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**USACE / NAVFAC / AFCEC** **UFGS-04 03 00 (November 2017)**

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**Preparing Activity: USACE** **Superseding**
**UFGS-04 01 20.70 (November 2015)**

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated July 2024**
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SECTION 04 03 00

CONSERVATION TREATMENT FOR PERIOD MASONRY

**11/17**

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SECTION 04 03 00

CONSERVATION TREATMENT FOR PERIOD MASONRY
**11/17**

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**NOTE: This guide specification covers the requirements for restoration and cleaning of masonry in historic structures.**

**Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.**

**Remove information and requirements not required in respective project, whether or not brackets are present.**

**Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).**

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PART 1 GENERAL

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**NOTE: Where the words "as indicated" are used, ensure that sizes, positions and other designated information are indicated on the design drawings.**

**The following publications, from the United States Department of the Interior - National Park Service, provide useful guidance in the restoration of historic masonry and may be included as addenda to the specifications.**

**The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring, and Reconstructing Historic Buildings (1995).**

**Preservation Brief #1 - (2000) Assessing Cleaning and Water-Repellent Treatments for Historic Masonry Buildings**

**Preservation Brief #2 - (1998) Repointing Mortar Joints in Historic Brick Buildings**

**Preservation Brief #6 - (1979) Dangers of Abrasive Cleaning to Historic Buildings**

**Preservation Brief #7 - (1979) The Preservation of Historic Glazed Architectural Terra-Cotta**

**Preservation Brief #22 - (1990) The Preservation and Repair of Historic Stucco**

**Preservation Brief #38 - (1995) Removing Graffiti from Historic Masonry**

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1.1 REFERENCES

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**NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.**

**Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.**

**References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.**

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

| | |
|---|---|
| ACGIH 0100 | (2017; Suppl 2020) Documentation of the Threshold Limit Values and Biological Exposure Indices |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM A36/A36M | (2019) Standard Specification for Carbon Structural Steel |

| | |
|---|---|
| ASTM C34 | (2023) Standard Specification for Structural Clay Loadbearing Wall Tile |
| ASTM C67/C67M | (2023a) Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile |
| ASTM C170/C170M | (2024a) Standard Test Method for Compressive Strength of Dimension Stone |
| ASTM C207 | (2024) Standard Specification for Hydrated Lime for Masonry Purposes |
| ASTM C216 | (2023) Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale) |
| ASTM C926 | (2024) Standard Specification for Application of Portland Cement-Based Plaster |
| ASTM C1196 | (2014) Standard Test Method for In Situ Compressive Stress Within Solid Unit Masonry Esitmated Using Flatjack Measurements |
| ASTM C1197 | (2014) Standard Test Method for In Situ Measurement of Masonry Deformability Properties Using the Flatjack Method |
| ASTM C1324 | (2020) Standard Test Method for Examination and Analysis of Hardened Masonry Mortar |
| ASTM C1364 | (2023) Standard Specification for Architectural Cast Stone |
| ASTM C1489 | (2015; R 2022) Standard Specification for Lime Putty for Structural Purposes |
| ASTM C1531 | (2015) Standard Test Methods for In Situ Measurement of Masonry Mortar Joint Shear Strength Index |
| ASTM C1601 | (2014) Standard Test Method for Field Measurement of Water Penetration of Masonry Wall Surfaces |
| ASTM C1713 | (2012) Standard Specification for Mortars for the Repair of Historic Masonry |
| ASTM E96/E96M | (2024) Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials |
| ASTM E2260 | (2012) Standard Guide for Repointing (Tuckpointing) Historic Masonry |
| ASTM E2659 | (2018) Standard Practice for Certificate Programs |

NATIONAL PARK SERVICE (NPS)

| | |
|---|---|
| NPS Hist Prop | (2017) National Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring, and Reconstructing Historic Buildings |
| NPS TPS Brief 1 | (2000) Assessing Cleaning and Water-Repellent Treatments for Historic Masonry Buildings |
| NPS TPS Brief 2 | (1998) Repointing Mortar Joints in Historic Masonry Buildings |

THE MASONRY SOCIETY (TMS)

| | |
|---|---|
| TMS MSJC | (2016) Masonry Standard Joint Committee's (MSJC) Book - Building Code Requirements and Specification for Masonry Structures, Containing TMS 402/ACI 530/ASCE 5, TMS 602/ACI 530.1/ASCE 6, and Companion Commentaries |

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

| | |
|---|---|
| GSA HPTP 07656-01 | Installing Lead Stone Flashing to Protect Masonry Joints |

## 1.2 DEFINITIONS

Terms are defined below as applicable to this project.

### 1.2.1 Aggregates

The sand component of mortar.

### 1.2.2 Biocides

A chemical treatment that inhibits, deters, or controls organic growth. Such growth is typically removed by cleaning following biocide treatment..

### 1.2.3 Binder

The component of mortar that binds together the aggregate particles into a cohesive material.

### 1.2.4 Dispersed Lime Crack Injection

A repair method in which dispersed lime material is injected into small cracks ranging in width from hairline to 3.2 mm 1/8 in by use of needle or syringe.

### 1.2.5 Consolidant

A chemical product meant to strengthen loose or deteriorated stone.

1.2.6 Dutchman

A repair method in which deteriorated stone is removed in part and replaced with salvaged, harvested or new stone to make a seamless patch.

1.2.7 Harvested

Units removed from inconspicuous areas of the building.

1.2.8 In situ

A term referencing a repair procedure in which the masonry units and mortar remain in place and are repaired without removal from the wall system

1.2.9 Joint Sealant

A flexible, chemical product that is used to create a weather-tight seal at the boundary of masonry units with other units or dissimilar materials.

1.2.10 Lead Flashing

An extruded lead material that is inserted into joints to assist in precluding water entry into the masonry.

1.2.11 Lime Wash

A protective surface treatment comprised of calcium hydroxide particles in suspension in water, along with small amounts of calcium carbonate, silica particles and other minerals.

1.2.12 Mockup

Specific area on the building approved by Contracting Officer to demonstrate the ability to apply, match and install specified materials.

1.2.13 Mortar

A mixture of binders, aggregates, and pigments used for reconstruction, repointing or stucco applications.

1.2.14 New Elements

New, non-historic materials added to masonry structures to aid in their ability to resist loads (typically seismic) or to resist water infiltration.

1.2.15 Patch

The use of substitute repair materials to treat damaged or deteriorated masonry units in situ.

1.2.16 Remediate

An intervention of a historic masonry structure and its component materials with the intent to maintain the original fabric to the greatest extent possible.

1.2.17 Remove

Specifically for historic masonry materials, the term means to detach an item from existing construction to the limits indicated.

1.2.18 Replace

To reinstall an item in its original position (or where indicated) after remedial treatment, or to duplicate and reinstall an entire item with new material; with the original item serving as the pattern for creating the duplicate.

1.2.19 Repoint

To remove existing mortar joints to the specified depth and replace with a mortar that matches in color, texture, and performance with water vapor transmission, bond, hardness, and flexibility compatible with original mortar, as assessed in accordance with ASTM C1713.

1.2.20 Retool

A repair method in which a chisel is used to re-create the surrounding stone texture finish by removing loose pieces of stone.

1.2.21 Stucco

A mixture of binders and aggregates, sometimes including animal hair or fibers used for the repair treatment of existing stucco.

1.2.22 Surface Treatment

The application of traditional materials or contemporary chemical products to the surface of masonry to provide protection to the masonry units and mortar and/or reduce water infiltration.

1.2.23 Test Panel

Specific area on the building approved by the Contracting Officer to demonstrate individual applicator competency and workmanship proficiency prior to the start of restoration work.

1.2.24 Tuckpointing

Often called skim-coating, an American practice of surface repairing mortar joints without the required removal of existing deteriorated mortar beneath. This practice is not recommended for mortar joint repair work on historic masonry. There is also an acceptable British form of tuckpointing practice that involves careful thin penciling of smaller joints within larger ones to give the wall the appearance of an ashlar finish.

1.2.25 Water Repellent

A surface-applied chemcial intended to reduce liquid water entry into a masonry wall without significantly affecting the vapro transmission properties of the original material.

1.2.26 Wall System

A term used to address the fact that masonry structures are comprised of

different materials but function holistically, requiring that all restoration and cleaning process take into account the implications of the treatment to the adjacent materials and the building as a whole.

1.2.27 Masonry Treatment Requirement (MTR)

Defined treatments that are required by the specification (contract) documents for project specific repairs to masonry.

1.2.28 Saturated Surface Dry (SSD)

Condition of the wall surface after water has been applied sufficient to saturate more than the surface, then allowed to dry until the surface is dry but the body of the masonry still has moisture.

