# Rockford School District #205
# MASONRY RE-POINTING

## TABLE OF CONTENTS

DOCUMENT 00730 – SUPPLEMENTARY CONDITIONS

1.01 CHANGE ORDER MARK-UPS:
Add the following to provisions regarding Change Order mark ups in Conditions of the Contract:

A. The combined overhead and profit included in the total cost to the Owner for a change in the Work shall be based on the following schedule:

1. For the Contractor, for Work performed by the Contractor's own forces, twelve percent of the cost.
2. For the Contractor, for Work performed by the Contractor's Subcontractors, five percent of the amount due the Subcontractors.
3. For each Subcontractor involved, for Work performed by that Subcontractor's own forces, five percent of the cost.
4. For each Subcontractor involved, for Work performed by the Subcontractor's Subcontractors, five percent of the amount due the Sub-subcontractor.
5. In order to facilitate checking of quotations for extras or credits, all proposals, except those so minor that their propriety can be seen by inspection, shall be accompanied by a complete itemization of costs including labor, materials and Subcontracts. Labor and materials shall be itemized in the manner prescribed above. Where major cost items are Subcontracts, they shall be itemized also.

1.02 REQUIRED

A. Despite anything to the contrary in the bid documents, bidders are required to submit an AIA Document A305-1986 Contractor’s Qualification Statement with their bid.

END OF SECTION

SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.01 SUMMARY

A. Project identification: Re-Pointing at Three RPS205 Schools

Locations:

Eisenhower Middle School (RPS205 #2005 BFA #1063C)
3525 Spring Creek Road
Rockford, IL 61107

Guilford High School (RPS205 #1904 BFA #1033A)
5620 Spring Creek Road
Rockford, IL 61114

Jefferson High School (RPS205 #2004 BFA #1063A
4145 Samuelson Road
Rockford, IL 61109

B. Project summary: Examine exterior, masonry walls of schools. Remove plant growth and clean surfaces. Repair masonry at areas indicated on drawings, including repointing mortar joints, consolidation treatment, and repair, replacement, and re-anchoring of damaged masonry units. Other tasks as required to perform masonry repairs, and as necessary to create a water-tight building envelope.

C. Particular project requirements:

1. Existing site conditions and restrictions:
   a. Confine parking and loading areas to areas on site as directed by the Owner's Representative and building principal.
   b. Provide fences, barricades, guard lights, etc. as required to protect persons and property from injury in conjunction with this contract work
   c. Building access shall only be as required to perform construction duties.
   d. Access shall be limited.
   e. Remove rubbish and debris daily. Remove excess materials and equipment from site upon completion of use.

2. Requirements for sequencing or scheduling:
   a. Hours of access shall be as allowed by SD 205. Typically 6am to 5pm
   b. The Contractor and all Subcontractors shall notify the Owner's Representative prior to beginning work each day.

3. Protect existing work:
   a. Protect existing building and surfaces to remain. Protect existing trees, shrubs, lawns, etc.
   b. Repair damage to this contract work at no cost to Owner.
   c. Water damage to building, including the interior, caused by Contractor's failure to properly protect the work, shall be the responsibility of the Contractor to correct.

4. Guarantee: Contractor is to guarantee all work for a minimum of three years after final acceptance.

5. Provide all items, articles, materials, operations, or methods listed, mentioned, or scheduled on the drawings and/or herein, including all equipment, and incidentals necessary and required pertaining to the work of this contract.

D. Permits and Fees: All permits and fees shall be secured and paid for by the owner.

E. Codes: Comply with applicable codes and regulations of authorities having jurisdiction. Submit copies of inspection reports, notices and similar communications to Owner.

F. Dimensions: Verify dimensions indicated on drawings with field dimensions before fabrication or ordering of materials. Do not scale drawings.

G. Existing Conditions: Notify Owner of existing conditions differing from those indicated on the drawings. Do not remove or alter structural components without prior written approval.

H. Coordination:

1. Coordinate the work of all trades.
2. Verify location of utilities and existing conditions.

I. Installation Requirements, General:

1. Inspect substrates and report unsatisfactory conditions in writing.
2. Do not proceed until unsatisfactory conditions have been corrected.
3. Take field measurements prior to fabrication where practical. Form to required shapes and sizes with true edges, lines and angles. Provide inserts and templates as needed for work of other trades.
4. Install materials in exact accordance with manufacturer's instructions and approved submittals.
5. Install materials in proper relation with adjacent construction and with proper appearance.
6. Restore units damaged during installation. Replace units which cannot be restored at no additional expense to the Owner.
7. Refer to additional installation requirements and tolerances specified under individual specification sections.

J. Definitions:

1. Provide: Furnish and install, complete with all necessary accessories, ready for intended use. Pay for all related costs.
2. Approved: Acceptance of item submitted for approval. Not a limitation or release for compliance with the Contract Documents or regulatory requirements. Refer to limitations of 'Approved' in General and Supplementary Conditions.
3. Match Existing: Match existing as acceptable to the Owner.

K. Intent: Drawings and specifications are intended to provide the basis for proper completion of the work suitable for the intended use of the Owner. Anything not expressly set forth but which is reasonable implied or necessary for proper performance of the project shall be included.

L. Writing style: Specifications are written in the imperative mode. Except where specifically intended otherwise, the subject of all imperative statements is the Contractor. For example, 'Provide tile' means 'Contractor shall provide tile.'

PART 2 - PRODUCTS - Not Applicable To This Section

PART 3 - EXECUTION - Not Applicable To This Section

END OF SECTION

SECTION 01030

ALTERNATES

PART 1 - GENERAL

1.01 SUMMARY

A. Provide list price for each alternate in Bid Form. Include cost of modifications to other work to accommodate alternate. Include related costs such as overhead and profit.

B. Owner will determine which alternates are selected for inclusion in the Contract.

C. Alternates are described briefly in this section. The Contract Documents define the requirements for alternates.

D. Coordinate alternates with related work to ensure that work affected by each selected alternate is properly accomplished.

PART 2 - PRODUCTS - Not Applicable To This Section

PART 3 - EXECUTION

3.02 SCHEDULE

Eisenhower Middle School

Alternate 1 - Replace sealant at Service Doors and Overhead Doors

Alternate 2 - Paint Service Doors and Frames

Alternate 3 - Stain Brick at Areas of Previous Graffiti Removal

Jefferson High School

Alternate 1 - Replace sealant at Service Doors and Overhead Doors

Alternate 2 - Paint Service Doors and Frames

END OF SECTION

SECTION 01045

CUTTING AND PATCHING

PART 1 - GENERAL

1.01 SUMMARY

A. Provide cutting and patching work to properly complete the work of the project, complying with requirements for:

1. Structural work.
2. Electrical systems.
3. Visual requirements, including detailing and tolerances.
4. Operational and safety limitations.
5. Fire resistance ratings.
6. Inspection, preparation, and performance.
7. Cleaning.

B. Do not cut and patch in a manner that would result in a failure of the work to perform as intended, decreased energy performance, increased maintenance, decreased operational life, or decreased safety.

PART 2 - PRODUCTS

2.02 MATERIALS

A. Match existing materials for cutting and patching work with new materials conforming to project requirements.

PART 3 - EXECUTION

3.02 INSTALLATION

A. Inspect conditions prior to work to identify scope and type of work required. Protect adjacent work. Notify Owner of work requiring interruption to building services or Owner's operations.

B. Perform work with workmen skilled in the trades involved. Prepare sample area of each type of work for approval.

C. Cutting: Use cutting tools, not chopping tools. Make neat holes. Minimize damage to adjacent work. Check for concealed utilities and structure before cutting.

