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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2014

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DIVISION 04 - MASONRY

SECTION 04 01 00.91

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SECTION 04 01 00.91

RESTORATION AND CLEANING OF MASONRY IN HISTORIC STRUCTURES 05/12

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 items(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).

PART 1 GENERAL

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

1.1 GENERAL REQUIREMENTS

It is the intent of this specification to protect historic structures to the greatest extent possible. 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. In addition to requirements in this section, comply with **NPS Hist Prop**.

1.2 REFERENCES

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 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.

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

(2001; Supplements 2002-2008)
Documentation of the Threshold Limit

Values and Biological Exposure Indices

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM C1324	(2010) Standard Test Method for Examination and Analysis of Hardened Masonry Mortar
ASTM C1364	(2010b) Standard Specification for Architectural Cast Stone
ASTM C144	(2011) Standard Specification for Aggregate for Masonry Mortar
ASTM C1489	(2001; E 2008; R 2008) Standard Specification for Lime Putty for Structural Purposes
ASTM C170/C170M	(2009) Standard Test Method for Compressive Strength of Dimension Stone
ASTM C207	(2006; R 2011) Standard Specification for Hydrated Lime for Masonry Purposes
ASTM C216	(2013) Facing Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C34	(2012) Structural Clay Load-Bearing Wall Tile
ASTM C67	(2013) Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile
ASTM C881/C881M	(2010) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM E11	(2013) Wire Cloth and Sieves for Testing Purposes
ASTM E2659	(2009; E 2010) Standard Practice for Certificate Programs
ASTM E96/E96M	(2012) Standard Test Methods for Water Vapor Transmission of Materials

NATIONAL PARK SERVICE (NPS)

NPS Hist Prop	(1995) 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

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

GSA HPTP 07656-01

Installing Lead Stone Flashing to Protect
Masonry Joints

1.3 DEFINITIONS

Terms are defined below as applicable to this project.

1.3.1 Aggregates

The sand component of mortar.

1.3.2 Biocides

A chemical treatment meant to eliminate organic growth on the masonry units and mortar and prohibit re-growth.

1.3.3 Binder

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

1.3.4 Dispersed Lime Crack Injection

A repair method in which dispersed lime material is injected into small hairline cracks by use of needle or syringe.

1.3.5 Consolidant

A chemical product meant to strengthen loose or deteriorated stone.

1.3.6 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.

1.3.7 Insitu

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

1.3.8 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.

1.3.9 Lead Flashing

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

1.3.10 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.

1.3.11 Mockup

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

1.3.12 Mortar

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

1.3.13 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.

1.3.14 Patch

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

1.3.15 Remediate

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

1.3.16 Remove

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

1.3.17 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.

1.3.18 Repoint

To remove existing mortar joints to the specified depth and replace with a mortar that matches in color, texture, and performance with maximum breathability, bond, and flexibility to accommodate movement.

1.3.19 Retool

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

1.3.20 Stucco

A mixture of binders and aggregates and animal hair or fibers used for the

repair treatment of original stucco.

1.3.21 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 prevent water infiltration.

1.3.22 Test Panel

Specific area on the building approved by the Contracting Officer to demonstrate individual applicator competency in workmanship proficiency during the on-site training program.

1.3.23 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.

1.3.24 Water Repellent

A chemical product designed to preclude water entry into a masonry wall system.

1.3.25 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.

1.3.26 Masonry Treatment Requirement (MTR)

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

1.3.27 Saturated Surface Dry (SSD)

Defined as a condition of the wall surface after water has been applied and allowed to dry to a point with no standing water visible.

1.4 PRE-CONSTRUCTION CONFERENCE

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 shall participate in this meeting.

1.5 SUBMITTALS

**NOTE: Review submittal description (SD) definitions
in Section 01 33 00 SUBMITTAL PROCEDURES and edit**

the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated 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 submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation 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][; G, [____]]
Project Training Program[; G][; G, [____]]

SD-02 Shop Drawings[; G][; G, [____]]

Documentation
Structural Upgrades[; G][; G, [____]]

SD-03 Product Data

Cleaning and Restoration Methods[; G][; G, [____]]
Cleaning Materials[; G][; G, [____]]
Qualifications
Water Infiltration[; G][; G, [____]]
Stone Consolidants[; G][; G, [____]]

SD-04 Samples

Mock-ups[; G][; G, [____]]

SD-07 Certificates

Repair Materials

1.6 QUALITY CONTROL

Submit resumes for all historic masonry workers, demonstrating the minimum experience required. Product manufacturers, vendors, distributors, or suppliers of materials will not be permitted to offer on-site project training certificates or historic masonry consultation services.

1.6.1 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 plan. At a minimum, include the items in the Quality Control Plan

- a. Describe methods of dust containment during the work specific to the restoration and cleaning work.
- 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 tools the contractor proposes to use for each MTR specified.
- d. Describe the sequence of each MTR.
- e. Describe how the sequence of MTR and the construction schedule changes as it relates to climate changes and protection of completed work.
- 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 for cleaning the masonry for reuse.
- i. Describe the method and approach to mortar joint removal.
- j. Describe the method and approach to cleaning mortar coating smears and old patching materials from the masonry surfaces.
- k. Describe, in detail, the procedures relating to techniques and tools proposed for masonry matching.
- l. 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.
- m. Describe the procedure for matching of different colors at different locations.