1.3 ADMINISTRATIVE REQUIREMENTS

1.3.1 Pre-Installation Meeting

Prior to beginning the work of this Section, convene a meeting with the Contracting Officer's Representative(s) to review the requirements of the Quality Control Plan, Project Training Program, installation procedures, location of required mockup areas, and all job conditions and processes. All subcontracting firms involved with this work must participate in this meeting.

1.4 SUBMITTALS

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**NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.**

**For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.**

**The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.**

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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Quality Control Plan; G, [_____]

Project Training Program; G, [_____]

Qualifications; G, [_____]

SD-02 Shop Drawings; G, [_____]

Photographic Documentation

Structural Upgrades; G, [_____]

SD-03 Product Data

Qualifications

Cleaning and Restoration Methods; G, [_____]

Cleaning Materials; G, [_____]

Biocides

Replacement Mortar And Stucco; G, [_____]

Mortar Mix; G, [_____]

Water Repellents Infiltration; G, [_____]

Stone Consolidants; G, [_____]

SD-04 Samples

Mock-ups; G, [_____]

SD-05 Design Data

Calculations for Structural Upgrades; G, [_____]

SD-06 Test Reports

Testing and Matching

Existing Sealants for Asbestos and PCBs

SD-07 Certificates

Repair Materials

## 1.5 QUALITY CONTROL

### 1.5.1 Quality Control Plan

[Prior to beginning restoration and cleaning work, submit a written Quality Control Plan.][Include a separate section in the overall project Quality Control Plan specifically addressing this restoration and cleaning work.] Do not proceed without written approval of the Quality Control Plan. At a minimum, include the following items in the Quality Control Plan:

a. Describe methods of dust containment during the work specific to the work of this section.

b. Describe the methods of protecting surrounding masonry, windows, doors, roof, and building trim as well as surrounding landscape. Provide drawings of protection when requested.

c. Describe the work procedures, materials, and proposed tools to use for each Masonry Treatment Requirement (MTR) specified.

d. Describe the sequence of each MTR.

e. Describe how each MTR sequence and the overall construction schedule changes with weather variations and how completed work will be protected.

f. Describe the methods for surveying original layout and collecting datum points and plumb lines for rebuilding masonry.

g. Describe the methods for shoring and providing a safe working environment.

h. Describe the methods for select deconstruction of individual masonry units and tools/methods for cleaning the masonry for reuse.

i. Describe the method and approach to mortar joint removal.

j. Describe the method and approach for assuring repair material compatibility with original materials.

k. Describe the method and approach to cleaning mortar, coating, smears and old patching materials from the masonry surfaces.

l. Describe, in detail, the procedures relating to techniques and tools proposed for masonry matching.

m. Describe the complete masonry removal and matching procedures; include equipment, approach, length of time the masonry will be out of the wall, documentation on mapping the location, and where (on-site or in shop) the masonry units will be repaired.

n. Describe the procedure for matching of different colors at different locations.

o. Describe the procedure for mixing and matching of repair materials.

p. Describe the methods and system by which the use of reclaimed masonry

units can be utilized.

q. Describe the methods for setting masonry back into its original position and maintaining the original bond patterns and joint width.

r. Describe the methods of transition points where replacement/preservation work will meet the original historic work.

s. Describe the on-site project training program. Provide the opportunity for workers to be trained in each masonry treatment requirement (MTR) as work proceeds.

1.5.2 Qualifications

1.5.2.1 Historic Masonry Consultant

a. Secure the services of a historic masonry consultant with a minimum of 10 years experience applying NPS Hist Prop as they relate to the work in this section.

b. Submit a resume that describes five relevant projects within that period and include how NPS Hist Prop was applied to the work of similar scope and scale and what jurisdiction or agency was involved in approving the work..

c. The consultant's services include:

(1) Investigating the condition of the masonry materials and mortar.

(2) Arranging for material analysis in the laboratory

(3) Recommending appropriate cleaning methods and materials

(4) Recommending restoration options.

(5) Providing project specific specifications.

(6) Providing an on-site training program.

(7) Providing quality control services during construction.

(8) Recommending appropriate repair and restoration materials.

1.5.2.2 Masonry Firm

a. The firm performing the masonry work must have a minimum of five years experience on relevant projects.

b. The firm must have completed work similar in material, design, and extent to that indicated for this Project and demonstrate a record of successful in-service performance.

c. Proven implementation of NPS Hist Prop and related Preservation Briefs are required.

d. Submit a resume that describes the required experience.

1.5.2.3 Field Supervisor

Retain an experienced full-time supervisor on the project site at all times when masonry restoration is in progress. A single individual must be responsible for supervising the historic masonry restoration work throughout the duration of the project.

Submit a resume that describes the required experience.

1.5.2.4 Masonry Applicator

a. Employ craftspeople who are experienced with and specialize in restoration work of the types they will be performing.

b. All masonry restoration treatments must be performed by a craftsperson that is familiar with historic masonry construction and has worked on historic masonry projects for at least five years.

c. Only skilled technicians who are familiar and experienced with the materials and methods specified may be used.

d. Submit resumes for all historic masonry applicators, demonstrating the required experience.

1.5.3 Project Training Definition and Use

In addition to five years demonstrable experience on masonry restoration projects, offer workers project training certificate(s) within the framework of ASTM E2659. Project training certificates are earned by individual workers and issued with the understanding that they are for limited time use, enforceable only to this specific project and for a specific MTR. It is not necessary, nor a requirement of this specification, that all restoration workers obtain all project training certificates offered. Rather it is desirable that workers be trained for each project specific task they will perform to ensure the highest quality results from the cleaning and restoration program.

1.5.4 Mortar Analyst

Laboratory mortar analysis equipment should be operated by and results analyzed by trained personnel experienced with analysis of historic masonry mortar.

1.5.5 Documentation

Submit digital photographic documentation of the all phases of masonry restoration, including prior to the start of restoration work.

Provide thorough photo documentation of the project and project details and targeted areas.

1.5.6 Cleaning and Restoration Methods

1.5.6.1 General Procedure

a. Submit the cleaning and restoration methods, and materials selected for a specific structure for approval before work starts.

b. Take into account the total construction system of the building to be

worked upon, including different masonry and mortar materials, as well as non-masonry elements which may be affected by the work.

c. Utilize mockups to identify the appropriate cleaning and restoration treatment and materials and set the standard for each project task.

d. Demonstrate the correct execution of the approved cleaning and restoration methods and materials during the on-site workmanship training program within the framework of ASTM E2659.

1.5.6.2 Cleaning Products and Procedures

1.5.6.2.1 General Cleaning Requirements

a. Establish cleaning products and procedures during the mockup process.

b. Select the least aggressive method used to achieve the desired level of cleanliness.

c. Where chemical products are selected for cleaning, use them in accordance with the manufacturer's instructions.

1.5.6.2.2 Cleaning Mock-Ups

a. Demonstrate the materials, equipment, and methods to be used in cleaning in a test section approximately 1 meter by 1 meter 3 feet by 3 feet.

b. Locate test patches in inconspicuous areas of the building. The areas tested are subject to approval by the Contracting Officer. The areas tested must exhibit soiling characteristics representative of those larger areas to be cleaned.

c. Adjust the cleaning process as required and the test section rerun until an acceptable process is obtained.

d. Conduct tests on areas to be stripped of paint.

e. Allow tested areas to dry before a determination is made on the effectiveness of a particular treatment.

1.5.7 Masonry Restoration Products and Procedures

1.5.7.1 General Restoration Requirements

a. Do not use masonry or mortar in the work until the mock-ups and the represented material and workmanship have been submitted and approved.

b. Demonstrate the methods and quality of workmanship to be performed in each masonry treatment requirement (MTR). Provide a mock-up for each MTR indicated.

1.5.7.2 General Restoration Mock-Up Requirements

a. Throughout restoration, retain approved mock-up panels in undisturbed condition, suitably marked, as a standard for judging completed work.

b. Review manufacturer's product data sheets to determine suitability of each product for each surface.

c. Apply products using manufacturer-approved application methods, determining actual requirements for application.

d. Obtain approval as to the preservation treatment approach, design, and workmanship to include, but not limited to the verification of all material applications and finishes as specified to the requirements of color, texture, profiles, and finishes before proceeding with work.

1.5.7.2.1 Mock-ups

May be performed on inconspicuous sections of actual construction under the same weather conditions expected the remainder of the work.

a. Location and number as directed[, but no more than [_____]].

b. Size: 1 m by 1 m 3 feet by 3 feet or as appropriate for the repair specified.

c. Repair unacceptable work.

1.5.7.3 Restoration Mock-Ups

1.5.7.3.1 Repointing

Repoint mortar joints, minimum acceptable mock up dimensions: twelve feet in length - 2/3 horizontal joints and 1/3 vertical joints. Demonstrate method for cutting out mortar joints, preparing wall for repointing, mixing mortar, installing mortar and curing the mortar. Prepare and place repointing mortar in accordance with NPS TPS Brief 2 and in compliance with NPS Hist Prop.