D. Patching: Make patches, seams, and joints durable and inconspicuous. Comply with tolerances for new work.

E. Clean work area and areas affected by cutting and patching operations.

END OF SECTION

SECTION 01100

PROJECT PROCEDURES

PART 1 - GENERAL

1.01 SUMMARY

A. Provide coordination of work.

1. Supervisory personnel.
2. Preconstruction conference.
3. Weekly job-site progress meetings.
4. Other meetings as requested by the Owner and/or Architect.

B. Submit reports as requested by the Owner and/or Architect.

C. Prepare schedules:
1. Submit progress schedule, updated weekly. Preliminary schedule to be provided PRIOR TO commencing work.
2. Prepare submittal schedule; coordinate with progress schedule.
3. Submit schedule of values PRIOR TO commencing work!!

D. Perform surveys:
1. Laying out the work and verifying locations during construction.

E. Submit and post a list of emergency telephone numbers and address for individuals to be contacted in case of emergency.

F. Submit payment request procedures.

G. Perform quality control during installation.

H. Clean and protect the work.

I. Damage to the building, including the interior, caused by contractor's failure to properly protect work, shall be the sole responsibility of the contractor to correct.

J.

PART 2 - PRODUCTS - Not Applicable To This Section

PART 3 - EXECUTION - Not Applicable To This Section

END OF SECTION

SECTION 01290

PROJECT INFORMATION AND PAYMENT PROCEDURES

PART 1 - GENERAL

1.01 SUMMARY

A. Information to assist the contractor.

1.02 PROJECT INFORMATION

A. Information required by RPS205 prior to the start of work. Before ANY work can begin, RPS205 Project Manager must be provided the following:
   1. Cleared Employee- background check, etc.
   2. Certificate of Insurance – proof of insurance
   3. Performance Bond – to guarantee satisfactory completion of the project by contractor.
   4. Payment Bond – surety bond posted by contractor to guarantee that subcontractors and material suppliers on the project will be paid
   5. Verify Door Lock Cylinders (Please ask what keyway is to be used)
   6. Preliminary Project Schedule.
   7. Schedule of Values

1.03 PAY APPLICATION

A. Pay Applications must consist of the following:
   1. Application and Certificate of Paymnet including the Continuation Sheet listing all subcontractors and suppliers with amounts paid and held in retainage **2-original copies signed and notarized.**
   2. Waiver of Lien to Date and Contractor's Affidavit. The amount of total labor and material MUST match amount of currrent payment due. **2-original copies signed and notarized.**
   3. Sub-Contractors and Suppliers Lien Waiver to Date or final Lien Waiver - **2-original copies signed and notarized.**
   4. Certified Payroll for contractor and sub-contractors. **1-set or originals**
   5. Pay applications CAN NOT be post dated. They may be dated before or on the date that they are delivered to the Architect.
   6. Once assembled, submit pay application directly to the Architect for their signature.

B. Pay Application Procedure
   1. Contractor to provide a draft copy for review by Architect and RPS205 Project Manager.
   2. Original Pay Application shall be submitted directly to the Architect for their signature.
   3. The Architect shall in turn send the Pay Application to the RPS205 Project Manager.
   4. RPS205 Project Manager will verify ALL documents are attached, and correct.
   5. RPS205 Project Manager will submit pay requests for approval.
   6. After Pay Requests are approved, they will be given to Accounts Payable Department. Checks are mailed the day after each RPS205 board meeting, listed on the district website.
   7. Contractor is advised to contact the RPS205 Project Manager for a Schedule.
   8. Failure to follow the Pay Application Schedule will delay payment.
   9. See attached examples.

PART 2 - PRODUCTS - Not Applicable To This Section

PART 3 - EXECUTION - Not Applicable To This Section

END OF SECTION

# Timeline and Process for 1st Payment Applications

## Contractor

**Submit Pencil Draft** are emailed within 24 Business Days before a Scheduled Board Meeting.
Must Include the Following Documents:
**AIA G702 Payment Application**
**AIA G703 (Schedule of Value Summary) -** a listing all the contractor's labor, material, and overhead; sub contractors and what is owed. All columns and totals must balance.
**Partial Waiver of Lean (Contractor's Affidavit)** - Listing contractors labor and overhead; sub-contractors and suppliers listed on G703.
**Certified Payroll for labor -** For days requesting payment for any labor done.

## Architect/Engineer & Project Manager

**AE to Review and add comments for corrections and return back to Contractor after discussing all issues with Project Manager**

## Contractor

Will make any corrections as instructed and return within 20 Business Days before a Scheduled Board Meeting to the Architect/Engineer:

**2-sets of Originals AIA Documents Signed and Notarized**
**2-sets Partial Waiver of Lien / Contractor's Affidavit, Signed & Notarized**
**1-set of Certified Payroll, Signed & Notarized**
***Copies will not not be accepted***

## Architect/Engineer

The AE is to sign all approved documents and deliver to the Project Manager within 16 Business Days before the next Scheduled Board Meeting

## Project Manager

**Is to verify all information is received from AE is complete.**
Pay Request Packet must consist of the following:
**AIA Documents G702 & G703 , Signed and Notarized.**
**Partial Waiver of Lien / Contractor's Affidavit, for current payment requested.**
*Signed and notarized.*
***Copies will not not be accepted***
Project Manager needs to have pay request packet turned into Operations Manager within 13 Business Days before Scheduled Board Meeting

## Operations Manager

Will obtain Final Approval/Signature for payment and submit to Accounts Payable Department 10 Business Days before Scheduled Board Meeting

## Accounts Payable Department

## Board Meeting

Checks are mailed or pickup the Wednesday after a board meeting

2/10/2017

# Timeline and Process for Payment Applications

## Contractor

**Submit Pencil Draft** are emailed within 24 Business Days before a Scheduled Board Meeting.
Must Include the Following Documents:
**AIA G702 Payment Application**
**AIA G703 (Schedule of Value Summary) -** a listing of all the contractor's labor, material, and overhead; sub-contractors and what is owed. All columns and totals must balance.
**Partial Waiver of Lean (Contractor's Affidavit)** - Listing contractors labor and overhead; sub-contractors and suppliers listed on G703.
**Individual Waiver of Lien(s)** - Report from each sub-contractor and supplier (draft copy)
**Certified Payroll for labor** - For days requesting payment for any labor done.

***Change Orders cannot be listed, unless revised purchase order is issued by RPS Purchasing Department***

## Architect/Engineer & Project Manager

**AE to Review and add comments for corrections and return back to Contractor after discussing all issues with Project Manager**

## Contractor

Will make any corrections as instructed and return within 20 Business Days before a Scheduled Board Meeting back to the **Architect/Engineer:**
**2-sets of Originals AIA Documents Signed and Notarized**
**2-sets Partial Waiver of Lien / Contractor's Affidavit Signed & Notarized**
**2-sets of Lien Waivers (Partial and/or Final) Signed & Notarized**
**1-set of Certified Payroll, Signed & Notarized**
***Copies will not not be accepted***

***Note: Final pay request will not be accepted unless all change orders are processed, close out documents are received, and must include all final waivers from sub-contractors and suppliers. If final waivers have already been submitted, please include copy of those waivers.***

## Architect/Engineer

The **AE** is to sign all approved documents and deliver to the **Project Manager** within 16 Business Days before the next Scheduled Board Meeting

## Project Manager

**Is to verify all information is received from AE is complete.**
Pay Request Packet must consist of the following:
**AIA Documents G702 & G703 ,** Signed and Notarized.
**Partial Waiver of Lien / Contractor's Affidavit,** for current payment requested. Signed and notarized
**Waiver of Lien(s)** - form each sub-contractor and supplier paid on pervious pay request.
***Signed and notarized.***
***Copies will not not be accepted***
**Project Manager** needs to have pay request packet turned into Operations Manager within 13 Business Days before Scheduled Board Meeting

## Operations Manager

Will obtain Final Approval/Signature for payment and submit to **Accounts Payable Department** 10 Business Days before Scheduled Board Meeting

## Accounts Payable Department

## Board Meeting

**Checks** are mailed or pickup the Wednesday after a board meeting

2/10/2017

## WAIVER OF LIEN TO DATE

RECEIVED

STATE OF ILLINOIS
COUNTY OF LAKE } SS

Gty # _____
Escrow # _____

TO WHOM IT MAY CONCERN:
WHEREAS the undersigned has been employed by _____
to furnish _____
for the premises know as _____
of which _____ is the owner.