- n. Describe the procedure for mixing and matching of substitute repair materials.
- o. Describe the methods and system by which the use of reclaimed masonry units can be utilized.
- p. Describe the methods for setting masonry back into its original position and maintaining the original bond patterns and joint width.
- q. Describe the methods of transition points where replacement/preservation work will meet the original historic work.
- r. Describe the on-site [project training program](#). Provide the opportunity for workers to be trained in each masonry treatment requirement (MTR) as work proceeds.

1.6.2 [Qualifications](#)

1.6.2.1 Historic Masonry Consultant

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. Submit five relevant projects within that period that 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. The consultant's services include; investigating the condition of the masonry materials and mortar, arranging for material analysis in the laboratory, recommending appropriate cleaning methods and materials, recommending restoration options, providing project specific specifications, providing an on-site training program and providing quality control services during construction.

1.6.2.2 Masonry Firm

The firm performing the masonry work shall have a minimum of five years experience on similar projects. The firm shall have completed work similar in material, design, and extent to that indicated for this Project and shall demonstrate a record of successful in-service performance. Proven implementation of [NPS Hist Prop](#) and related Preservation Briefs are required.

1.6.2.3 Field Supervision

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

1.6.2.4 Masonry Applicator

Employ craftspeople who are experienced with and specialize in restoration work of the types they will be performing. 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. Only skilled journeyman masons who are familiar and experienced with the materials and methods specified may be used.

1.6.3 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.

1.6.4 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.

1.6.5 Cleaning and Restoration Mock-ups

1.6.5.1 Cleaning and Restoration Methods

Submit the cleaning and restoration methods, and materials selected for a specific structure for approval before work starts. 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. Utilize mockups to identify the appropriate cleaning and restoration treatment and materials and set the standard for each project task. 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](#).

1.6.5.2 Cleaning Products and Procedures

Establish cleaning products and procedures during the mockup process; selecting the least aggressive method used to achieve the desired level of clean. Where chemical products are selected for cleaning, use them in accordance with the manufacturer's instructions.

1.6.6 Masonry Mock-ups

Submit mock-ups of each treatment proposed for use in the work. No masonry or mortar shall be used in the work until the mock-ups and the represented material and workmanship have been approved. Materials shall be submitted and approved prior to the creation of mock-ups. The location for placement, size, and location of mock-ups will be [as directed] [_____].

Mock-ups must demonstrate the methods and quality of workmanship to be performed in each masonry treatment requirement (MTR). Provide a mockup for each MTR indicated[and included in related specification Sections].

- a. Prepare mock-ups on existing walls under the same weather conditions expected during the remainder of the work.
- b. Throughout restoration, retain approved mock-up panels in undisturbed condition, suitably marked, as a standard for judging completed work.

- c. Review manufacturer's product data sheets to determine suitability of each product for each surface.
- d. Apply products using manufacturer-approved application methods, determining actual requirements for application.
- e. 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.
- f. Mock-ups: May be performed on inconspicuous sections of actual construction
 - (1) Location and number as directed[, but no more than [____]].
 - (2) Size: 600 mm by 900 mm 2 feet by 3 feet or as appropriate for the repair specified
 - (3) Repair unacceptable work.

1.6.6.1 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.

1.6.6.2 Retooling Stone Masonry Insitu

Demonstrate treatment technique and methods to retool three deteriorated stone faces insitu in all known historic profile textures identified. Finishes include, but are not limited to, corduroy and point chisel finishes.

1.6.6.3 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.

1.6.6.4 Substitute Repair Material

1.6.6.4.1 Patching

Apply substitute 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 substitute repair material on the second masonry unit (where applicable).

1.6.6.4.2 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.

1.6.6.5 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 substitute repair materialt.

1.6.6.6 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 any 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.

1.6.6.7 New Masonry Elements

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

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

1.7 DELIVERY, STORAGE, AND HANDLING

Furnish cement in suitable bags used for packaging cements. Labeling of packages shall clearly define contents, manufacturer, and batch identification. Detergents, masonry cleaners, paint removers, solvents, epoxies and other chemicals used for masonry cleaning shall be 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. Store materials in weathertight structures which will exclude moisture and contaminants. Accessories shall be stored avoiding contamination and deterioration. Admixtures which have been in storage onsite for six months or longer, or which have been subjected to freezing, shall not be used unless retested and proven to meet the specified requirements.

1.8 FIELD CONDITIONS

1.8.1 General Ambient Conditions

Masonry, mortar, and epoxy adhesives shall not be placed when weather

conditions detrimentally affect the quality of the finished product. No masonry or mortar shall be placed when the air temperature is below 5 degrees C 40 degrees F in the shade. When air temperature is likely to exceed 35 degrees C 90 degrees F masonry and mortar shall have a temperature not exceeding 35 degrees C 90 degrees F when deposited. Materials to be used in the work shall be neither produced nor placed 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. Masonry surfaces shall be cleaned only 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.