1.5.7.3.2 Retooling Stone Masonry In Situ

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**NOTE: Common historic finish textures include, but are not limited to, corduroy and point chisel finishes.**

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Demonstrate treatment technique and methods to retool three deteriorated stone faces in situ in all known historic profile textures identified.

1.5.7.3.3 Masonry Removal and Replacement

Fully remove masonry and replace to specified dimensions and texture. Select size of masonry units representing typical conditions. Return one masonry unit to same location, set to surrounding profile joint width and bond pattern. Set masonry unit using specified mortar. Confirm with Contracting Officer's Representative that the replacement masonry units meet specification requirements for matching and that sufficient quantity required for the work have been identified. Leave one stone dry-set into opening set on wood shims for evaluation and approval of preparation conditions.

1.5.7.3.4 Repair Material

1.5.7.3.4.1 Patching

Apply repair material on at least two masonry units for repair. Include one masonry unit on which to demonstrate proficiency in removing previous patching material and repairing with new substitute repair material. Include the removal of metal anchors at two locations and fill in the holes with repair material on the second masonry unit (where applicable).

1.5.7.3.4.2 Dutchman

Undertake dutchman repairs in two locations, including one that is only cut and prepared for application. Demonstrate the quality of the stone insert, as well as the workmanship and techniques to be performed in the dutchman repairs. Do not proceed with other dutchman repairs until the technique has been approved.

1.5.7.3.5 Crack Repair

Repair one crack, 600 mm 2 feet in length, using mortar. Repair one crack, 600 mm 2 feet in length, using dispersed hydrated lime injection technique with appropriate repair material.

1.5.7.3.6 Surface Treatments

Install a minimum 1.5 square meter 16 square foot mockup for each surface treatment on each substrate to be treated. For stucco, demonstrate the means for installing each coat; including mechanical support systems such as wood or metal lath. For water repellents and/or consolidants, demonstrate the equipment and installation procedure. Allow 48 hours for limewash applications to dry to their final color and appearance.

1.5.7.3.7 New Masonry Elements

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**NOTE: Consideration of new elements on a historic structure should only be undertaken once the addition is approved by the Contracting Officer. New accessories are intended to provide structural strengthening or facilitate weather protection.**

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Install new components in a manner demonstrating their final installation on the structure.

1.6 DELIVERY, STORAGE, AND HANDLING

a. Furnish cement in suitable bags used for packaging cements.

b. Provide packages with labeling that clearly defines contents, manufacturer, and batch identification.

c. Provide detergents, masonry cleaners, paint removers, solvents, epoxies and other chemicals used for masonry cleaning in sealed containers that legibly show the designated name, formula or specification number, quantity, date of manufacture, manufacturer's formulation number, manufacturer's directions including any warnings and special precautions, and name of manufacturer.

d. Store materials in weathertight structures which will protect all materials from moisture and contaminants.

e. Store accessories to avoid contamination and deterioration.

f. Do not use admixtures which have been in storage onsite for six months or longer, or which have been subjected to freezing, unless retested and proven to meet the specified requirements.

1.7 PROJECT/SITE CONDITIONS

1.7.1 Environmental Requirements

a. Do not place materials when weather conditions adversely affect the quality of the finished product.

b. Do not place masonry or mortar when the air or surface temperature is below 5 degrees C 40 degrees F in the shade and will remain so for at least 48 hours after completion of the work. Heated enclosures may be used to overcome ambient weather restrictions, where such enclosures are feasible.

c. Do not place masonry or mortar when air or surface temperature is above 35 degrees C 90 degrees F with a wind speed above13 kilometers per hour8 miles per hour and will remain so for at least 48 hours after completion of the work.

d. Do not place masonry or mortar when air or surface temperature is above 38 degrees C100 degrees F with or without wind and will remain so for at least 48 ours after completion of the work.

e. Do not product or place materials during periods of rain or other precipitation. Stop material placements, and protect all in-place material from exposure, during periods of rain or other precipitation.

f. Clean masonry surfaces when air temperatures are above 5 degrees C 40 degrees F and will remain so until masonry has dried out, but for not less than 7 days after completion of the work.

g. Do not perform work in wind conditions that may blow materials onto surfaces not intended to be treated.

1.7.2 Masonry Installation Requirements

a. Phase work during hot weather by performing work on the shady side(s) of the building during daylight hours and on the daylight side(s) of the building during cooler evening hours to prevent premature evaporation of the water from the mortar.

b. Do not use frozen materials or materials mixed or coated with ice or frost. Do not apply materials to frozen surfaces; allow complete thawing prior to installation.

c. Do not lower the freezing point of mortar by the use of admixtures or anti-freeze agents. Do not add chlorides or admixtures containing greater than 0.2 percent chlorides to the mortar, per TMS MSJC.

d. Prevent mortar from staining the face of the masonry or other exposed

surfaces. Immediately remove mortar that comes in contact with such surfaces. Cover partially completed work when work is not in progress. Protect sills, ledges and projections from mortar droppings. Building damage resulting from work of this Section is the Contractor's responsibility. Restore damaged areas to the satisfaction of the Owner at no expense to the Owner. Do not apply products under conditions outside product manufacturer's requirements.

1.8 WARRANTY

1.8.1 Cleaning Warranty

Warrant cleaning procedures for a period of two years against harm to substrate (masonry and mortar) or to adjacent materials including, but not limited to discoloration of substrate from improper procedures or usage, chemical damage from inadequate rinse procedures, and abrasive damage from improper procedures.

1.8.2 Repair Warranty

Warrant repair procedures, including repointing, for a period of two years against: discoloration or mismatch of new mortar to adjacent original historic mortar, discoloration or damage to masonry from improper mortar clean-up, loss of bond between masonry and mortar, fracturing of masonry edges from improper mortar joint preparation procedures or improper mortar formulation, and occurrence of efflorescence from improper repair procedures.

PART 2 PRODUCTS

2.1 CLEANING MATERIALS

2.1.1 General Requirements

Selection of appropriate cleaning products requires a clear understanding of the masonry materials to be cleaned, a rationale for the cleaning, and an understanding of the anticipated level of cleanliness expected from the cleaning program. Overly aggressive cleaning methods and materials can cause subtle, long-term damage to masonry units. Use products that have a minimum 5 year performance record on relevant projects. Select the products predicated on long-term negative effects to the masonry rather than current level of cleanliness of the comparable structure.

2.1.2 Paint Removers

a. Provide chemical paint removers that are water soluble, low toxicity products, effective for removal of paint on masonry without altering, damaging, or discoloring the masonry surface.

b. Provide commercially available poulticing materials designed to adhere to and peel off paint without damaging the underlying masonry or project specific mixtures that include absorbent materials and cleaning solutions which can be demonstrated to do no harm to the masonry.

2.1.3 Chemical Cleaners

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**NOTE: Chemical cleaners range from acidic to**

**alkaline in their chemcial makeup. Selected products must be suitable for the type of masonry units to be cleaned.**

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a. Provide commercially available products that have a proven record of cleaning masonry without altering, damaging or discoloring the masonry units, mortar or surrounding materials.

b. Provide the associated pre and post treatment material to neutralize the long term effects of the chemicals.

2.1.4 Biocides

Provide commercially available biocides with accompanying product literature containing information on the product as well as the expected service life of the material and any detrimental effects it may have on the masonry or mortar.

2.1.5 Liquid Strippable Masking Agent

Provide manufacturer's standard liquid, film-forming, strippable masking material for protecting glass, metal, and polished stone surfaces from the damaging effect of acidic and alkaline masonry cleaners.

2.1.6 Cleaning Implements

Furnish brushes that contain natural or nylon fiber bristles only. Do not use metallic wire brushes. Use scrapers and application paddles made of wood with rounded edges. Metallic tools are not permitted.

2.1.7 Water

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**NOTE: Filtering and neutralizing pH is rarely conducted for masonry cleaning, except for statues or museum pieces.**

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Obtain potable water from a local source. [Filter to remove minerals resulting in a neutral pH, prior to application.]

2.2 REPAIR MATERIALS

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**NOTE: Use materials, physical and chemical properties, and composition of masonry and mortar in renovation work that match the original existing masonry and mortar to be repaired, unless samples and testing determine that existing mixtures and materials are faulty or nonperforming. Match masonry materials used for repair and renovation to the original existing historic materials as closely as possible in composition, color, texture, strength, size, finishing and porosity. Refer to ASTM C1713 for matching mortar.**

**********

2.2.1 General

Use repair materials of one type and from one source, when used in repair treatments that will have surfaces exposed in the finished structure.

