

- Care should be taken when working with historic materials containing lead-based paint. For example, damp methods may be used for sanding and removal to minimize air-borne particles. Special protection is required for workers and appropriate safety measures should be followed.
- Materials encountered during maintenance work, such as droppings from pigeons and mice, can cause serious illnesses. Appropriate safety precautions need to be followed. Services of a licensed contractor should be obtained to remove large deposits from attics and crawlspaces.
- Heat removal of paint involves several potential safety concerns. First, heating of lead-containing paint requires special safety precautions for workers. Second, even at low temperature levels, heat removal of paint runs the risk of igniting debris in walls. Heat should be used only with great caution with sufficient coverage by smoke detectors in work areas. Work periods need to be timed to allow monitoring after completion of paint removal each day, since debris will most often smolder for a length of time before breaking out into open flame. The use of torches, open flames, or high heat should be avoided.
- Many chemical products are hazardous and volatile organic compounds (VOC) are banned in many areas. If allowed, appropriate respirators and other safety precautions are essential for use.
- Personal protection is important and may require the use of goggles, gloves, mask, closed-toed shoes, and a hard hat.
- Electrical service should be turned off before inspecting a basement after a flood or heavy rain, where there is high standing water.



pest infestation. Construction assemblies and joints between materials allow for expansion and contraction and the diffusion of moisture vapor, while keeping water from penetrating the building envelope. Older buildings use such features effectively and care must be taken to retain them, avoiding the temptation to reduce air infiltration or otherwise alter them.

Monitoring, inspections, and maintenance should all be undertaken with safety in mind. Besides normal safety procedures, it is important to be cognizant of health issues more commonly encountered with older buildings, such as lead-based paint, asbestos, and bird droppings, and to know when it is necessary to seek professional services (see sidebar).

Original building features and examples of special craftsmanship should be afforded extra care. The patina or aging of historic materials is often part of the charm and character of historic buildings. In such cases, maintenance should avoid attempts to make finishes look new by over-cleaning or cladding existing materials. As with any product that has the potential to harm historic materials, the selection of a cleaning procedure should always involve testing in a discreet location on the building to ensure that it will not abrade, fade, streak, or otherwise damage the substrate (Fig 1).

## Maintenance Plan, Schedules and Inspection

Organizing related work into a written set of procedures, or a Maintenance Plan, helps eliminate duplication, makes it easier to coordinate work effort, and creates a system for prioritizing maintenance tasks that takes into account the most vulnerable and character-defining elements.

The first time a property owner or manager establishes a maintenance plan or program, it is advisable to have help from a preservation architect, preservation consultant, and/or experienced contractor. Written procedures should outline step-by-step approaches that are custom-tailored to a building. No matter how small the property, every historic site should have a written guide for maintenance that can be as simple as:

- 1) Schedules and checklists for inspections;
- 2) Forms for recording work, blank base plans and elevations to be filled in during inspections and upon completion of work;
- 3) A set of base-line photographs to be augmented over time;
- 4) Current lists of contractors for help with complex issues or in case of emergencies;
- 5) Written procedures for the appropriate care of specific materials, including housekeeping, routine care, and preventive measures;
- 6) Record-keeping sections for work completed, costs, warranty cards, sample paint colors, and other pertinent material.

This information can be kept in one or more formats, such as a three-ring binder, file folders, or a computer

database. It is important to keep the files current with completed work forms to facilitate long-term evaluations and planning for future work (Fig 2).

Proper maintenance depends on an organized plan with work prescribed in manageable components. Regular maintenance needs to be considered a priority both in terms of time allotted for inspections and for allocation of funding.

Maintenance work scheduling is generally based on a variety of factors, including the seriousness of the problem, type of work involved, seasonal appropriateness, product manufacturer's recommendations, and staff availability. There are other variables as well. For example, building materials and finishes on southern and western exposures will often weather faster than those on northern or eastern exposures. Horizontal surfaces facing skyward usually require greater maintenance than vertical ones; in regions with moderate or heavy rainfall, wood and other materials in prolonged shadow are subject to more rapid decay.

Maintenance costs can be controlled, in part, through careful planning, identification of the amount of labor required, and thoughtful scheduling of work. Maintenance schedules should take into account daily and seasonal activities of the property in order to maximize the uninterrupted time necessary to complete the work. Institutions generally need to budget annually between 2 and 4 percent of the replacement value of the building to underwrite the expense of full building maintenance.<sup>2</sup> Use of trained volunteers to undertake maintenance can help reduce costs.

Exterior inspections usually proceed from the roof down to the foundation, working on one elevation at

Cyclic Building Inspection Checklist: Horse Stable			Inspection date: 04/24/05	
Building Feature	Material(s)	Condition Description	Maintenance Action Required	Work Done
ROOF:				
Covering	Clay tile	Two slipped tiles	Reattach tiles	5/4/05
	Painted metal standing seam	Slight corrosion; blistering paint on metal roof section	Sand and repaint area that is peeling	6/8/05
Flashing	Painted metal	Flashing in good condition	N/A	N/A
Gutters/ Downspouts	6" half round galvanized metal	Gutter sagging; downspouts OK	Realign gutter and put on new hanger strap	5/4/05
			Flush out downspouts	5/5/05
Chimneys	No masonry chimney	N/A	N/A	N/A
Attachments/ Penetrations	Metal vent stack and weathervane	Vent stack hood has some peeling paint; vane OK	Sand and repaint vent stack	6/8/05

Figure 2. All personnel associated with a historic structure need to become acquainted with how existing building features should appear and during their daily or weekly routines look for changes that may occur. This will help augment the regular maintenance inspection that will occur at specified intervals based on seasonal changes, use, and other factors. A segment of an inspection form showing the roof elements of a horse stable is shown. The inspection report should be kept along with the maintenance plan and other material in notebook, file or electronic form.

a time, moving around the building in a consistent direction. On the interior, the attic, inside surfaces of exterior walls, and crawlspaces or basements should be examined for signs of potential or existing problems with the building envelope.

The following chart lists suggested inspection frequencies for major features associated with the building's exterior, based on a temperate four-season climate and moderate levels of annual rainfall. For areas of different climate conditions and rainfall, such as in the more arid southwest, the nature of building decay and frequency of inspections will vary. For buildings with certain inherent conditions, heavy use patterns, or locations with more extreme weather conditions, the frequency of inspections should be altered accordingly.

*Note: All building features should be inspected after any significant weather event such as a severe rainstorm or unusually high winds.*

Survey observations can be recorded on a standardized report form and photographs taken as a visual record. All deficient conditions should be recorded and placed on a written schedule to be corrected or monitored.

## BUILDING COMPONENTS

For purposes of this discussion, the principal exterior surface areas have been divided into five components and are presented in order from the roof down to grade. While guidance for inspection and maintenance is provided for each component, this information is very general in nature and is not indeed to be comprehensive in scope. Examples have been selected to address some typical maintenance needs and to help the reader avoid common mistakes.

### Roofs/chimneys

The roof is designed to keep water out of a building. Thus one of the principal maintenance objectives is to ensure water flows off the roof and into functional gutters and downspouts directly to grade and away from the building—and to prevent water from penetrating the attic, exterior walls, and basement of a building. (Note: Some buildings were designed without gutters and thus assessments must be made as to whether rain water is being properly addressed at the foundation and perimeter grade.) Keeping gutters and downspouts cleared of debris is usually high on the list of regular maintenance activities (Fig 3). Flashing around chimneys, parapets, dormers, and other appendages to the roof also merit regular inspection and appropriate maintenance when needed. The material covering the roof—wood shingles, slate, tile, asphalt, sheet metal, rolled roofing—requires maintenance both to ensure a watertight seal and to lengthen its service life; the type and frequency of maintenance varies with the roofing material. Older chimneys and parapets also require inspection and maintenance. With the exception of cleaning and minor repairs to gutters and downspouts, most roof maintenance work will necessitate use of an outside contractor.

#### Inspection:

The functioning of gutters and downspouts can be safely observed from the ground during rainy weather and when winter ice has collected. Binoculars are a useful tool in helping to identify potential roofing problems from the same safe vantage point. Careful observation from grade helps to identify maintenance needs between close-up inspections by an experienced roofer. Observation from the building interior is also important to identify possible leak locations. When access can be safely gained to the roof, it is important to wear shoes with slip-resistant soles and to use safety ropes.

INSPECTION FREQUENCY CHART		
Feature	Minimum Inspection Frequency	Season
Roof	Annually	Spring or fall; every 5 years by roofer
Chimneys	Annually	Fall, prior to heating season; every 5 years by mason
Roof Drainage	6 months; more frequently as needed	Before and after wet season, during heavy rain
Exterior Walls and Porches	Annually	Spring, prior to summer/fall painting season
Windows	Annually	Spring, prior to summer/fall painting season
Foundation and Grade	Annually	Spring or during wet season
Building Perimeter	Annually	Winter, after leaves have dropped off trees
Entryways	Annually; heavily used entries may merit greater frequency	Spring, prior to summer/fall painting season
Doors	6 months; heavily used entry doors may merit greater frequency	Spring and fall; prior to heating/cooling seasons
Attic	4 months, or after a major storm	Before, during and after wet season
Basement/Crawlspace	4 months, or after a major storm	Before, during and after rain season

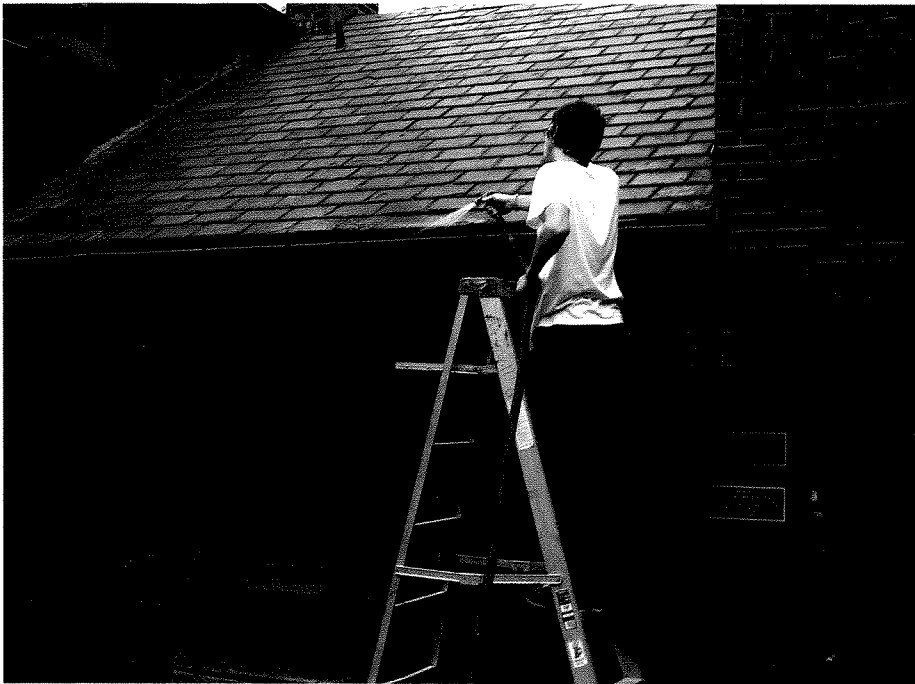


Figure 3. Keeping gutters clean of debris can be one of the most important cyclical maintenance activities. On this small one-story addition, a garden hose is being used to flush out the trough to ensure that the gutter and downspouts are unobstructed. Gutters on most small and medium size buildings can be reached with an extension ladder and a garden hose. Photo: Bryan Blundell.

Depending on the nature of the roof, some common conditions of concern to look for are:

- sagging gutters and split downspouts;
- debris accumulating in gutters and valleys;
- overhanging branches rubbing against the roof or gutters
- plant shoots growing out of chimneys;
- slipped, missing, cracked, bucking, delaminating, peeling, or broken roof coverings;
- deteriorated flashing and failing connections at any intersection of roof areas or of roof and adjacent wall;
- bubbled surfaces and moisture ponding on flat or low sloped roofs;
- evidence of water leaks in the attic;
- misaligned or damaged elements, such as decorative cresting, lightning rods, or antennas; and
- cracked masonry or dislodged chimney caps.

#### *Maintenance:*

- Remove leaves and other debris from gutters and downspouts. Utilize a ladder with a brace device, if

necessary, to keep the ladder from crushing the gutter. Use a garden hose to flush out troughs and downspouts. Patch or repair holes in gutters using products such as fiberglass tape and epoxy adhesive in metal gutters. Avoid asphalt compounds since acidic material can cause further deterioration of metal gutters.

- Correct misaligned gutters and adjust, if necessary, so that water flows to drains and does not pond. If gutter edges sag, consider inserting wooden wedges between the fascia board and the back of the gutter to add support. Seal leaking seams or pinholes in gutters and elbows.
- Broom sweep branch or leaf debris away from shingles, valleys, and crickets, particularly around chimneys and dormers.

• Where mechanical equipment is mounted on flat or low-sloped roofs, ensure that access for maintenance can be provided without damaging the roof. Clean out trapped leaves and debris from around equipment base and consider adding a protective walkway for access.

• Remove biological growth where it is causing erosion or exfoliation of roofing. Use low-pressure garden hose water and a natural or nylon scrubbing brush to remove such growth, scraping with a plastic putty knife or similar wood or plastic tool as needed on heavier buildup. Most growth is acidic and while there are products designed to kill spores, such as diluted chlorine bleach, they should be avoided. Even fairly weak formulas can still cause unexpected color changes, efflorescence, or over-splash damage to plantings or surfaces below the roof. Where appropriate, trim adjacent tree branches to increase sunlight on the roof since sunlight will deter further biological growth.

• Re-secure loose flashing at the dormers, chimneys or parapets. Clean out old mortar, lead, lead wool, or fastening material and make sure that flashing is properly inserted into reglet (slot) joints, taking care not to damage the substrate. Avoid installing new step flashing as a single metal component where multiple pieces are required to provide proper waterproofing. Also avoid attaching step flashing with mastic or sealant. Properly re-bed all step flashing. Use appropriate non-ferrous flashing metal or painted metal if needed. Since cap, step, valley, cricket, and apron flashings each have specific overlap and extension requirements, replacement flashing should match the existing material unless there has been a proven deficiency.





*Figure 4. Damage to roofs often requires immediate attention. As a temporary measure, this damaged roof tile could be replaced with a brown aluminum sheet wedged between the existing tiles. Photo: Chad Randl.*



*Figure 5. The use of a sealant to close an exposed joint is not always an effective long-term solution. Where this decorative wood element connects to the slate roof, the sealant has failed within a short time and a proper metal flashing collar is being fitted instead. Photo: Bryan Blundell.*

- Repoint joints in chimneys, parapet, or balustrade capping stones using a hydraulic lime mortar or other suitable mortar where the existing mortar has eroded or cracked, allowing moisture penetration. In general, a mortar that is slightly weaker than the adjacent masonry should be used. This allows trapped moisture in the masonry to migrate out through the mortar and not the masonry. Spalled masonry is often evidence of the previous use of a mortar mix that was too hard.
- Use professional services to repair chimneys and caps. Avoid the use of mortar washes on masonry since they tend to crack, allowing moisture to penetrate and promoting masonry spalling. Repoint masonry with a durable mortar that is slightly weaker than the adjacent masonry. Slope the masonry mortar cap to insure drainage away from the flue. If a chimney rain cap is installed, ensure adequate venting and exhaust.
- As a temporary measure, slip pieces of non-corrosive metal flashing under or between damaged and missing roofing units until new slate, shingles, or tile can be attached. Repair broken, missing or damaged roofing units with ones that match. Follow roofing supplier and industry guidance on inserting and attaching replacement units (Fig 4). Avoid using temporary asphalt patches as it makes a proper repair difficult later on.
- For long-term preservation of wooden shingle roofs coated with a preservative, recoat every few years following the manufacturer's recommendations. Be aware of environmental considerations.
- Scrape and repaint selected areas of coated ferrous metal roofing as needed; repaint on a regularly

scheduled basis. Ferrous metal roofs can last a long time if painted regularly. Alkyd coatings are generally used on metal roofs; be sure to wash and properly prepare the area beforehand. Environmental regulations may restrict the use of certain types of paints. Apply the coating system in accordance with manufacturer's recommendations. Prepare the surface prior to application to obtain good adhesion with the prime coat. Apply both a prime coat and a topcoat for good bonding and coverage; select primer and topcoat products from the same manufacturer.

- Re-secure loose decorative elements, such as finials and weathervanes. Seek professional advice if decorative elements exhibit considerable corrosion, wood rot, or structural instability. Small surface cracks may benefit from a flexible sealant to keep moisture out; sealants have a limited life and require careful inspection and periodic replacement (Fig 5).

## Exterior Walls

Exterior walls are designed to help prevent water infiltration, control air infiltration, and serve as a barrier for unwanted animals, birds and insects. The primary maintenance objective is to keep walls in sound condition and to prevent water penetration, insect infestation, and needless decay (Fig 6). Depending on the materials and construction methods, walls should have an even appearance, free from unwanted cracks, and should be able to shed excess moisture. Where surfaces are significantly misaligned or where there are bulging wall sections

or cracks indicative of potential structural problems, seek professional guidance as to the cause of distress and appropriate corrective measures. Wood-frame construction generally will require more frequent maintenance than buildings constructed of brick, stone, or terra cotta (Fig 7).

### *Inspections:*

It is best to inspect walls during dry as well as wet weather. Look for moisture patterns that may appear on the walls after a heavy or sustained rainfall or snow, recording any patterns on elevation drawings or standard recording forms. Monitoring the interior wall for moisture or other potential problems is important as well. Look for movement in cracks, joints, and around windows and doors and try to establish whether movement is seasonal in nature (such as related to shrinkage of wood during dry weather) or signs of an ongoing problem. For moderate size buildings, a ladder or mechanical lift may be necessary, though in some cases the use of binoculars and observations made from windows and other openings will be sufficient. When examining the walls, some common conditions of concern to look for are:

- Misaligned surfaces, bulging wall sections, cracks in masonry units, diagonal cracks in masonry joints, spalling masonry, open joints, and nail popping;
- Evidence of wood rot, insect infestation, and potentially damaging vegetative growth;
- Deficiencies in the attachment of wall mounted lamps, flag pole brackets, signs, and similar items;
- Potential problems with penetrating features such as water spigots, electrical outlets, and vents;
- Excessive damp spots, often accompanied by staining, peeling paint, moss, or mold; and
- General paint problems (Fig 8).

### *Maintenance:*

- Trim tree branches away from walls. Remove ivy and tendrils of climbing plants by first cutting at the base of the vine to allow tendrils to die back, and later using a plastic scraper to dislodge debris and an appropriate digging tool to dislodge and remove root systems. Be cautious if using a commercial chemical to accelerate root decay; follow safety directions and avoid contact of chemicals with workers and wall materials.

- Wash exterior wall surfaces if dirt or other deposits are causing damage or hiding deterioration; extend



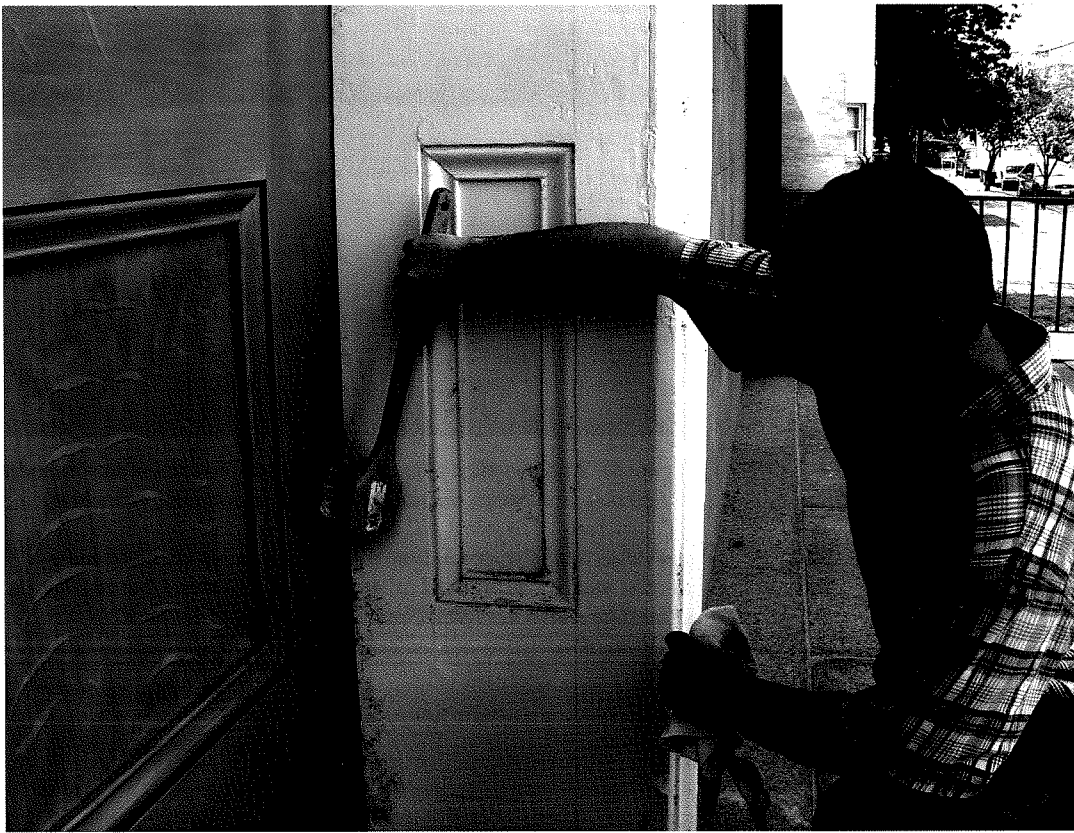
*Figure 6. Stucco applied to an exterior wall or foundation was intended to function as a watertight surface. Unless maintained, rainwater will penetrate open joints and cracks that may occur over time. A spalled section of stucco indicates some damage has occurred and a wooden mallet is being used to tap the surface to determine whether the immediate stucco has lost adhesion. Photo: Bryan Blundell.*



*Figure 7. One of the advantages of wood shingles as a wall covering is that individual shingles that are damaged can easily be replaced. On this highly exposed corner, worn shingles have been selectively replaced to help safeguard against water damage. The new shingles will be stained to match the existing shingles.*



*Figure 8. The paint on the siding of this south-facing wall needs to be scraped, sanded, primed and repainted. Postponing such work will lead to further paint failure, require greater preparatory costs, and could even result in the need to replace some siding. Photo: Charles Fisher.*



*Figure 9. To help extend a repainting cycle, dirt and spider webs should be removed before permanent staining occurs. In this case, a natural bristle brush and a soft damp cloth are being used to remove insect debris and refresh the surface appearance.*

scheduled times for cleaning for cosmetic purposes to reduce frequency (Fig 9). When cleaning, use the gentlest means possible; start with natural bristle brushes and water and only add a mild phosphate-free detergent if necessary. Use non-abrasive cleaning methods and low-pressure water from a garden hose. For most building materials, such as wood and brick, avoid abrasive methods such as mechanical scrapers and high-pressure water or air and such additives as sand, natural soda, ice crystals, or rubber products. All abrasives remove some portion of the surface and power-washing drives excessive moisture into wall materials and even into wall cavities and interior walls. If using a mild detergent, two people are recommended, one to brush and one to prewet and rinse. When graffiti or stains are present, consult a preservation specialist who may use poultices or mild chemicals to remove the stain. If the entire building needs cleaning other than described above, consult a specialist.

- Repoint masonry in areas where mortar is loose or where masonry units have settled. Resolve cause of cracks or failure before resetting units and repointing. Rake out joints by hand, generally avoiding rotary saws or drills, to a depth of 2 ½ times the width of the joint (or until sound mortar is encountered), to make sure that fresh mortar will not pop out. Repointing mortar should be lime-rich and formulated to be slightly weaker than the masonry units and to match the historic mortar in color, width, appearance, and tooling. Off-the-shelf pre-mixed cement mortars are not appropriate for most historic buildings. Avoid use of joint sealants in place of

mortar on vertical masonry wall surfaces, as they are not breathable and can lead to moisture-related damage of the adjacent masonry (Fig 10).

- Correct areas that trap unwanted moisture. Damaged bricks or stone units can sometimes be removed, turned around, and reset, or replaced with salvaged units. When using traditional or contemporary materials for patching wood, masonry, metal, or other materials, ensure that the materials are compatible with the substrate; evaluate strength, vapor permeability, and thermal expansion, as well as appearance.
- When patching is required, select a compatible patch material. Prepare substrate and install patch material according to manufacturer's recommendations; respect existing joints. Small or shallow surface defects may not require patching; large or deep surface defects may be better addressed by installation of a dutchman unit than by patching.
- Where a damaged area is too large to patch, consider replacing the section with in-kind material. For stucco and adobe materials, traditional patching formulas are recommended.
- When temporarily removing wood siding to repair framing or to tighten corner boards and loose trim, reuse the existing siding where possible. Consider using stainless steel or high strength aluminum nails as appropriate. Putty or fill nail holes flush with siding prior to repainting. Back-prime any installed wood with



Figure 10. Repointing of masonry should usually be approached as repair rather than maintenance work in part because of the need for a skilled mason familiar with historic mortar. In this case, a moisture condition was not corrected and the use of a waterproof coating and off-the-shelf Portland cement mortar trapped water and resulted in further damage to these 19th century bricks. Photo: NPS files.

one coat of primer and coat end grain that might be exposed with two coats of primer.

- Prepare, prime, and spot paint areas needing repainting. Remember that preparation is the key to a successful long lasting paint job. Ensure beforehand the compatibility of new and existing paints to avoid premature paint failure. Remove loose paint to a sound substrate; sand or gently rough surface if needed for a good paint bond; wipe clean; and repaint with appropriate primer and topcoats. Follow manufacturer's recommendations for application of coatings, including temperature parameters for paint application. Use top quality coating materials. Generally paint when sun is not shining directly onto surfaces to be painted.

- Remove deteriorated caulks and sealants, clean, and reapply appropriate caulks and sealants using backer rods as necessary. Follow manufacturer's instructions regarding preparation and installation.

- Correct deficiencies in any wall attachments such as awning and flag pole anchors, improperly installed electrical outlets, or loose water spigots.

## Openings

Exterior wall openings primarily consist of doors, windows, storefronts, and passageways. The major maintenance objectives are to retain the functioning nature of the opening and to keep in sound condition the connection between the opening and the wall in order to reduce air and water infiltration.