The undersigned for and in consideration of _____
$ _____ Dollars, and other good and valuable considerations, the receipt whereof is hereby acknowledged, do(es) hereby waive and release any and all lien or claim of, or right to, lien, under the statutes of the State of Illinois, relating to mechanics' liens with respect to and on said above - described premises, and the improvements thereon, and on the material, fixtures, apparatus or machinery furnished, and on the moneys, funds or other considerations due or to become due from the owner, on account of all labor, services, material, fixtures, apparatus or machinery, furnished to this date by the undersigned for the above-described premises, INCLUDING EXTRAS.*

Date _____ Company Name _____
Address _____

**SIGNATURE AND TITLE** _____

*EXTRAS INCLUDE BUT ARE NOT LIMITED TO CHANGE ORDERS, BOTH ORAL AND WRITTEN, TO THE CONTRACT

## CONTRACTOR'S AFFIDAVIT

STATE OF ILLINOIS
COUNTY OF LAKE } SS

TO WHOM IT MAY CONCERN:
THE UNDERSIGNED, (NAME) _____ BEING DULY SWORN, DEPOSES
AND SAYS THAT HE OR SHE IS (POSITION) _____ OF
(COMPANY NAME) _____ WHO IS THE CONTRACTOR
FURNISHING _____ WORK ON THE BUILDING
LOCATED AT _____
OWNED BY _____

That the total amount of the contract including extras* is $ _____ on which he or she has received payment of $ _____ prior to this payment. That all waivers are true, correct and genuine and delivered unconditionally and that there is no claim either legal or equitable to defeat the validity of said waivers. That the following are the names and addresses of all parties who have furnished material or labor, or both, for said work and all parties having contracts or sub contracts for specific portions of said work or for material entering into the construction thereof and the amount due or to become due to each, and that the items mentioned include all labor and material required to complete said work according to plans and specifications:

| NAMES AND ADDRESSES | WHAT FOR | CONTRACT PRICE INCLUDING EXTRAS | AMOUNT PAID | THIS PAYMENT | BALANCE DUE |
|---|---|---|---|---|---|
| All material out of Stock | | | | | |
| Labor | | | | - | - |
| Each Sub | | | | | - |
| Each Supplier | | | | | - |
| | | | | | |
| | | | | | - |
| TOTAL LABOR AND MATERIAL INCLUDING EXTRAS* TO COMPLETE. | | | | | |

That there are no other contracts for said work outstanding, and that there is nothing due or to become due to any person for material, labor or other work of any kind done or to be done upon or in connection with said work other than above stated.

**DATE** _____ **SIGNATURE** _____

SUBSCRIBED AND SWORN TO BEFORE ME THIS _____ DAY OF _____

* EXTRAS INCLUDE BUT ARE NOT LIMITED TO CHANGE ORDERS, BOTH ORAL AND WRITTEN, TO THE CONTRACT.

"OFFICIAL SEAL"
Notary Public. State of Illinois

_____
NOTARY PUBLIC

## FINAL WAIVER OF LIEN

S STATE OF ILLINOIS

Gty #

COUNTY OF _Winnebago____

Escrow #

TO WHOM IT MAY CONCERN:
WHEREAS the undersigned has been employed by Sjostrom & Sons
to furnish glass and glazing
for the premises known as Kennedy Middle School Pool Renovations
of which Rockford School District #205 is the owner.

THE undersigned, for and in consideration of **
($ **) Dollars, and other good and valuable considerations, the receipt whereof is hereby acknowledged, do(es) hereby waive and release any and all lien or claim of, or right to, lien, under the statutes of the State of Illinois, relating to mechanics' liens, with respect to and on said above-described premises, and the improvements thereon, and on the material, fixtures, apparatus or machinery furnished, and on the moneys, funds or other considerations due or to become due from the owner, on account of all labor, services, material, fixtures, apparatus or machinery, heretofore furnished, or which may be furnished at any time hereafter, by the undersigned for the above-described premises, INCLUDING EXTRAS.*

DATE 09/02/2016 COMPANY NAME

ADDRESS

**SIGNATURE AND TITLE** _____

*EXTRAS INCLUDE BUT ARE NOT LIMITED TO CHANGE ORDERS, BOTH ORAL AND WRITTEN, TO THE CONTRACT

## CONTRACTOR'S AFFIDAVIT

STATE OF ILLINOIS

COUNTY OF Winnebago

TO WHOM IT MAY CONCERN:

THE UNDERSIGNED, (NAME) DEPOSES
AND SAYS THAT HE OR SHE IS (POSITION) OF
(COMPANY NAME) WHO IS THE
CONTRACTOR FURNISHING WORK ON THE BUILDING
LOCATED AT :
OWNED BY

That the total amount of the contract including extras* is $** ** on which he or she has received payment of $** * prior to this payment. That all waivers are true, correct and genuine and delivered unconditionally and that there is no claim either legal or equitable to defeat the validity of said waivers. That the following are the names and addresses of all parties who have furnished material or labor, or both, for said work and all parties having contracts or sub contracts for specific portions of said work or for material entering into the construction thereof and the amount due or to become due to each, and that the items mentioned include all labor and material required to complete said work according to plans and specifications:

| NAMES AND ADDRESSES | WHAT FOR | CONTRACT PRICE INCLDG EXTRAS* | AMOUNT PAID | THIS PAYMENT | BALANCE DUE |
|---|---|---|---|---|---|
| All material out of Stock | | | | | |
| Labor | | | | | |
| Each Sub | | | | | |
| Each Supplyer | | | | | |
| | | | | | |
| | | | | | |
| TOTAL LABOR AND MATERIAL INCLUDING EXTRAS* TO COMPLETE. | | | | | |

That there are no other contracts for said work outstanding, and that there is nothing due or to become due to any person for material, labor or other work of any kind done or to be done upon or in connection with said work other than above stated.

**DATE**_____ **SIGNATURE:**_____

SUBSCRIBED AND SWORN TO BEFORE ME THIS_____ DAY OF_____

*EXTRAS INCLUDE BUT ARE NOT LIMITED TO CHANGE ORDERS, BOTH ORAL AND WRITTEN, TO THE CONTRACT.

NOTARY PUBLIC

OFFICIAL SEAL
State of Illinois
My Commission Expires

F.3870 R5/96

Provided by Chicago Title Insurance Company

SECTION 01300

SUBMITTALS

PART 1 - GENERAL

1.01 SUMMARY

A. Provide types of submittals listed in individual sections and number of copies required.

1. Shop drawings, reviewed and annotated. 2.
2. Product data.
3. Samples - 3, plus extra samples as required to indicate range of color, finish, and texture to be expected. ONLY physical samples will be accepted. NO electronic submission.
4. Inspection and test reports.
5. Warranties - Three (3) hard-copies, signed and sealed as appropriate. NO electronic submission.
6. Closeout submittals.

B. Comply with project format for submittals.
1. Provide two (3) copies of all written material, one (1) copy to be returned.
or
2. Provide editable pdf. Copy will be returned via email.
a. NO colors will be selected from electronic submissions!

C. Provide required resubmittals if original submittals are not approved. Provide distribution of approved copies including modifications after submittals have been approved.

D. Samples and shop drawings shall be prepared specifically for this project. Shop drawings shall include dimensions and details, including adjacent construction and related work. Note special coordination required. Note any deviations from requirements of the Contract Documents.

E. Provide warranties as specified; warranties shall not limit length of time for remedy of damages Owner may have by legal statute. Warranties shall be signed by contractor, supplier or installer responsible for performance of warranty.