2.2.2 Mortar and Stucco

**********
**NOTE: Mortar types L and K are not included in ASTM C270. Type L mortar uses only hydrated lime or lime putty as binder. Type K mortar has typical proportions in the range of 1 part cement, 2 to 3 parts lime, and 2 1/4 to 3 times the combined cement and lime components as sand.**
**********

2.2.2.1 Testing and Matching

a. Take test specimens of existing mortar and stucco from a sound and intact representative portion of the structure, at locations [indicated][ or ][by the Contracting Officer's Representative] and assess in accordance with ASTM C1713 and ASTM C1324.

b. Subject a part of the historic mortar sample to petrographic examination and differential thermal analysis, or X-ray diffraction, or analytical chemistry to determine the binder components.

c. Aggregate Analysis

(1) Separate aggregate of the mortar sample from the binder [by taking the crushed mortar sample and either gently blowing away the fine binder material, placing the crushed sample in a centrifuge, or chemically separating the aggregate from the binder].

(2) Rinse the separated aggregate clean with water and dry. [Examine the aggregate with a magnifying glass, and record the component materials as to range of materials, sizes, colors, as well as the presence of other materials.]

(3) Perform sand analysis using a sieve analysis of the aggregate as part of the ASTM C1324 process.

d. Match the replacement mortar and stucco to the original existing material in color, texture and tooling.

2.2.2.2 Replacement Mortar and Stucco

Provide replacement mortar and stucco that will:

a. Coexist with the old in a sympathetic, supportive and, if necessary, sacrificial capacity.

b. Have greater vapor permeability and be softer (measured in compressive strength) than the masonry units.

(1) Measure water vapor transmission in accordance with ASTM E96/E96M.

(2) Prepare ASTM E96/E96M water vapor transmission specimens with thickness similar to that expected in service, or a maximum of 13

mm 1/2 inch, whichever is thinner.

c. Be as vapor permeable, and as soft, or softer, (measured in compressive strength) than the existing historic mortar or stucco.

2.2.2.3 Binder Content

**********

**NOTE: Historic mortars can represent four different binder types, or combination of them, depending on the time period of construction. A building constructed in the early 1800s is likely built with a straight lime putty binder type because the discovery of natural cement binder types had not occurred until the early 1820s. A building constructed in 1940 might be built with portland cement (1871) and hydrated lime (1930s). The historic binder types include: non-hydraulic lime (fat lime, lime putty or hydrated lime); hydraulic lime (feebly, NHL 2, moderately, NHL 3.5, and imminently, NHL 5.0); natural cement; and portland cement. The binder types are all derived from limestone. Each successive type is fired at higher temperatures in a kiln to the point of vitrification or liquid phase (1204-1540 degrees C2200-2800 degrees F) when Portland cement is developed. Lime can be slaked into a hydrate powder or putty form by adding water due to the lower firing temperatures ( 900-1093 degrees C1650-2000 degrees F), while cement products must be crushed mechanically into a powder form before use. Each binder type has its own unique performance properties in relation to historic masonry units and the building wall design. A mortar formula made from lime putty (low compressive strength) will accommodate building movement in load-bearing masonry much more effectively than a portland cement formula of much higher compressive strength. Identify performance characteristics of the replacement mortar carefully based upon evaluation of the existing historic mortar.**

**********

Provide binder type or mixture of mortar (and stucco) with a cement, lime, or combination thereof consistent with the original existing mortar (and stucco) content in order to provide uniform durability, weathering characteristics, and the same, or better, life-cycle performance expectations.

2.2.2.4 Repointing Mortar

**********

**NOTE: If mortar testing is performed prior to project bidding and the compatible mortar type is known, select from the following choices. Otherwise, delete the following paragraph and allow mortar to be determined by the above described testing.**

**********

[Pre-blend repointing mortar in single containers in a factory-controlled environment.][Repointing mortar may be site mixed, Type S, Type N, Type L, Type O and Type K.][Use lime for repointing mortar that conforms to ASTM C207, Type S, or ASTM C1489 or unless otherwise specified.]

2.2.2.5 Admixtures

Do not use admixtures in the mortar or stucco unless specifically approved in writing by the Contracting Officer.

2.2.3 Crack Injection

**********

**NOTE: Dispersed hydrated lime (specified herein) is suitable for injection of cracks up to 3.2 mm1/8 inch wide for architectural purposes (sealing, restoring appearance, preventing moisture infiltration) but has low bond and is not the best material for structural repairs. Masonry injection grouts (not specified herein) may be more suitable for structural repairs.**

**********

a. Comply with the dispersed hydrated lime manufacturer's written instructions.

b. Inject cracks that are no greater than 3 mm 1/8 inch in width and masonry is soundly bonded but cracked.

c. Inject the full length of the cracks unless specifically instructed otherwise.

2.2.4 Replacement Masonry Materials

2.2.4.1 Clay Brick

a. Provide replacement brick matching color, shape, size, texture, appearance, and thermal expansion properties of the existing historic brick.

b. Test brick in comparison to the original existing historic brick using ASTM C67/C67M.

c. Do not use reclaimed brick unless approved by Contracting Officer.

d. Provide brick meeting the requirements of ASTM C216 Grade SW, including a rating of "not effloresced", unless otherwise specified.

2.2.4.2 Stone

a. Provide replacement sotne matching type, color, shape, size, texture, finish-profile, and compressive strength of the existing historic stone units.

b. Test replacement stone in comparison to the existing historic stone using ASTM C170/C170M.

2.2.4.3 Terra Cotta

a. Provide replacement terra cotta matching color, shape, size, texture and finish-profile of the existing historic terra cotta units.

b. Test replacement terra cotta in comparison to the existing historic terra cotta using ASTM C34.

2.2.4.4 Architectural Precast Stone

a. Provide replacement architectural precast stone matching color, shape, size, texture and finish-profile of the existing historic architectural precast stone units.

b. Test replacement architectural precast stone in comparison to the existing historic architectural precast stone using ASTM C1364.

2.2.5 Surface Treatments

2.2.5.1 General

Provide commercially available coatings with water vapor permeabillity of 0.98 or greater, as measured in accordance with ASTM E96/E96M, including silanes and siloxanes.

2.2.5.2 Consolidants

Provide commercially available consolidants designed to strengthen loose or deteriorated stone without damaging intact stone or reducing water vapor permeability below 0.98, as measured in accordance with ASTM E96/E96M.

2.2.5.3 Water Repellents

Provide commercially available water repellents designed to preclude water droplet entry into the masonry walls without reducing water vapor permeability below 0.98. as measured in accordance with ASTM E96/E96M.

2.2.6 Miscellaneous Materials

2.2.6.1 Cementitious Grout

Use cementitious grout, recommended by the manufacturer for the application, to bond steel anchors to masonry.

2.2.6.2 Metal Attachments

a. Provide threaded or deformed stainless steel anchors for spall repairs, size as indicated.

b. Provide other plates, angles, anchors, and embedments conforming to ASTM A36/A36M, prime painted with inorganic zinc primer.

2.2.6.3 Lead Flashing

Provide commercially available lead flashing conforming to GSA HPTP 07656-01.

## 2.3 EQUIPMENT

### 2.3.1 Cleaning Equipment

Provide cleaning equipment that does not cause staining, erosion, marring, or other damage or changes in the appearance of the surfaces to be cleaned.

#### 2.3.1.1 Sandblasting

Use of sandblasting equipment is not allowed for cleaning masonry surfaces.

#### 2.3.1.2 Water Blasting

a. Provide water blasting equipment including a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water re-supply equipment.

b. Do not operate the equipment at a pressure which will cause etching or other damage to the masonry surface or mortar joints. Operate the equipment at a discharge capacity of 0.38 to 3.0 MPa 55 to 400 psi and 9.5 to 11.4 L/m 2.5 to 3 gpm for general surface cleaning operations.

c. Provide water tank and auxiliary re-supply equipment of sufficient capacity to permit continuous operations.

d. Provide protective covers and barriers as required to prevent over-spray onto adjacent surfaces.

#### 2.3.1.3 Alternative Blasting Equipment

a. Alternative blasting methods require equipment designed to discharge sponges, walnut shells, ice, soda and other friable materials.

b. Operate equipment in accordance with manufacturer's recommendations and maintain in good working order.

c. Do not operate equipment at a pressure which will cause etching or other damage to the masonry surface or mortar joints.

d. Determine discharge capacity on a case by case basis during the mockup test panel demonstration and approval process.

e. Provide protective covers and barriers as required to prevent over-spray onto adjacent surfaces.