1.8.2 Masonry Installation Conditions

Do not perform any masonry repointing unless air temperatures are between 10 degrees C 40 degrees F and 32 degrees C 95 degrees F and will remain so for at least 48 hours after completion of work. Phase repointing during hot weather by completing process on the shady side of the building or schedule installation of materials during cooler evening hours to prevent premature evaporation of the water from the mortar. Do not use frozen materials or materials mixed or coated with ice or frost. Do not lower the freezing point of mortar by the use of admixtures or anti-freeze agents. Do not add chlorides to the mortar. Prevent repointing mortar from staining the face of the masonry or other exposed surfaces. Immediately remove all repointing 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. If the Contractor fails to protect against building damage as a result of work of this Section, such damage shall be the Contractor's responsibility. The Contractor shall restore damaged areas to the complete satisfaction of the Owner at no expense to the Owner. Do not apply products under conditions outside manufacturer's requirements, which include:

- a. Surfaces that are frozen; allow complete thawing prior to installation.
- b. Surface and air temperatures below 5 degrees C 40 degrees F.
- c. Surface and air temperatures above 35 degrees C 95 degrees F.
- d. When surface or air temperature is not expected to remain above 5 degrees C 40 degrees F for at least 48 hours after application.
- e. Wind conditions that may blow materials onto surfaces not intended to be treated.

1.9 WARRANTIES

1.9.1 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.

1.9.2 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.

PART 2 PRODUCTS

2.1 CLEANING MATERIALS

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. 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. Research has determined that 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 similar projects. Selection of the products shall be predicated on long-term negative effects to the masonry rather than current level of cleanliness of the comparable structure.

2.1.1 Paint Removers

- a. Provide chemical paint removers which are manufacturer's 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.

2.1.2 Chemical Cleaners

Chemical cleaners range from acidic to alkaline in their chemical makeup. Along with the cleaner, provide the associated pre and post treatment material to neutralize the long term effects of the chemicals. All products shall be commercially available and have a proven record of cleaning masonry without altering, damaging or discoloring the masonry units or mortar.

2.1.3 Biocides

Use biocides that are chemical treatments designed to remove organic growth from masonry. The manufacturer's literature for all biocides shall contain 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.

2.1.4 Liquid Strippable Masking Agent

Liquid strippable masking agent shall be 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.

2.1.5 Cleaning Implements

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

2.1.6 Water

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

2.2 REPAIR MATERIALS

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 non-performing. Masonry materials used for repair and renovation shall match the original existing historic materials as closely as possible in composition, color, texture, strength, size, finishing and porosity. Substitute repair materials shall be of one type and from one source, when used in repair treatments which will have surfaces exposed in the finished structure.

2.2.1 Mortar and Stucco

The replacement mortar and stucco shall coexist with the old in a sympathetic, supportive and, if necessary, sacrificial capacity. The replacement mortar and stucco shall have greater vapor permeability and be softer (measured in compressive strength) than the masonry units. The replacement mortar or stucco shall be as vapor permeable, and as soft, or softer, (measured in compressive strength) than the existing historic mortar or stucco. Measure water vapor transmission in accordance with [ASTM E96/E96M](#).

2.2.1.1 Matching

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]. The replacement mortar and stucco shall match the original existing material in color, texture and tooling. The sand shall match the sand in the original existing mortar and stucco by color, shape and particle size distribution as defined using [ASTM C144](#); [ASTM E11](#) sieves. Use of admixtures is subject to approval.

2.2.1.2 Binder Content of Historic Mortar

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 (2200-2800F) 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 (1650-2000F), 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. Each binder type or mixture of mortar (and stucco) shall have 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.

2.2.1.3 Crack Injection

Comply with the dispersed hydrated lime manufacturer's written instructions. Inject cracks that are no greater than 3 mm 1/8 inch in width and masonry is soundly bonded but cracked. Unless specifically instructed inject the full length of the cracks.

2.2.2 Replacement Masonry Materials

2.2.2.1 Replacement Brick

Replacement brick shall match in color, shape, size, texture and appearance to the existing historic brick. Test brick in comparison to the original existing historic brick using ASTM C67. Reclaimed brick shall be used only upon Contracting Officer approval. Brick shall meet the requirements of ASTM C216 Grade SW unless otherwise specified.

2.2.2.2 Replacement Stone

Replacement stone shall match in type, color, shape, size, texture and finish-profile the appearance of the existing historic stone units. Test replacement stone in comparison to the existing historic stone using ASTM C170/C170M.

2.2.2.3 Replacement Terra Cotta

Replacement terra cotta shall match in color, shape, size, texture and finish-profile to the appearance of the existing historic terra cotta units. Test replacement terra cotta in comparison to the existing historic terra cotta using ASTM C34.

2.2.2.4 Replacement Architectural Precast Stone

Replacement architectural precast stone shall match in color, shape, size, texture and finish-profile to the appearance of the existing historic architectural precast stone units. Test replacement architectural precast stone in comparison to the existing historic architectural precast stone using ASTM C1364.