### Inspection:

Wall openings are typically inspected from inside as well as out. Examinations should include the overall material condition; a check for unwanted water penetration, insect infiltration, or animal entry; and identification of where openings may not be properly functioning. Frames should be checked to make sure they are not loose and to ascertain whether the intersection between the wall and the frame is properly sealed. Secure connections of glazing to sash and between sash and frames are also important. Particular attention should be placed on exposed horizontal surfaces of storefronts and window frames as they tend to deteriorate much faster than vertical surfaces. Inspections should identify:

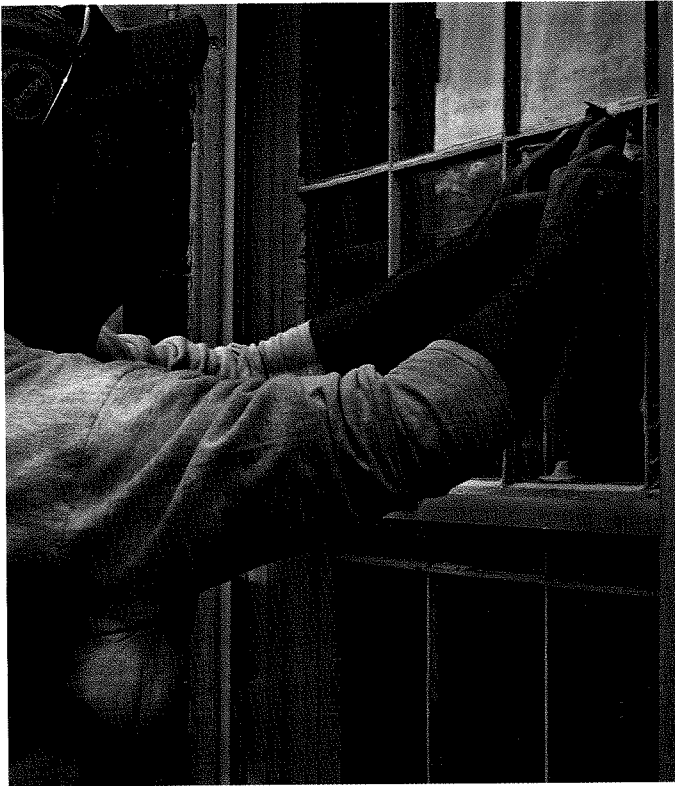
- loose frames, doors, sash, shutters, screens, storefront components, and signs that present safety hazards;
- slipped sills and tipped or cupped thresholds;
- poorly fitting units and storm assemblies, misaligned frames, drag marks on thresholds from sagging doors and storm doors;
- loose, open, or decayed joints in door and window frames, doors and sash, shutters, and storefronts;
- loose hardware, broken sash cords/chains, worn sash pulleys, cracked awning, shutter and window hardware, locking difficulties, and deteriorated weatherstripping and flashing;
- broken/cracked glass, loose or missing glazing and putty;
- peeling paint, corrosion or rust stains; and
- window well debris accumulation, heavy bird droppings, and termite and carpenter ant damage.

### Maintenance:

- Replace broken or missing glass as soon as possible; in some cases cracked glass may be repaired using specialty glues. For historic crown glass and early cylinder glass, a conservation approach should be considered to repair limited cracks. Where panes with a distinct appearance are missing, specialty glass should be obtained to match, with sufficient inventory kept for future needs. Avoid using mechanical devices to remove old putty and match historic putty bevels or details when undertaking work.

- Reputty window glazing where putty is deteriorated or missing. Take care in removing putty so as not to crack or break old glass or damage muntins and sash frames. Re-glaze with either traditionally formulated





*Figure 11. Glazing putty should be maintained in sound condition to prevent unwanted air infiltration and water damage. New glazing putty should be pulled tight to the glass and edge of the wood, creating a clean bevel that matches the historic glazing.*

oil putties or modern synthetic ones, making sure to properly bed the glass and secure with glazing points (Fig 11).

- Clean window glass, door glazing, storefronts, transom prism lights, garage doors, and storm panels using a mild vinegar and water mixture or a non-alkaline commercial window cleaner. Be cautious with compounds that contain ammonia as they may stain brass or bronze hardware elements if not totally removed. When using a squeegee blade or sponge, wipe wet corners with a soft dry cloth. Avoid high-pressure washes.
- Clean handles, locks and similar hardware with a soft, damp cloth. Use mineral spirits or commercial cleaners very sparingly, as repeated use may remove original finishes. Most metal cleaners include ammonia that can streak and stain metal, so it is important to remove all cleaning residue. Polished hardware subject to tarnishing or oxidation, particularly doorknobs, often benefits from a thin coat of paste wax (carnauba), hand buffed to remove extra residue. Avoid lacquer finishes for high use areas, as they require more extensive maintenance. Patinated finishes should not be cleaned with any chemicals, since the subtle aged appearance contributes to the building's character.

- Remove and clean hardware before painting doors and windows; reinstall after the paint has dried.
- Tighten screws in doorframes and lubricate door hinges, awning hardware, garage door mechanisms, window sash chains, and pulleys using a graphite or silicone type lubricant.

## Contracting Maintenance and Repair Work

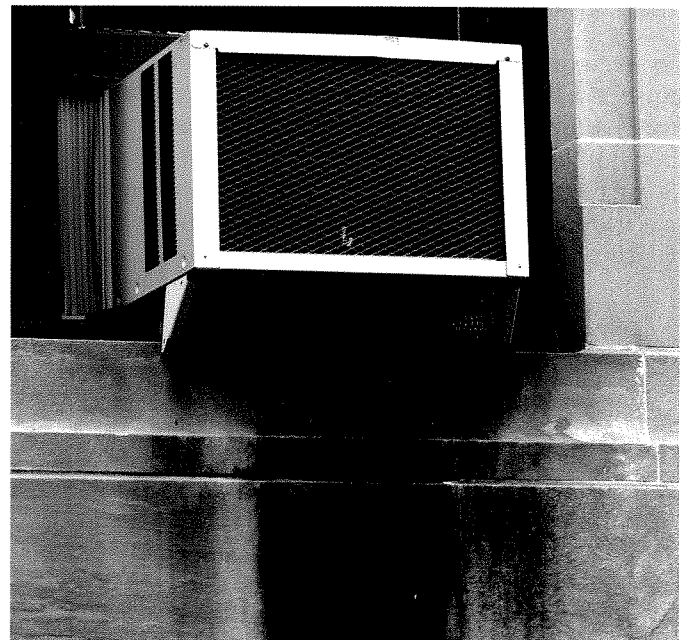
Many contractors are very proficient in using modern construction methods and materials; however, they may not have the experience or skill required to carry out maintenance on historic buildings. The following are tips to use when selecting a contractor to work on your historic building:

1. Become familiar with work done on similar historic properties in your area so that you can obtain names of possible preservation contractors.
2. Be as specific as possible in defining the scope of work you expect to undertake.
3. Ask potential contractors for multiple references (three to five) and visit previous work sites. Contact the building owner or manager and ask how the job proceeded; if the same work crew was retained from start to finish; if the workers were of a consistent skill level; whether the project was completed in a reasonable time; and whether the person would use the contractor again.
4. Be familiar with the preservation context of the work to be undertaken. Use the written procedures in your maintenance plan to help define the scope of work in accordance with preservation standards and guidelines. Always request that the gentlest method possible be used. Use a preservation consultant if necessary to ensure that the work is performed in an appropriate manner.
5. Request in the contract proposal a detailed cost estimate that clearly defines the work to be executed, establishes the precautions that will be used to protect adjoining materials, and lists specific qualified subcontractors, if any, to be used.
6. Insure that the contractor has all necessary business licenses and carries worker compensation.

- Check weather stripping on doors and windows and adjust or replace as necessary. Use a durable type of weather stripping, such as spring metal or high quality synthetic material, avoiding common brush and bulb or pile weather stripping that require more frequent replacement.
- Adjust steel casement windows as needed for proper alignment and tight fit. Avoid additional weather stripping as this may lead to further misalignment, creating pathways for air and water infiltration.
- Check window sills for proper drainage. Fill cracks in wood sills with a wood filler or epoxy. Follow manufacturer's instructions for preparation and installation. Do not cover over a wood sill with metal panning, as it may trap moisture and promote decay.
- Repair, prime, and repaint windows, doors, frames, and sills when needed. Clean out putty debris and paint chips from windows using a wet paper towel and dispose of debris prior to repair or repainting. Take appropriate additional precautions when removing lead-based paint. Sand and prepare surfaces and use material-specific patching compounds to fill any holes or areas collecting moisture (Fig 12). Avoid leaving exposed wood unpainted for any length of time, as light will degrade the wood surface and lead to premature failure of subsequent paint applications. Immediately prime steel sash after paint is removed and the substrate prepared for repainting.
- Adjust wood sash that bind when operated. Apply beeswax, paraffin, or similar material to tracks or sash runs for ease of movement. If sash are loose, replace worn parting beads. Sash runs traditionally were unpainted between the stop and parting bead; removing subsequent paint applications will often help improve sash operation.
- Correct perimeter cracks around windows and doors to prevent water and air infiltration. Use traditional material or modern sealants as appropriate. If fillers such as lead wool have been used, new wool can be inserted with a thin blade tool, taking care to avoid damage to adjacent trim. Reduce excess air infiltration around windows by repairing and lubricating sash locks so that windows close tightly.



*Figure 12. Good surface preparation is essential for long lasting paint. Scraping loose paint, filling nail holes and cracks, sanding, and wiping with a damp cloth prior to repainting are all important steps whether touching up small areas or repainting an entire feature. Always use a manufacturer's best quality paint. Windows and shutters may need repainting every five to seven years, depending on exposure and climate.*



*Figure 13. Window air conditioning units can cause damage to surfaces below when condensation drips in an uncontrolled manner. Drip extension tubes can sometimes be added to direct the discharge.*

- Remove debris beneath window air conditioning units and ensure that water from units does not drain onto sills or wall surfaces below (Fig 13). Removal of air conditioning units when not in season is recommended.
- Adjust storm panels and clean weep holes; check that weep holes at the bottom of the panels are open so water will not be trapped on the sill. Exterior applied storm windows are best attached using screws and not tightly adhered with sealant. Use of sealant makes storm units difficult to remove for maintenance and can contribute to moisture entrapment if weep holes become clogged.
- Remove weakened or loose shutters and store for later repair. Consider adding a zinc or painted metal top to shutters as a protective cap to cover the wood's exposed end grain. This will extend the life of the shutters.

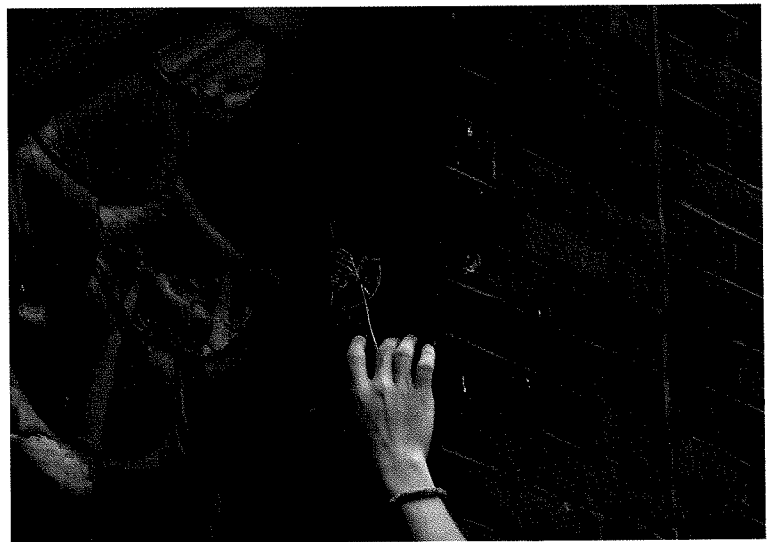
## Projections

Numerous projections may exist on a historic building, such as porches, dormers, skylights, balconies, fire escapes, and breezeways. They are often composed of several different materials and may include an independent roof. Principal maintenance objectives include directing moisture off these features and keeping weathered surfaces in good condition. Secondary projections may include brackets, lamps, hanging signs, and similar items that tend to be exposed to the elements.

### *Inspection:*

In some cases, projections are essentially independent units of a building and so must be evaluated carefully for possible settlement, separation from the main body of the building, and materials deterioration. Some electrical features may require inspection by a electrician or service technician. Common conditions of concern to look for are:

- damaged flashing or tie-in connections of projecting elements;
- misaligned posts and railings;
- deteriorated finishes and materials, including peeling paint, cupped and warped decking, wood deterioration, and hazardous steps;
- evidence of termites, carpenter ants, bees, or animal pests (Fig 14);
- damaged lamps, unsafe electrical outlets or deteriorated seals around connections;
- loose marker plaques, sign, or mail boxes; and



*Figure 14. When inspecting connections between projections and the main building, look for areas where birds, bees and pests may enter or nest. Birds have been nesting in this porch roof and the area is being cleaned of their debris. Where an opening exists, it may be necessary to cover it with a trim piece, screening, or sealant. Photo: Bryan Blundell.*

- rust and excessive wear of structural, anchorage, and safety features of balconies and fire escapes.

### *Maintenance:*

- Selectively repair or replace damaged roofing units on porches and other projections. Ensure adequate drainage away from the building. Repair flashing connections as needed; clean and seal open joints as appropriate.
- Secure any loose connections, such as on porch rails or fire escapes.
- Maintain ferrous metal components by following manufacturer's recommendation for cleaning and repainting. Remove rust and corrosion from porch handrails, balconies, fire escapes, and other metal features; prepare, prime, and repaint using a corrosion-inhibitive coating system. Apply new primer before new corrosion sets in, followed by new topcoat. Take appropriate safety measures when dealing with existing lead-based paint and in using corrosion-removal products (Fig 15).
- Reattach loose brackets, lamps, or signs. With electrical boxes for outlets or lighting devices, ensure that cover plates are properly sealed. Prime and paint metal elements as needed.
- Keep porch decks and steps free from dust, dirt, leaf debris, and snow as soon as it accumulates using a broom or plastic blade shovel.
- Repair areas of wood decay or other damage to railings, posts, and decorative elements. Repair with wood dutchman, wood putty, or epoxy filler, as appropriate; replace individual elements as needed.

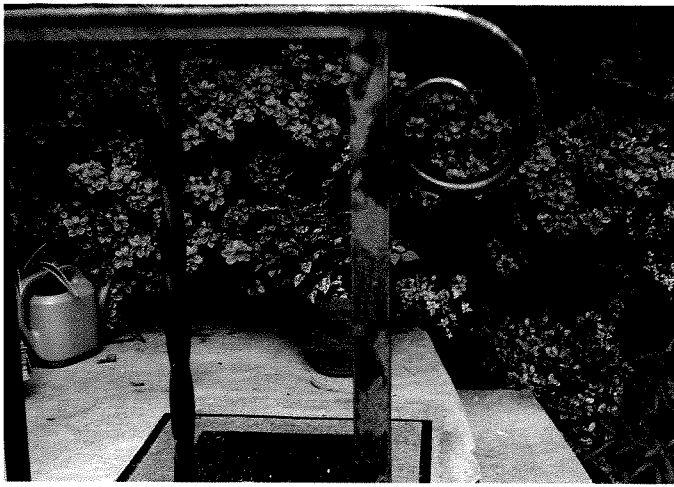


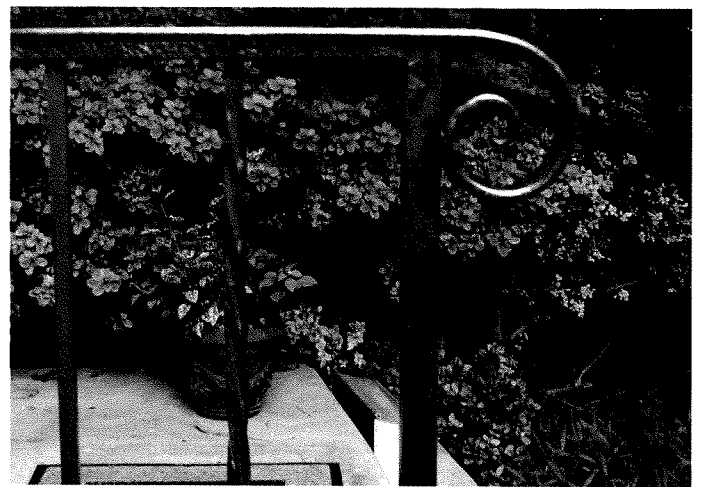
Figure 15. Metal projecting elements on a building, such as sign armatures and railings, are easily subject to rust and decay. Proper surface preparation to remove rust is essential. Special metal primers and topcoats should be used.

Prime and repaint features when necessary and repaint horizontal surfaces on a more frequent basis.

- Sand and repaint porch floorboards to keep weather surfaces protected. The exposed ends of porch floorboards are especially susceptible to decay and may need to be treated every year or two.
- Carefully cut out damaged or buckled porch flooring and replace with wood to match. Back-prime new wood that is being installed; treat end grain with wood preservative and paint primer. Ensure that new wood is adequately kiln or air-dried to avoid shrinkage and problems with paint adherence.
- Repair rotted stair stringers; adjust grade or add stone pavers at stair base to keep wooden elements from coming into direct contact with soil.
- Consider durable hardwoods for replacement material where beading, chamfering, or other decorative work is required in order to match existing features being replaced. Although appropriate for certain applications, pressure treated lumber is hard to tool and may inhibit paint adherence if not allowed to weather prior to coating application.
- Clean out any debris from carpenter bees, ants, termites, and rodents, particularly from under porches. Replace damaged wood and add screening or lattice to discourage rodents. Consider treating above ground features with a borate solution to deter termites and wood rot and repaint exposed surfaces.

## Foundations and Perimeter Grades

The foundation walls that penetrate into the ground, the piers that support raised structures, and the ground immediately around a foundation (known as grade) serve important structural functions. To help sustain these functions, it is important that there is



good drainage around and away from the building. The maintenance goal is to prevent moisture from entering foundations and crawl spaces and damaging materials close to the grade, and to provide ventilation in damp areas.

### Inspection:

Inspections at the foundation should be done in conjunction with the inspection of the downspouts to ensure that water is being discharged a sufficient distance from the building perimeter to avoid excessive dampness in basements or crawl spaces. In addition, crawl spaces should be adequately vented to deter mold and decay and should be screened or otherwise secured against animals. Look for:

- depressions or grade sloping toward the foundation; standing water after a storm;



Figure 16. This chronically wet area has a mildew bloom brought on by heat generated from the air-conditioning condenser unit. The dampness could be caused by a clogged roof gutter, improper grading, or a leaking hose bibb.



## Sealants and Caulks

Using sealants and caulks has become a familiar part of exterior maintenance today. As the use of precision joinery and certain traditional materials to render joints more weathertight has waned in recent years, caulks and more often elastomeric sealants are used to seal cracks and joints to keep out moisture and reduce air infiltration. Where cracks and failing joints are indicators of a serious problem, sealants and caulks may be used as a temporary measure. In some cases they may actually exacerbate the existing problem, such as by trapping moisture in adjacent masonry, and lead to more costly repairs.

Manufacturer's recommendations provide instructions on the proper application of caulks and sealants. Special attention should be placed on ensuring that the subsurface or joint is properly prepared and cleaned. Backer rods may be necessary for joints or cracks. Tooling of the caulk or sealant is usually necessary to ensure contact with all edge surfaces and for a clean and consistent appearance.

Caulks generally refer to older oil resin-based products, which have relatively limited life span and limited flexibility. Contemporary elastomeric sealants are composed of polymer synthetics. Elastomeric sealants are more durable than caulks and have greater flexibility and wider application. Caulks and sealants can become maintenance problems, as they tend to deteriorate faster than their substrates and must be replaced periodically as a part of cyclical maintenance of the structure.

The selection criteria for caulks and sealants include type of substrate, adhesion properties, size and configuration of joint, intended appearance/color and paintability, movement characteristics, and service life. Both one-part and two-part sealants are available; the latter require mixing as part of the application process. Sealants are commonly used for a variety of places on the exterior of a building such as around windows and doors, at interfaces between masonry and wood, between various wood features or elements, and at attachments to or through walls or roofs, such as with lamps, signs, or exterior plumbing fixtures. Their effectiveness depends on numerous factors including proper surface preparation and application. Applications of sealants and caulks should be examined as part of routine maintenance inspection, irrespective of their projected life expectancy.

Installation of caulks and sealants often can be undertaken by site personnel. For large and more complex projects, a contractor experienced in sealant installation may be needed. In either case, the sealant manufacturer should be consulted on proper sealant selection, preparation, and installation procedures.

- material deterioration at or near the foundation, including loss of mortar in masonry, rotting wood clapboards, or settlement cracks in the lower sections of wall;
- evidence of animal or pest infestation;
- vegetation growing close to the foundation, including trees, shrubs and planting beds;
- evidence of moisture damage from lawn and garden in-ground sprinkler systems;
- evidence of moss or mold from damp conditions or poorly situated downspout splash blocks (Fig 16); and
- blocked downspout drainage boots or clogged areaway grates.

### *Maintenance:*

- Remove leaves and other debris from drains to prevent accumulation. Detach drain grates from paved areas and extract clogged debris. Flush with a hose to ensure that there is no blockage. Use a professional drain service to clear obstructions if necessary.
- Conduct annual termite inspections. Promptly address termite and other insect infestations. Use only licensed company for treatment where needed.
- Keep the grade around the foundation sloping away from the building. Add soil to fill depressions particularly around downspouts and splash blocks. Make sure that soil does not come too close to wooden or metal elements. A 6" separation between wooden siding and the grade is usually recommended.
- Avoid use of mulching material immediately around foundations as such material may promote termite infestation, retain moisture or change existing grade slope.
- Reset splash blocks at the end of downspouts or add extender tubes to the end of downspouts as necessary (Fig 17).
- Lubricate operable foundation vent grilles to facilitate seasonal use; paint as needed.
- Manage vegetation around foundations to allow sufficient air movement for wall surfaces to dry out during damp periods. Trim plantings and remove weeds and climbing vine roots. Be careful not to scar foundations or porch piers with grass or weed cutting equipment. If tree roots appear to be damaging a foundation wall, consult an engineer as well as a tree company.



- Wash off discoloration on foundations caused by splash-back, algae, or mildew. Use plain water and a soft natural or nylon bristle brush. Unless thoroughly researched and tested beforehand on a discreet area of the wall, avoid chemical products that may discolor certain types of stone. If cleaning products are used, test beforehand in a discreet area; and avoid over splash to plantings and adjacent building materials.
- Selectively repoint unit masonry as needed. Follow guidance under the wall section in regard to compatible mix, appearance, and texture for pointing mortar.
- Avoid using salts for de-icing and fertilizers with a high acid or petro-chemical content around foundations, as these materials can cause salt contamination of masonry. Use sand or organic materials without chloride additives that can damage masonry. Where salt is used on icy walks, distribute it sparingly and sweep up residual salt after walks have dried.
- Use snow shovels and brooms to clean snow from historic paths and walkways. Avoid blade-type snow removers as they may chip or abrade cobblestones, brick, or stone paving. Note that use of steel snow removal tools in areas where salt-containing snow melters are used may result in rust staining from steel fragments left on the paving.

## Conclusion

Maintenance is the most important preservation treatment for extending the life of a historic property. It is also the most cost effective. Understanding the construction techniques of the original builders and the performance qualities of older building materials, using traditional maintenance and repair methods, and selecting in-kind materials where replacements are needed will help preserve the building and its historic character.

Maintenance can be managed in small distinct components, coordinated with other work, and scheduled over many years to ensure that materials are properly cared for and their life span maximized. A written maintenance plan is the most effective way to organize, schedule, and guide the work necessary to properly care for a historic building. The maintenance plan should include a description of the materials and methods required for each task, as well as a schedule for work required for maintenance of different building materials and components.

Historic house journals, maintenance guides for older buildings, preservation consultants, and preservation maintenance firms can assist with writing appropriate procedures for specific properties. Priorities should be established for intervening when unexpected damage occurs such as from broken water pipes or high winds.



*Figure 17. Extending downspouts at their base is one of the basic steps to reduce dampness in basements, crawl spaces and around foundations. Extensions should be buried, if possible, for aesthetics, ease of lawn care, and to avoid creating a tripping hazard. Photo: NPS files.*

Worker safety should always be paramount. When work is beyond the capabilities of in-house personnel and must be contracted, special efforts should be made to ensure that a contractor is both experienced in working with historic buildings and utilizes appropriate preservation treatments.

A well-maintained property is a more valuable property and one that will survive as a legacy for generations to come.

## Endnotes

1. *The Secretary of the Interior's Standards for the Treatment of Historic Properties*. Washington, D.C.: U.S. Department of the Interior, National Park Service, 1995.
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## Acknowledgements

Sharon C. Park FAIA, is the former Chief of Technical Preservation Services, Heritage Preservation Services, National Park Service, in Washington, D.C. and currently is the Associate Director for Architectural History and Historic Preservation, Smithsonian Institution.

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This publication has been prepared pursuant to the National Historic Preservation Act, as amended, which directs the Secretary of the Interior to develop and make available information concerning historic properties. Comments about this publication should be made to: Charles Fisher, Technical Publications Program Manager, Technical Preservation Services-2255, National Park Service, 1849 C Street, NW, Washington, D.C. 20240. Additional information offered by Technical Preservation Services is available on our website at <[www.nps.gov/history/hps/tps](http://www.nps.gov/history/hps/tps)>. This publication is not copyrighted and can be reproduced without penalty. Normal procedures for credit to the author and the National Park Service are appreciated. Unless otherwise noted, photographs in this Brief are by Sharon C. Park, FAIA. Except for the author's photos, the photographs used in this publication may not be used to illustrate other publications without permission of the owner.



# PRESERVATION

## Tech Notes

NATIONAL PARK SERVICE  
U.S. DEPARTMENT OF THE INTERIOR  
WASHINGTON, D.C.

### WINDOWS

#### NUMBER 10

#### WORTHINGTON HOUSE Monocacy National Battlefield Frederick County, Maryland

Located on the grounds of the Monocacy National Battlefield, the Worthington House is a mid-19th century ell-shaped brick farmhouse. Judging from the modest exterior, it is rather surprising to find that the building contains noteworthy interior stenciling. The two front rooms on either side of the center stair hall and the stair hall itself all have remarkably intact examples of *trompe l'oeil* stenciled panelling combined with an egg and dart motif frieze border.

The National Park Service acquired the 282 acre Worthington property in 1982, principally to protect this detached portion of the battlefield from intensive development. At the time of acquisition, the farmhouse was vacant and severely deteriorated with extensive water damage occurring as a result of major roof leaks and a predominance of broken and missing windows. Vines and saplings were growing up through the building and roof, destroying the mortar and displacing the bricks. The one-story porch across the front had collapsed, causing noticeable dislocation of the front masonry wall. In several areas large numbers of the handmade brick had been scavenged from the exterior, leaving gaping holes in the bearing walls.

With no immediate use planned for the building, it was necessary to repair and stabilize the structure or lose it to deterioration. Work was undertaken using limited funds to make the building structurally sound, weathertight, and less vulnerable to vandalism. Rather than using traditional mothballing techniques, which rely heavily on temporary measures and the

introduction of non-historic elements, the project team utilized high quality but cost-effective stabilization measures whenever possible to ensure the long-term preservation of the historic building. Temporary features, such as window vents, were designed and installed in such a manner as to be reversible and to cause little additional loss of historic fabric.

#### Preservation Problem

Situated on a very windy knoll, the Worthington House had several immediate preservation problems. The interior was waterlogged. Rain entered through broken and missing windows and through the deteriorated slate roof. At the time of acquisition, the structure had been occupied sporadically for approximately 10 years by vagrants and had received no upkeep at all. Rodent and insect infestation was also contributing to the deterioration of the structure.

Early work focused on the need to make the building as weathertight as possible, yet allow for adequate ventilation. Consideration was given to devising a solution that would incorporate the window work with a passive ventilation system. It was recognized that if the house was tightly sealed with insufficient ventilation, the building would be particularly susceptible to condensation and moisture damage. Another factor to consider was that the building would remain unheated and unoccupied for an undetermined length of time.