### 2.3.2 Spray Equipment

a. Provide spray equipment for chemical cleaners with low-pressure tanks or chemical pumps suitable for chemical cleaner indicated, and equipped with stainless steel, cone-shaped spray-tip.

b. Disperse water through a fan-shaped spray tip at an angle of not less than 15 degrees.

c. Deliver water at a pressure not greater than 3.0 MPa 400 psi and at a volume between 9.5 and 11.4 L/m 2.5 and 3 gpm.

d. Deliver heated water at flow rates indicated maintaining between 60 and 82 degrees C 140 and 180 degrees F.

2.3.3 Drilling Equipment

a. Use standard small, powered, handheld masonry drills, commonly used for drilling small holes in concrete and masonry to drill holes in masonry for patch anchors and other applications.

b. Use drills in rotary mode only. Do not use impact type drills.

2.3.4 Compressed Air Supplies

a. Use compressed air equipment that delivers clean, oil and moisture free compressed air at the surface to be cleaned. Use a minimum of two in-line air filters to remove oil and moisture from the air supply.

b. Test the compressed air supply during each shift for the presence of oil and moisture.

2.3.5 Material Handling and Associated Equipment

2.3.5.1 Mixing, Transporting, and Placing Job Materials

a. Provide equipment used for mixing, transporting, placing, and confining masonry and mortar placements capable of satisfactorily mixing material and supporting uninterrupted placement operations.

b. Provide equipment used for mixing, conveying, and placing of materials that is clean, free of old materials and contaminants, and in conformance with material manufacturer's recommendations.

2.3.5.2 Associated Equipment

Provide associated equipment, such as mixer timing equipment, valves, pressure gauges, pressure hoses, other hardware, and tools, as required to ensure a continuous supply of material and operation control.

2.4 Mortar Mix

2.4.1 General

a. Proportion materials appropriately with regard to the effect of moisture content on the individual components (cement, sand and lime).

b. Batch materials using volumetric measurement devices and consistently consolidate the material in these devices to ensure the uniformity of the mortar. Do not batch by shovel counts.

2.4.2 Batching

a. Utilize a calibrated measuring device for batching Portland cement.

b. Utilize a calibrated measuring device for batching hydrated lime or lime putty.

c. Utilize a calibrated measuring device for batching the sand.

2.4.3 Cement and Lime Proportions

a. Fill the measuring device with portland cement, hydrated lime or lime

putty.

b. Briskly strike the bottom of the measuring device against the ground a minimum of ten times and then strike the top flush.

**********

**NOTE: Dry hydrate lime experiences a significant volumetric loss when converted to a wet paste during mixing. Volume changes that occur when dry hydrated lime is converted to a wet paste can cause sizable errors in proportioning mortar formulations. Because mortar ingredients are often measured dry in restoration work, the most likely error is over-sanding. A given amount of hydrated lime occupies far more volume as a dry powder than it does after mixing with water. Thus, when lime is measured as a dry powder, less is actually put into the mixture than is used if the lime is measured as putty. When wetted, dry hydrate lime will typically contract, on average, to 75 percent of the original dry volume. Using a nominal 1:2:9 mixture (Type O) cement/lime/sand, the variation caused by wet verses dry measure of the lime results in a 1:1.5:9 mixture. This ratio exceeds the allowable sand content in ASTM C270 of 2.5 to 3 times the binder, and is 3.75 times the cement plus lime; thus an unintended over-sanded mixture results. To avoid this problem an additional amount of dry hydrate lime (25 percent) must be added to all formulations during the proportioning stage. Volume loss occurs when dry hydrate lime is mixed to a paste that is more than 42 percent solid. Note: Portland cement does not experience this volumetric loss when converted to a wet paste during mixing.**

**********

c. For dry hydrate lime, fill the measuring device using a minimum of three lifts, strike the bottom of the measuring device against the ground a minimum of ten times for each lift and then strike the top flush. Mix dry hydrate lime to a wet paste that is 40 to 42 percent solid.

d. For lime putty briskly strike the bottom of the measuring device against the ground a minimum of ten times and then strike the top flush. No additional lime is required when measuring from putty.

2.4.4 Sand Proportions

a. Proportion sand when the sand is in saturated surface dry (SSD), loose damp condition.

b. Proportion the sand by filling a measuring device using a minimum of three lifts, striking the sides a minimum of ten times, and then striking the top flush.

PART 3 EXECUTION

3.1 EXAMINATION

a. Undertake masonry renovation only after complete evaluation and analysis of the areas to be repaired are completed, including sampling and testing of the existing mortar to determine its composition and qualities. Do not start repair work until conditions that have caused masonry deterioration have been identified and corrected.

b. Use the gentlest means to perform the work and take the greatest of care to ensure that the historic materials are not damaged in the process of the work, as established by mock-ups and testing.

c. In addition to requirements in this Section, comply with NPS Hist Prop.

3.1.1 Field (In Situ) Mortar Examination

a. Detect cracks, degradation and de-bonding from the surrounding masonry.

b. Determine previous surface coating treatments that may be contributing to the current conditions.

c. Compare the bedding mortar with the pointing mortar and determine the cross-sectional characteristics of the wall.

d. Determine the level of moisture movement in the in situ mortar, and if the mortar or masonry units are handling the brunt of the water movement through the wall.

**********

**NOTE: Mortar shear strength may be needed for structural masonry walls that resist in-plane loads (wind or seismic).**

**********

e. Evaluate in situ mortar joint shear strength in accordance with ASTM C1531.

3.1.2 Taking and Preparation of Samples

a. Take and analyze samples of unweathered original historic mortar and different types of mortar in the structure in order to match the new mortar to be used for repointing.

b. Remove three or four samples of each type of mortar to be matched with a hand chisel from several locations on the building. Mortar samples to be intact pieces with a minimum size of 28 grams1 ounce.

c. Set aside the largest sample for comparison with the repointing mortar.

d. Place the remaining samples in labeled, sealed sample bags for transport to the laboratory for evaluation per Part 2 of this Specification.

## 3.2 PREPARATION

### 3.2.1 Protection

a. Protect persons, motor vehicles, adjacent surfaces, surrounding buildings, equipment, and landscape materials from chemicals used and runoff from cleaning and paint removal operations.

b. Erect temporary protection covers, which will remain in operation during the course of the work, over pedestrian walkways and at personnel and vehicular points of entrance and exit.

c. Protect the interior of buildings from the weather, cleaning, and repair operations at all times.

d. Do not expose workers to chemical substances in excess of the limits established by ACGIH 0100. Comply with more stringent regulations where applicable.

### 3.2.2 Surface Preparation

a. Do not proceed with cleaning until mock-ups have been approved.

b. Do not proceed with repointing or stucco until existing mortar and stucco have been analyzed and suitable repair materials have been determined.

c. Do not proceed with restoration work until the cause of observed distresses have been identified and corrected.

d. Do not proceed with surface treatments until all other restoration work has been completed.

### 3.2.3 Equipment and Techniques Demonstration

a. Demonstrate equipment and techniques of operation in an approved location.

b. Assemble dependable and sufficient equipment, appropriate and adequate to accomplish the work specified, at the work site with sufficient lead time before the start of the work to permit inspection, calibration of weighing and measuring devices, adjustment of parts, and the making of any repairs that may be required.

c. Maintain the equipment in good working condition throughout the project.

## 3.3 MASONRY CLEANING

### 3.3.1 General

a. Exercise caution against over-cleaning of surfaces, which may be detrimental, and which may remove desirable historic surface details or patinas. For example, if cleaning reveals unexpected joint painting or historic signage; suspend the cleaning action, protect the exposed area and notify the Contracting Officer.

b. Do not damage or mar historic materials in the process of cleaning.

c. Perform cleaning per NPS TPS Brief 1.

d. Protect open joints to prevent water and cleaner intrusion into the interior of the structure.

e. Protect non-masonry materials and severely deteriorated masonry by approved methods prior to initiation of cleaning operations.

f. Remove all organic and inorganic contaminants from the surface and pores of the substrate, without causing any short or long-term negative consequences.

g. Clean surfaces evenly with no evidence of streaking or bleaching.

h. Do not affect the density, porosity, or color of the existing masonry or mortar.

i. Maintain a neutral pH on surface of cleaned masonry units.

j. Use the gentlest methods possible for cleaning historic masonry to achieve the desired results.

k. Proceed with cleaning in an orderly manner, working from top to bottom of each scaffold width and from one end of each elevation to the other.

l. Perform cleaning in a manner which results in uniform coverage of all surfaces, including corners, moldings, interstices and which produces an even effect without streaking or damage to masonry.

m. Use the following sequence of methods to determine the least aggressive, effective cleaning method:

(1) Water with non-metallic brushes (cold water).
(2) Water with mild soap
(3) Water with stronger soap
(4) Water with stronger soap plus ammonia
(5) Water with stronger soap plus vinegar (but not on calcareous masonry)
(6) Stronger chemical cleaners, only when above methods are determined to be ineffective by the Contracting Officer

3.3.2 Chemical Cleaners

a. Do not use chemical cleaners without approval from the Contracting Officer.

b. Do not use acidic chemical cleaners on limestone, marble, concrete and other calcareous (calcium containing) masonry materials. If chemical cleaners are used on such materials, use alkaline based cleaners with neutralizing afterwashes.