2.2.3 Masonry Elements

2.2.3.1 Epoxy Anchor Adhesives

Use an epoxy-resin grout to bond steel anchors to masonry. The grout shall be a 100 percent solids, moisture insensitive, low creep, structural

adhesive. The epoxy shall conform to ASTM C881/C881M, Type IV; Grade and Class selected to conform to the manufacturer's recommendations for the application.

2.2.3.2 Metal attachments

Anchors for spall repairs shall be threaded stainless steel, size as indicated. Other plates, angles, anchors, and embedments shall conform to ASTM A36/A36M, and shall be prime painted with inorganic zinc primer.

2.2.3.3 Lead Flashing

Lead flashing conforming to GSA HPTP 07656-01 shall be a commercially available product designed for installation in mortar joints to help protect against water infiltration.

2.2.4 Surface Treatments

Contemporary chemical treatments to stabilize masonry units without impeding water vapor transmission are permitted for use, including, silanes and siloxanes that react chemically with the masonry.

2.2.4.1 Consolidants

Consolidants shall be commercially available products designed to strengthen loose or deteriorated stone without damaging intact stone or affecting the vapor transmission properties of the original material.

2.2.4.2 Water Repellents

Water repellents shall be commercially available products designed to preclude water droplet entry into the masonry walls without affecting the vapor transmission properties of the original material.

2.3 EQUIPMENT

2.3.1 Cleaning Equipment

Cleaning equipment shall not cause staining, erosion, marring, or other damage or changes in the appearance of the surfaces to be cleaned.

2.3.1.1 Sandblasting

Sandblasting equipment is not allowed for cleaning masonry surfaces.

2.3.1.2 Water Blasting

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. 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. The water tank and auxiliary re-supply equipment shall be of sufficient capacity to permit continuous operations. Provide protective covers and barriers as required to prevent over-spray onto adjacent surfaces.

2.3.2 Spray Equipment

Spray equipment for chemical cleaners shall be low-pressure tanks or chemical pumps suitable for chemical cleaner indicated, and shall be equipped with stainless steel, cone-shaped spray-tip. Spray equipment for water shall disperse water through a fan-shaped spray tip at an angle of not less than 15 degrees. Spray equipment shall 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. Spray equipment for heated water shall be capable of maintaining temperature, at flow rates indicated, between 60 and 82 degrees C 140 and 180 degrees F. Keep the spray-tip at a 255 mm 10-inch minimum distance from the wall surface during operations.

2.3.3 Alternative Blasting Methods

Alternative blasting methods require equipment designed to discharge sponges, walnut shells, ice, soda and other friable materials. These are specially designed systems that must be operated in accordance with manufacturer's recommendations and maintained in good working order. Do not operate the equipment at a pressure which will cause etching or other damage to the masonry surface or mortar joints. Determine the discharge capacity on a case by case basis during the mockup test panel demonstration and approval process. Provide protective covers and barriers as required to prevent over-spray onto adjacent surfaces.

2.3.4 Drilling Equipment

Use standard handheld masonry drills, commonly used for drilling small holes in concrete and masonry to drill holes in masonry for patch anchors and other applications. The drill shall be a small, powered, handheld type, using rotary drilling mode only. Impact and rotary impact type drills will not be allowed.

2.3.5 Compressed Air Supplies

Compressed air equipment shall deliver clean, oil and moisture free compressed air at the surface to be cleaned. The compressed air line shall have at least two in-line air filters to remove oil and moisture from the air supply. Test the compressed air supply during each shift for the presence of oil and moisture.

PART 3 EXECUTION

3.1 EVALUATION AND ANALYSIS

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. No repair work shall be undertaken until conditions that have caused masonry deterioration have been identified. Correct such conditions, if possible, prior to start of the work.

3.1.1 Mortar Analysis

Analyze existing original historic mortar before repointing in order to provide a match with the new repointing mortar. Historic mortars are usually softer than newer mortars, often using lime as a binder rather than cement. Lime for repointing mortar shall conform to ASTM C207, Type S, or ASTM C1489 unless otherwise specified. Full laboratory analysis of the

existing mortar shall conform to [ASTM C1324](#), and include methods for precise determination of the binder constituents. Field analysis of the existing mortar shall be as specified below.

3.1.1.2 Field (Insitu) Mortar Analysis

- a. Analyze the mortar composition and detect cracks, degradation and de-bonding from the surrounding masonry. Also determine previous surface coating treatments that may be contributing to the current conditions.
- b. Compare the bedding mortar with the pointing mortar and determine the cross-sectional characteristics of the wall.
- c. Determine the level of moisture movement in the insitu mortar, and if the mortar or masonry units are handling the brunt of the water movement through the wall.
- d. Assess the physical characteristics of the mortar and determine indirect compressive strength. Gather data on insitu mortar joint shear strength.

3.1.1.3 Taking and Preparation of Samples

Take and analyze samples of unweathered original historic mortar and different type of mortar in the structure in order to match the new mortar to be used for repointing. Remove three or four samples of each type of mortar to be matched with a hand chisel from several locations on the building. Set aside the largest sample for comparison with the repointing mortar. Place the remaining samples in labeled, sealed sample bags for transport to the laboratory.