Neither boarding over the openings nor installing full sash throughout would provide optimum ventilation on the interior. This would be required to deter fungal decay of the wood and to avoid condensation damage to plaster walls and to their decorative

### Temporary Window Vents in Unoccupied Historic Buildings

**Charles E. Fisher**

Preservation Assistance Division  
National Park Service  
and

**Thomas A. Vitanza**

Williamsport Preservation Training Center  
National Park Service

*Special care should be taken to provide sufficient ventilation in unoccupied historic buildings to deter fungal decay and condensation damage.*

stencil work. Hot daytime temperatures followed by cold nights in the spring and early fall could result in significant condensation damage to the plaster and stencil work. Damage would be particularly acute when nighttime temperatures fell below freezing. Furthermore, the hot moist air of the long Maryland summer would create problems, since high humidity can present a favorable condition for fungal growth. This is particularly true when the drying effect of air movement, normally induced in an occupied building, is not present. The potential for damage in these circumstances was great. Once wood absorbs enough moisture from the hot humid air and if fungal attack begins, the process of wood decay would enable the fungi to maintain the wood in a wet condition since fungi reduces wood to water and carbon dioxide. While such moisture problems could arise throughout the house, the basement was particularly susceptible to such damage due to moisture infiltration through the dirt floor, the below grade location, and seepage through the walls and basement doors.

## Preservation Solution

Since the stabilization plan did not call for the installation of either a heating or a mechanical ventilation system, the solution to the air circulation needs was to install window vents. The basic "rule-of-thumb" used by the project staff for determining the amount of open air needed for good air circulation in this building is to use 50 percent of the sash units for ventilation. This approach has been successfully used by the Williamsport Preservation Training Center in previous projects. Depending upon individual conditions, some adjustment needs to be made based on the layout of rooms, interior walls, door locations, and number and location of stair shafts and windows.

Because cross-room ventilation was desirable, the location of the ventilating louvers was critical. With proper planning, natural ventilation could be induced through the "chimney" or "updraft effect" within the building by which warm air raises and escapes through higher level vents, to be replaced with cooler air entering at lower levels.

Good air movement would also tend to equalize interior and exterior temperatures, thus lessening condensation problems within the brick walls and on interior painted plaster surfaces.

The window louvers had to be located so as to promote cross-room ventilation and avoid stagnant air pockets in the rooms. Furthermore, improvements to the appearance of the exterior of this long neglected building were desired. Efforts were taken, therefore, to locate as many of the louvers as possible on side and rear

elevations, thereby minimizing the visual impact on the front elevation. Full double-sash vents could be placed in some side and rear windows to permit more glass on the front elevation. Even the glazing in the reconditioned or replacement windows would help to facilitate air movement within the building, since the sunlight passing through the glass would heat inside air and cause it to rise out through upper floor level vents. Cooler air entering through the basement windows would replace the warmer air.

A survey of the building's 31 window openings established that on the first floor all but one sash were either missing or beyond repair. Altogether, only about one-third of the individual sash units were repairable. Most of those that were reconditioned required muntin replacement. In order to save on the final production costs involved in repairing or constructing the 52 individual sash units, all sash work was completed in one shop operation. The louvered vents were temporarily installed in lieu of the glazed sash on the bottom half of most window openings as part of the "mothballing" and stabilization efforts.

## Louvered Window Vents

Wooden fixed louver vents were custom-made and installed. The easily fabricated louvers were sized to fit the lower sash opening — 34½" wide by 34¼" high on the first floor, while those for the smaller second floor windows were only 25¼" high. Full units were installed in all single-sash basement windows, since the window area was much less and the moisture problems more severe (see figure 1). At the same time, the three attic windows were also replaced with full louvers to encourage thorough multi-level ventilation.

Custom-built wooden louvers were selected over stock, pre-fabricated metal vents for the following reasons: most pre-fabricated vent systems would require modifications of the historic jamb in order to get a secure fit; a single style metal unit could not be found to fit the variety of opening sizes and the depth of the jamb; costs would be greater than making the custom units; and most important, it was felt that the thin gauge metal units offered little or no deterrent to unlawful entry. The wooden units presented a more secure system.

**Figure 1. Full louvered vents were installed in all single-sash openings in the basement because of the more severe moisture problems present in that location. Photo: Charles Fisher**



The louver frame was designed to fit snugly into the existing sash tracks and simultaneously to secure the glazed upper sash. An added benefit of the 6" stock width is that it provided a fairly rigid — and thus secure — louver frame. The louver frame was constructed of 1" x 6" shelf grade northeastern white pine; the louver slats were

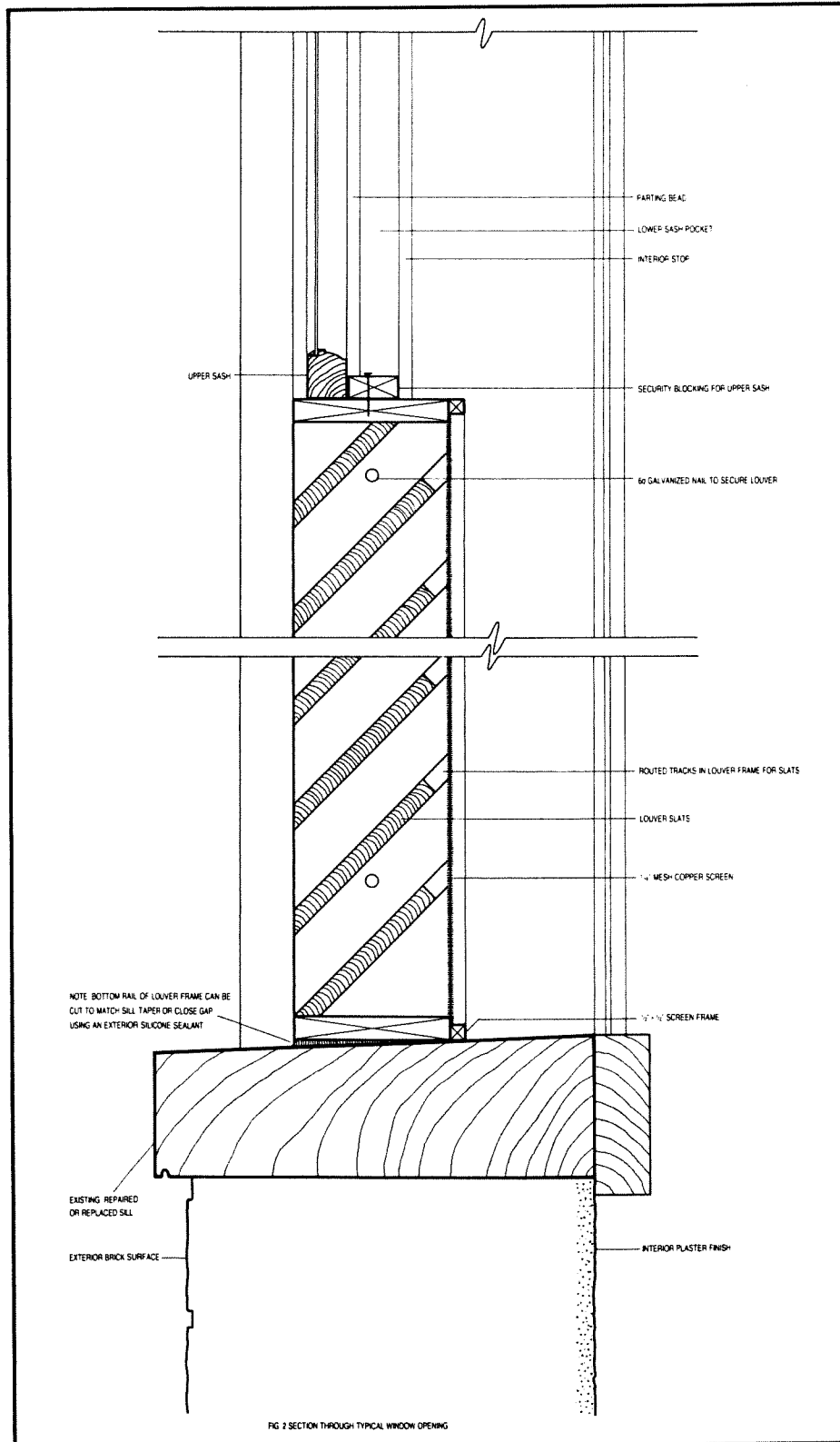
made from 1" x 8" pine (see figure 2). The spacing of the louver slats did not exceed 4" in order to provide additional lateral strength (and security) to the frame. The relative closeness of the slats also would make it more difficult to kick out the grade level units. The slats were set into the frame at a 45 degree angle by routing a 1/4" deep dado

cut into the jamb of the louver. The exposed edges of the slats were plumb cut in order to create a water drip on the exterior.

Prior to assembly, the louver members were primed using an alcohol base paint in order to get at least one protective coat on all surfaces. After assembly, they were given one shop coat of oil base exterior house paint. A final coat was applied after installation. For aesthetic reasons, the paint color used on the sash and trim was selected for the final coat on the louvers (see figure 3).

In order to secure the vents in place, common 6d galvanized box nails were driven through the louver jambs into the sash tracks of the historic window jambs. To keep the jamb and stops from being damaged by the louver installation, temporary blocking was set between the parting bead and the inner and outer stops (see figure 4). By attaching the vents in this location, little damage was done as the nails were driven into the sash track rather than an exposed portion of the jamb. Once the building is returned to use, the lower sash will be installed and the nail holes will be filled with wood putty. Since the nails were driven in on the interior of the building, nearly 3" from the exterior wall, adequate security was achieved without driving the nails all the way in. Thus it will be relatively easy to grab onto the nail heads and back them out when the vents are eventually removed.

**Figure 2. Section of the wooden louvers shows the simple manner in which they were made and assembled. Drawing: Thomas Vitanza**



**Figure 3. The exposed edges of the louver slats were plumb cut in order to create a water drip on the exterior. For aesthetic reasons, the louvers were painted the same color as the sash and trim. Photo: Charles Fisher**





**Figure 4. The lower sash (Figure 4a) were removed to permit installation of the louvers. To minimize damage to historic fabric in installing the louvers, temporary blocking was set between the parting bead and stops prior to nailing the units in place (Figure 4b). Drawings: Thomas Vitanza and Christina Henry.**

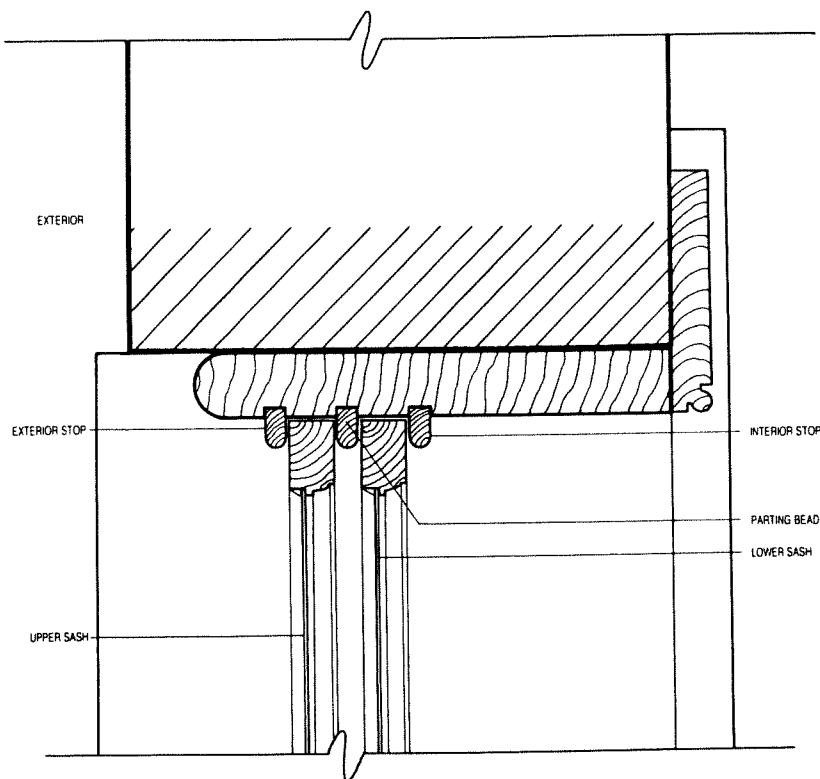


FIG 4A. EXISTING WINDOW JAMB PRIOR TO LOUVER INSTALLATION

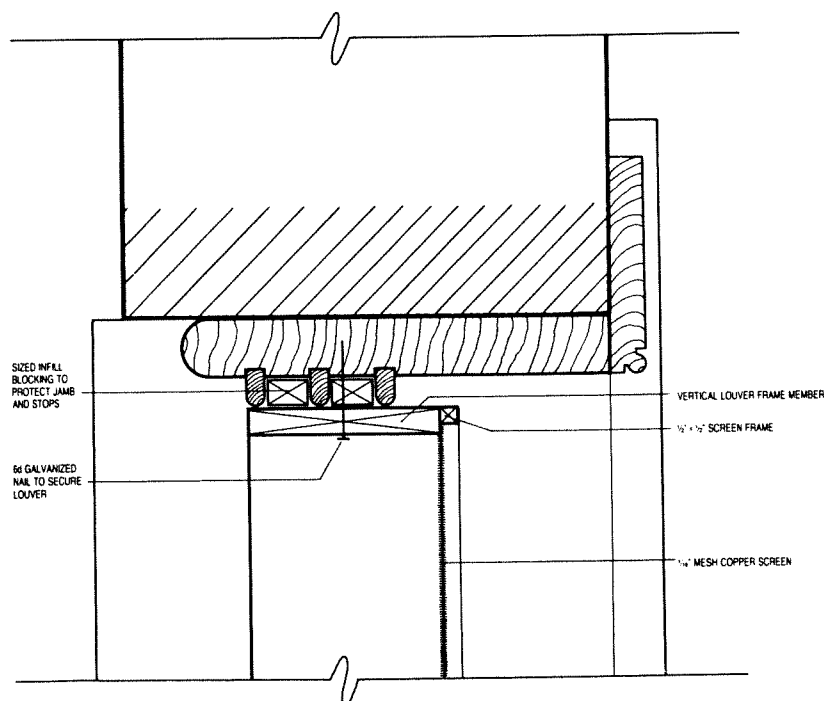


FIG 4B. LOUVER IN PLACE

After the louvers were secured in place, 1/16" mesh copper wire screening was installed on the interior of the louver frame using a 1/2" square wood frame. The screening is an integral part of the louver design. This seemingly minor detail was necessary to prevent the recurrence of insect, bird, and rodent infestation (see figure 5). The 1/16" mesh was specified to keep out the ever-present mud-dauber wasp, whose hive-building instincts have no regard for historic plaster or paint.

The cost of constructing and installing the louvers in 27 window openings was around \$1,800, including 17 full size louvers, 7 basement and 3 attic units. This work was undertaken concurrently with the construction and installation of the reconstructed window sash and repairs to the frames, sills, jambs, and surrounding brickwork. The total cost of the window work was less than \$9,000, involving 31 window openings.

**Figure 5. Screening was attached to the back side of the louvers to prevent the recurrence of insect, bird, and rodent infestation. Photo: Charles Fisher**



## Project Evaluation

The window louvers installed in the Worthington House have proven effective over the past two years in providing the necessary ventilation for the building (see figure 6). Neither fungal attack nor condensation damage has recurred, and the interior air lacks even the typically humid, musty odor typically found in many older buildings. The louvers provide for good air movement within the building and a greater equilibrium between interior and exterior humidity levels and air temperatures, thus helping to protect the historic plaster and the significant interior finishes. The installation of the louver system in conjunction with the other sash work, and the overall exterior stabilization work has stimulated an interest in finding a use for the structure. As a temporary solution to a complex set of problems, the louver vents in the Worthington House have resolved a variety of issues. When used together with additional weatherproofing measures, this venting solution can be adopted for use in other buildings being mothballed.

**Figure 6. The window louvers installed in the Worthington House have proven effective over the past two years in providing the necessary ventilation for the building. Photo: Tom Vitanza.**



## PROJECT DATA

### Building:

Worthington House  
Monocacy National Battlefield  
Frederick County, Maryland

### Owner:

National Park Service  
Antietam National Battlefield  
Sharpsburg, Maryland

**Project Date:** January-June 1983

### Project Staff:

Williamsport Preservation Training Center  
National Park Service  
Williamsport, Maryland

Douglas C. Hicks  
Project Supervisor  
Supervisory Exhibit Specialist

Thomas A. Vitanza  
Project Leader  
Historical Architect Trainee

William Hose  
Exhibit Specialist Trainee

Bruce Martin  
Woodworking Specialist

**Project Cost:** Material and labor for construction of the 17 full size, 7 basement and 3 attic louvers was approximately \$1,800. The material and labor cost for reconstruction of the sash, including glazing, painting, sizing and installation was around \$5,200 (roughly \$100 per sash unit), involving 21 pairs of double-hung sash and 7 basement and 3 attic windows. All other related work for the 31 openings, including sizing and installation of the louvers, repair to window openings (repair/replacement of sills and jambs and related masonry work), painting, and installation of screening and blocking cost between \$1,000 and \$2,000. Total window costs for complete sash and the louvers as well as installation and finish work was between \$8,000 and \$9,000.

This PRESERVATION TECH NOTE was prepared by the National Park Service. Charles E. Fisher, Preservation Assistance Division, National Park Service serves as Technical Coordinator for the PRESERVATION TECH NOTES. Special thanks go to James S. Askins, Branch Chief, Williamsport Preservation Training Center, for his time and generous assistance in providing information concerning the ventilation problems of mothballed historic buildings. Thanks also go to Doug Hicks, Project Supervisor, Williamsport Preservation Training Center, for his contributions to this Tech Note. The following Preservation Assistance Division staff contributed to the production of this Tech Note: Michael J. Auer, Brenda Johnson, Christina Henry, Janet L. Thomas, Theresa Robinson, and Alicia Hardison.  
Cover Photo: Tom Vitanza.

This and many of the PRESERVATION TECH NOTES on windows are included in "The Window Handbook: Successful Strategies for Rehabilitating Windows in Historic Buildings," a joint publication of the Preservation Assistance Division, National Park Service, and the Center for Architectural Conservation, Georgia Institute of Technology. For information write to The Center for Architectural Conservation, P.O. Box 93402, Atlanta, Georgia 30377.

PRESERVATION TECH NOTES are designed to provide practical information on practices and innovative techniques for successfully maintaining and preserving cultural resources. All techniques and practices described herein conform to established National Park Service policies, procedures, and standards. This Tech Note was prepared pursuant to the National Historic Preservation Act Amendments of 1980 which directs the Secretary of the Interior to develop and make available to government agencies and individuals information concerning professional methods and techniques for the preservation of historic properties.

Comments on the usefulness of this information are welcomed and should be addressed to PRESERVATION TECH NOTES, Preservation Assistance Division-424, National Park Service, P.O. Box 37127, Washington, D.C. 20013-7127.

ISSN:0741-9023

PTN-11

August 1985

## **Appendix D**

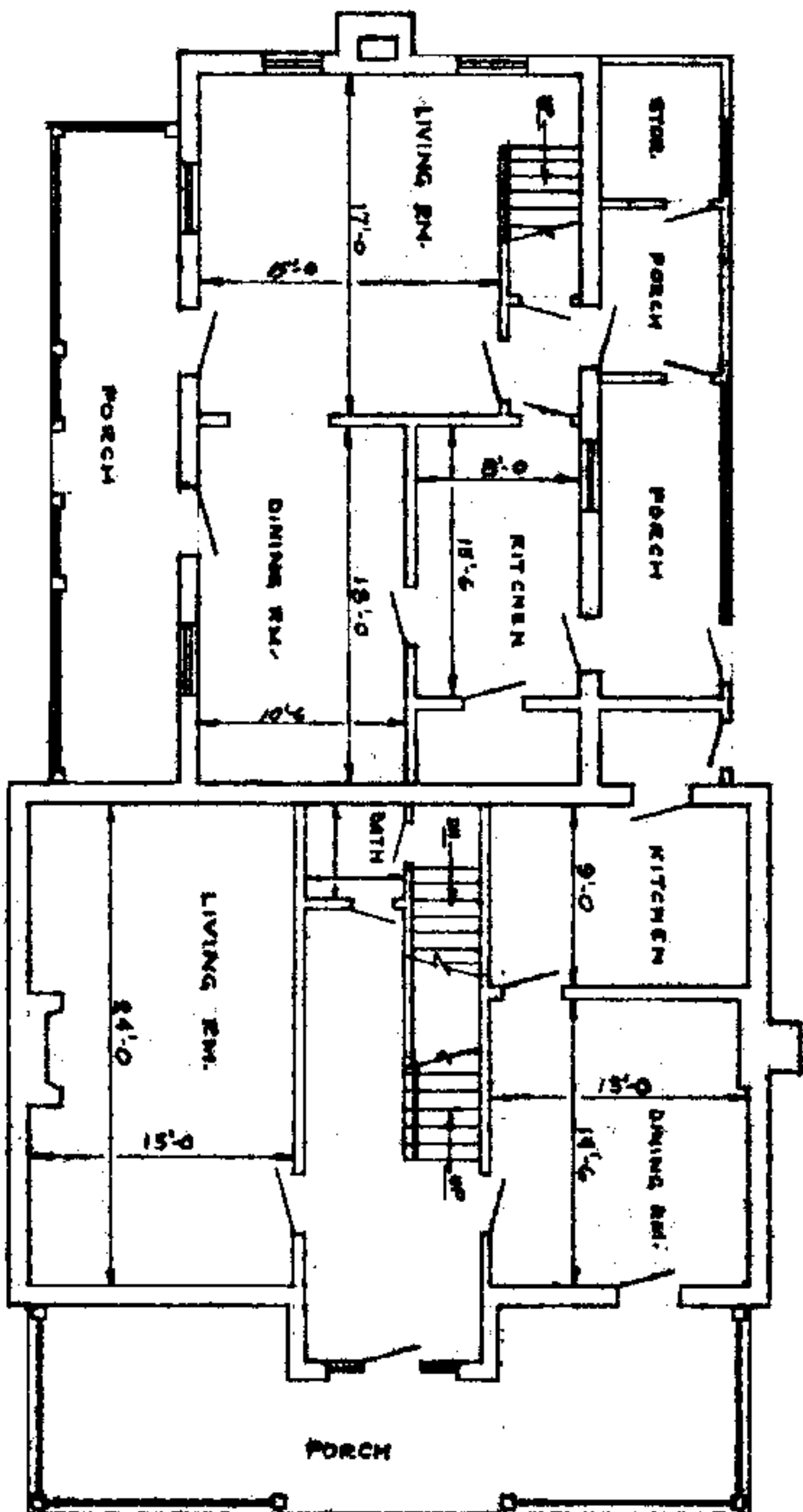
### **U.S. Army Corps of Engineers Archival Drawings**

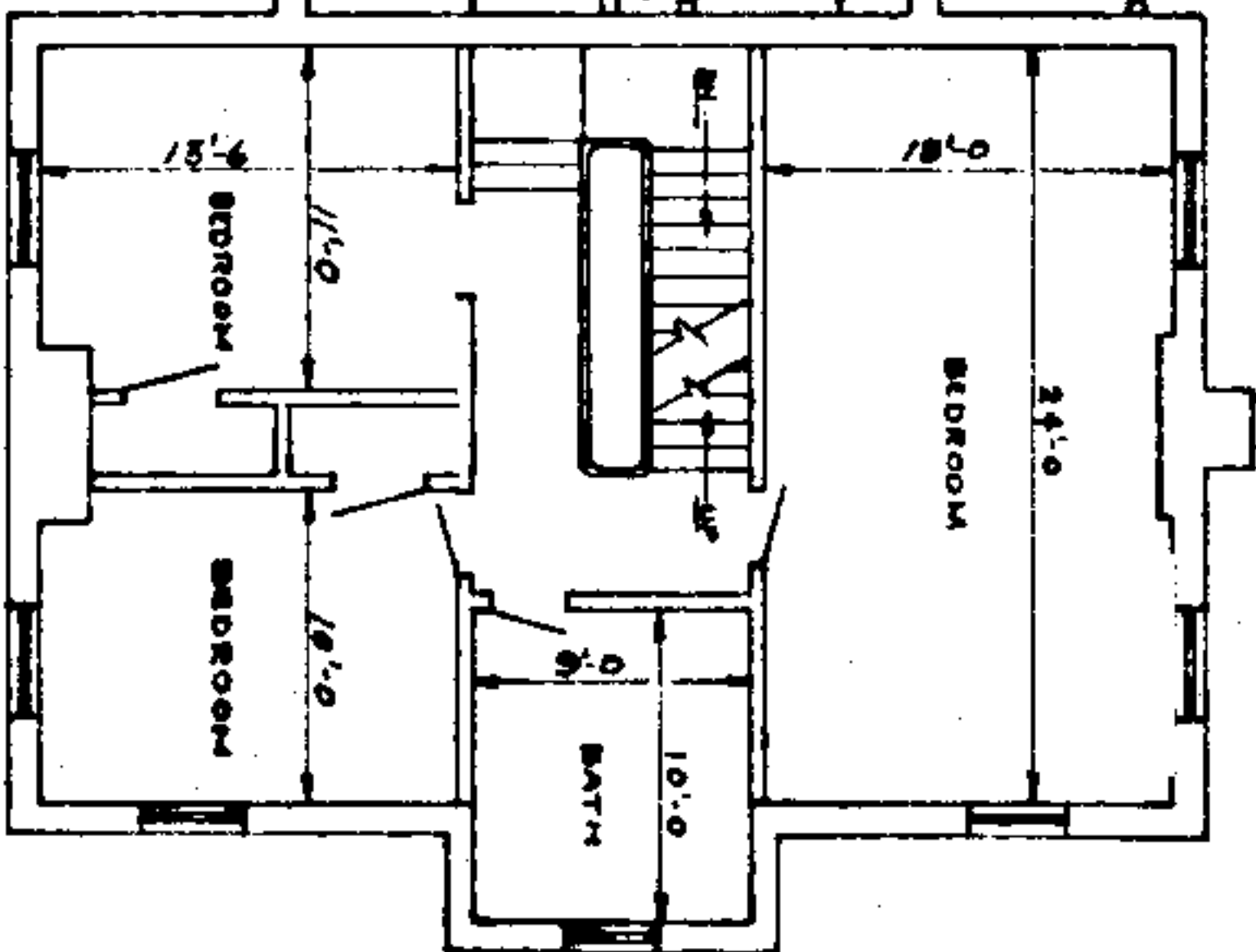
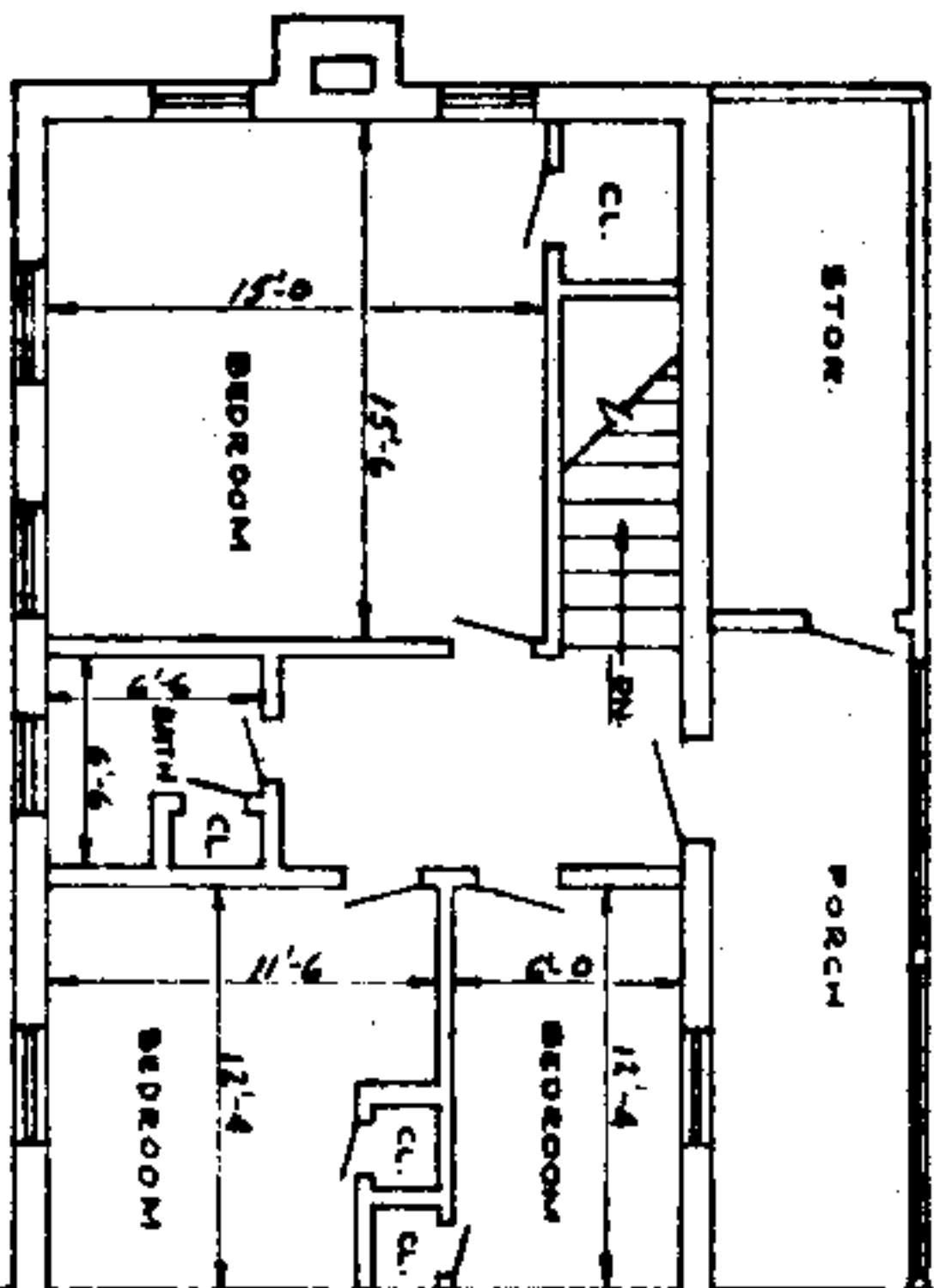
The following drawings for Building 839 were provided by the Directorate of Public Works at Carlisle Barracks:

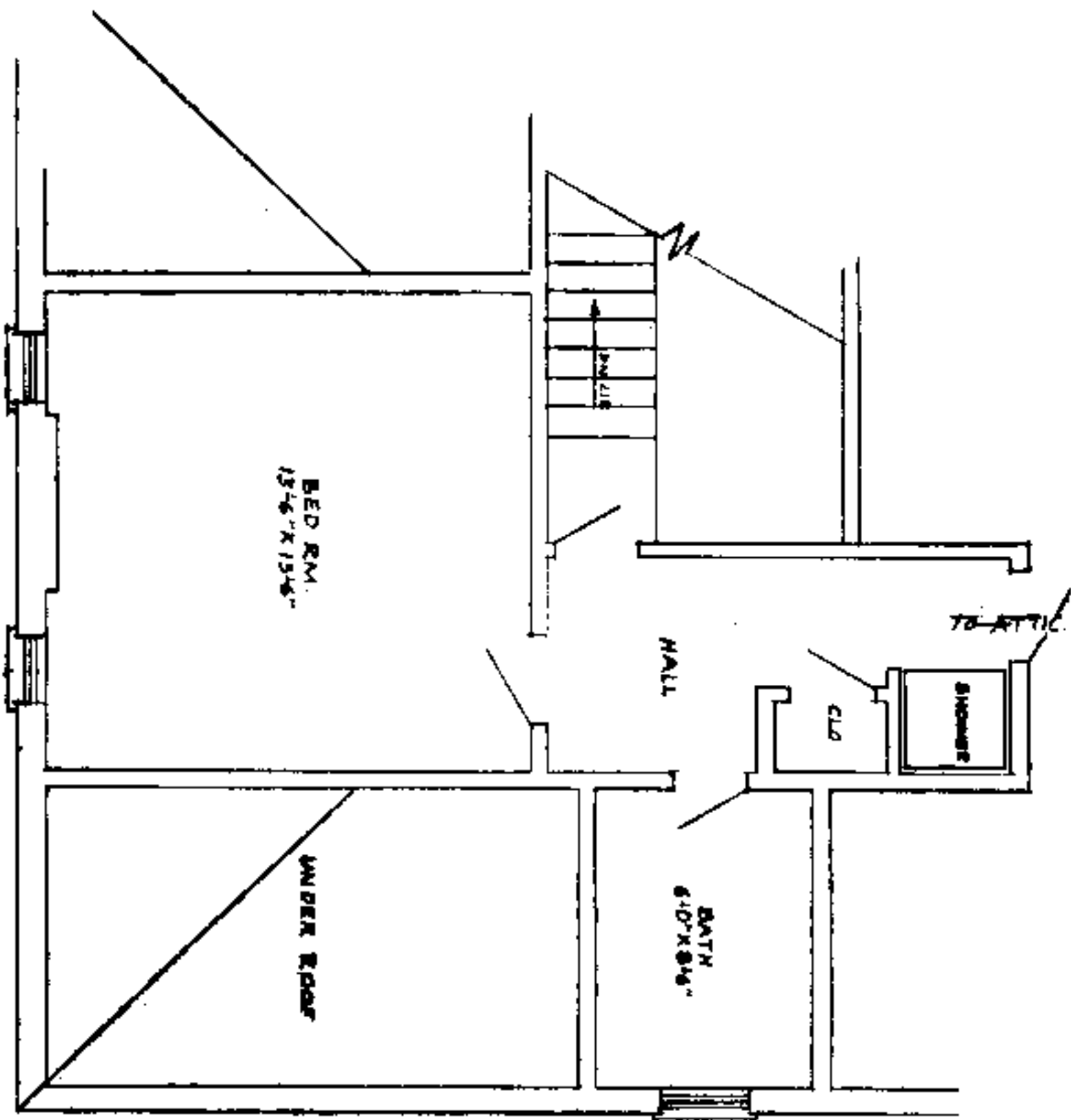
- Untitled first, second, and third floor plans. No date. 3 sheets.
- "Second Floor Plan, Building 839 A & B." Office of the Post Engineer, Carlisle Barracks. Drawing No. PE 115-1. July 8, 1947. 1 sheet.
- G. D. M. "Building Number 39-A,B." Basement, first, and second floor plans. The Army War College Carlisle Barracks, PA. Office of the Post Engineer. No date. 1 sheet.
- Evangelist, D.A. "Reroof – Bldg 839." Headquarters, Carlisle Barracks, PA, Directorate of Facilities Engineering. Drawing No. 1185B. July 7, 1977. Sheet 2 of 2.
- Kraybill. "Repair of Quarters 839A." Headquarters, Carlisle Barracks, PA, Directorate of Facilities Engineering. Drawing No. 1273. Sept. 24, 1980. 1 sheet.
- Kraybill. "Replace Sewer System, Bldg 839, Plans & Details." Drawing No. 1314. June 3, 1982. 1 sheet.
- Vogel. "Renovate Kitchens and Bathrooms, Bldg. 839." Department of the Army, Directorate of Installation Support, Carlisle Barracks, PA. Drawing No. RMD-008. August 1992. 2 sheets.

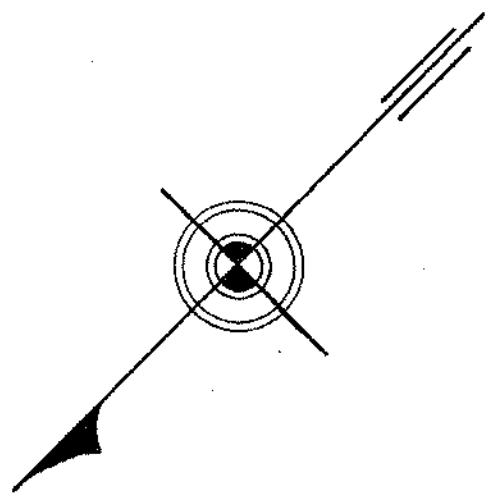






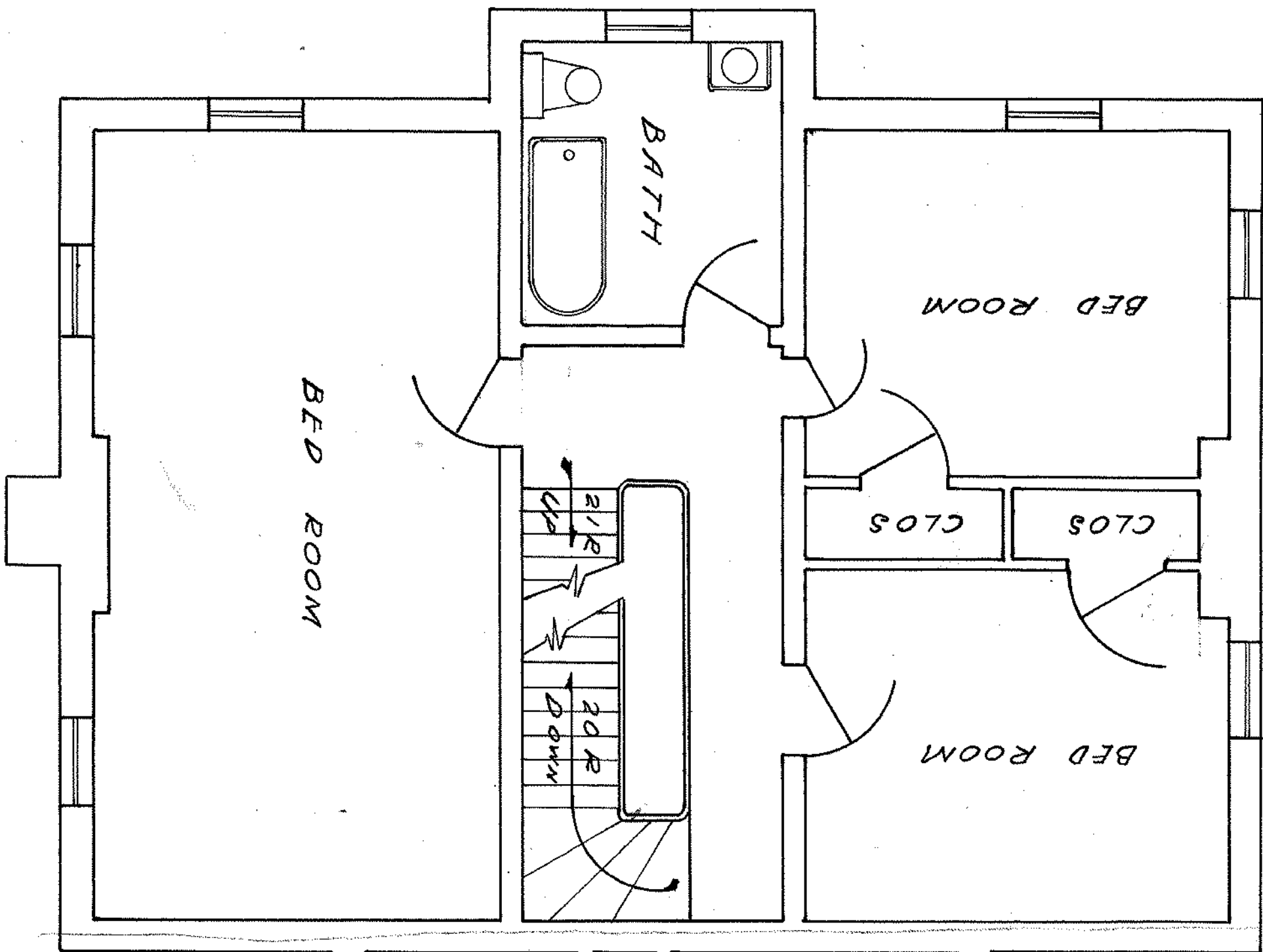




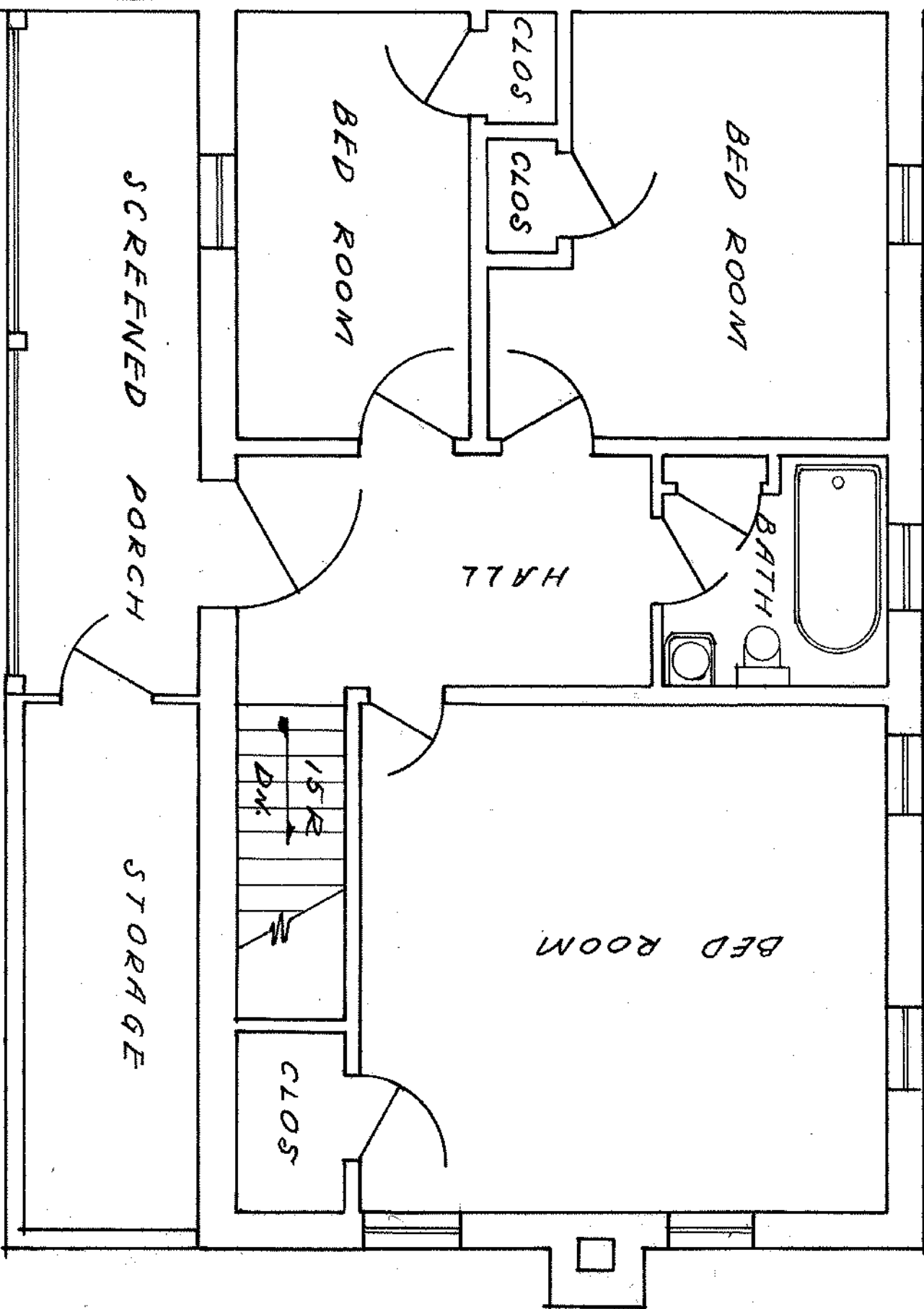


• SECOND FLOOR •

CEILING HEIGHT 10'-6"

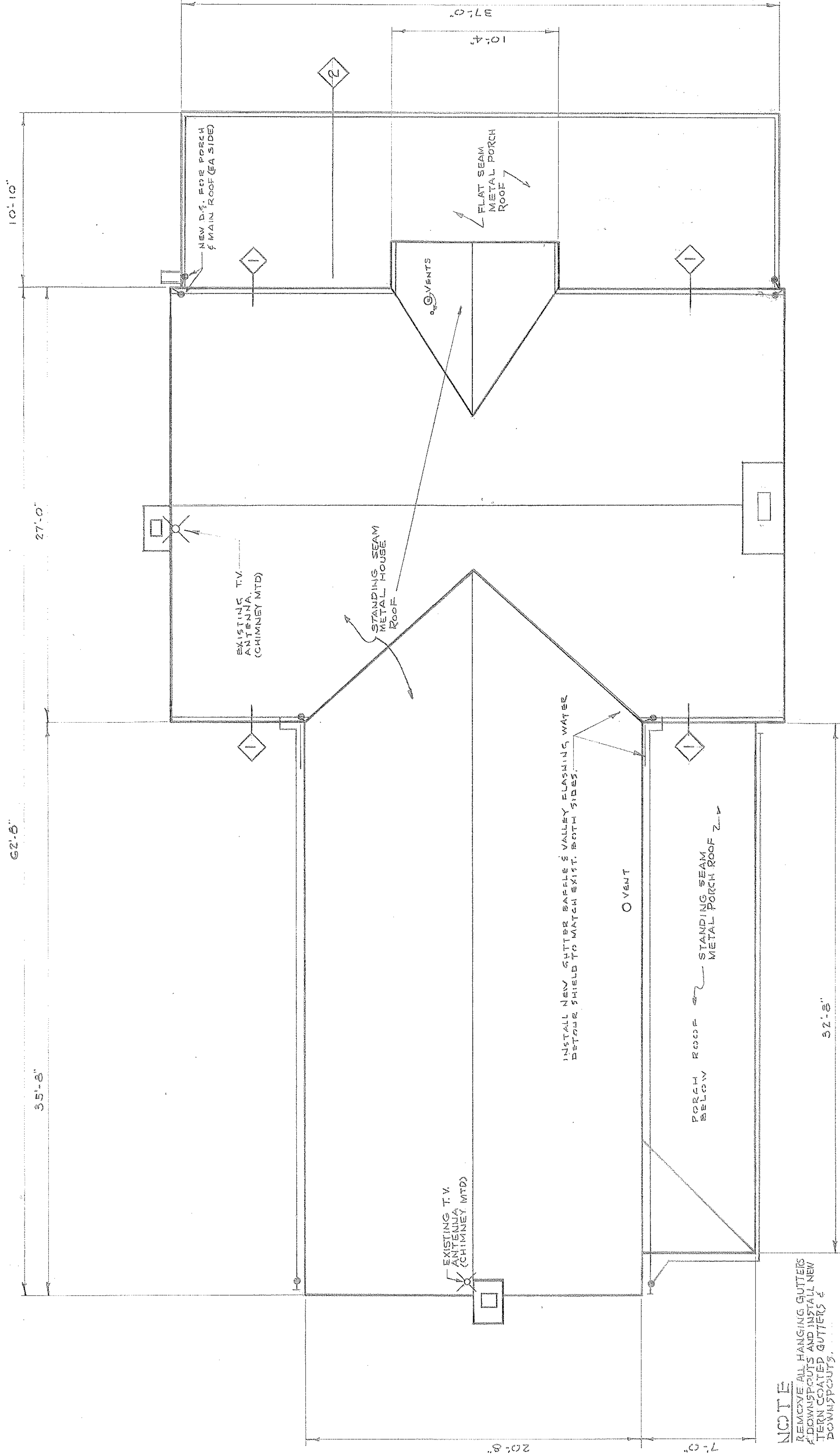


CEILING HEIGHT 9'-2"



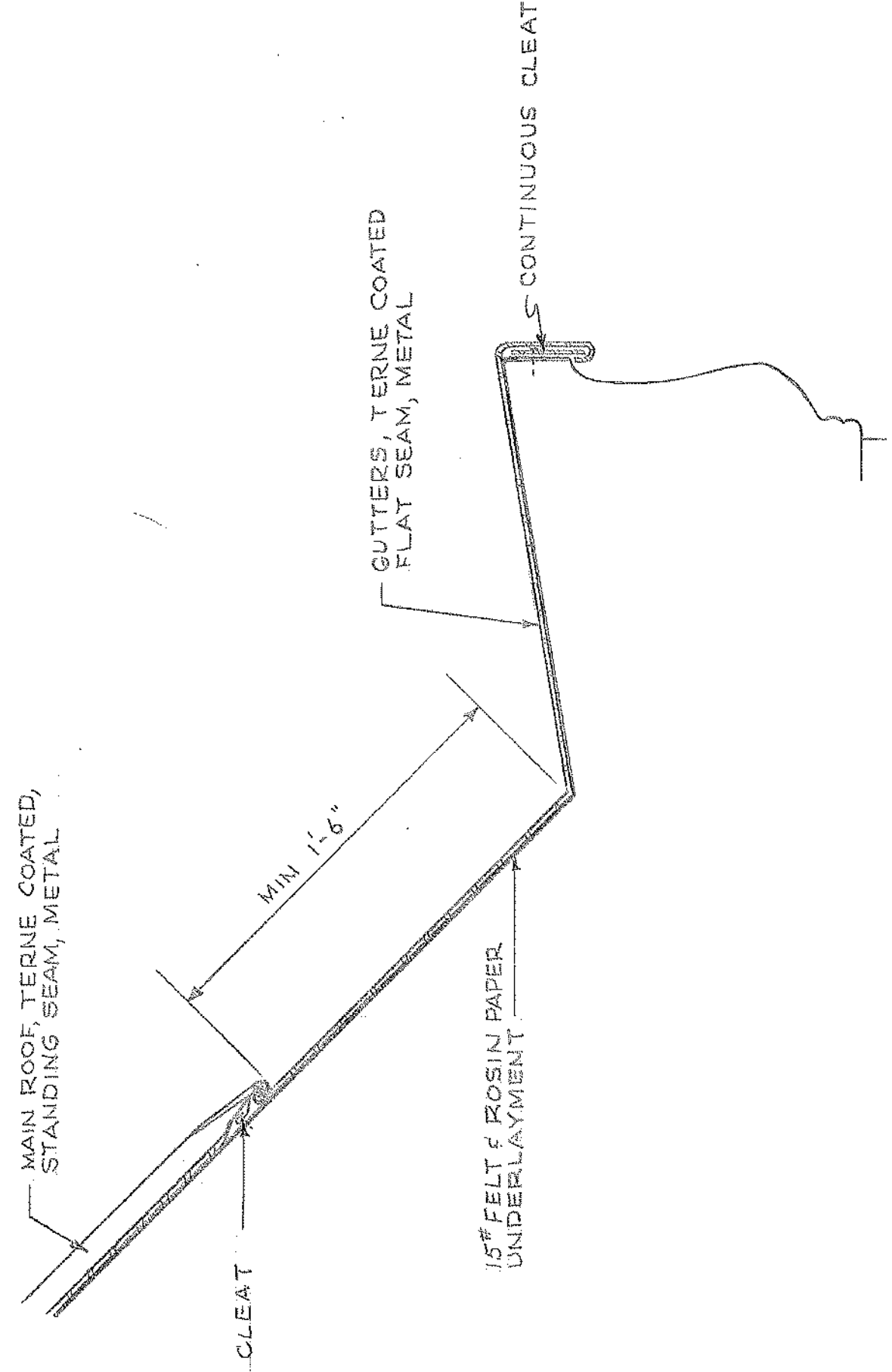
CHECKED BY DATE 7-8-47	REVISIONS	OFFICE OF THE POST ENGINEER CARLISLE BARRACKS
SECOND FLOOR PLAN		
BUILDING 39A & B		
DRAWN BY SUBMITTED BY	MAJOR G.E.	POST ENGINEER
TRACED BY	D.S.G.	COMMANING BRIG. GENERAL U.S.A.
7-8-47	DWG. NO. 12-115-1	DATE 7-8-47

839

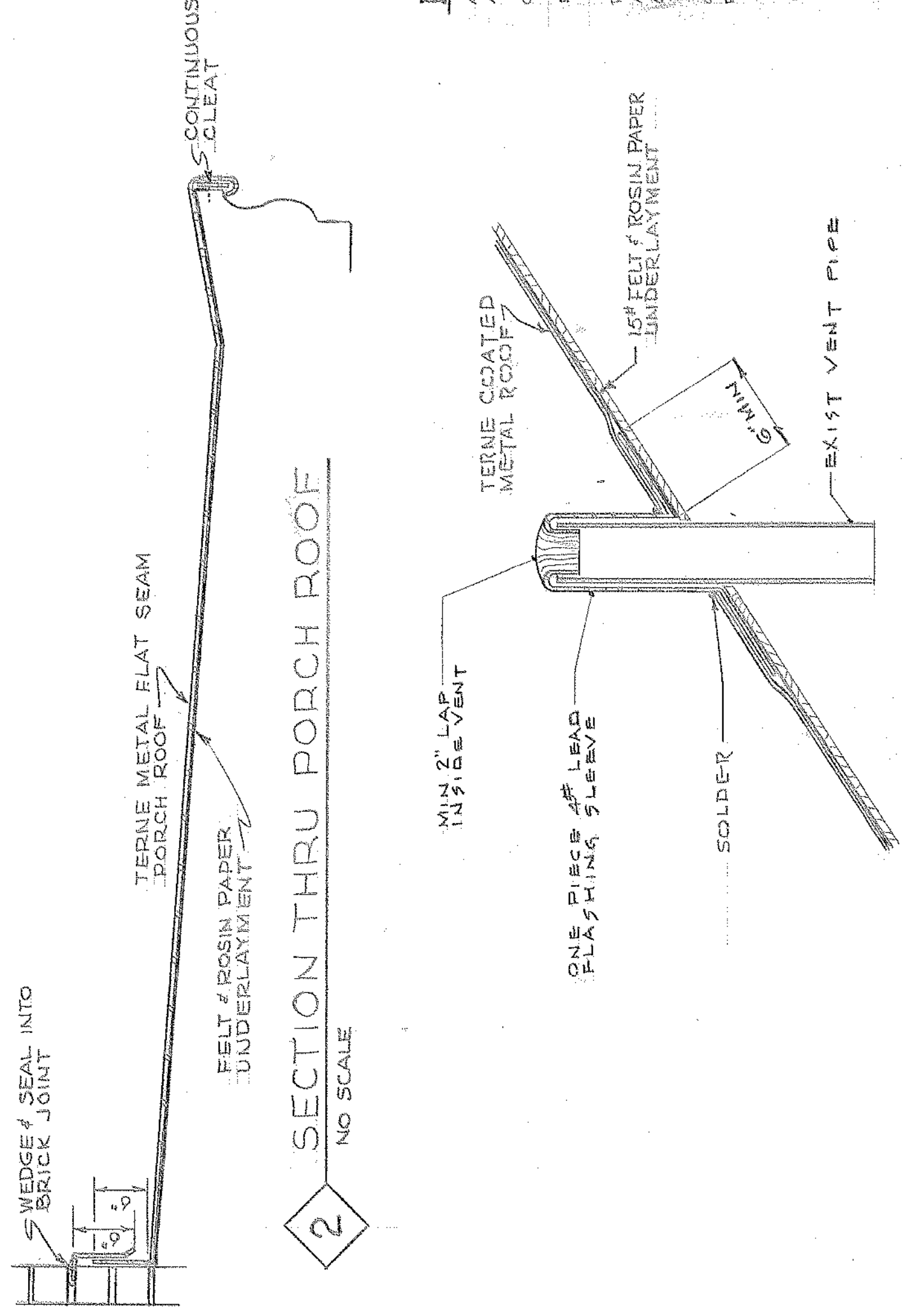


NOTE  
REMOVE ALL HANGING GUTTERS  
& DOWNSPUTS AND INSTALL NEW  
TERNE COATED GUTTERS &  
DOWNSPUTS.