3.3.3 Paint Removal

a. Prior to removal, test existing paint for lead in accordance with Section 02 83 00 LEAD REMEDIATION.

b. Clean areas where paint is to be removed with water and detergent solution to remove surface dirt. Rinse and allow to dry.

c. Remove paint and other coatings from masonry surfaces in areas indicated prior to general cleaning.

d. Do not damage or mar masonry in the process of paint removal.

e. Apply chemical paint removers in accordance with manufacturer's instructions.

f. Protect surrounding painted surfaces from exposure to chemical paint removers to avoid damage.

g. Remove paint containing lead in accordance with Section 02 83 00 LEAD REMEDIATION.

3.3.4 Water Cleaning

3.3.4.1 Pressure Spraying

a. Spray apply water to masonry surfaces to comply with requirements indicated by test patches for location, purpose, water temperature, pressure, volume, and equipment.

b. Unless otherwise indicated, wash the surface with clean, low pressure water (pressure of less than 0.38 MPa 55 psi and 9.5 to 11.4 L/m 2.5 to 3 gpm discharge) and hold spray nozzle not less than 300 mm 12 inches from surface of masonry.

c. Apply water side to side and top to bottom in overlapping bands to produce uniform coverage.

3.3.4.2 Hand Scrubbing

a. Scrub surfaces to be cleaned to remove surface contaminants.

b. Pre-wet surfaces and use hand-held natural bristle or nylon brushes.

c. Do not use wire brushes.

3.3.4.3 Rinsing

a. Rinse scrubbed surfaces clean of all contaminants and cleaning solutions with water in a low-to-moderate pressure spray, working from top to bottom of each treated area.

b. Remove all traces of contaminants and cleaning solutions.

3.3.5 Chemical Cleaning

3.3.5.1 General

a. Chemical cleaning is the use of any product in addition to water, including detergents, ammonia, vinegar, and bleach.

b. Use gentlest means possible to achieve the desired result as determined by test patches.

c. Proceed in an orderly manner, working from top to bottom of each scaffold width and from one end of each elevation to the other.

d. Provide uniform coverage of all surfaces, including corners, moldings, interstices and produce an even effect without streaking or damage to masonry.

e. Do not apply chemical cleaners to the same masonry surfaces more than twice.

3.3.5.2 Surface Prewetting

a. Wet masonry surfaces to be cleaned with chemical cleaners with water using a low pressure spray before application of any cleaner.

b. Prewet walls working from top to bottom, except work bottom to top on one-story walls.

c. Do not prewet masonry surface prior to applying biocides.

3.3.5.3 Acidic Chemical Cleaning

**********
**NOTE: Buffered acidic cleaners are generally safer for masonry substrates.**
**********

a. Apply acidic chemical cleaners according to manufacturer's instructions.

b. Do not apply acidic chemical cleaners to masonry with high calcium content (e.g. marble, limestone.

c. Apply acidic cleaners to masonry surfaces by low pressure spray 0.35 MPa 50 psi max., roller, or brush.

d. Leave cleaner on on masonry surface for the time period recommended by the manufacturer.

e. Employ manual scrubbing by brushes as indicated by test patches for the specific location.

f. Rinse cleaned surfaces with a low-to-moderate pressure spray of water to remove all traces of chemical cleaner.

3.3.5.4 Alkaline Chemical Cleaning

3.3.5.4.1 Prewash Phase

a. Apply alkaline chemical cleaners to masonry surfaces according to manufacturer's instructions, by low pressure spray 0.35 MPa 50 psi max., roller, or brush.

b. Leave cleaner on masonry surface for the time period recommended by the manufacturer.

c. Employ manual scrubbing by brushes as indicated by test patches for the specific location.

d. Rinse cleaned surfaces with a low-to-moderate pressure spray of water.

3.3.5.4.2 Afterwash Phase

a. Immediately after rinsing of alkaline cleaned surfaces, apply a neutralizing afterwash to the cleaned masonry areas.

b. Apply neutralizing afterwash according to manufacturer's instructions, by low pressure spray 0.35 MPa 50 psi max., roller, or brush.

c. Leave afterwash on masonry surface for the time period recommended by manufacturer.

d. Rinse cleaned surfaces with a low-to-moderate pressure spray of water to remove all traces of chemical cleaners.

3.3.5.5 Rinsing and pH Testing

a. Determine the pH of masonry surfaces that have been chemically cleaned using pH monitoring pencils or papers.

b. Rinse chemically cleaned masonry, using a low pressure spray, until a neutral pH (7) reading is obtained from the masonry unit surface.

3.4 MASONRY REPAIR

**********
**NOTE: Provide missing information; if a reference is added, revise paragraph REFERENCES accordingly.**
**********

3.4.1 General

a. Match repaired surfaces with adjacent existing surfaces in all respects.

b. Demonstrate the materials, methods and equipment proposed for use in the repair work in mock-ups, as specified in PART 2.

c. Use products in accordance with the manufacturer's instructions.

d. Proceed with masonry repair only after the cause of deterioration has been corrected.

e. Assist Historic Masonry Consultant with performing field investigation to determine the causes and extent of degradation. Utilize the following techniques.

(1) Employ a field microscope to closely assess the conditions at the surface of the mortar and masonry units. Detect cracks and assess for degradation and debonding from the surrounding masonry. Detect previous surface coating treatments on the mortar and masonry that may be contributing to the current conditions.

(2) Employ a boroscope to examine mortar deeper in the joint. Compare the bedding mortar with the pointing mortar and ascertain the cross-sectional characteristics of the wall.

(3) Employ moisture meters to determine the level of moisture in the mortar and masonry, and if the mortar or masonry units are handling the brunt of the water movement through the wall.

Infrared thermography, employed by a trained investigator, can provide additional information on the moisture conditions.

(4) Employ RILEM tubes using the method of RILEM II.4 or water penetration testing in accordance with ASTM C1601 to determine the rate of water uptake into the masonry.

(5) To access the physical characteristics of hard mortar, use a spring loaded or pendulum impact device to determine surface hardness as an indicator of relative compressive strength. For evaluating softer mortars, mortar integrity deeper in the wall, and the condition of the masonry units, use a drill resistance tool by an experienced consultant.

(6) Utilize technologies such as ground penetrating radar or metal detection equipment to map metal reinforcement and embedments in the wall.

(7) Use flat jack or jacks and rams to gather information on in situ compressive stress (ASTM C1196, masonry compressive response ASTM C1197, and mortar joint shear strength ASTM C1531.

3.4.2 Repointing Masonry

Repoint masonry in accordance with NPS TPS Brief 2, using ASTM E2260 as a reference guide.

3.4.2.1 Wall Preparation

a. Remove old caulking, grout, or non-original mortar from previously repaired joints to a minimum depth of 2.5 times the width of the joint. Cut all joints (unless otherwise noted) back to sound, solid, back up material. Leave a clean, square face at the back of the joint to provide for maximum contact of repointing mortar.

b. Shallow or feather edging is not permitted. Remove loose particles from joints. Clean joints, followed by blowing with filtered, dry, compressed air or vacuum.

c. Cut out existing horizontal mortar joints (bed joints) that are filled with a hard Portland mortar using a diamond blade that is narrower than the joint width. Cut out the middle one-third of the mortar joint using a rotary power saw. Remove the remaining mortar from the masonry joints by hand using masonry chisels or pneumatic carving tools.

d. Do not use rotary power saws to cut out vertical joints (head joints) . Remove all vertical head joints by hand using a pneumatic carving tool, or hammer and chisel.

e. Remove existing historic lime-based mortar using only small-headed chisels that are no wider than half the width of the existing masonry joints. Pneumatic air carving chisels are permitted as are specially designed mortar removal reciprocating tools (i.e. Arbortech Saw).

f. Do not widen the existing masonry joints. Do not chip or spall the surrounding masonry edges in the process of mortar removal. Damage to surrounding masonry units resulting from rotary blade over running is not permitted. Damages to adjacent materials exceeding 3.2 mm1/8 inch

in size are the responsibility of the contractor and must be repaired by removal and replacement of damaged materials.

g. Permit applicators to be trained at the project site in this masonry treatment requirement.