PART 2 - PRODUCTS - Not Applicable To This Section

PART 3 - EXECUTION - Not Applicable To This Section

END OF SECTION

SECTION 01500

TEMPORARY FACILITIES

PART 1 - GENERAL

1.01 SUMMARY

A. Provide temporary services and utilities, including utility costs:

1. Water: Temporary water service required for the work will be available from the Owner's existing system as directed by the Owner. Owner will pay cost of water used.
2. Lighting and power: The contractor shall provide all temporary electricity as required for the work by extending proper feeders, switches, etc. from the Owner's existing system. Current available at no cost to Contractor. Do not connect any equipment requiring more than 110 volts to Owner's system.
3. Telephone: Shall be furnished by the Contractor.
4. Toilet facilities: Contractor to provide toilet facilities, as may be required by contractors personal. Location on site shall be as directed by Owner.
5. Materials storage: Exterior storage to be limited to areas on the site as directed by the Owner's Representative. Interior material storage is not available.
6. Contractor parking and site access to be restricted to areas designated by SD205.

B. Provide construction and personnel support facilities:

1. None. Field office, if desired by the contractor, shall be at contractor's sole expense.
2. Provide waste-collection containers in sizes adequate to handle waste from construction operations. Collect waste daily and, when containers are full, legally dispose of waste off-site.
3. Install project identification and other signs in locations approved by Owner to inform the public and persons seeking entrance to Project.

C. Provide security and protection requirements:

1. Fire extinguishers.
2. Site enclosure, fences, barricades, warning signs, lights, etc. as required to protect persons and property from injury in conjunction with this contract work.
3. Environmental protection.

PART 2 - PRODUCTS - Not Applicable To This Section

PART 3 - EXECUTION - Not Applicable To This Section

END OF SECTION

SECTION 01600

PRODUCTS AND SUBSTITUTIONS

PART 1 - GENERAL

1.01 SUMMARY

A. Provide products from one manufacturer for each type or kind as applicable. Provide secondary materials as recommended by manufacturers of primary materials.

B. Provide products selected or Owner approved equal. Products submitted for substitution shall be submitted with acceptable documentation, and include costs of substitution including related work.

C. Request for substitution must be in writing. Conditions for substitution include:

1. An 'or equal' phrase in the specifications.
2. Specified material cannot be coordinated with other work.
3. Specified material is not acceptable to authorities having jurisdiction.
4. Substantial advantage is offered to the Owner in terms of cost, time, or other valuable consideration.

D. Substitutions shall be submitted prior to award of contract, unless otherwise acceptable. Approval of shop drawings, product data, or samples is not a substitution approval unless clearly presented as a substitution at the time of submittal.

E. All substitutions must be Approved by Owner.

PART 2 - PRODUCTS - Not Applicable To This Section

PART 3 - EXECUTION - Not Applicable To This Section

END OF SECTION

SECTION 01700

CONTRACT CLOSEOUT

PART 1 - GENERAL

1.01 SUMMARY

A. The following are prerequisites to substantial completion. Provide the following:

1. Punch list.
2. Supporting documentation.
3. Warranties.
4. Certifications.
5. Obtain and submit releases/inspections from AHJ.
6. Inspection reports from B&H Technical.

B. Provide the following prerequisites to final acceptance:

1. Final payment request with supporting affidavits.
2. Completed punch list.

C. Provide a marked-up set of drawings including changes which occurred during construction.

D. Provide the following closeout procedures:

1. Electronic Closeout Documentation.
2. Paper Closeout Documentation
3. Training and turnover to Owner's personnel.
4. Final cleaning and touch-up.
5. Removal of temporary facilities, fences, barricades, etc.
6. Excess construction materials and construction equipment.

E. Electronic Closeout Documentation:

1. Provide a complete project closeout documentation package in electronic format. Provide clean and accurate copies of the marked-up Record Documents. Provide as (2) flash drives - (1) for Architect and (1) for RPS205. This package shall include:
   a. Project Record Documents.
   b. Approved Submittals.
   c. Operation and Maintenance Manuals.
   d. Warrantees.
   e. Owner training materials/DVD's.
   f. Project Contact Directory.
   g. Provide contact information for the individual responsible for the collection and transfer of the electronic closeout documentation package contents.

F. Paper Closeout Documentation:

1. Provide a complete project closeout documentation package in written/paper format. Provide as (2) copies for RPS205. Include ALL materials in Electronic Closeout above.
   a. Bind all materials in heavy-duty, three-ring, vinyul covered loose leaf binder, appropriate thickness to accommodate contents, and sized to receive "letter size" paper.
   b. Provide heavy duty paper dividers with plastic-covered tabs for each section and sub-section.

PART 2 - PRODUCTS - Not Applicable To This Section

PART 3 - EXECUTION - Not Applicable To This Section

END OF SECTION

SECTION 02050

DEMOLITION

PART 1 - GENERAL

1.01 SUMMARY

A. Selective Demolition:

1. Protection of site work and adjacent structures.
2. Disconnection, capping, and removal of utilities.
3. Pollution control during building demolition, including noise control.
4. Rem oval and legal disposal of materials.
5. Selective demolition of building components designated to be removed.
6. Protection of portions of structure adjacent to or affected by selective dem olition.
7. Rem oval of abandoned utilities and wiring.
8. Notification to Owner of schedule of shut-off of utilities.

B. Asbestos and hazardous materials demolition or removal work is not part of this contract.

1.02 DEFINITIONS

A. Remove and Salvage: Carefully detach from existing construction, in a manner to prevent damage, and deliver to Owner.

B. Remove and Reinstall: Detach item s from existing construction, prepare for reuse, and reinstall where indicated.

C. Existing to Remain: Existing item s of construction that are not to be permanently removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

D. Remove: Detach item s from existing construction and legally dispose of them off-site unless indicated to be removed and salvaged or removed and reinstalled.

1.03 MATERIALS OWNERSHIP

A. Unless otherwise indicated, demolition waste becomes property of Contractor.

1.04 SUBMITTALS

A. Submit for approval selective demolition schedule, including schedule and methods for capping utilities to be abandoned and maintaining existing utility service.

B. Proposed Protection Measures: Submit report, including drawings, that indicates the measures proposed for protecting individuals and property, for dust control, and for noise control. Indicate proposed locations and construction of barriers.

C. Schedule of Selective Demolition Activities: Indicate the following:

1. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure Owner's on-site operations are uninterrupted.
2. Interruption of utility services. Indicate how long utility services will be interrupted.
3. Coordination for shutoff, capping, and continuation of utility services.
4. Coordination of Owner's continuing occupancy of portions of existing building and of Owner's partial occupancy of completed Work.

D. Inventory: Submit a list of items to be removed and salvaged and deliver to Owner prior to start of demolition.

E. Predemolition Photographs or Video: Submit before Work begins.

F. Warranties: Documentation indicated that existing warranties are still in effect after completion of selective demolition.

1.05 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Use experienced workers.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

C. Standards: Comply with ANSI/ASSE A10.6 and NFPA 241.

1.06 PROJECT CONDITIONS

A. Immediate areas of work will not be occupied during selective demolition. Adjacent areas may be occupied by the public, including children.

B. Notify Architect of discrepancies between existing conditions and Drawings before proceeding with selective demolition.

C. Hazardous Materials:

1. If suspected hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. Hazardous materials will be removed by Owner under a separate contract.

D. Storage or sale of removed items or materials on-site is not permitted.

E. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.

1.07 WARRANTY

A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials so as not to void existing warranties. Notify warrantor before proceeding.

B. Notify warrantor on completion of selective demolition, and obtain documentation verifying that existing system has been inspected and warranty remains in effect. Submit documentation at Project closeout.