3.1.1.3.1 Laboratory Mortar Analysis Equipment

Equipment for evaluating historic mortar in the lab includes physical preparation and analysis equipment such as scales, ovens, compression machines, sieves, sieve shakers and the like. All lab equipment should be calibrated and in good working condition. To accurately determine the binder constituents and proportions requires additional equipment such as high magnification microscopes to perform petrography, specialized ovens to perform Differential Thermal Analysis and specialized equipment to perform X-Ray diffraction analysis. This specialized equipment should be operated and the results analyzed only by trained, experienced personnel.

3.1.1.3.2 Laboratory Masonry Unit Evaluation Equipment

Equipment for evaluating masonry units in the lab includes physical preparation and analysis equipment such as scales, ovens, compression machines, freeze-thaw equipment, soaking chambers and the like. All lab equipment should be calibrated and in good working condition.

3.1.1.4 Binder Analysis

Subject a part of the historic mortar sample to Differential Thermal Analysis or X-ray Diffraction to determine the binder components.

3.1.1.5 Aggregate Analysis

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]. The separated aggregate shall be rinsed clean with water and dried.[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.][Perform sand analysis using a sieve analysis of the aggregate as part of the [ASTM C1324](#) process.]

3.2 PREPARATION

3.2.1 Material Handling and Associated Equipment

3.2.1.1 Mixing, Transporting, and Placing Job Materials

Provide equipment used for mixing, transporting, placing, and confining masonry and mortar placements capable of satisfactorily mixing material and supporting uninterrupted placement operations. Equipment used for mixing, conveying, and placing of materials shall be clean, free of old materials and contaminants, and shall conform to the material manufacturer's recommendations.

3.2.1.2 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.

3.2.2 Protection

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

3.2.2.1 Interior Protection

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

3.2.2.2 Worker Exposures

Exposure of workers to chemical substances shall not exceed the limits established by [ACGIH 0100](#), or those required by a more stringent applicable regulation.

3.3 EQUIPMENT AND TECHNIQUES DEMONSTRATION

Demonstrate equipment and techniques of operation in an approved location. Dependable and sufficient equipment, appropriate and adequate to accomplish the work specified, shall be assembled at the work site in 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. Maintain the equipment in good working condition throughout the project.

3.4 MASONRY CLEANING

Historic materials shall not be damaged or marred in the process of cleaning. Cleaning shall conform to [NPS TPS Brief 1](#). Protect open joints to prevent water and cleaner intrusion into the interior of the structure from pressure spraying. Protect non-masonry materials and severely deteriorated masonry by approved methods prior to initiation of cleaning operations. Masonry cleaning shall remove all organic and inorganic contaminants from the surface and pores of the substrate, without causing any short or long-term negative consequences. Surfaces shall be evenly cleaned with no evidence of streaking or bleaching. The cleaning process shall not affect the density, porosity, or color of the masonry or mortar. Cleaned masonry shall have a neutral pH. Use the gentlest methods possible for cleaning historic masonry to achieve the desired results. Make test patches to determine a satisfactory cleaning result. Cleaning shall proceed in an orderly manner, working from top to bottom of each scaffold width and from one end of each elevation to the other. 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. The cleaning materials, equipment, and methods shall not result in staining, erosion, marring, or other damage to the surfaces of the structure. Following an initial inspection and evaluation of the structure and surfaces, give the structure a surface cleaning which shall be completed prior to start of repair work, and sampling and testing of mortars. The work shall provide for the complete cleaning of all exterior masonry surfaces of the structures, removing all traces of moss, dirt, and other contaminants to allow determination of the masonry's color and shades, finish and texture, and other properties. Following completion of the surface cleaning of the structure (or side of structure) the masonry shall be dried prior to the start of any repair work. The following sequence of methods shall be used to determine the least aggressive, effective cleaning method:

1. Water with brushes
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

3.4.1 Chemical Cleaners

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, they shall be alkaline based and utilized with neutralizing afterwashes.

3.4.2 Test Patches

Demonstrate the materials, equipment, and methods to be used in cleaning in a test section approximately [1 m by 1 m](#) [3 feet by 3 feet](#). The location of the test section, and the completed test section is subject to approval. Adjust the cleaning process as required and the test section rerun until an acceptable process is obtained. Locate test patches in inconspicuous areas of the building. The areas tested shall exhibit soiling characteristics representative of those larger areas to be cleaned. Also conduct tests on areas to be stripped of paint. Allow tested areas to dry before a determination is made on the effectiveness of a particular treatment.

3.4.3 Paint Removal

Remove paint and other coatings from masonry surfaces in areas indicated prior to general cleaning. Masonry shall not be damaged or marred in the process of paint removal. Areas where paint is to be removed shall first be cleaned with water and detergent solution to remove surface dirt, rinsed, and allowed to dry. Apply chemical paint removers in accordance with manufacturer's instructions. Surrounding painted surfaces to remain intact shall be protected from exposure to chemical paint removers to avoid damage. Remove paint containing lead in accordance with Section 02 83 19.00 10 LEAD BASED PAINT HAZARD ABATEMENT, TARGET HOUSING & CHILD OCCUPIED FACILITIES.