3.4.2.2 Presoaking Masonry / Mortar Consistency / Lifts

a. Use the same mortar as the repointing mortar for setting the replacement masonry.

b. Soak exposed surfaces of historic masonry adjacent to joint with water prior to repointing.

c. Allow time for excess water to run off and evaporate prior to repointing. Joint surfaces must be damp but free from standing water.

d. Maintain a water sprayer on site at all times during the repointing process.

e. The mortar material must resemble the consistency of brown sugar during installation. This drier consistency enables the material to be tightly packed into the joint, allows for cleaner work, and prevents shrinkage cracks as the mortar cures.

f. Allow mixed repointing mortar to stand for not less than one-half hour and not more than one and one-half hours for pre-hydration to reduce post-curing shrinkage. After this time, water can be added to small batches by hand to bring the mortar to a stiff yet workable consistency. Use repointing mortar within two and one-half hours after initial mixing and within one hour after adding water to bring the mortar to a working consistency. Retempering of the mortar to replace evaporated water is permitted within these time frames.

g. Point joints in layers or "lifts" where the joints are deeper than 32 mm 1-1/4 inch. Apply in layers not less than 1/2 the depth but not more than 32 mm 1-1/4 inch or until a uniform depth is formed.

3.4.2.3 Compression / Joint Finish / Curing

a. Compress each layer thoroughly.

b. When mortar is thumbprint hard at the surface of the wall, finish the joints to match the original historic joint profile.

c. For Type L mortar:

(1) Allow water evaporation from the freshly repointed walls in order to initiate the carbonation process in high lime content mortars. The carbonation of lime mortar initially requires wet-and-dry cycles, which can be created by water misting the joints after the mortar application when dry weather conditions prevail. Finish the joint profile before these cycles are started.

(2) Depending on the environmental conditions (temperature and humidity), carry out water misting until a full nine alternating wet-and-dry cycles are completed.

(3) Adjust curing methods to ensure that the repointing mortar is

damp without eroding the surface of the mortar.

3.4.2.4 Protection

a. Keep the mortar from drying out too quickly or from becoming too wet.

b. Protect mortar from direct sun and high winds for the first 72 hours after installation or from driving rain for the first 24 hours, using plastic sheeting if necessary. Do not create a greenhouse effect by sealing off air movement in an attempt to protect the wall with plastic. Allow for air circulation to facilitate the carbonation process.

3.4.3 Retooling Stone Masonry In situ

a. Scale off all loose pieces of original stone from masonry intended to remain in place, including surface material in powder or granular form and detachments of planer elements, spalls and chips.

b. Assess all stone on building by sounding (tapping with a small hammer) or by using impact echo (for massive stones), surface penetrating radar, or infrared thermography in order to distinguish fully intact stone from those in which delamination may be hidden or pieces of unstable material may not be immediately visible.

c. Remove and replace stone units that are designated for retooling in situ, but develop a solid stone substrate that is no longer in plane or plumb with the surrounding stone masonry surfaces after chiseling is complete.

3.4.4 Masonry Removal and Replacement

a. Before removing any deteriorated masonry units, establish bonding patterns, levels and coursings. Remove masonry that has deteriorated or is damaged beyond repair, as determined through investigation and evaluation. Carefully demolish or remove entire units from joint to joint, without damaging surrounding units in a manner that permits replacement with full-size units. Support and protect remaining masonry work that surrounds removal area. Maintain flashing, reinforcement, lintels, and adjoining construction in an undamaged condition. Notify Contracting Officer of unforeseen detrimental conditions including voids, cracks, bulges, and loose masonry units in existing masonry backup, rotted wood, rusted metal, and other deteriorated items. Remove as many whole masonry units as possible without damage.

b. Remove mortar, loose particles, and soil from masonry by cleaning with hand chisels, non-metallic brushes, and water.

c. Remove sealants by cutting close to masonry units with utility knife and cleaning with solvents. Clean surrounding masonry areas by removing mortar, dust, and loose particles in preparation for replacement.

d. Replace removed masonry with masonry units removed from inconspicuous areas of the building, where possible, or with new masonry units matching the existing units. Butter vertical joints for full width before setting and set units in full bed of mortar, unless otherwise indicated. Remove mortar used for laying/setting masonry units before

mortar sets to the repointing depth of the surrounding area. Repoint new mortar joints in repaired area to comply with requirements for repointing at existing masonry units.

e. If a few isolated masonry units are to be replaced, remove each without disturbing the surrounding masonry. Remove deteriorated masonry units and mortar requiring replacement by hand chiseling. Do not damage adjoining masonry units during the removal of deteriorated units and mortar.

f. Test the new element for fitting into its space without mortar. Use wedges made from non-expanding, non-corrosive material such as plastic to support and align the new unit, cover them with at least 38 mm 1-1/2 inches of mortar when pointing is complete.

g. Cover the four sides of the space with sufficient mortar to ensure that there will be no air spaces when the new unit is set. Fill the back of the space with mortar only if it matches existing construction.

h. Line up and set the new unit by tapping it into place with a wooden or rubber mallet. Align the face of new unit with that of existing masonry.

i. Repoint joints to match the rest of the wall after new units have been properly installed and adjusted.

j. Clean replacement areas with a non-metallic brush and water to remove excess mortar.

3.4.5 Material Repair

Repair or replace original historic masonry materials only if surfaces are extensively deteriorated (surface missing to a depth of 100 mm 4 inches or more) or are threatening the safety of the structure or individuals. If additional damage is found, notify the Contracting Officer. Repairs and replacements must match the materials, colors, and finish of the existing historic masonry as closely as possible.

3.4.5.1 Selective Demolition

a. Remove unsound, weak, or damaged masonry and mortar in areas as indicated.

b. Remove loose particles, laitance, spalling, cracked, or debonded masonry and mortar and foreign materials with hand tools unless otherwise noted.

c. Clean surfaces prepared for repair free of dust, dirt, masonry chips, oil or other contaminants, rinsed with water, and dried before repair work is begun.

d. Protect surfaces of the structure, and surfaces adjacent to the work area from damage which may result from removal, cleaning, and repair operations.

3.4.5.2 Application of Substitute Repair Materials

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**NOTE: Use repair materials as a last resort after all other repair treatments are determined to be ineffective or cost prohibitive.**

**********

a. Place repair materials to rebuild spalled or damaged areas to match the original surface finish, level, texture, bonding patterns, color and porosity. Match the finished appearance of the substitute repair material patch with the adjacent existing surface. Apply samples to the masonry units in situ.

b. Do not install repair material in thicknesses exceeding 50 mm 2 inches. Utilize a Dutchman repair approach or replacement unit for masonry repairs in excess of 50 mm 2 inches.

c. Remove loose mortar and masonry prior to installation of the repair material. "Sound" the masonry with a hammer to verify its integrity. If necessary, cut away an additional 12.7 mm 1/2 inch of the masonry substrate to ensure the surface to be repaired is solid and stable.

d. Remove all deteriorated stone, mortar, sealant residue, and previous repair materials back to sound substrate using hammer and chisel or power equipment. Finish edges square to a minimum depth of 12.7 mm1/2 inch. Do not feather edges. Roughen substrate surface to achieve surface roughness required by manufacturer for good bond, but do not overly damage the substrate surface.

e. Remove sealant residue. Cut out used anchors, threaded rod anchors and/or dowels within the damaged masonry area. Any anchors that are free of rust, solidly embedded, and do not project beyond the solid masonry surface may remain.

f. Using clean water and a non-metallic scrub brush, clean dust from surface and pores of the substrate.

g. Pre-wet the substrate with water prior to the application of the repair material to prevent the substrate from drawing out the moisture too quickly. Re-wet the surface with water again immediately before applying the repair material. Use methods approved by the repair material manufacturer to deliver the substitute repair work as demonstrated.

h. Follow manufacturers' instructions pertaining to the placement of materials. If the manufacturer requires that installers of a specified product be trained, provide this documentation to the Contracting Officer. Training certificates previously issued by product companies for the application of specified products cannot be substituted for the Project Training "Substitute Repair Material Certificate" on this project.

i. Masonry and Material Repair Finishes and Color

(1) Match the exposed surfaces of masonry and substitute material repair finish, color, texture, and surface detail with the original surface. Mechanical finishing and texturing may be required to produce the required finish and appearance.

(2) Conceal bond lines between the repaired area and adjacent surfaces.

(3) Replicate all surface details, including tooling and machine marks.

(4) Use low-impact energy type equipment in finishing and texturing, which will not weaken the patch or damage the patch bond and the adjacent masonry.

3.4.5.3 Patch Anchors

a. Provide patch anchors to ensure that the patch is tied to the existing masonry structure at a frequency of at least one patch anchor per 2580 square mm 4 square inches of patch plan surface area; specific locations for patch anchors must be as indicated.

b. Use small handheld, low-speed rotary masonry drills to produce holes in the existing masonry, within the limits for the patch anchor installation.

(1) Drill holes into the existing substrate material of the masonry using rotary (non-hammer) drills making holes with a diameter of 3 mm 1/8 inch larger than the anchor diameter and a depth of 101 mm 4 inches, except as otherwise indicated or directed.