ROOF PLAN  
NOT TO SCALE

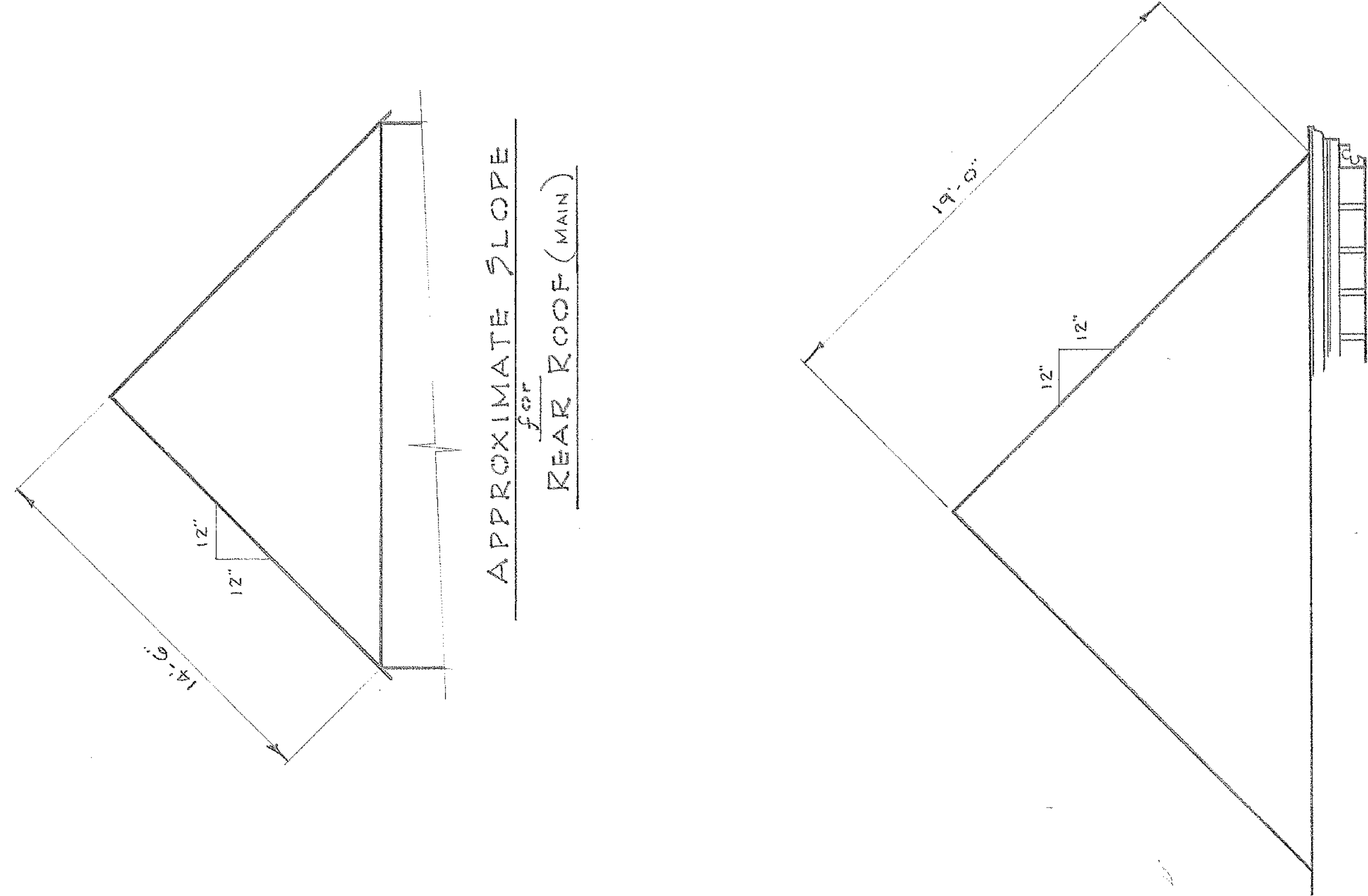


1 RAIN GUTTER DETAIL-MAIN ROOF  
NO SCALE



2 SECTION THRU PORCH ROOF  
NO SCALE

TYPICAL VENT PIPE FLASHING  
NOT TO SCALE



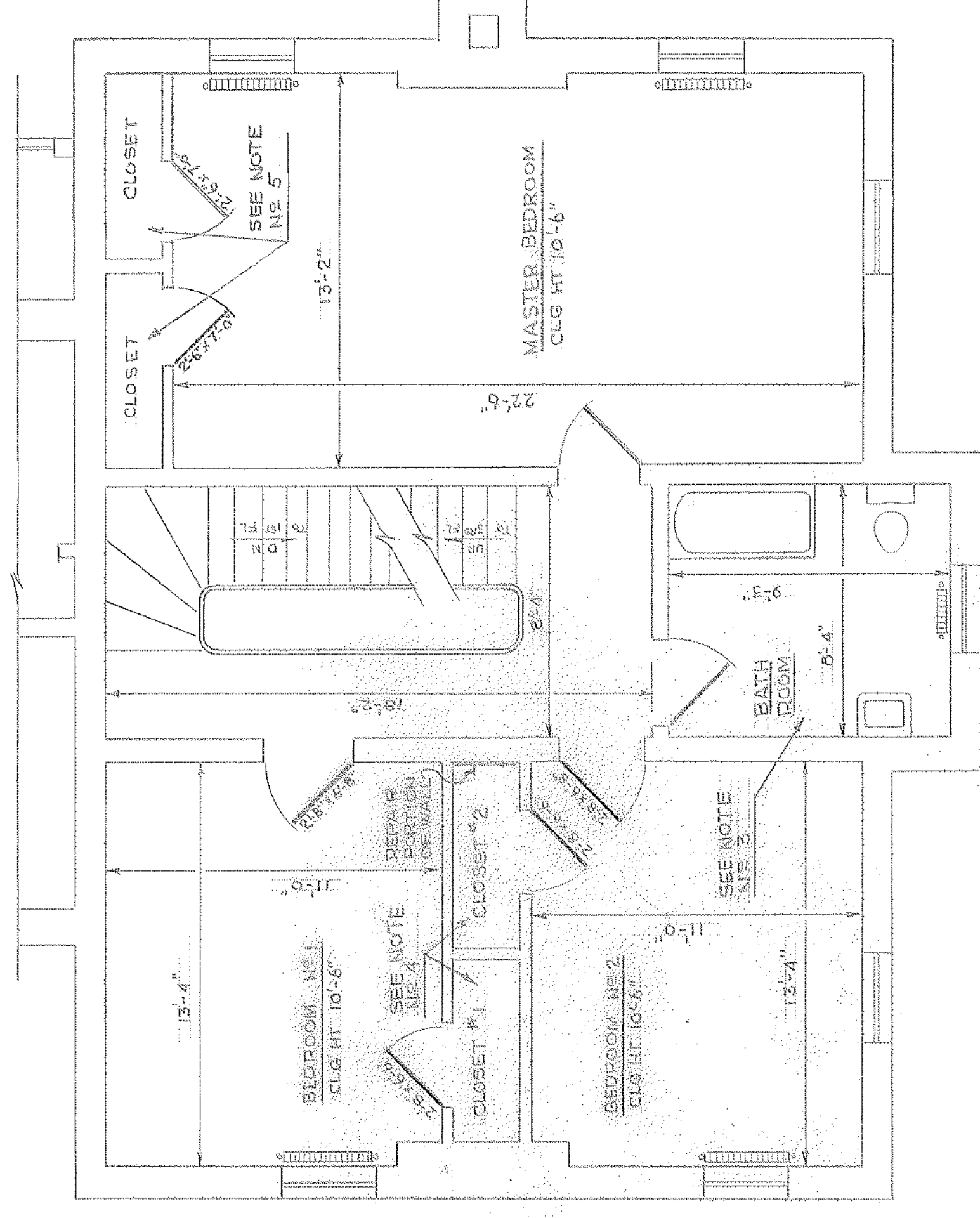
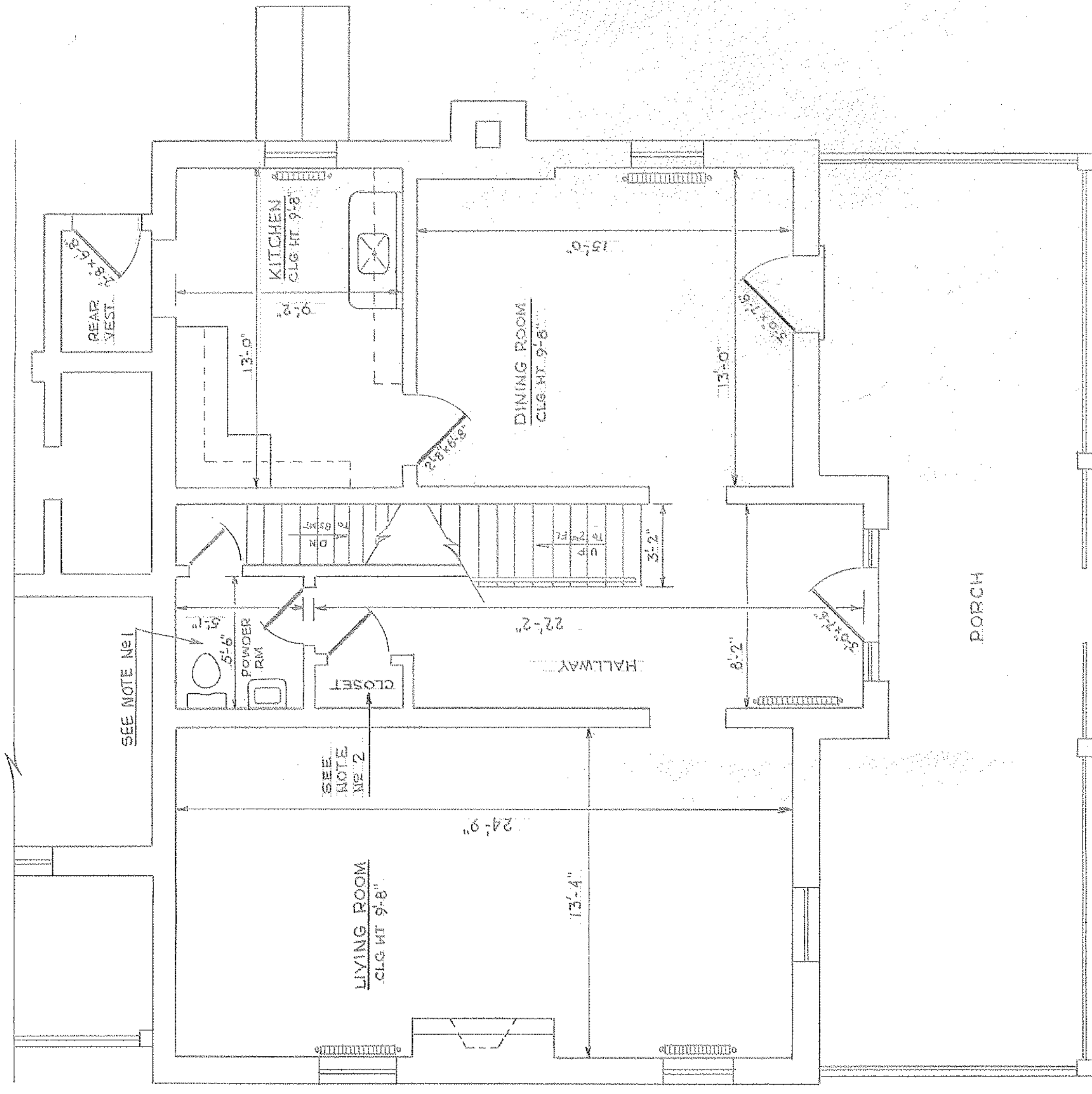
APPROXIMATE SLOPE  
for  
FRONT ROOF (MAIN)

NOTE

ALL DIMS & EXISTING CONDITIONS SHALL BE CHECKED & VERIFIED BY THE CONTRACTOR AT THE SITE.  
GUTTERS & DS. TO BE 26 GAUGE TERNE COATED STAINLESS STEEL  
FLASHING TO BE 26 GAUGE TERNE COATED STAINLESS STEEL  
REMOVE ANY DETERIORATED AND DAMAGED WOOD & REPLACE WITH NEW WOOD  
ALL NEW EXPOSED WOOD SHALL RECEIVE 1 PRIME COAT F&B SPEC. TT-P-25 & 2 FIN COATS TT-P-112B.  
CONTRACTOR SHALL REMOVE ALL ROOF DEBRIS AS IT ACCUMULATES & LEAVE THE PREMISES EACH DAY IN A CLEAN CONDITION.  
CONTRACTOR SHALL SUBMIT TO THE COR FOR APPROVAL SAMPLES FOR ALL REPAIRING ITEMS TO BE USED PRIOR TO USE OR INSTALLATION.

REVISION	DATE	BY	DESCRIPTION
ISSUED BY	DATE	BY	
SUBMITTED BY	DATE	BY	
CHIEF, ENG. PLANS	DATE	BY	
CHIEF, INTERIOR	DATE	BY	
CHIEF, ELEC. & MECH.	DATE	BY	
FIRE CHIEF	DATE	BY	
PORT ENGINEER	DATE	BY	
APPROVING AUTHORITY	DATE	BY	
APPROVING AUTHORITY	DATE	BY	
SCALE	NONE	SHEET	2 OF 2
PROJECT NO.	CEL-442 (14)	DRAWING NO.	1185B
PROJECT NAME	HEADQUARTERS, P.A.	DIRECTORATE OF FACILITIES ENGINEERING	
PROJECT LOCATION	REAR OF BLDG 839		

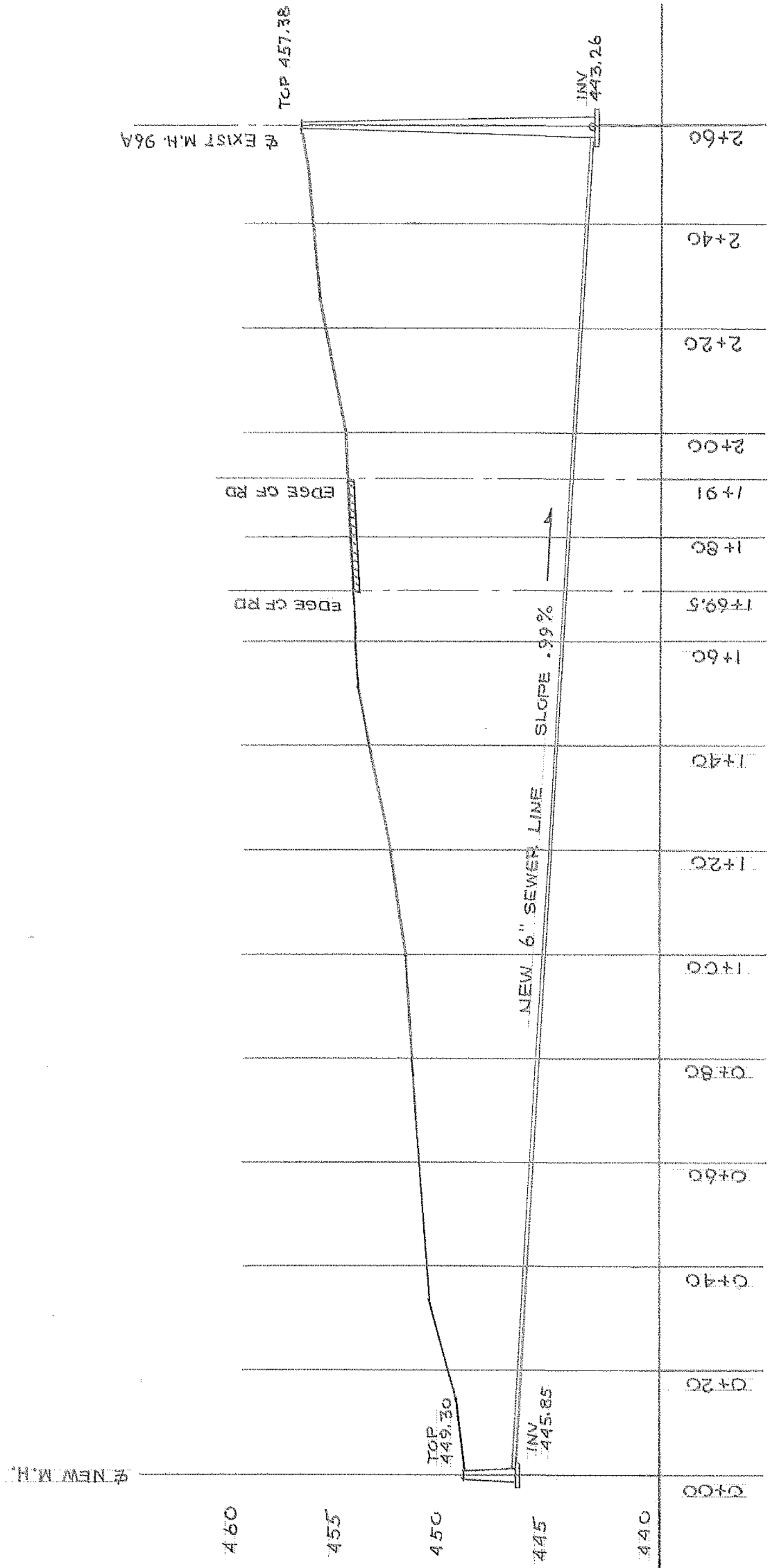
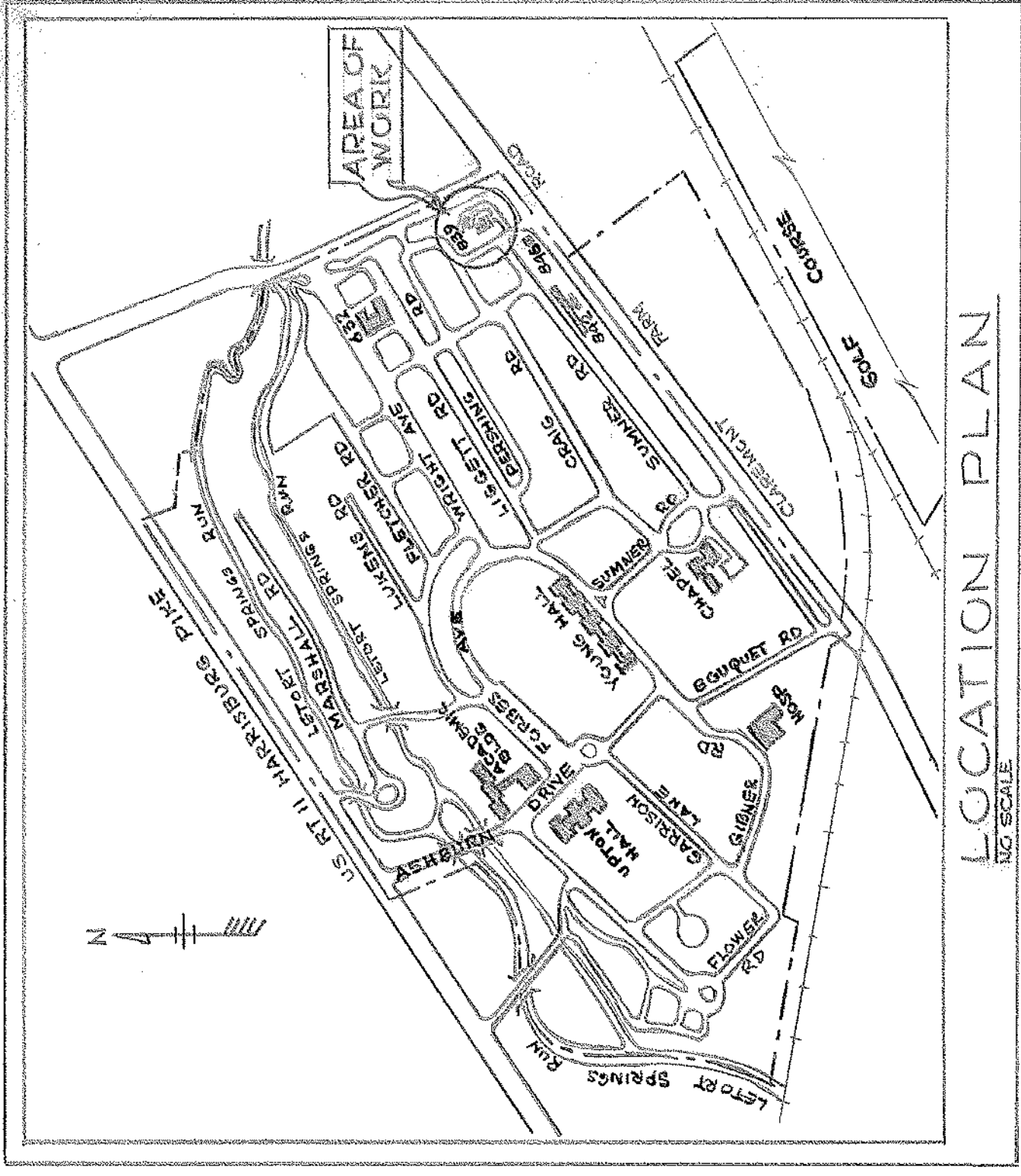




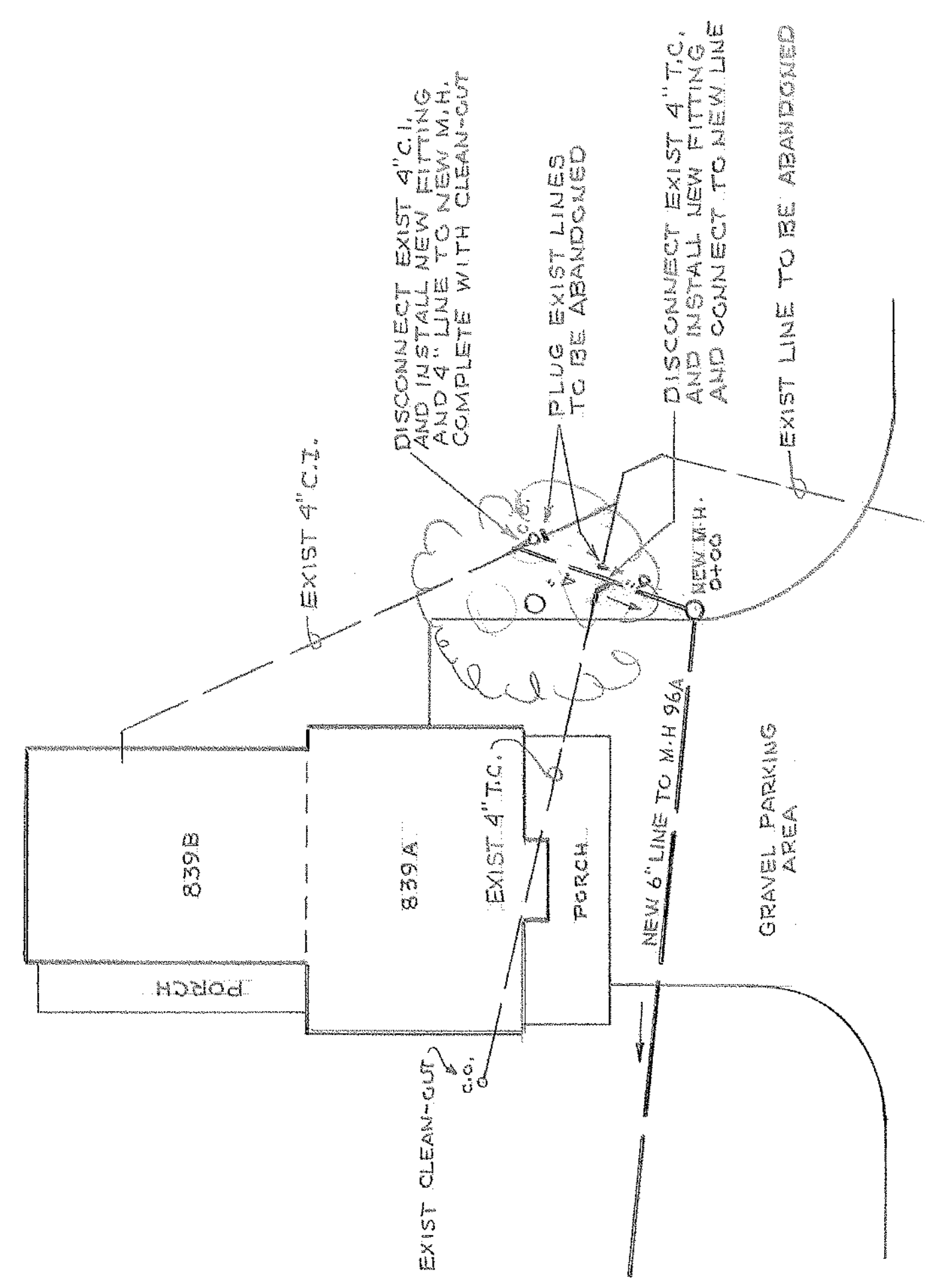
ETON

1. NO WORK REQUIRED IN POWDER ROOM.
2. NO WORK REQUIRED ON INTERIOR OR EXTERIOR WALLS AND CEILING OF HALLWAY CLOSET.
3. INSTALL WALLBOARD CEILING ONLY IN BATHROOM. REPAIR EXISTING WALLBOARD IN BATHROOM. ALL EXISTING TILE, GLASS, AND CERAMIC TILE TO REMAIN. SHALL BE PROTECTED AND ANY DAMAGE DUE TO THE NEGLIGENCE OF THE CONTRACTOR SHALL BE REPAIRED AT THE CONTRACTOR'S EXPENSE.
4. NO WORK REQUIRED IN INTERIOR OF BEDROOM CLOSETS #1 & 2 EXCEPT AS NOTED.
5. CONSTRUCT FRAMING AND LOWER NEW CEILING TO 5'-0" AFF IN 2 EACH MASTER BEDROOM CLOSETS.