3.4.4 Water Cleaning

3.4.4.1 Pressure Spraying

Spray apply water to masonry surfaces to comply with requirements indicated by test patches for location, purpose, water temperature, pressure, volume, and equipment. Unless otherwise indicated, the surface washing shall be done 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 the spray nozzle shall not be held less than 300 mm 12 inches from surface of masonry. Water shall be applied side to side in overlapping bands to produce uniform coverage.

3.4.4.2 Hand Scrubbing

Scrub surfaces to be cleaned to remove surface contaminants. Pre-wet surfaces and use hand-held natural bristle or nylon brushes. Do not use wire brushes.

3.4.4.3 Rinsing

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

3.4.5 Chemical Cleaning

Chemical cleaning of historic masonry shall use the gentlest means possible to achieve the desired result as determined by test patches. Chemical cleaning is the use of any product in addition to water, including detergents, ammonia, vinegar, and bleach. Proceed in an orderly manner, working from top to bottom of each scaffold width and from one end of each elevation to the other. Cleaning shall result in uniform coverage of all surfaces, including corners, moldings, interstices and produce an even effect without streaking or damage to masonry. Do not apply chemical cleaners to the same masonry surfaces more than twice.

3.4.5.1 Surface Prewetting

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

3.4.5.2 Acidic Chemical Cleaning

Apply acidic chemical cleaners according to manufacturer's instructions.

Acidic chemical cleaners shall not be applied to masonry with high calcium content (e.g. marble, limestone). Apply acidic cleaners to masonry surfaces by low pressure spray 0.35 MPa 50 psi max., roller, or brush. Cleaner shall remain on masonry surface for the time period recommended by manufacturer. Manual scrubbing by brushes shall be employed as indicated by test patches for the specific location. Cleaned surfaces shall be rinsed with a low-to-moderate pressure spray of water to remove all traces of chemical cleaner.

3.4.5.3 Alkaline Chemical Cleaning - Prewash Phase

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. Cleaner shall remain on masonry surface for the time period recommended by the manufacturer. Manual scrubbing by brushes shall be employed as indicated by test patches for the specific location. Cleaned surfaces shall be rinsed with a low-to-moderate pressure spray of water.

3.4.5.4 Alkaline Chemical Cleaning - Afterwash Phase

Immediately after rinsing of alkaline cleaned surfaces, apply a neutralizing afterwash to the cleaned masonry areas. Neutralizing afterwash shall be applied according to manufacturer's instructions, by low pressure spray 0.35 MPa 50 psi max., roller, or brush. Afterwash shall remain on masonry surface for the time period recommended by manufacturer. Cleaned surfaces shall be rinsed with a low-to-moderate pressure spray of water to remove all traces of chemical cleaners.

3.4.5.5 pH Testing

Determine the pH of masonry surfaces which have been chemically cleaned using pH monitoring pencils or papers. Rinse chemically cleaned masonry of all chemical residues until a neutral pH (7) reading is obtained from the masonry surface.

3.5 MASONRY REPAIR

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

Match repaired surfaces with adjacent existing surfaces in all respects. Proceed with masonry repair only after the cause of deterioration has been identified and corrected. Demonstrate the materials, methods and equipment proposed for use in the repair work in test panels. The location, number, size and completed test panels is subject to approval. Use products in accordance with the manufacturer's instructions.

3.5.1 Deterioration Investigation

Perform a field investigation, conducted by the historic masonry consultant, to determine the causes and extent of degradation. To facilitate the investigation utilize the following techniques.

- a. Employ a field microscope to closely assess the conditions at the surface of the mortar and masonry units. Determine the mortar composition, 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. 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.

- b. 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. Employ rilem tubes to determine the rate of water uptake into the masonry. To access the physical characteristics of hard mortar, use a spring loaded impact device to determine indirect compressive strength. For evaluating softer mortars, mortar integrity deeper in the wall, and the condition of the masonry units, a drill resistance tool shall be employed by an experienced consultant. Utilize technologies such as ground penetrating radar or metal detection equipment to map metal reinforcement and embedments in the wall. Use flat (bladder) jacks or jacks and rams to gather data on insitu mortar joint shear strength and deformation and stress in the wall.

3.5.2 Repointing Masonry

Repoint masonry in accordance with [NPS TPS Brief 2](#).

3.5.2.1 Wall Preparation

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.

- a. Shallow or feather edging is not permitted. Remove loose particles from joints. Clean joints, followed by blowing with filtered, dry, compressed air or vacuum.
- b. Existing horizontal mortar joints (bed joints) that are filled with a hard Portland mortar may be cut out using a diamond blade that is narrower than the joint width. The middle one-third of the mortar joint may be cut using a rotary power saw. The remaining mortar shall be removed from the masonry joints by hand using masonry chisels or pneumatic carving tools.
- c. Vertical joints (head joints) shall not be cut out using rotary power saws. All vertical head joints must be removed by hand using a pneumatic carving tool, or hammer and chisel.
- d. 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).
- e. Do not widen the existing masonry joints. The surrounding masonry edges shall not be spalled or chipped in the process of mortar removal. Damage to surrounding masonry units resulting from rotary blade over running is not permitted. Replace all masonry units damaged during mortar removal with replacement units that match the original.