(2) Drill holes must not penetrate completely through the masonry, and must provide at least 25 mm 1 inch of cover around the drill hole.

(3) Clean holes by water blasting to remove drill dust and other debris and then blow dry with filtered, dry, compressed air.

(4) Condition drill holes in accordance with the epoxy adhesive manufacturer's recommendations.

c. Clean anchors to remove all contaminants which may hinder epoxy bond.

d. Pressure inject adhesive into the back of the drilled holes.

(1) Fill holes without spilling excess grout when the anchors are inserted.

(2) Insert anchors immediately into the holes.

(3) Set back anchors from the exterior face at least 25 mm 1 inch.

(4) Install anchors without breaking or chipping the exposed masonry surface.

(5) Use socked or screen tube anchors where voids exist in the masonry units or between the wythes.

3.4.5.4 Cleanup

a. Protect masonry surfaces from excess grount adhesive and spills.

b. Leave the surface of the masonry in a clean and uncontaminated condition.

3.4.6 Dutchman Repairs

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**NOTE: A Dutchman repair is a process of removing**

**damaged stone to a specified depth and inserting a new piece of stone to fit in the opening to create the appearance of a seamless patch. The process involves careful and precise removal of select deteriorated stone material, usually in a larger stone.**

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a. Select stone for Dutchman repairs from the following three sources listed in order of priority:

(1) Stone harvested from the same elevation and stone type.

(2) Approved salvaged stone.

(3) New stone made from a similar stone type.

b. Fit the new piece into place with tolerances of no more than plus or minus 1.6 mm 1/16-inch.

c. Provide supporting rods of stainless steel as necessary for the extent of the repair and the location.

d. Closely blend repairs in with the surrounding original materials.

3.4.7 Crack Injection with Dispersed Hydrated Lime (DHL)

3.4.7.1 General

a. Notify the Contracting Officer as to when and where the installation will occur at least 48 hours prior to start.

b. Provide samples to the Government representative from the dispenser during the course of the injection.

c. Apply in accordance with the manufacturer's instructions.

3.4.7.2 Application of DHL

a. Drill 3.2 mm 1/8-inch diameter, downward-sloping injection holes. For transverse cracks less than 3.2 mm 1/8 inch wide, drill holes through center of crack at 25 to 40 mm 1 to 1.5 inches on center.

b. Clean out drill holes and cracks with compressed air and potable water. Remove dirt and organic matter, loose material, sealants, and failed crack repair materials.

c. Inject Dispersed Hydrated Lime using hypodermic needles or pressure ports through holes sequentially, beginning at one end of area and working to opposite end. Do not exceed 0.069 MPa10 psi injection pressure. Where possible begin at lower end of injection area and work upward. Inject Dispersed Hydrated Lime until it extrudes from adjacent holes. After Dispersed Hydrated Lime has set, remove excess material and patch injection holes and surface of cracks with appropriate surface treatment.

3.4.7.3 Tools and Equipment

Do not use tools and equipment that have not been cleaned of set dispersed

hydrated lime.

3.4.8 Surface Treatments

3.4.8.1 Stucco

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**NOTE: The correct finish is project specified. Specify the desired finish as appropriate for the project... Possible finishes include; tight-trowel, smooth; wet/damp sponge; or dry wood float. In rare cases, a pebble-dash finish may be required where screened aggregates are cast into the wet finish coat and pressed back with a wood float or left exposed. Historic stuccos may also include animal hair for reinforcement. Ox or cattle hair is the preferred choice, but horse or goat hair may be used.**

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a. Apply stucco on a clean surface in accordance with ASTM C926 at a thickness matching surrounding historic surfaces.

b. Soak the substrate with water to saturated surface dry (SSD) condition prior to application of scratch-coat.

c. Apply the scratch-coat and allow to partially-set on the wall surface.

d. Use a scratch rake to create the keys into the scratch coat for acceptance of the finish coat.

e. Apply the finish coat approximately 24 hours after the scratch coat application.

f. Soak the scratch coat with water to SSD condition prior to the application of the finish coat.

g. Apply the textured finish and profile [to match the surrounding historic surfaces].

3.4.8.2 Limewashes

a. Apply limewash using fiber brushes in three thin coats on saturated surface dry (SSD) raw masonry surfaces.

b. Do not allow the material to dry out before it has had a chance to absorb into the masonry surfaces.

c. Work from top to bottom of the wall working from the dry-edge.

d. Allow six hours drying time between coats

e. Where colors are desired, use natural earth pigments.

f. Verify all applications, materials and colors through mock ups panels applied to the substrate prior to the start of the work.

3.4.8.3 Water Repellents Infiltration

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**NOTE: Water proofing, for the purposes of this specification, is considered any continuous chemical coating designed to sit on the surface of the masonry and preclude water movement through the pore structure of the masonry units, mortar or at their intersection. Historic Masonry structures were typically intended to manage moisture movement by allowing water vapor transmission through the pores and by allowing the dew point to move in the wall. While water proofing may preclude water ingress into the masonry system, it also precludes water vapor egress and is therefore not acceptable.**

**Water repellents are designed to resist water infiltration through the pore structure of masonry while allowing water vapor transmission. Unfortunately, evidence exists that some water repellents do not perform as advertised and can impede vapor transmission. Only when all other water infiltration control methods have been considered carefully and disqualified, and the extreme decision has been reached to potentially risk a loss of historic material, will water repellents be allowed.**

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Application of water proofing is not allowed.

Application of water repellents may be performed upon Contracting Officer approval of the recommendation and justification, by the historic masonry consultant, that no other means will control water infiltration. Apply water repellents per manufacturer's instructions.

3.4.8.4 Stone Consolidants

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**NOTE: Consolidants are chemical treatments designed to replace the natural cementing materials in stone. Stone formation in nature is a complex process of chemical reactions, pressure and time which consolidants are not able to successfully duplicate.**

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Use of stone consolidants requires Contracting Officer approval of the historic masonry consultants recommendation, including justifying data. Apply stone consolidants per manufacturer's instructions.

3.5 INSTALLATION OF NEW ELEMENTS

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**NOTE: Issues such a seismic upgrades and remediating ongoing water infiltration issues may lead to the introduction of new elements to historic structures. Consult with the Historic Preservation Officer when such additions are being considered. New materials and components can have both functional and aesthetic impacts on historic structures and must be considered carefully.**

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Evaluate new materials and components for both functional and aesthetic impacts on historic structures.

3.5.1 Structural Upgrades

For mechanical anchors used to reinforce masonry structures, provide design by a registered professional structural engineer. Strengthening measures must take into account the current loads and stresses in the structure and the nature in which the building has historically managed thermal and other environmental changes or cycles.

Submit manufacturers literature, design analysis and detail drawings for the proposed additional materials.

3.5.2 Joint Sealant and Lead Flashing

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**NOTE: Joint sealant is a flexible material that may be found in historic structures as a replacement for the original material used in construction. Typically, it is used in lieu of mortar around windows and in masonry joints and in masonry joints between stone elements at vulnerable areas such as copings and sills..**

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a. Test existing sealants for asbestos and PCBs before performing demolition.

b. Provide joint sealing as specified in Section 07 92 00 JOINT SEALANTS.

(1) Augmentation with lead flashing is allowed for upward facing joints exposed to weather.

(2) Install sealants and lead flashing in accordance with manufacturer's recommendations.

3.6 FINAL CLEANING

a. No sooner than 72 hours after completion of the repair work and after joints are sealed, wash down faces and other exposed surfaces of masonry with water applied with a soft bristle brush, then rinse with clean water.

b. Discolorations that cannot be removed by these procedures, are considered defective work.

c. Perform cleaning work when temperature and humidity conditions allow the surfaces to dry rapidly.

d. Protect adjacent surfaces from damage during cleaning operations.

3.7 PROTECTION OF WORK

Protect work against damage from subsequent operations.

## 3.8 DEFECTIVE WORK

Repair or replace defective work as directed by Contracting Officer, using approved procedures.

## 3.9 FINAL INSPECTION

Following completion of the work, inspect the structure for damage, staining, and other distresses. Inspect the patches for cracking, crazing, delamination, unsoundness, staining and other defects. Inspect the finish, texture, color and shade, and surface tolerances of the patches to verify that all requirements have been met. Repair surfaces exhibiting defects as directed.

a. Following completion of the work, inspect the structure for damage, staining, and other distresses.

   (1) Inspect patches for cracking, crazing, delamination, unsoundness, staining and other defects.

   (2) Inspect finish, texture, color and shade, and surface tolerances of the patches to verify that all requirements have been met.

b. Repair surfaces exhibiting defects as directed by Contracting Officer.

-- End of Section --