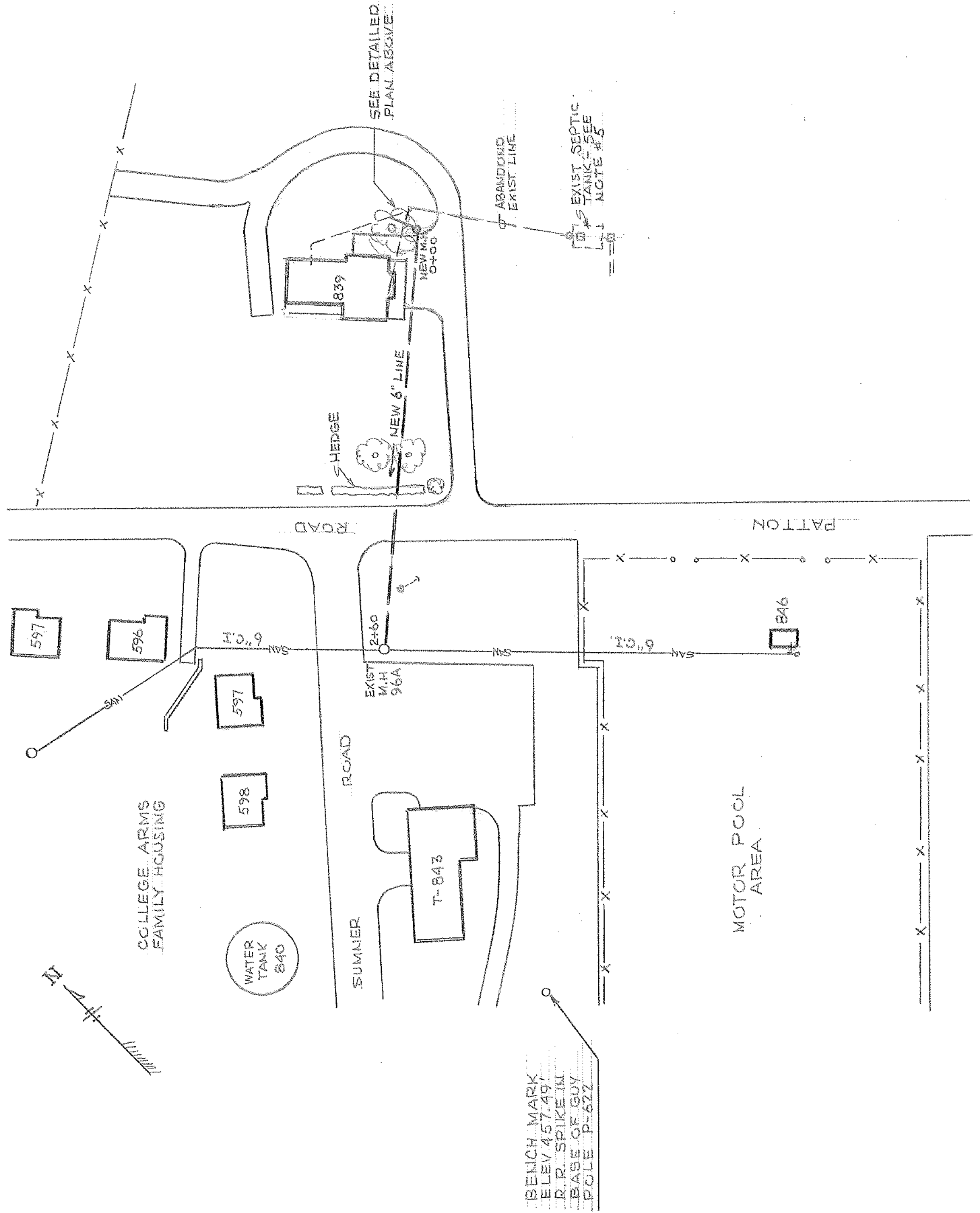
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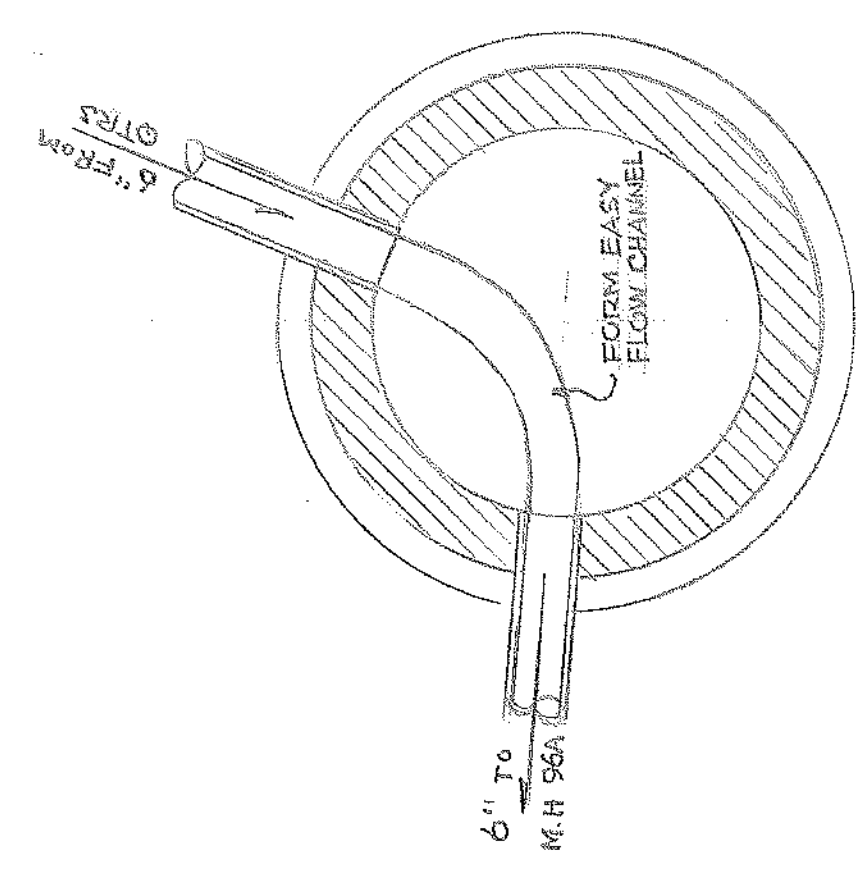
PROFILE - NEW 6" SEWER LINE  
HORIZONTAL 1"=20'  
VERTICAL 1"=5'



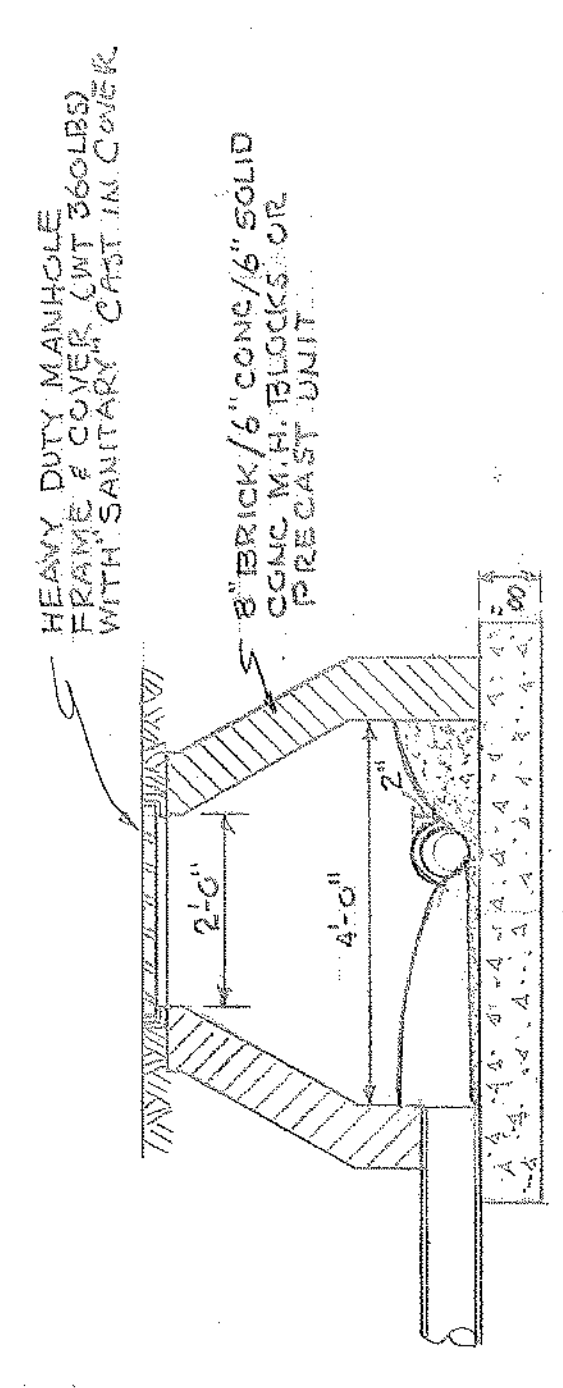
DETAILED PLAN AT BLDG 839  
1/2"=10'



PLOT PLAN  
1"=50'



PLAN



SECTION

MANHOLE DETAIL  
1/2"=10"

STRUCTURAL NOTES

1. EXCAVATE AND INSTALL NEW SEWER LINE AND CONNECT TO EXISTING SERVICE LINES COMPLETE WITH NEW MANHOLE AND ALL REQUIRED FITTINGS. BECAUSE OF THE DEEP CUT EXTRA CARE SHALL BE TAKEN TO PROTECT EXISTING UTILITIES AND TO PROTECT THE WORK AND PERSONNEL.
2. MODIFY BOTTOM OF EXISTING MANHOLE 96A AND FORM AN EASY FLOW CHANNEL FOR NEW LINE.
3. REMOVE HEDGE AS REQUIRED TO INSTALL NEW LINE AND REINSTALL AFTER COMPLETION OF WORK.
4. REPAIR BITUMINOUS PAVEMENT DISTURBED TO ACCOMPLISH WORK AS SPECIFIED.
5. PUMP EXISTING SEPTIC TANK (500 GAL), DESTROY THE BOTTOM AND TOP 18\"/>
6. PROVIDE MINIMUM 4\"/>
7. DUE TO THE QUANTITY OF ROCK EXCAVATION ANTICIPATED, LIGHT CHARGES OF EXPLOSIVES WITH PROTECTIVE MATING WILL BE USED FOR ROCK REMOVAL BY LICENSED HANDLERS ACCORDING TO STATE REGULATIONS.

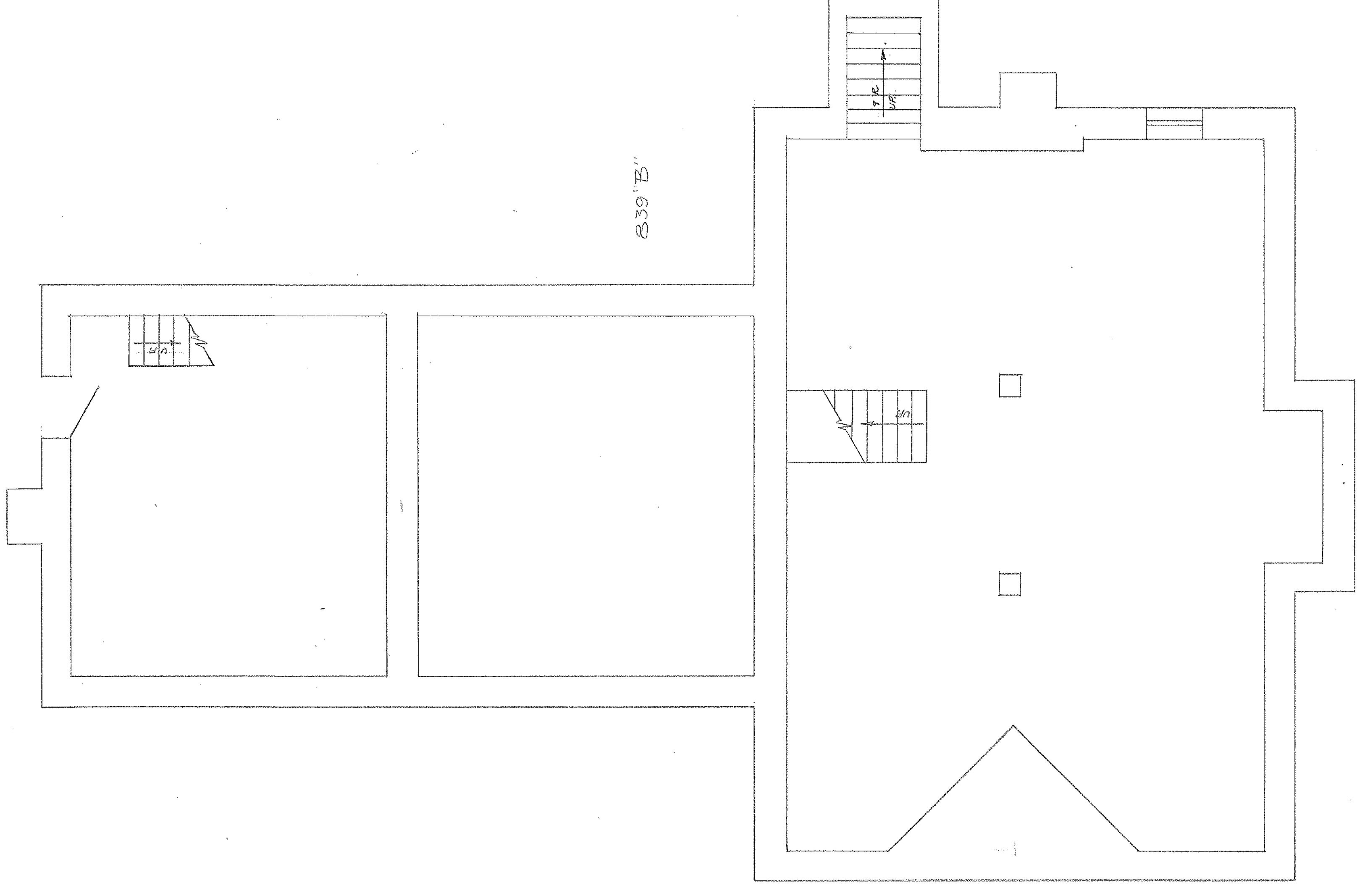
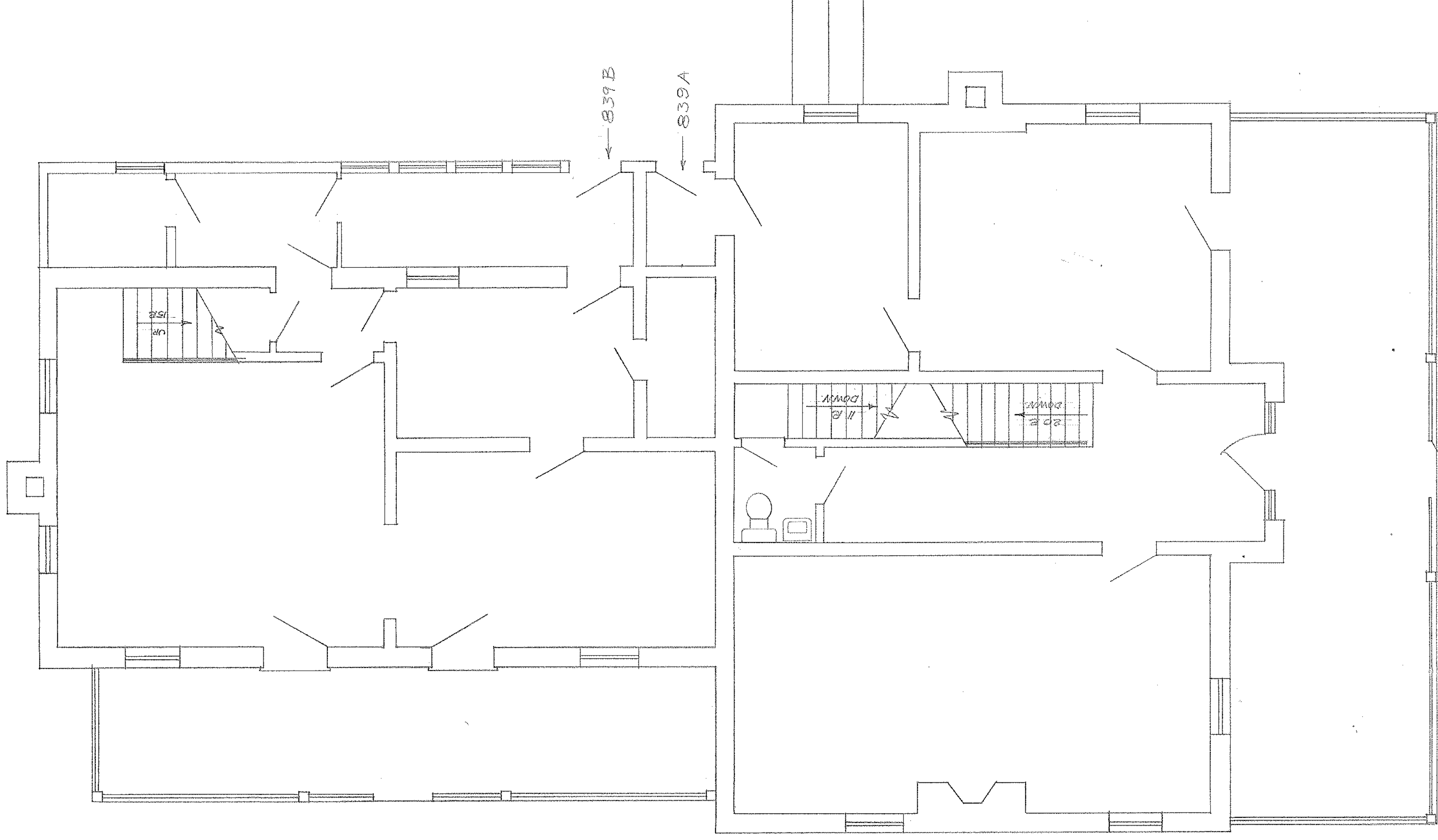
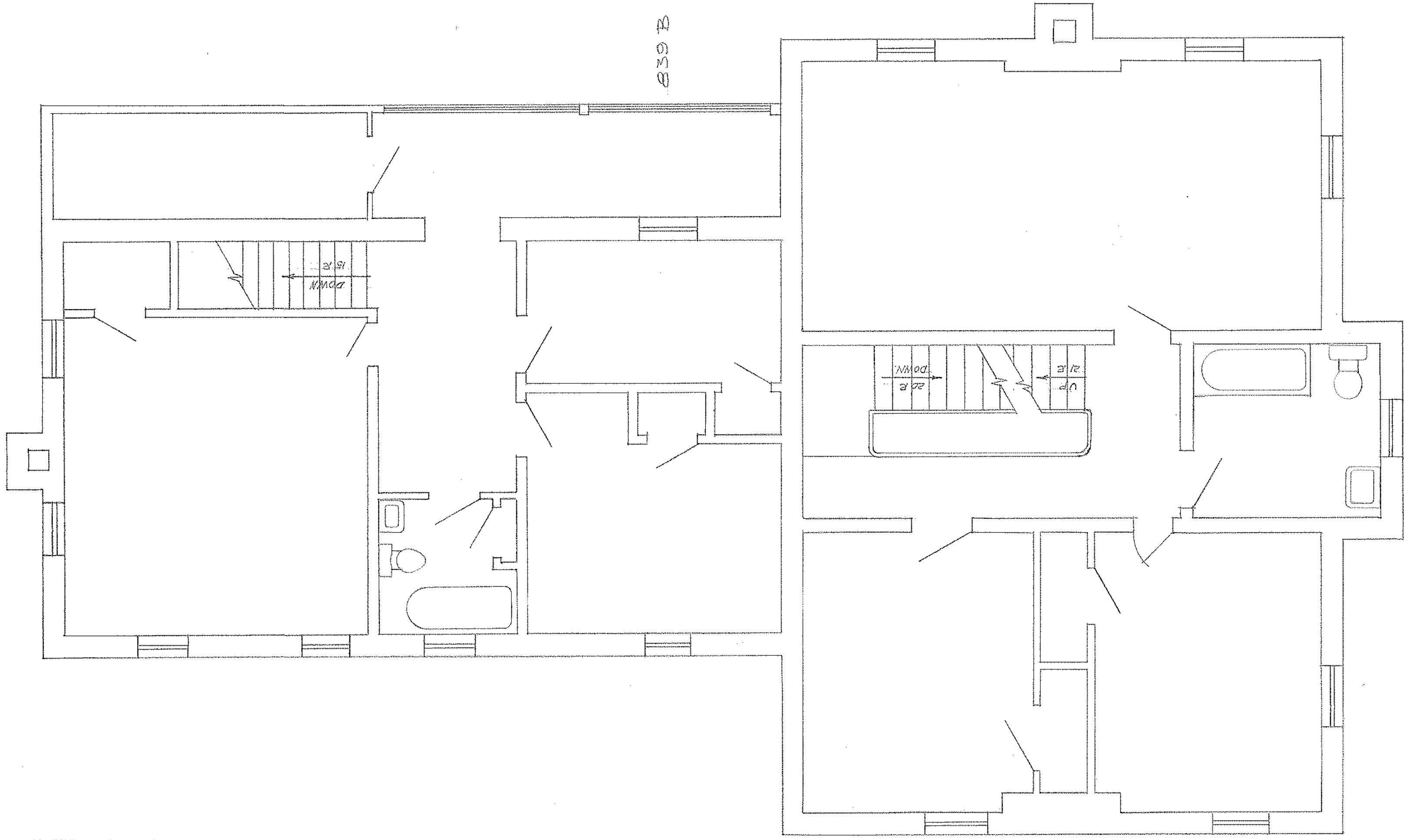
REVISION	DATE	BY	DESCRIPTION
DRAWN BY	DESIGN BY	DATE	
SUBMITTED BY	DATE		
CHIEF, ENGINEERING			
CHIEF, PLANS			
CHIEF, OPER & MAINT			
CHIEF, HOUSING			
CHIEF, FIRE			
CHIEF, SAFETY			
CHIEF, OFFICE			
APPROVAL			
APPLY USING ACTIVITY			
PROJECT NO.	CEKS 063-81		
DRAWING NO.	1314		
SCALE	AS NOTED	SHEET	1 OF 1

HEADQUARTERS  
CARLISLE BARRACKS, PA.  
DIRECTORATE OF FACILITIES ENGINEERING

REPLACE SEWER SYSTEM  
BLDG 839  
PLANS & DETAILS

APPROVED BY: [Signature]  
DATE: [Date]



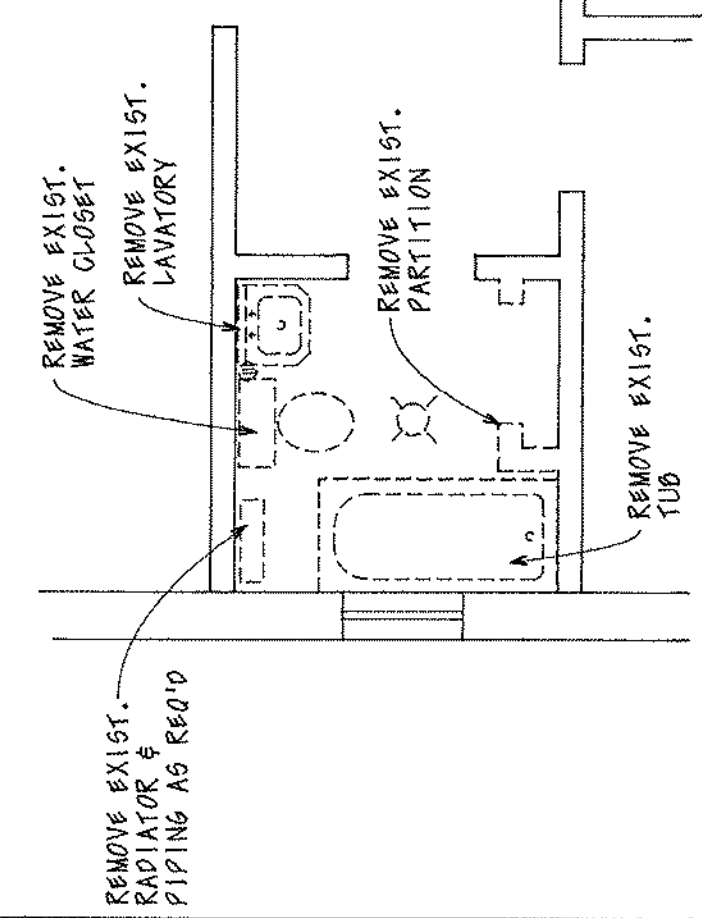


SECOND FLOOR  
CH. 104-6  
839 A

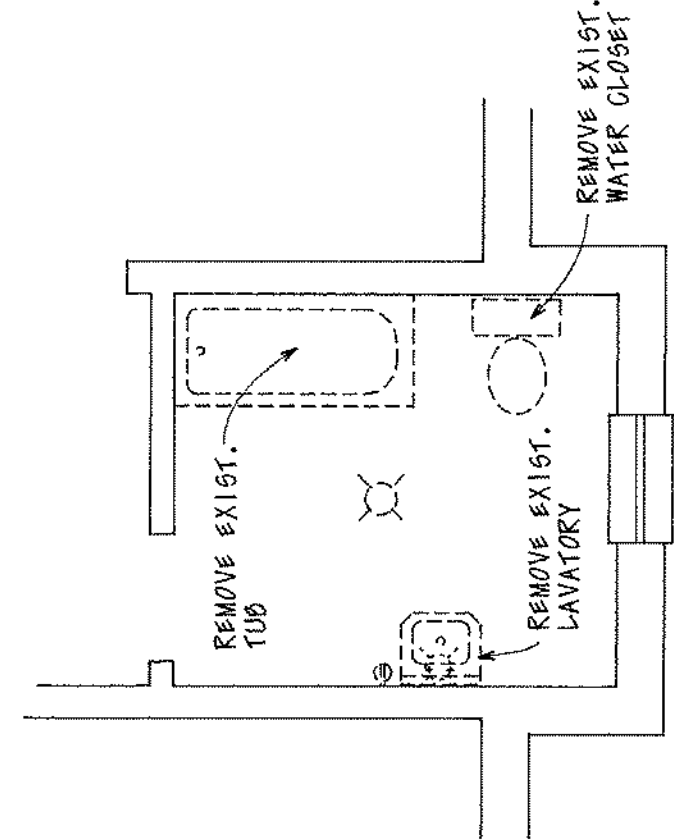
FIRST FLOOR  
CH. 91-3  
839 A

BASEMENT  
CH. 640-0  
839 A

DATE	PROJECT NO.
SCALE 1/4" = 1'	THE ARMY WAR COLLEGE CARLISLE BARRACKS, PA.
DRAWN BY G.D.M.	OFFICE OF THE POST ENGINEER
TRACED BY	BUILDING NUMBER 39-A
CHECKED BY	839
SUBMITTED BY	DRAWING NO.
APPROVED BY	SHEET OF