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

3.5.2.2 Mixing and Installation

[Repointing mortar shall be pre-blended in single containers in a factory-controlled environment.] [Repointing mortar may be site mixed, Type L, Type O and Type K. Ensure appropriate material proportions as regards to the affect of moisture content on the individual components (cement, sand and lime. Batch materials using volumetric measurement devices (not shovels) and consistently consolidate the material in these devices to ensure the uniformity of the mortar.

3.5.2.2.1 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 devices for batching the sand.

3.5.2.2.2 Cement and Lime Proportions

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

- a. 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. Note: Portland cement does not experience this volumetric loss when converted to a wet paste during mixing.

- b. For dry hydrate lime, fill the measuring device using a minimum of 3 lifts, strike the bottom of the measuring device against the ground a minimum of ten times and then strike the top flush. Dry hydrate lime experiences a significant volumetric loss when converted to a wet paste during mixing; therefore, add additional 25 percent dry hydrate lime to the formulation.
- c. 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.

3.5.2.2.3 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 3 lifts, striking the sides a minimum of ten times, and then striking the top flush.

]3.5.3 Presoaking Masonry / Mortar Consistency / Lifts

Use the same mortar as the repointing mortar for setting the replacement masonry. Soak exposed surfaces of historic masonry adjacent to joint with water prior to repointing. Allow time for excess water to run off and evaporate prior to repointing. Joint surfaces shall be damp but free from standing water. Maintain a water sprayer on site at all times during the repointing process. The mortar material shall 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. 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.

3.5.4 Compression / Joint Finish / Curing

- a. Compress each layer thoroughly and allow it to become thumbprint hard before applying the next layer.
- b. When mortar is thumbprint hard at the surface of the wall, finish the joints to match the original historic joint profile. 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. Depending on the environmental conditions (temperature and humidity), carry out water misting until a full nine alternating wet-and-dry cycles are completed.
- c. Adjust curing methods to ensure that the repointing mortar is damp without eroding the surface of the mortar.

3.5.5 Protection

Keep the mortar from drying out too quickly or from becoming too wet. Protect it 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. Be careful not to 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.

3.5.6 Retooling Stone Masonry Insitu

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. Sound all stone on building by using the "ring test method" 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. Any stone that is designated for retooling insitu can become a candidate for removal if, after chiseling is completed, the solid stone substrate is no longer in plane or plumb with the surrounding stone masonry surfaces.

3.5.7 Masonry Removal and Replacement

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.

- a. Remove mortar, loose particles, and soil from masonry by cleaning with hand chisels, brushes, and water.
- b. 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.
- c. Replace removed masonry with harvested masonry units, 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 existing masonry units.
- d. 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.
- e. Test the new element for fitting into its space without mortar. If wedges are used to support and align the new unit, cover them with at least 38 mm 1-1/2 inches of mortar when pointing is complete.
- f. Cover the four sides and back of the space with sufficient mortar to ensure that there will be no air spaces when the new unit is set. 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.

- g. Repoint joints to match the rest of the wall after new units have been properly installed and adjusted.
- h. Clean replacement areas with a non-metallic brush and water to remove excess mortar.

3.5.8 Substitute 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. Deteriorated surfaces shall be removed and repaired or replaced only upon approval. Repairs and replacements shall match the materials, colors, and finish of the existing historic masonry as closely as possible.

3.5.8.1 Areas To Be Removed

Remove unsound, weak, or damaged masonry and mortar in areas as indicated. Loose particles, laitance, spalling, cracked, or debonded masonry and mortar and foreign materials shall be removed with hand tools unless otherwise noted. Surfaces prepared for repair shall be cleaned free of dust, dirt, masonry chips, oil or other contaminants, rinsed with water, and dried before repair work is begun. Protect surfaces of the structure, and surfaces adjacent to the work area from damage which may result from removal, cleaning, and repair operations.

3.5.8.2 Application of Substitute Repair Materials

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

Place substitute 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 insitu.

- a. Substitute repair material shall not be installed in thicknesses exceeding 50 mm 2 inches. Masonry repairs in excess of 50 mm 2 inches thick shall utilize a Dutchman repair approach or replacement unit.
- b. Remove all loose mortar and masonry prior to installation of the substitute repair material. "Sound" the masonry with a hammer to verify its integrity. If necessary, cut away an additional 13 mm 1/2 inch of the masonry substrate to ensure the surface to be repaired is solid and stable.
- c. Remove any 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.

- d. Using clean water and a scrub brush, clean all dust from surface and pores of the substrate.
- e. 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 approved methods to deliver the substitute repair work as demonstrated.
- f. 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.

3.5.8.3 Masonry and Substitute Material Repair Finishes and Color

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. The finishing and texturing shall conceal bond lines between the repaired area and adjacent surfaces. The texturing shall provide replication of all surface details, including tooling and machine marks. 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.