PART 2 - PRODUCTS - Not Applicable To This Section

PART 3 - EXECUTION

3.02 EXAMINATION

A. Verify that utilities have been disconnected and capped before starting selective demolition operations.

B. Review record documents of existing construction provided by Owner. Owner does not guarantee that existing conditions are same as those indicated in record documents.

C. Survey existing conditions and correlate with requirements indicated to determine extent of

selective demolition required.

D. When unanticipated mechanical, electrical, or structural elements that conflict with intended function or design are encountered, investigate and measure the nature and extent of conflict. Promptly submit a written report to Architect and Owner.

E. Survey of Existing Conditions: Record existing conditions by use of preconstruction photographs.

3.03 PREPARATION

A. Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

B. Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.

1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
2. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas..

C. Temporary Shoring: Provide and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished. Strengthen or add new supports when required during progress of selective demolition.

3.04 DEMOLITION

A. Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:

1. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.
2. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
3. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain fire watch and portable fire-suppression devices during flame-cutting operations. Maintain adequate ventilation when using cutting torches.
4. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
5. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
6. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.

B. Except for items or materials indicated to be reused, salvaged, reinstalled, or otherwise indicated to remain Owner's property, remove demolished materials from Project site.

1. Dispose of demolished items and materials promptly. Do not allow demolished materials to accumulate on-site.

2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.

3. Remove debris from elevated portions of building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.
4. Burning: Do not burn demolished materials.
5. Disposal: Transport demolished materials off Owner's property and legally dispose of them.

C. Removed and Salvaged Items:

1. Clean salvaged items.
2. Pack or crate item s after cleaning. Identify contents of containers.
3. Store items in a secure area until deliver y to Owner.
4. Transport items to Owner's storage area designated by Owner.
5. Protect items from damage during transport and storage.

D. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition.

3.05 CLEANING

A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

END OF SECTION

SECTION 04451

CONSOLIDATION REPAIR OF LIMESTONE

PART 1 - GENERAL

1.01 SUMMARY

A. Repair of limestone.

1.02 SUBMITTALS

A. Submit the following items in time to prevent delay of the work and to allow adequate time for review and resubmittals, if needed; do not order materials or start work before receiving the written approval:
   1. Certificates stating that all Installers of the repair mortar have successfully completed the training workshop for installation of the mortar (minimum 3-days).
   2. Samples of all specified materials and Material Safety Data Sheets (MSDS) as appropriate.
   3. Install mortar samples, for approval, on the building.
   4. Written verification from the Contractor that all specified items will be used. Provide purchase orders, shipping tickets, receipts, etc. to prove that the specified materials were ordered and received.

1.03 QUALITY ASSURANCE

A. All repairs shall be performed by a trained installer holding a Training Workshop Certificate from the product manufacturer. Contractor shall maintain proof of this credential for each installer at the site at all times.

B. Prepare a sample of each type of repair to be performed on a “rear face” / not prominent location. Prepare, install, and finish each sample repair according to the specifications. Allow samples to cure at least three days (or longer, if possible) before obtaining Architect and Owner's approval.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Materials are to be delivered, stored, and handled to protect them from damage, extreme temperature, and moisture in accordance with Manufacturer's written instructions.

B. Deliver and store material in Manufacturer's original, unopened containers with the production date shown on the container or packaging.

C. Comply with the Manufacturer's written specifications and recommendations for mixing, application, and curing of mortars.

1.05 PROTECTION/SITE CONDITIONS

A. Cold Weather Requirements: Do not work in temperatures below 40° F, when the substrate is colder than 40° F, or when the temperature is expected to fall below 40° F for 48 hours after installation of repair mortars. Building an enclosure and heating areas to maintain this temperature may only be done with the written approval of the material supplier.

B. Hot Weather Requirements: Protect repair mortar from direct sunlight and wind. Do not use or prepare mortar when ambient air temperature is above 90° F.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Product to be a premixed cementitious repair material(s) formulated to match the color and texture of the existing masonry. Products shall not contain any acrylic, latex, or other synthetic polymer additives. Product may be mixed with clean, potable water. Substitutions: If proposed equal is submitted, provide a lab test to establish equivalent

performance levels. Use an independent testing laboratory, as determined by the Owner, and paid for by the submitting party.
1. Repair of Limestone: Jahn Restoration Mortar (M70).
2. Setting anchors in existing masonry: Jahn Anchor Setting Mortar (M80).
3. Mechanical anchors and dowels: Stainless steel threaded rod (ASTM F593) with appropriate diameter, bent and cut to lengths required to secure masonry in-place.

PART 3 - EXECUTION

3.01 WORKMANSHIP

A. Do not use any additives, such as bonding agents, accelerators, or retardants in the mortar.

3.02 PREPARATION FOR REPAIRS

A. Remove all loose mortar and masonry prior to installation of the repair mortar. "Sound" masonry with a hammer to verify its integrity. If necessary, cut away an additional 1/2" of the substrate to ensure the surface to be repaired is solid and stable. Remove any sealant residue.

B. Where cramp anchors, threaded rod anchors, or dowels have been cut and pieces remain embedded in the substrate: Anchors that are free of rust, solidly embedded, and do not project beyond the surface of the masonry unit may remain. All others should be removed.

C. Cut the edges of the repair area to provide a minimum depth of 1/4". The edges of the repair should be square cut. Do not allow any feathered edges in the repair area.

D. Install mechanical anchors in all repair areas if necessary to firmly secure existing masonry.

E. Install anchors as follows:
1. Drill holes.
2. Clean holes using compressed, oil-free air, and bristle brushes, until no dust cloud is produced when a brush, inserted the full depth of the hole, is pulled out of the hole.
3. Embed anchors in back-up using Jahn M80, or owner approved equal, mixed according to Manufacturer's instructions.
4. Anchors should be covered with a minimum of 3/4" repair material.

F. Clean all dust from surface and pores of the substrate, using clean water and a scrub brush.

G. For very dry or porous surfaces, pre-wet the substrate ahead of time to prevent the substrate from drawing moisture out of the repair too quickly. Re-wet the surface immediately before applying the repair material.

3.03 MIXING MORTAR FOR REPAIR

A. Do not mix more material than can be used within 30 minutes. Discard any mixed material that has been unused for 30 minutes or more.

B. Mixing ratios for limestone shall be as specified by the material supplier.
1. For Jahn M70 Limestone mortar mix: 5 parts dry material to 1 part water.

C. Add water to dry ingredients and mix well. Adjust amount of water according to the weather and the porosity of the substrate.

3.04 APPLICATION OF REPAIR MATERIAL

A. Apply the mortar mix using a trowel, to place and compress the mortar into the repair ensuring not to leave any voids, in a series 1" lifts allowing mortar to dry approximately 10-20 minuets between lifts. For overhead repairs thicker than 2", apply mortar in layers, allowing the first layer to cure for two to four hours before applying the second layer. If applied in layers, scrape off any cement skin that has formed and continue application. Dampen the surface before applying the next layer. Work mortar firmly into the surface of the masonry, including the corners, and under and around all mechanical anchors.

B. Build up repair material so that it is slightly above the adjacent masonry surface. Allow mortar 15 to 60 minutes to set slightly (wait time will vary with temperature and humidity-longer in cool

weather), and then scrape off excess material using a straight edge (a plasterer's miter rod is good for this). Do not press down or "float" the repair. Where repairs occur at panel edges or corners, form mortar to match the profile of the surrounding masonry. In all cases, finish and texture repair so that it is as indistinguishable as possible from the adjacent masonry.

3.05 FINISHING TECHNIQUES

A. To obtain a smooth finish to match limestone, the finished repair can be trowelled to leave a smooth surface. This may cause the repair to lighten and may need to be stained or painted to match.

B. Clean any mortar residues from area surrounding the repair by sponging as many times as necessary with clean water. This should be done before repair material sets.