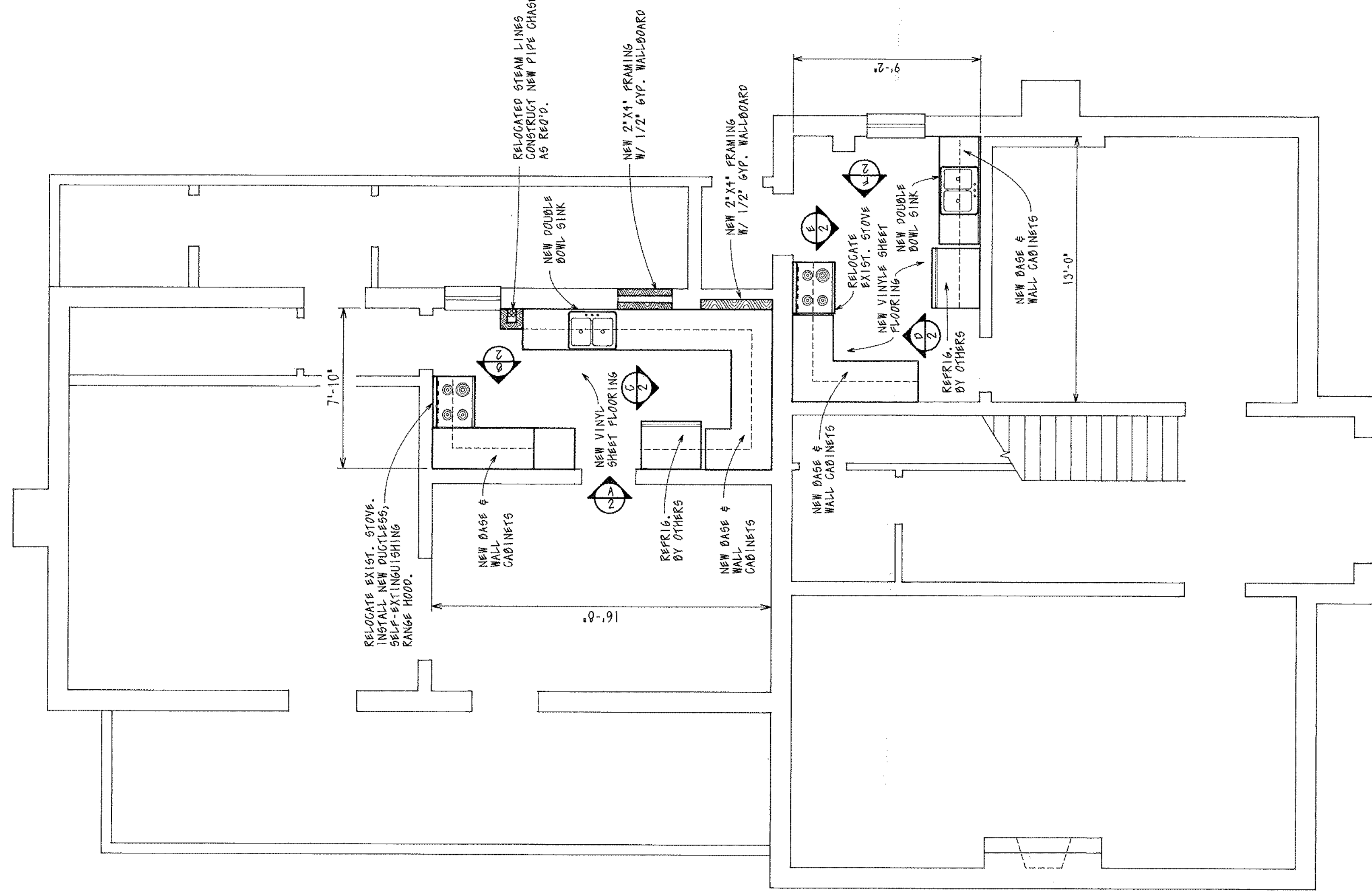


REMOVAL PLAN - 0106. 039 D  
SCALE: 1/4" = 1'-0"

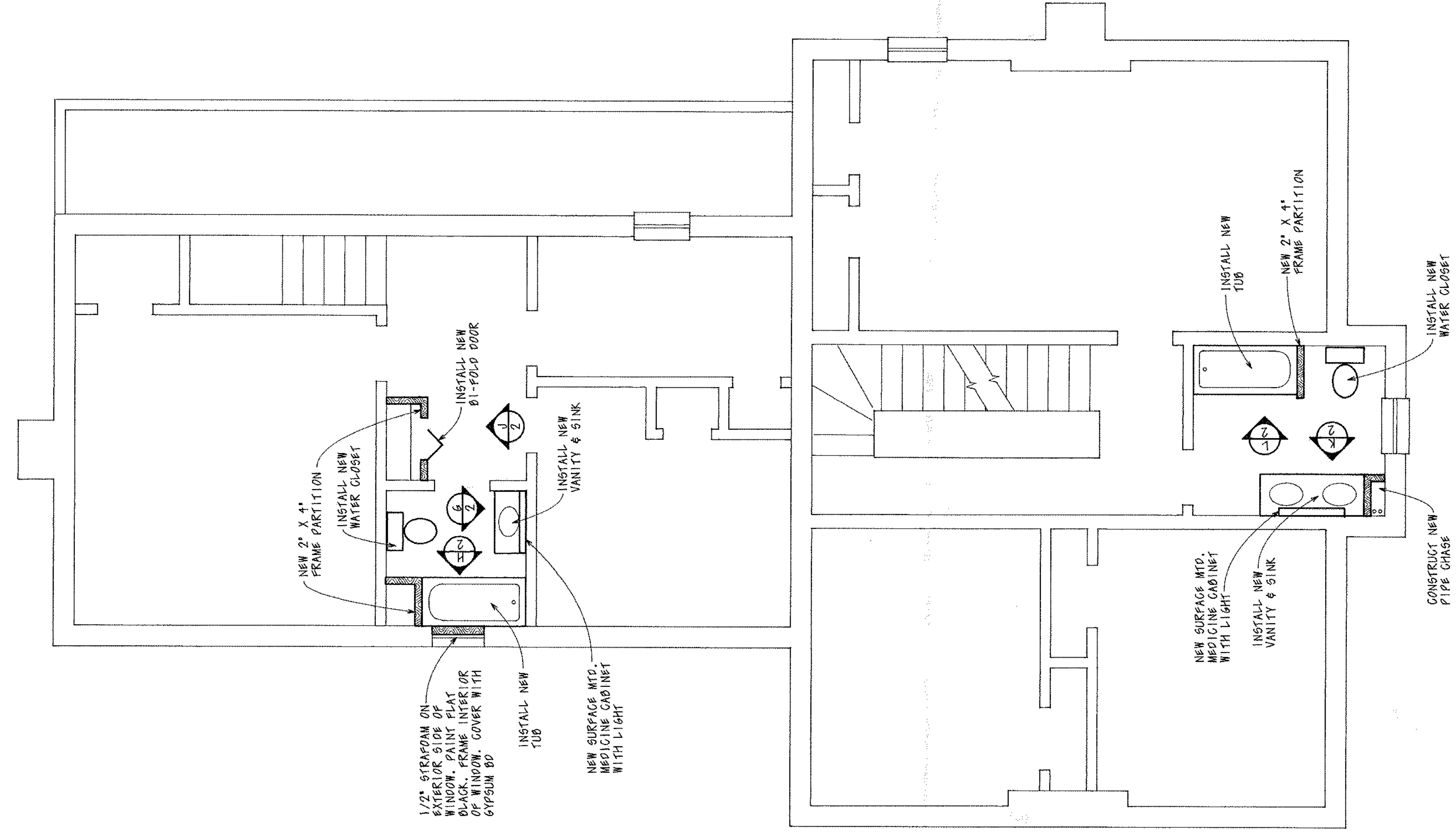


REMOVAL PLAN - 0106. 039 A  
SCALE: 1/4" = 1'-0"

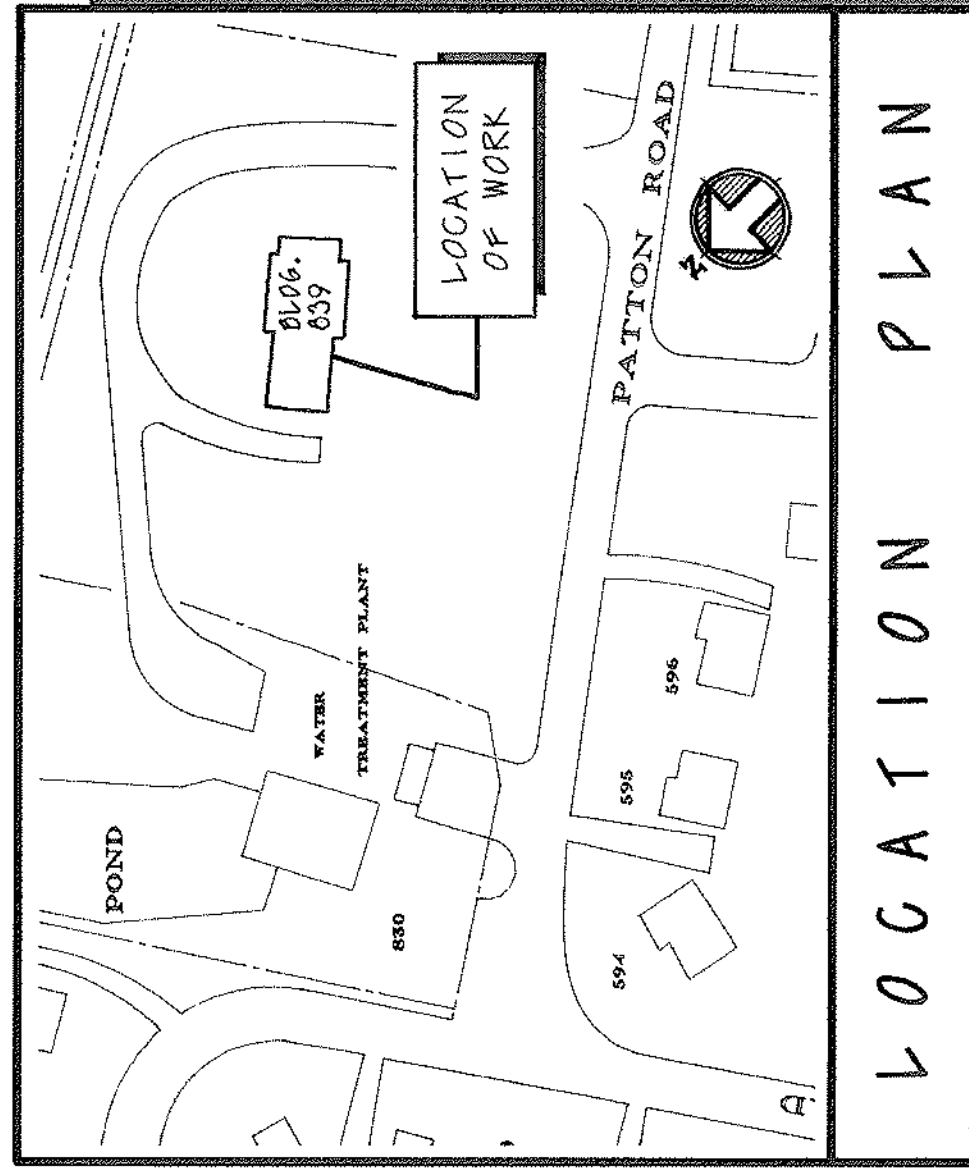
- GENERAL NOTES:
1. RELOCATE STEAM LINES, WATER SUPPLY, DRAIN LINES AND ELECTRIC AS REQUIRED FOR NEW LAYOUT OF KITCHENS AND BATHROOMS.
  2. ALL ELECTRICAL SHALL CONFORM TO THE NEC
  3. PAINT BATHROOMS AND KITCHENS 1 PRIME COAT AND 2 FINISH COATS SEMI GLOSS LINEN.



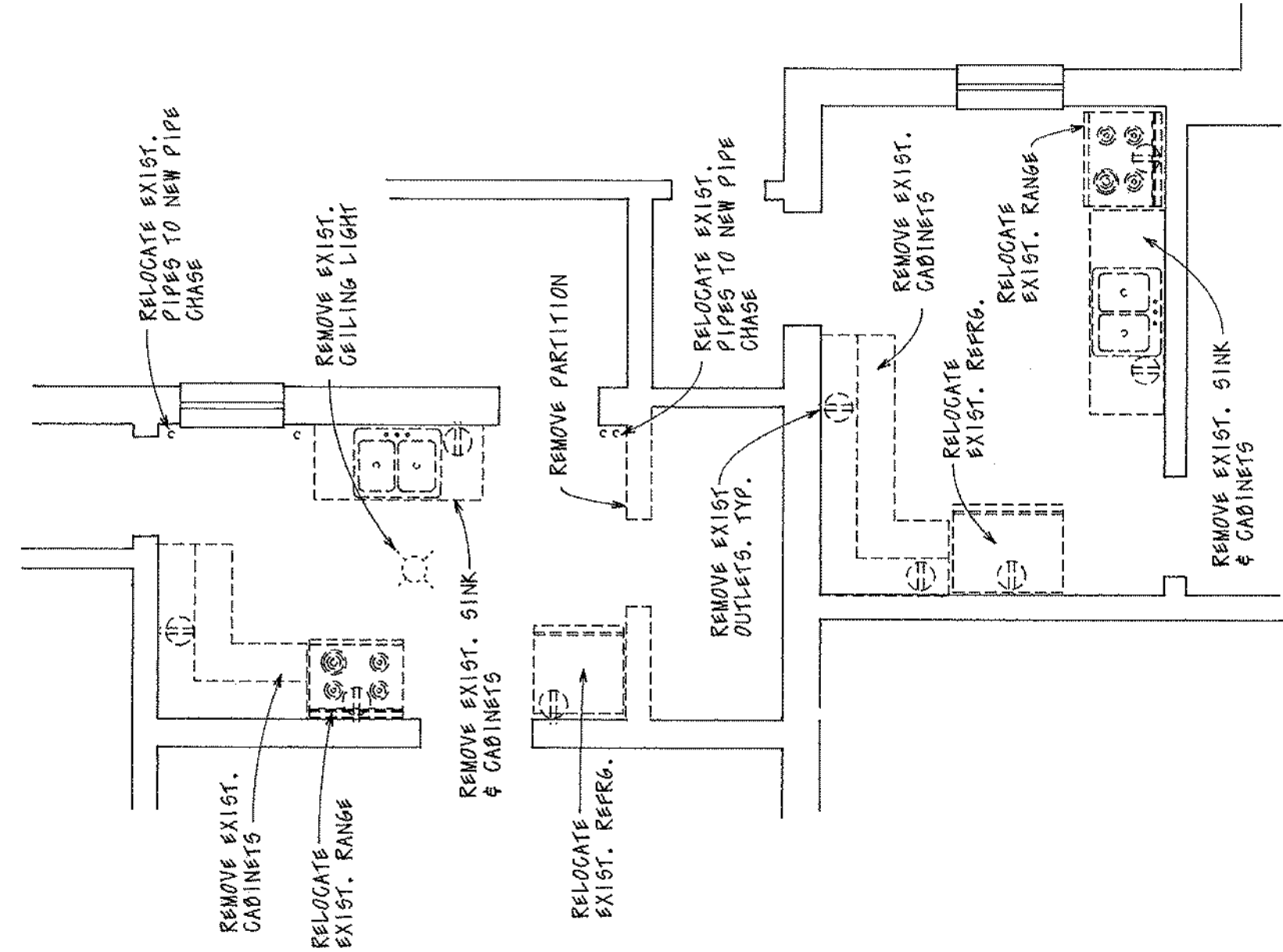
FLOOR PLAN - 0106. 039 - FIRST FLOOR  
SCALE: 1/4" = 1'-0"



FLOOR PLAN - 0106. 039 - SECOND FLOOR  
SCALE: 1/4" = 1'-0"



LOCATION PLAN



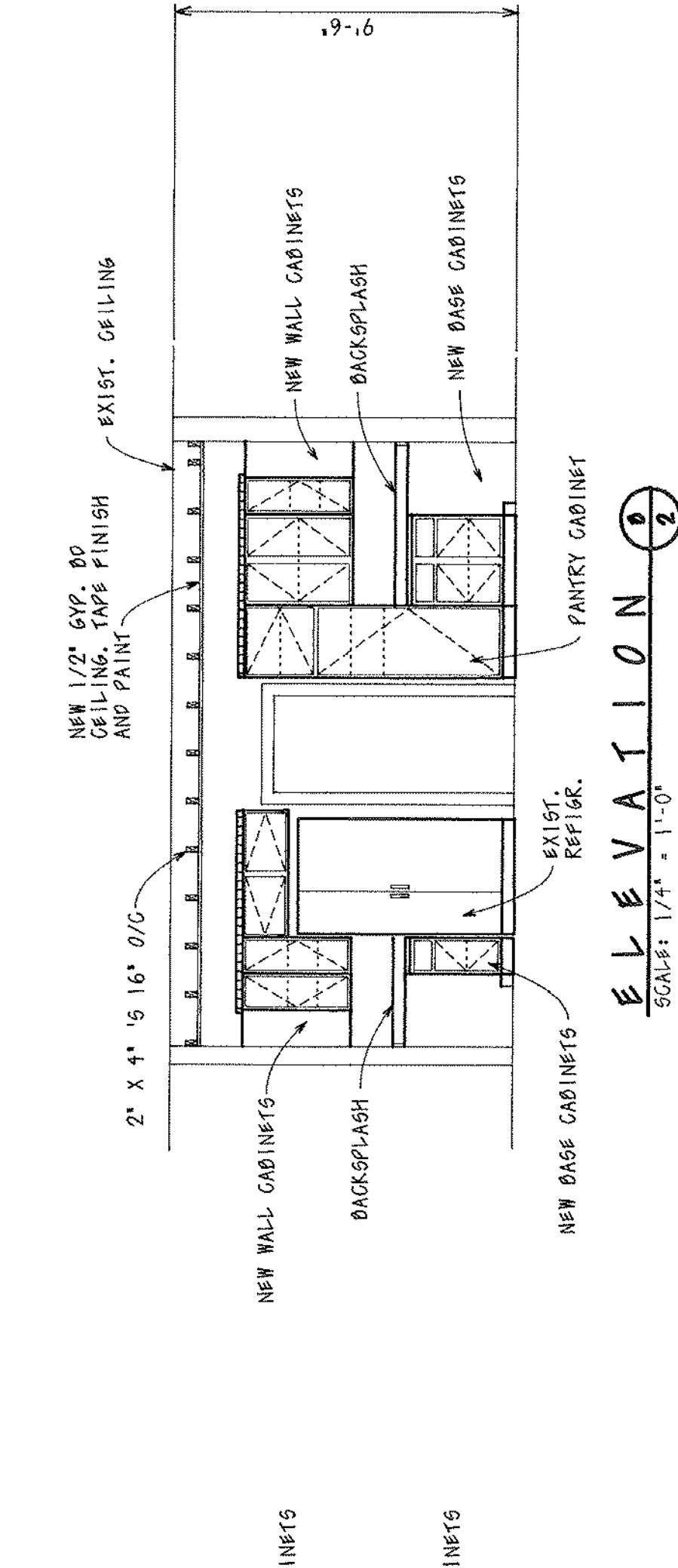
REMOVAL PLAN - 0106. 039 A & D  
SCALE: 1/4" = 1'-0"

REVISION	DATE	DESCRIPTION
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2	AUG. 92	ISSUED FOR CONSTRUCTION
3	AUG. 92	ISSUED FOR CONSTRUCTION
4	AUG. 92	ISSUED FOR CONSTRUCTION
5	AUG. 92	ISSUED FOR CONSTRUCTION
6	AUG. 92	ISSUED FOR CONSTRUCTION
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9	AUG. 92	ISSUED FOR CONSTRUCTION
10	AUG. 92	ISSUED FOR CONSTRUCTION
11	AUG. 92	ISSUED FOR CONSTRUCTION
12	AUG. 92	ISSUED FOR CONSTRUCTION
13	AUG. 92	ISSUED FOR CONSTRUCTION
14	AUG. 92	ISSUED FOR CONSTRUCTION
15	AUG. 92	ISSUED FOR CONSTRUCTION
16	AUG. 92	ISSUED FOR CONSTRUCTION
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98	AUG. 92	ISSUED FOR CONSTRUCTION
99	AUG. 92	ISSUED FOR CONSTRUCTION
100	AUG. 92	ISSUED FOR CONSTRUCTION

ALL CONSTRUCTION PRACTICES SHALL CONFORM WITH CURRENT OSHA REGULATIONS.

ALL DIMENSIONS AND EXISTING CONSTRUCTION TO BE VERIFIED BY THE CONTRACTOR IN THE FIELD.

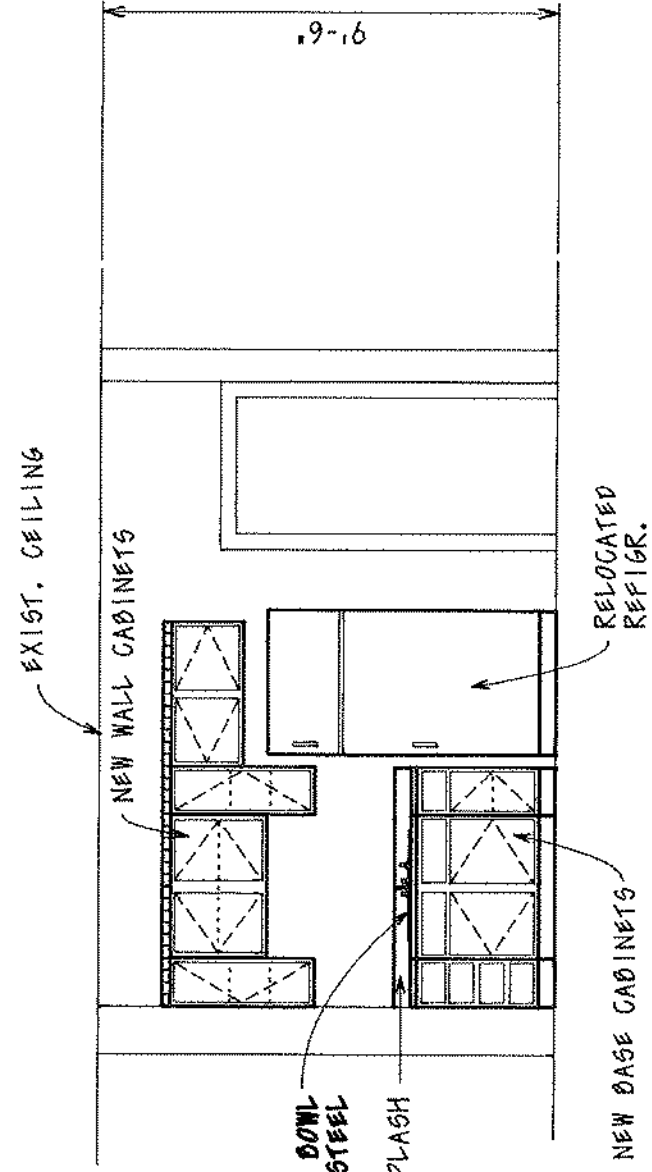




ELEVATION

SCALE:  $1/4" = 1'-0"$

2

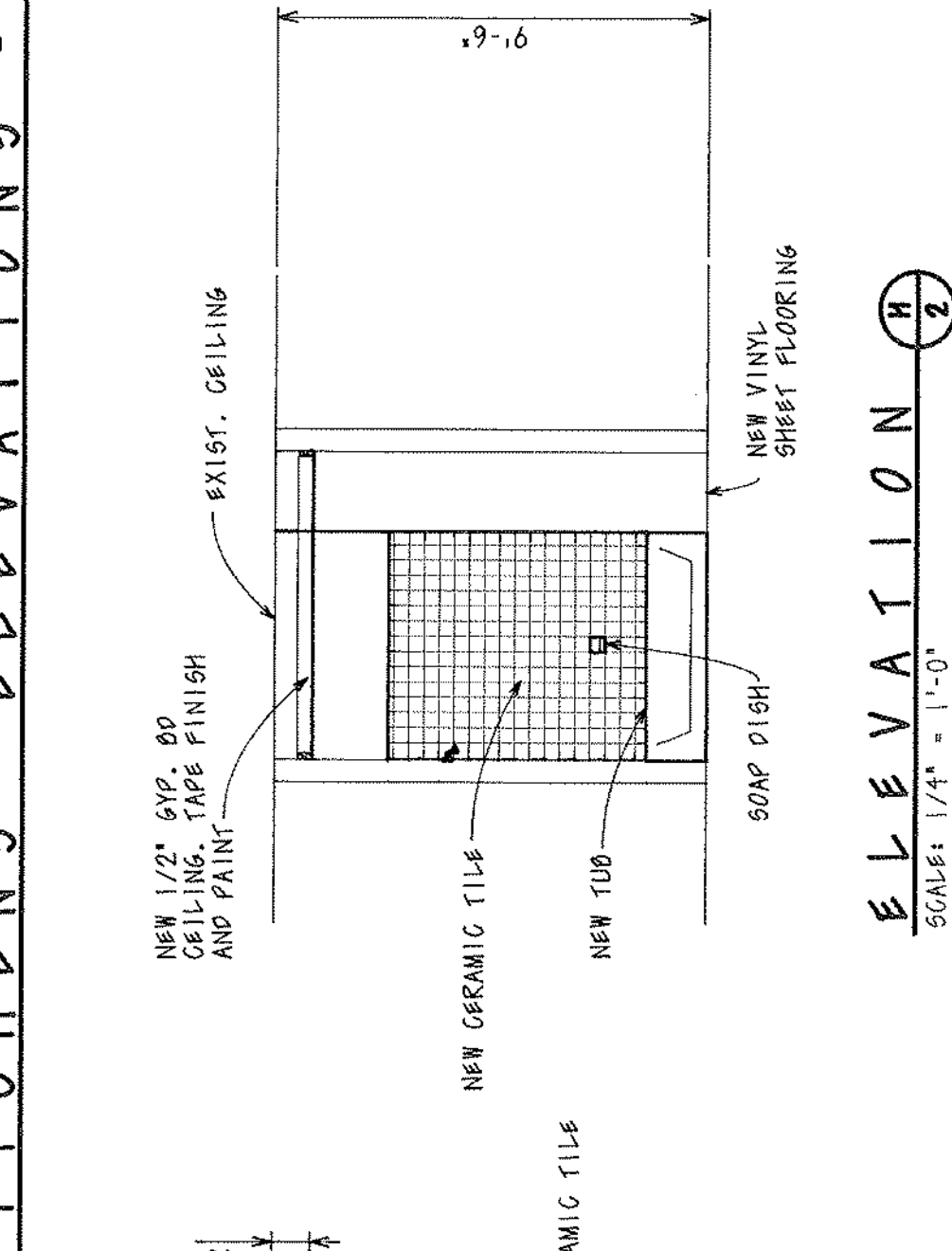


ELEVATION

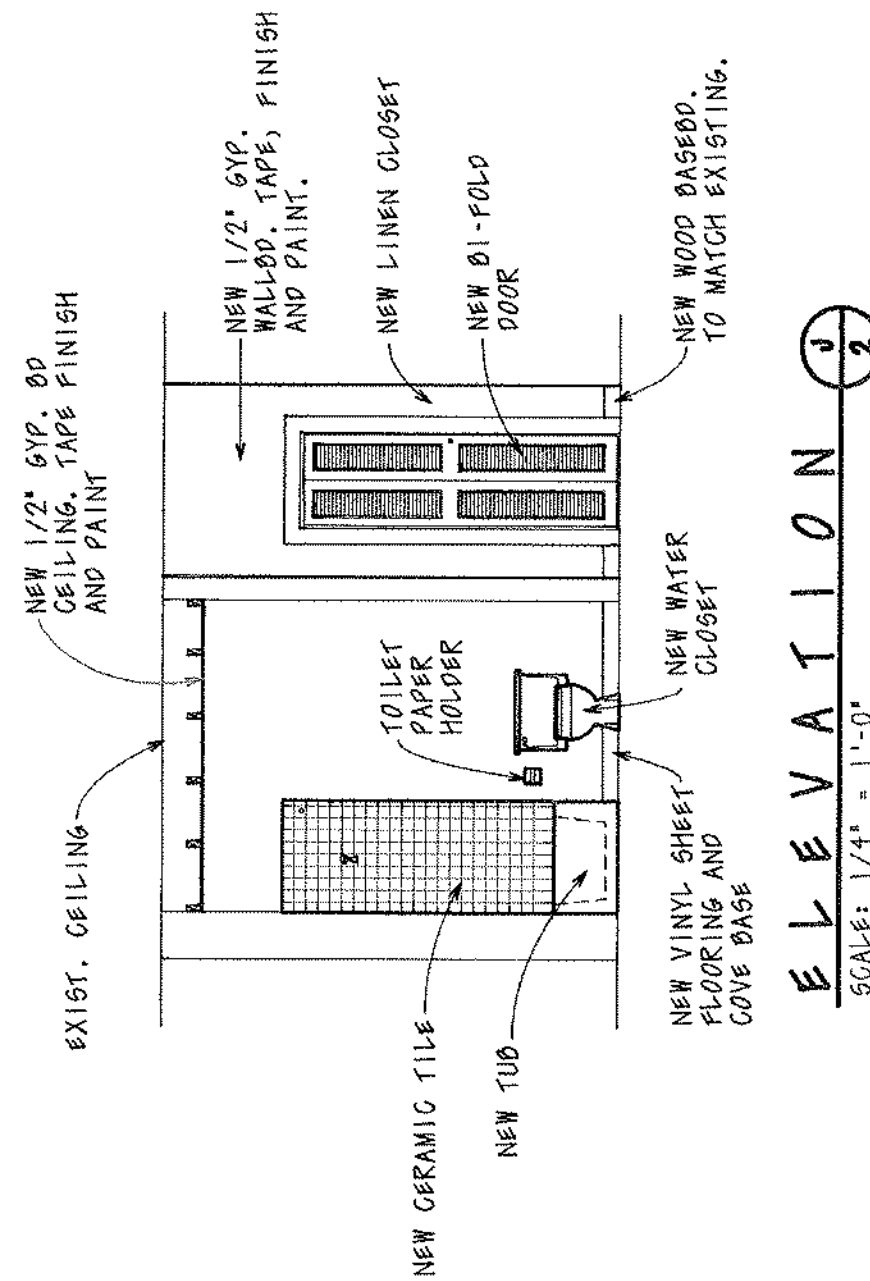
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SCALE:  $1/4" = 1'-0"$