3.5.8.4 Patch Anchors

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 2600 square mm 4 square inches of patch plan surface area; specific locations for patch anchors shall be as indicated. Use small handheld, low-speed rotary masonry drills to produce holes in the existing masonry, within the limits for the patch anchor installation.

3.5.8.5 Holes

Drill holes into the existing substrate material of the masonry using rotary (non-hammer) drills. Holes shall have a diameter of 3 mm 1/8 inch larger than the anchor diameter. The holes shall be drilled to a depth of 100 mm 4 inches, except as otherwise indicated or directed. Drill holes shall not penetrate completely through the masonry, and shall provide at least 25 mm 1 inch of cover around the drill hole. Holes shall be cleaned by water blasting to remove drill dust and other debris and then blown dry with filtered, dry, compressed air. Drill holes shall be conditioned in accordance with the epoxy adhesive manufacturer's recommendations.

3.5.8.6 Anchor Installation

Clean anchors to remove all contaminants which may hinder epoxy bond. Epoxy adhesive shall be pressure injected into the back of the drilled holes. The epoxy shall fill the holes without spilling excess epoxy when the anchors are inserted. Insert anchors immediately into the holes. The anchors shall be set back from the exterior face at least 25 mm 1 inch. Install anchors without breaking or chipping the exposed masonry surface. Where voids exist in the masonry units or between the wythes, use socks to

contain the epoxy.

3.5.8.7 Cleanup

Remove excess epoxy and spills from the surface of the masonry. Leave the surface of the masonry in a clean and uncontaminated condition. Remove spills on adjacent surfaces and repair surfaces as required.

3.5.8.8 Dutchman Repairs

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.

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. Fit the new piece into place with tolerances of no more than plus or minus 1.5 mm 1/16-inch. Provide supporting rods of stainless steel as necessary for the extent of the repair and the location. Closely blend repairs in with the surrounding original materials.

3.5.9 Crack Injection

3.5.9.1 Application of Dispersed Hydrated Lime (DHL)

Notify the Contracting Officer as to when and where the installation will occur at least 48 hours prior to start. Provide samples to the Government representative from the dispenser during the course of the injection. Apply in accordance with the manufacturer's instructions.

- a. Drill 3 mm 1/8-inch diameter, downward-sloping injection holes. For transverse cracks less than 10 mm 3/8 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 distilled water. Remove dirt and organic matter, loose material, sealants, and failed crack repair materials.
- c. Inject Dispersed Hydrated Lime through holes sequentially, beginning at one end of area and working to opposite end. 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.

3.5.9.2 Tools and Equipment

Do not use tools and equipment in the work that have not been cleaned of set dispersed hydrated lime.

3.5.10 Surface Treatments

3.5.10.1 Stucco

Apply stucco on a clean surface. Ensure the substrate is SSD prior to application. Apply the scratch-coat and allow to partially-set on the wall surface. Use a scratch rake to create the keys into the scratch coat for acceptance of the finish coat. Apply the finish coat approximately 24 hours after the scratch coat application. Soak the scratch coat with water to SSD condition prior to the application of the finish coat. Apply the textured finish and profile to match the surrounding historic surfaces. Acceptable 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 used for reinforcement. Ox or cattle hair is the preferred choice, but horse or goat may be used.

3.5.10.2 Limewashes

Apply limewash in three thin coats on SSD raw masonry surfaces. Do not allow the material to dry out before it has had a chance to absorb into the masonry surfaces. Work from top to bottom of the wall working from the dry-edge. Allow six hours drying time between coats. Where colors are desired, use natural earth pigments. Verify all applications, materials and colors through mock ups panels applied to the substrate prior to the start of the work.

3.5.10.3 Water Infiltration

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 preclude 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.

Application of water proofing is not allowed. Water repellents may be applied upon Contracting Officer approval of the recommendation and

justification, by the historic masonry consultant, that no other means will control water infiltration.

3.5.10.4 Stone Consolidants

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.

Use of stone consolidants requires Contracting Officer approval of the historic masonry consultants recommendation, including justifying data.

3.6 NEW ELEMENTS

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.

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

3.6.1 Structural Upgrades

Mechanical anchors used to reinforce masonry structures shall be designed by a registered professional structural engineer. It is critical that such strengthening measures 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.

3.6.2 Joint Sealant and Lead Flashing

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.

Provide joint sealing as specified in Section 07 92 00 JOINT SEALANTS. Augmentation with lead flashing is allowed for skyfacing joints. Install sealants and lead flashing in accordance with manufacturer's recommendations.

3.7 FINAL CLEANING

No sooner than 72 hours after completion of the repair work and after joints are sealed, faces and other exposed surfaces of masonry shall be washed down with water applied with a soft bristle brush, then rinsed with clean water. Discolorations which cannot be removed by these procedures, shall be considered defective work. Perform cleaning work when temperature and humidity conditions allow the surfaces to dry rapidly. Protect adjacent surfaces from damage during cleaning operations.

3.8 PROTECTION OF WORK

Protect work against damage from subsequent operations.

3.9 DEFECTIVE WORK

Defective work shall be repaired or replaced, as directed, using approved procedures.

3.10 FINAL INSPECTION

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

-- End of Section --