3.06 CURING PROCEDURE

A. Lightly mist the repair with water to wet the entire surface of the finished repair approximately 30 minutes to 1 hour after completion on hot sunny days, and approximately 2 hours or longer, on cool or cloudy days. Time will vary with temperature and humidity. Mist several times a day during the 72 hours following the repair installation. Should access to the repairs be impossible for a period of time, plastic may be used to cover them temporarily. The application of plastic, however, does not remove the need for normal curing techniques. Never cover repairs with plastic immediately after finishing-the water in the repair will be trapped on the surface, causing it to lighten.

3.07 CLEAN UP

A. Remove uncured mortar from the perimeter of the repair before it dries using clean water and a rubber sponge. Repeat several times with clean water to prevent a halo effect (staining of adjacent masonry).

B. Remove uncured mortar from tools and equipment with water as soon as possible. Cured material may only be removed chemically or mechanically.

END OF SECTION

SECTION 04460

DUTCHMAN REPAIR OF LIMESTONE

PART 1 - GENERAL

1.01 SUMMARY

A. This procedure includes guidance on the repair of damaged limestone using a dutchman. As used here, the term “Dutchman" refers to any new or salvaged stone fitted into the existing facade stone. New stone shall match existing.

B. Dutchman repair is sometimes recommended for large spalls or spalls that would be visually detracting.

1.02 SUBMITTALS

A. Sample Stone Repair:

1. Reattach stone fragments and patch stone at locations selected by the Contracting Officer using methods specified. Provide one sample each for granite and limestone.

2. If samples are unsatisfactory, Contractor shall make the needed modifications and prepare new samples until they are satisfactory.

3. The samples accepted by the Contracting Officer shall serve as the standard for the entire job. They shall be marked and left unpointed until all other pointing is completed.

1.03 QUALITY ASSURANCE

A. Contractor: A skilled firm with not less than three (3) years experience in masonry repointing and restoration. The Contractor shall submit references for five (5) successfully completed projects of similar nature.

B. Work Standards: Repointing basic reference and standard for stone repointing shall be National Park Service Preservation Briefs: 2 Repointing Mortar Joints in Historic Brick Buildings, by Robert C. Mack AIA, de Teel Patterson Tiller, and James S. Askins for any aspect of masonry repointing work not herein specified.

C. Source of Material: Obtain materials for stone restoration from a single source for each type of material required, to ensure match of quality, color, pattern, and texture.

1.04 PROJECT/SITE CONDITIONS

A. Environmental Requirements: Perform work only in dry and otherwise favorable weather conditions. Protect repaired masonry against freezing or excessively rapid drying for at least 48 hours after being laid; no masonry shall be laid when temperature is below 32 F on a rising thermometer or below 40 F on a falling thermometer.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Laticrete International, Inc., Sika Corporation, or owner approved equal.

2.02 MATERIALS

A. Polymer Admixture (for Setting Dutchman) such as "Laticrete 3701 or 4237 Grout and Mortar Admixture" (Laticrete International, Inc.), or owner approved equal.

B. Metal attachments for setting stone Dutchman:

1. All wire, pins, anchors, and bars shall be stainless steel, Type 302 and 304.

2. Provide anchors as follows:
   a. 1/8" diameter round stock, stainless steel wire with turned-up ends for small veneers.
   b. 3/8" diameter round stock, stainless steel rod for direct pinning and drop dowels.

3. The quantity of individual attachments shall not be less than two attachments for small dutchman, and one attachment every two square feet for larger panels.

4. All attachments shall be fastened by mechanical locking, in addition to appropriate adhesives and mortars.

C. Adhesives for attaching anchors and for direct pinning: Where permitted, anchors may be held in place with high modulus, high strength, moisture insensitive, epoxy adhesive. Adhesive shall be two-component 100% solids, epoxy resin system with a viscosity similar to petroleum jelly "Sikadur Hi-Mod Gel" (Sika Corporation), or owner approved equal.

D. Pigments for altering the color of cement: All pigments shall be alkali proof, non-fading, and of synthetic iron oxides.

E. Water: Clean and free of amounts of oils, acids, alkalies, salts, organic materials, or other substances that may be deleterious to mortar or any metal in the wall.

## PART 3---EXECUTION

### 3.01 PREPARATION

A. Protection: Contractor shall take whatever precautions are necessary to protect the existing building from damage resulting from work under this section.

B. Surface Preparation: Cut existing spalls to form rectangular losses with square corners, minimum 2" thickness.

### 3.02 ERECTION, INSTALLATION, APPLICATION

A. Mortar for setting limestone Dutchman shall be mixed in a ratio of one part by volume white portland cement and three parts by volume sand, tempered to a workable consistency with a polymer admixture.

1. The use of Laticrete 3701, or owner approved equal, shall produce the equivalent of high strength "thick set" mortar. Limestone must be temporarily held in place with wood wedges or other means until the mortar has sufficiently set.

2. "Thinset" mortars for special conditions shall employ Laticrete 4237, or owner approved equal. It can be used when the mortar bed is less than 3/8" thick to produce an initially tacky mortar exhibiting high strength properties when set.

B. Dutchman shall be fastened with stainless steel wire, pins, and anchors, as necessary, designed to facilitate mechanical locking and to prevent possible slippage of the stone. The metal fasteners shall be positioned without weakening the stone in any way.

C. Cement mortar containing "Laticrete" latex emulsion additives, or owner approved equal, shall be used for all setting purposes. All insertion shall be fully dressed on all sides, and carefully fitted to the patch opening, with an allowance of not more than 1/8" buttered joint between front edges. Undercutting shall not weaken the stone in any way. The joints between new and old work shall be finished to match the color and texture of the stone. See 04520-02-R for guidance on repointing.

D. The surface of the new stone shall be dressed to resemble the appearance of the adjoining stone by an approved method. All surface dressing of new work shall be done before the stone is set.

E. Protect the limestone during the process of stone restoration. Any mortar accidentally splashed onto existing limestone shall be wiped and rinsed with water.

END OF SECTION

SECTION 04500

MASONRY RESTORATION AND CLEANING

PART 1 - GENERAL

1.01 SUMMARY

A. Provide masonry restoration.

1. Repointing mortar joints.
2. Repair of damaged masonry units.
3. Replacement of damaged masonry units.
4. Re-anchoring.
5. Consolidation treatment.

B. Provide masonry cleaning.

1. Removal of plant growth.
2. Washing and cleaning exposed masonry surfaces.

C. Provide Building and Occupant Protection.

1. General Protection: Protect persons, motor vehicles, adjacent surfaces, surrounding buildings, equipment, and landscape materials from chemicals used and runoff from cleaning 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.
2. Interior Protection: Protect the interior of buildings from the weather, cleaning, and repair operations at all times. Protect air intakes.
3. Worker Exposures: Exposure of workers to chemical substances shall not exceed the limits established by ACGIH 0100Doc, or those required by a more stringent applicable regulation.
4. Environmental Considerations: Minimize environmental pollution and damage that may occur as the result of construction operations. The environmental resources within the project boundaries and those affected outside the limits of permanent work must be protected during the entire duration of this contract. Comply with all applicable environmental Federal, State, and local laws and regulations. Any delays resulting from failure to comply with environmental laws and regulations will be the Contractor's responsibility.
5. Coordinate the work to minimize exposure of building occupants, other Contractor personnel, and visitors to mists and odors from surface preparation, cleaning, and repair operations.

D. Schedule: Refer to Drawings for extent.

1.02 SUBMITTALS

A. Submit for approval

1. Product data.
2. Mortar mix proposed for use, for each type of repointing.
3. Cleaning products, other than water, proposed for use.
4. Test reports

B. Mock-ups: Drawings will indicate the general area for a 4' by 4' mock-up indicating the full range of deviation to be expected in repointing and cleaning.