2



ELEVATION  $\frac{H}{2}$   
SCALE:  $1/4" = 1'-0"$

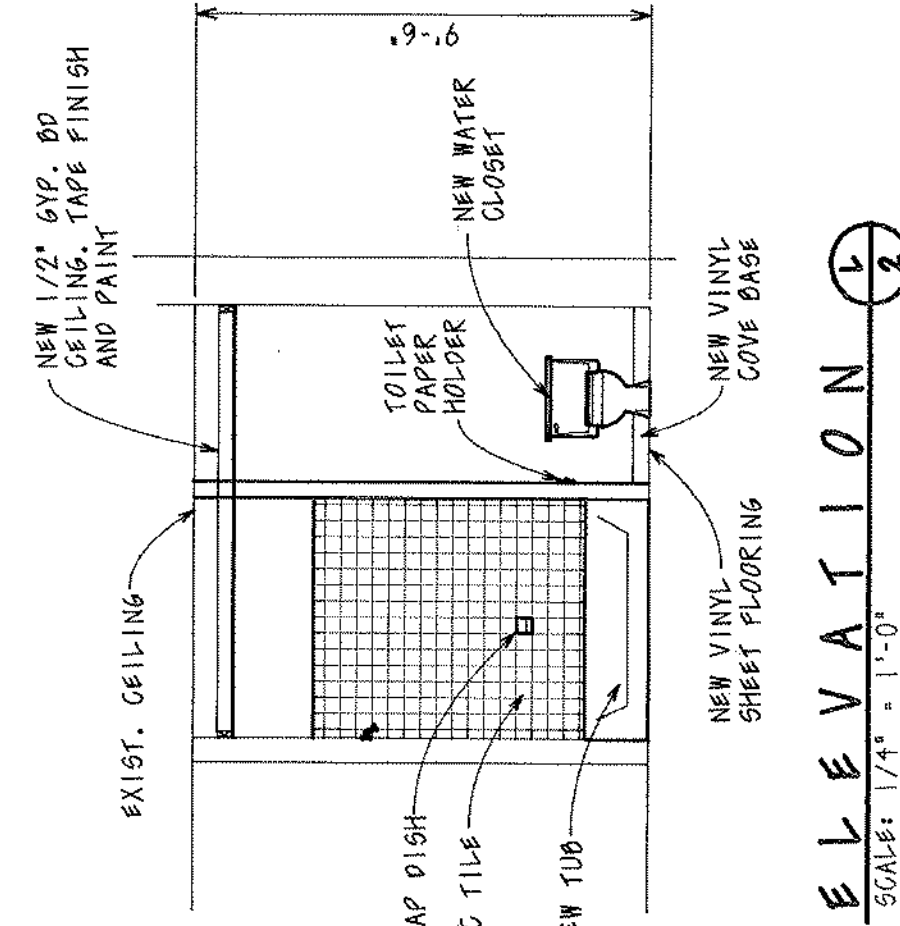


ELEVATION

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SCALE:  $1/4" = 1'-0"$

2



ELEVATION

SCALE:  $1/4" = 1'-0"$

K 2

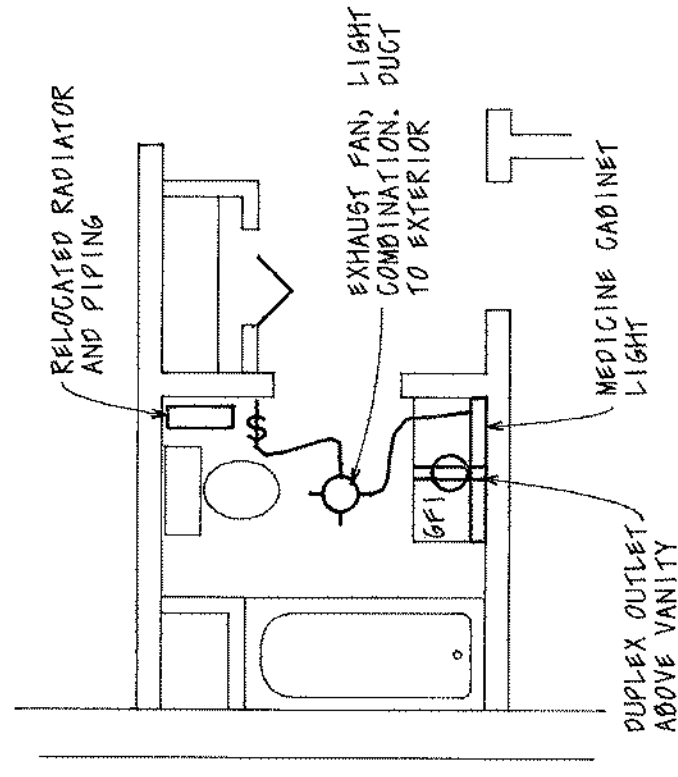
ELEVATION

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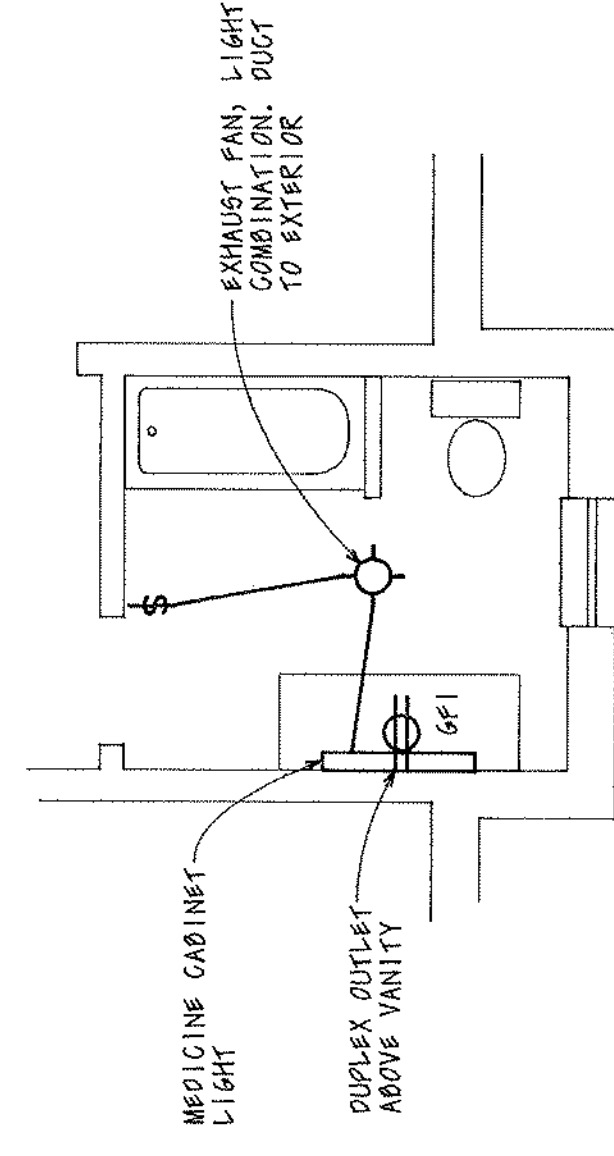
SCALE:  $1/4" = 1'-0"$

2

BATHROOM ELEVATIONS - BLDG. 839A



ELECTRICAL PLAN - BATHROOM 8390  
SCALE: 1/4" = 1'-0"



ELECTRICAL PLAN - BATHROOM 839A  
SCALE: 1/4" = 1'-0"

REVISION DATE DRAWN BY PROJECT ENGINEER MECHANICAL ENGINEER CIVIL ENGINEER ELECTRICAL ENGINEER PREVENTIVE MEDICINE ENVIRONMENTAL ENG. FIRE SAFETY SAFETY OFFICER	AUG. 92 PROJECT ENGINEER <i>J. H. Thompson</i> CIVIL ENGINEER MECHANICAL ENGINEER PREVENTIVE MEDICINE ENVIRONMENTAL ENG. FIRE SAFETY SAFETY OFFICER	IMPARTMENT OF THE ARMY DIRECTORATE OF INSTALLATION SUPPORT CAMPBELL PARKWAY PA  RENOVATE KITCHENS AND BATHROOMS BLDG. 839  PLANS AND ELEVATIONS  PROJECT NO. 401 - 9J DRAWING NO. RMO-0008 SHEET 2 OF 2 DIRECTOR, INSTALLATION SUPPORT ALAN K. THOMPSON P.E. <i>Alan K. Thompson</i>
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ALL CONSTRUCTION PRACTICES SHALL BE IN ACCORDANCE WITH CURRENT OSHA REGULATIONS.

ALL DIMENSIONS AND EXISTING CONSTRUCTION TO BE VERIFIED BY THE CONTRACTOR IN THE FIELD.

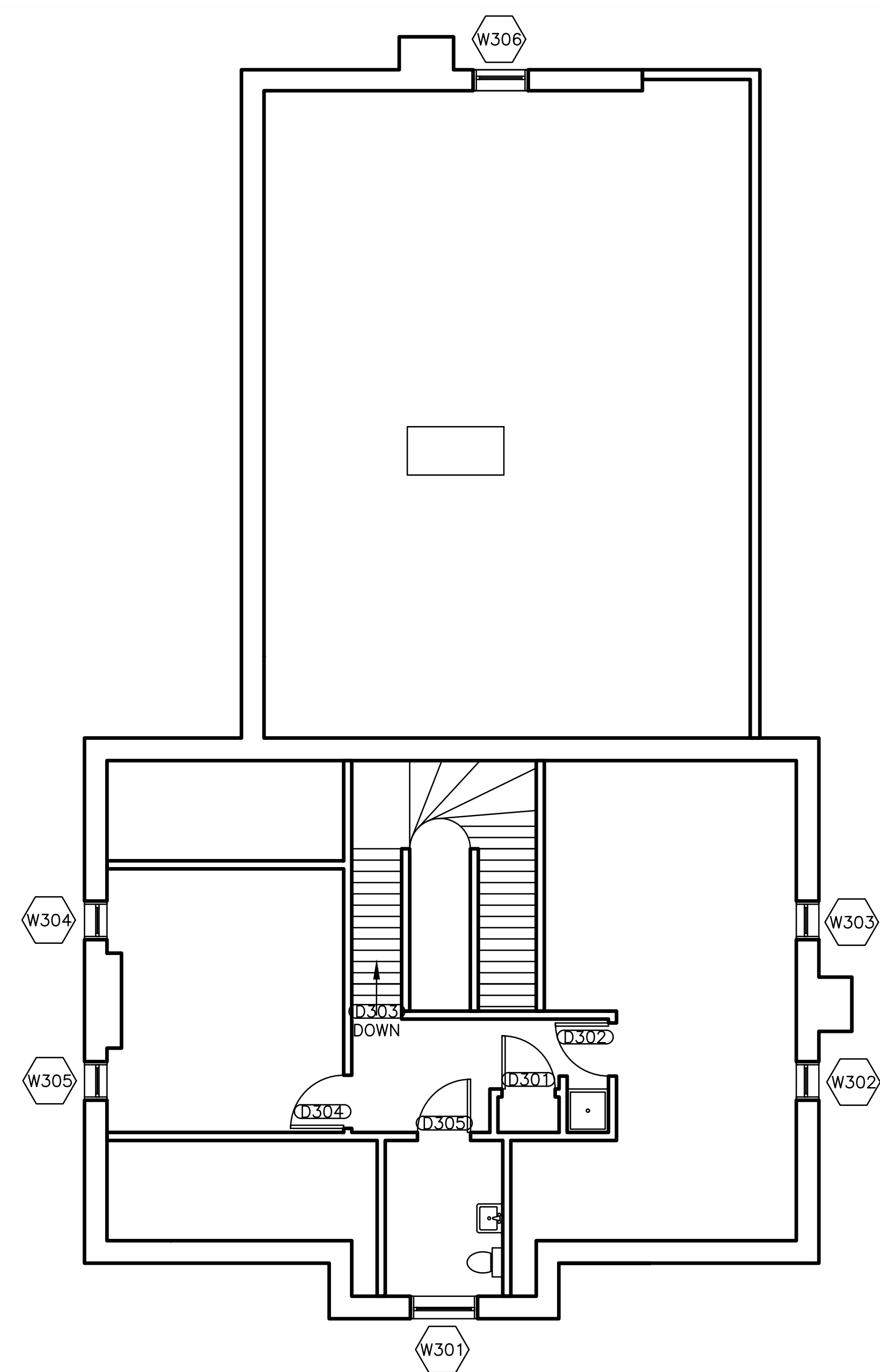
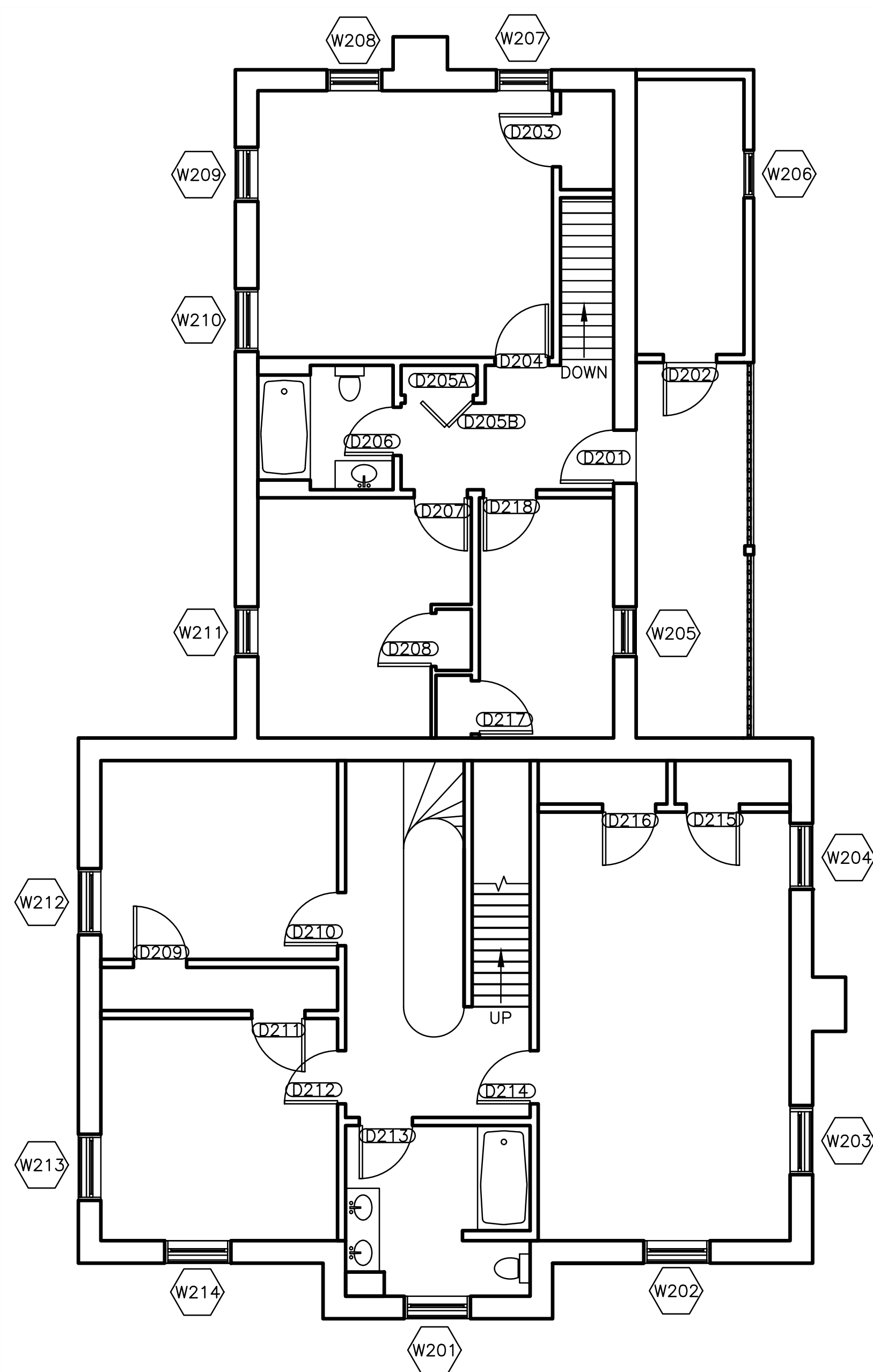


## **Appendix E**

### Existing Conditions Drawings

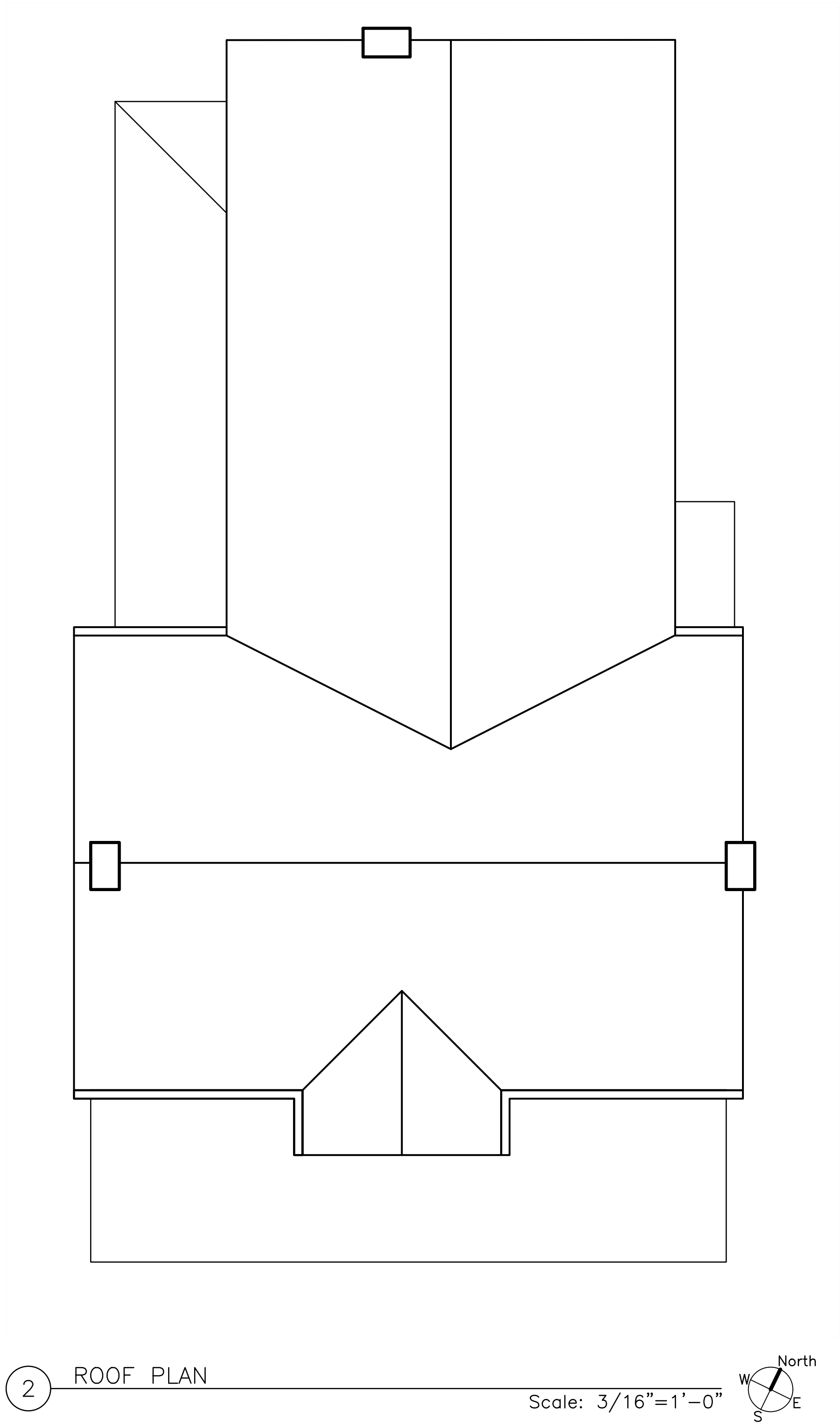
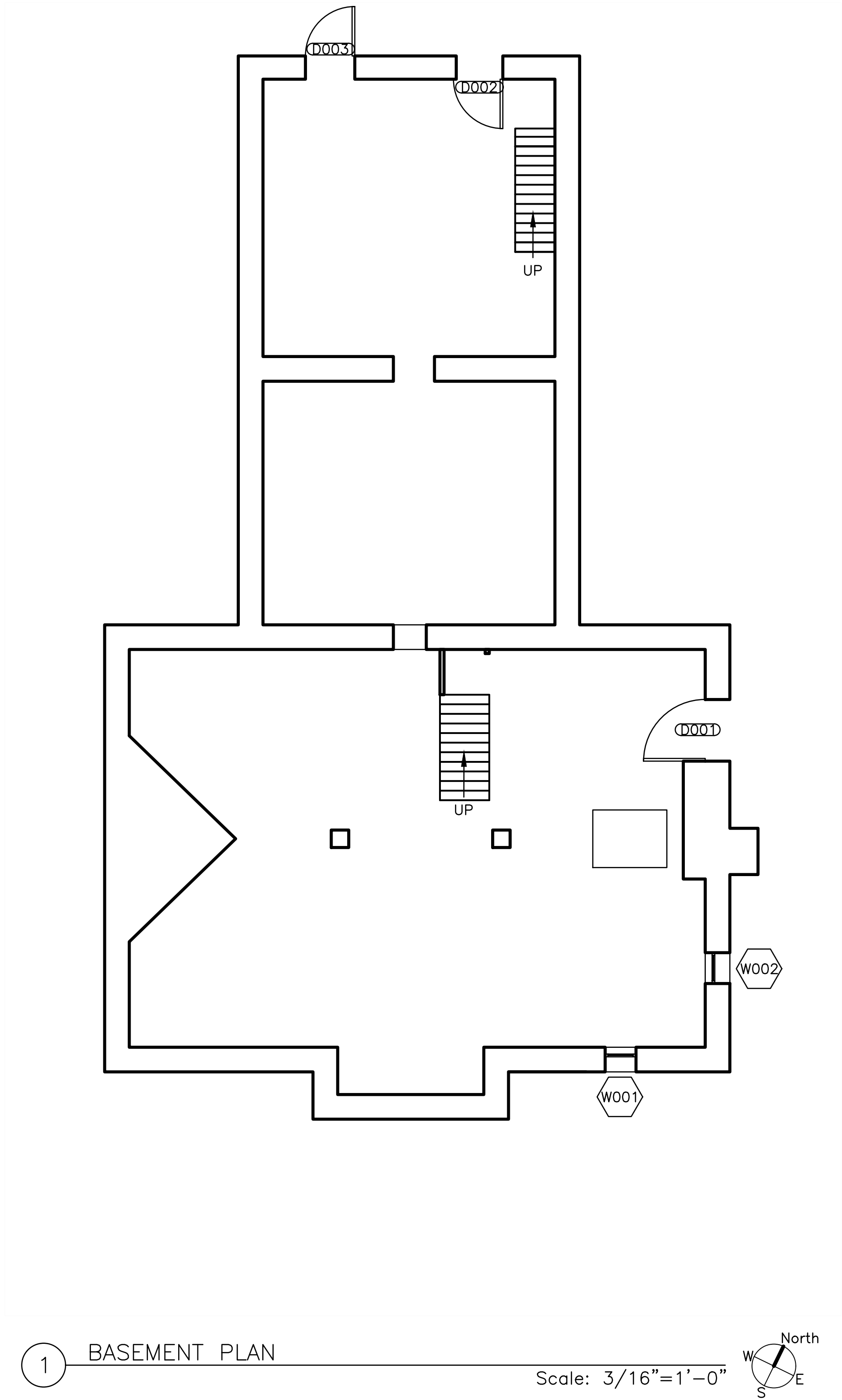
The following field drawings were created on site at Building 839 by the HPTC project team on May 2-3, 2017. Rooms, windows, and doors were numbered by the project team.





DESIGNED:	SUB SHEET NO.	TITLE OF SHEET <b>BUILDING #839</b> <b>EXISTING PLANS</b>  CARLISLE BARRACKS	DRAWING NO.
HLG	<div style="font-size: 48pt; text-align: center;">A1</div>		_____
<b>GA</b> <b>DD</b>			
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TECH. REVIEW:			PMIS/PKG NO.
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REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
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				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)  Tom Vitanza, Mark Slater, and Caitlin Clinton-Selin				5d. PROJECT NUMBER 461561	
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13. SUPPLEMENTARY NOTES					
14. ABSTRACT  Building 839 at Carlisle Barracks is a farmhouse that was likely constructed in the middle 1850s. It was utilized as a farmhouse by individual owners until the Carlisle Indian Industrial School acquired the farm in 1887. The school utilized the house as living quarters for its farmer and as classroom space for the farm unit of the school until 1918. After the War Department reacquired Carlisle Barracks in 1918, the farm-house was used for officer housing. It was determined in a 2013 analysis and report to Carlisle Barracks that Building 839 should be included within the existing Carlisle Indian Industrial School National Historic Landmark District.  Architectural historians at the U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratory (ERDC-CERL), who conducted the previous analysis of Building 839, requested assistance from the Historic Preservation Training Center (HPTC) of the National Park Service to prepare an abbreviated Historic Structure Assessment Report (HSAR). Besides the HSAR reported herein, the work also includes government Class C cost estimates for five potential treatments for Building 839: restoration, rehabilitation, stabilization and mothballing, relocation, and demolition.					
15. SUBJECT TERMS Historic buildings, Historic preservation, Architectural surveys, Structural health monitoring, Cultural property, Carlisle Barracks (Pa.)					
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