1.03 QUALITY ASSURANCE

A. Submit documentation showing Contractor's experience of 5 consecutive years in masonry restoration, plus a list of similar jobs to the one specified herein. Provide required qualifications for workers trained and experienced in restoration of masonry in historic structures, and furnish documentation of 5 consecutive years of work of this type. A list of similar jobs shall be provided identifying when, where, and for whom the work was done.

B. No masonry or mortar shall be used in the work until the samples and the represented mixture have been approved. Submit information indicating interface with adjacent materials, and special placing instructions, in sufficient detail to cover fabrication, placement, and finishing.

C. Perform test cleaning to demonstrate/select appropriate cleaning materials, mixes, and methods.

D. Perform test re-pointing to demonstrate/select appropriate mortar mix and method.

E. Demonstrate equipment and techniques of operation in an approved location and subject to approval. 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.

F. Comply with governing codes and regulations. Provide products of acceptable manufacturers which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

1.04 DELIVERY STORAGE AND HANDLING

A. 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.

1.05 PROJECT CONDITIONS

A. Comply with applicable sections of "Recommended Practices for Cold Weather Construction" as published by International Masonry Industry All Weather Council.

B. Protect persons and property from injury and damage from cleaning operations. Coordinate the work to minimize exposure of building occupants, other Contractor personnel, and visitors to mists and odors from surface preparation, cleaning, and repair operations.

C. Do no work when winds prevent control of sand, cleaners or rinse water. Dispose of run-off in a legal manner.

D. 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.

PART 2 - PRODUCTS

2.02 MATERIALS

A. Replacement Masonry Units

1. Face Brick: ASTM C216, Grade SW, Type FBS. Brick shall be classified slightly efflorescent or better when tested in accordance with ASTM C67.
2. Face brick shall match facing brick of the existing building(s) that is being tuck pointed.
3. Other Units to match existing

B. Repair Materials: Materials used for repair and renovation shall match the original existing materials as closely as possible in composition, color, texture, strength, size, finishing and porosity. Materials, physical and chemical properties, and composition of masonry and mortar used in renovation work shall match that of original existing masonry and mortar to be repaired, unless samples and testing determine that existing mixtures and materials are faulty or non-performing. Submit certificates of compliance attesting that the materials, equipment, and cleaning agents (chemicals, detergents, etc.) to be used in the work meet the specified requirements.

1. Repointing Mortar: Materials shall be of one type and from one source. Composition shall match that of existing mortar to be repaired, as determined by mason and approved by architect and owner, and shall conform to ASTM C270. Match existing color, texture, and appearance.
   a. Portland Cement: ASTM C 150, Type I.
   b. Hydrated Lime: High calcium lime conforming to ASTM C 207, Type S or Lime Putty ASTM C1489 for Historic Restoration projects. Maximum 0.60 alkali to avoid efflorescence.
   c. Aggregate Sand: Rounded natural sand conforming to ASTM C 144. Match particle appearance and gradation by sieving sand.
   d. Admixtures ASTM C1384.
   e. Colored Pigment: ASTM C979, maximum 10%.
   f. Water: Obtain potable water from a local source. Water shall be filtered to remove minerals resulting in a neutral pH, prior to application. Provide backflow prevention devices at the point of connection to the water supply.
   g. Water content to be determined by mason for best workability. Retempering is permitted, but only to the extent that it is used to replace water lost thru evaporation.
   h. Pre-hydrate mortar.
   i. Mortar to be used within 2-1/2 hours after mixing.

C. Patching and Restoration Materials: Compatible with existing materials-visual matching.

1. Epoxy Anchor Adhesives: An epoxy-resin grout shall be used to bond steel anchors to masonry. Shall be a 100 percent solids, moisture insensitive, low creep, structural adhesive conforming to ASTM C 881/C 881M, Type IV; Grade and Class selected to conform to the manufacturer's recommendations for the application.
2. Metal attachments: Anchors for spall repairs shall be threaded stainless steel, size as indicated on the drawings. Plates, angles, anchors, and embedments shall conform to ASTM A 36/A 36M, and shall be prime painted with inorganic zinc primer.
3. Patching and re-consolidation mortars; See Section 04451.

D. Cleaning Agents

1. Paint Removers: 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.
2. Detergent Cleaners: shall be as recommended by the manufacturer.
3. Ionic Cleaners.
   a. Alkaline Prewash Cleaner: shall be as recommended by the manufacturer.
   b. One-Part Masonry Cleaner: shall be the standard, acid formulation recommended by the manufacturer.
   c. Two-Part Limestone Cleaner: shall be manufacturer's standard, two-part masonry cleaning system consisting of an alkaline prewash cleaner followed by acidic afterwash rinse.
   d. Standard Strength Acidic Cleaner: shall be manufacturer's standard strength, acidic masonry restoration cleaner composed of hydrofluoric acid blended with other acids and combined with special wetting systems and inhibitors.
   e. Extra Strength Acidic Cleaner: Not allowed.

4. 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.

5. Cleaning Implements: Furnish brushes that have natural or nylon fiber bristles only. Wire brushes shall not be used. Scrapers and application paddles shall be made of wood with rounded edges. Metallic tools shall not be used.

6. Water: Obtain potable water from a local source and shall be filtered to remove minerals resulting in a neutral pH, prior to application. Provide backflow prevention devices at the point of connection to the water supply.
7. Manufacturers: Diedrich Technologies, Hydrochemical Techniques, ProSoCo or owner approved equal.

PART 3 - EXECUTION

3.02 INSTALLATION

A. Evaluation and Analysis: Masonry renovation shall be undertaken 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; such conditions shall be corrected, if possible, prior to start of the work.

B. Masonry Cleaning: Historic materials shall not be damaged or marred in the process of cleaning. Cleaning shall conform to BIA Tech Note 20. Temporarily caulk or otherwise 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, returning the masonry to its natural color. 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. Protect adjacent surfaces with masking agent or other effective means.
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 as agreed upon by the Contractor, Owner, and Architect.
Clean surfaces in strict conformance with approved field tests and match mock-up panels

1. Acidic chemical cleaners shall not be used 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.
2. Test Patches: The materials, equipment, and methods to be used in cleaning shall be demonstrated in a test section approximately 1 by 1 m 3 by 3 ft square. The location of the test section, and the completed test section shall be subject to approval. Adjust the cleaning process as required and the test section rerun until an acceptable process is obtained. Test patches shall be located 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. Tested areas shall be allowed to dry before a determination is made on the effectiveness of a particular treatment.
3. Paint Removal: Remove paint and other coatings from masonry surfaces, in areas indicated on drawings, 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.

4. Water Cleaning
   a. 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 12 inches from surface of masonry. Water shall be applied side to side in overlapping bands to produce uniform coverage.
   b. Handscrubbing: Pre-wetted surfaces shall be scrubbed using hand-held natural bristle or nylon brushes. Wire brushes shall not be used. Surfaces to be cleaned shall be scrubbed to remove surface contaminants.
   c. Rinsing: Scrubbed surfaces shall be rinsed 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.
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 shall be the use of any product in addition to water, including detergents, ammonia, vinegar, and bleach. 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. Cleaning shall result in uniform coverage of all surfaces, including corners, moldings, interstices and shall produce an even effect without streaking or damage to masonry. Chemical cleaners shall not be applied to the same masonry surfaces more than twice.
   a. Surface Prewetting: Masonry surfaces to be cleaned with chemical cleaners shall be wetted with water using a low pressure spray before application of any cleaner.
   b. 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.
   c. 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.
   d. 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.
   e. pH Testing: Masonry surfaces which have been chemically cleaned shall be pH tested using pH monitoring pencils or papers. Chemically cleaned masonry shall be rinsed of all chemical residues until a neutral pH (7) reading is obtained from the masonry surface.

C. Masonry Repair: Repaired surfaces shall match adjacent existing surfaces in all respects. Masonry repair shall proceed only after the cause of deterioration has been identified and corrected. Masonry repair shall conform to ACI C-20. Repair of terra cotta masonry shall conform to ACI 530.1. Masonry repair shall proceed only after the area to be repaired has been cleaned. The materials, methods and equipment proposed for use in the repair work shall be demonstrated in test panels. The location, number, size and completed test panels shall be subject to approval. Use products in accordance with the manufacturer's instructions.
   1. 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 C 207, Type S, unless otherwise specified. Full laboratory analysis of the existing mortar shall conform to ASTM C 1324. Field analysis of the existing mortar shall be as specified below.
      a. 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. Three or four samples of each type of

mortar to be matched shall be removed with a hand chisel from several locations on the building. Set aside the largest sample for comparison with the repointing mortar. The remaining samples shall be broken apart with a wooden mallet, powdering them into their constituent parts.

b. Binder Analysis: A part of the sample shall be stirred into diluted hydrochloric acid. If a vigorous chemical reaction (bubbling) occurs and most of the binder disappears, leaving clean aggregate, the binder was lime. A portland cement binder will result in a murky liquid and will dissolve very slowly over several days.

c. 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.

2. Repointing: Repointing work shall be [as directed] [in accordance with BIA TN 8, and BIA TN 46. Old caulking, grout, or mortar shall be removed from previously repaired cracks where it is failing. Remove loose particles from cracks. Cracks shall be cleaned, rinsed with water followed by blowing with filtered, dry, compressed air.

a. Cut out existing mortar joints (both bed and head joints) and remove by means of a toothing chisel and mallet, unless Contractor can demonstrate that a special pointer's grinder will not damage masonry. Grind to to a uniform depth of 2-1/2 times joint width, but in no case less than 3/4-inch, or until sound mortar is reached. Take care to not damage edges of existing masonry units to remain.

b. Remove dust and debris from the joints by brushing, blowing with air or rinsing with water. Do not rinse when temperature is below freezing.

c. Protect newly pointed joints from rain, until pointed joints are sufficiently hard enough to prevent damage.

d. Repointing may be performed in freezing weather when methods of protection are utilized. Comply with applicable sections of "Recommended Practices for Cold Weather Construction" as published by International Masonry Industry All Weather Council. Existing surfaces at temperatures to prevent mortar from freezing or causing other damage to mortar.

e. Immediately prior to application of mortar, dampen joints to be tuck pointed. Prior to application of pointing mortar, allow masonry units to absorb surface water.

f. Tightly pack mortar into joints in thin layers, approximately 1/4-inch thick maximum.

g. Allow layer to become "thumbprint hard" before applying next layer.

h. Pack final layer flush with surfaces of masonry units. When mortar becomes "thumbprint hard", tool joints.

i. Tool joints with a jointing tool to produce a smooth, compacted, concaved joint. Tool joints in patch work with a jointing tool to match the existing surrounding joints.

j. Periodically wet type O, K, and L mortars.

3. Mechanical Repair: Repair or replace original historic masonry materials only if surfaces are extensively deteriorated (surface missing to a depth of 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.

a. 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.

b. Application of Masonry and Mortar: Place masonry and mortar to rebuild spalled or damaged areas to match the original surface finish, level, texture, and color. The finished appearance of the patch shall match the adjacent existing surface.

c. Patch Anchors: Provide patch anchors to ensure that the patch is tied to the existing masonry structure, frequency of at least one patch anchor per 1 square foot of patch plan surface area; specific locations for patch anchors shall be as indicated on the drawings. Use small handheld, low-speed rotary masonry drills to produce holes in the existing masonry, within the limits for the patch anchor installation.

d. Holes: Drill holes into the existing substrate material of the masonry using rotary (non-hammer) drills. Holes shall have a diameter of 1/8 inch larger than the anchor diameter. The holes shall be drilled to a depth of 4 inches, except as otherwise indicated or directed. Drill holes shall not penetrate completely through the masonry,

and shall provide at least 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.

e. 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 1 inch. Install anchors without breaking or chipping the exposed masonry surface.

f. Epoxy-resin Grout: The epoxy adhesive shall be conditioned, proportioned, mixed, applied, protected, and cured in accordance with the manufacturer's recommendations, except as otherwise specified herein or indicated on the drawings. Maintain the adjacent surfaces and ambient conditions within the manufacturer's recommendations. The patch anchors and epoxy adhesive shall be protected from displacement and disturbances.

1). Mixing Epoxy-Resin Grout Components: Mix epoxy-resin grout components in the proportions recommended by the manufacturer. The components shall be conditioned within 20 to 30 degrees C, 70 to 85 degrees F, for 48 hours prior to mixing. Mix the two epoxy components with a power-driven, explosion-proof stirring device in a metal or polyethylene container having a hemispherical bottom. The polysulfide curing agent component shall be added gradually to the epoxy-resin component with constant stirring until a uniform mixture is obtained. The rate of stirring shall be such that the entrained air is at a minimum.

(a). Tools and Equipment: Clean tools and equipment to be used again in the work before the epoxy-resin grout sets.

g. Cleanup: Remove excess epoxy and spills from the surface of the masonry. The surface of the masonry shall be left in a clean and uncontaminated condition. Spills on adjacent surfaces shall also be removed and surfaces repaired as required.

h. Dutchman Repairs: See Section 04460.

i. Patching and re-consolidation mortars; See Section 04451.

D. Masonry Replacement: Replace masonry with material that matches the original in terms of composition, color, texture, strength, finishing, and porosity as closely as possible. If a few isolated masonry units are to be replaced, remove each without disturbing the surrounding masonry. Deteriorated masonry units and mortar requiring replacement shall be removed by hand chiselling. Adjoining masonry units shall not be damaged during the removal of deteriorated units and mortar. Test the new element for fitting into its space without mortar. If wedges are used to support and align the new unit, they shall be covered with at least 1-1/2 inches of mortar when pointing is complete. 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. The new unit shall be lined up and set by tapping it into place with a wooden or rubber mallet. Align face of new unit with that of existing masonry. Joints shall be repointed to match the rest of the wall after new units have been properly installed and adjusted. Clean replacement areas with a non-metallic brush and water to remove excess mortar.

1. Cut out mortar joints surrounding masonry units that are to be removed and replaced.
   a. Units removed may be broken and removed, providing surrounding units to remain are not damaged.
   b. Once the units are removed, carefully chisel out the old mortar and remove dust and debris.
   c. If units are located in exterior wythe of a cavity or veneer wall, exercise care to prevent debris falling into cavity.
2. Dampen surfaces of the surrounding units before new units are placed.
   a. Allow existing masonry to absorb surface moisture prior to starting installation of the new replacement units.
   b. Butter contact surfaces of existing masonry and new replacement masonry units with mortar.
   c. Center replacement masonry units in opening and press into position.
   d. Remove excess mortar with a trowel.
   e. Point around replacement masonry units to ensure full head and bed joints.
   f. When mortar becomes "thumbprint hard", tool joints. Tool joints in patch work with a jointing tool to match the existing surrounding joints.

E. Masonry and Mortar Finishes and Color: The exposed surfaces of masonry and mortar repair shall match the finish, color, texture, and surface detail of 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. The equipment used in finishing and texturing shall be a low-impact energy type which will not weaken the patch or damage the patch bond and the adjacent concrete.

F. Masonry Mortaring:
   1. Mix in a mechanically operated mortar mixer. Mix mortar for at least three minutes but not more than five minutes.
   2. Measure ingredients by volume. Measure by the use of a container of known capacity.
   3. Mix water with dry ingredients in sufficient amount to provide a workable mixture which will adhere to vertical surfaces of masonry units. Mason to determine water content for best workability.
   4. Re-temper mortar that has stiffened because of loss of water through evaporations by adding water to restore to proper consistency and workability.
   5. Discard mortar that has reached its initial set or has not been used within two hours.
   6. Pointing Mortar: Mix dry ingredients with enough water to produce a damp mixture of workable consistency which will retain its shape when formed into a ball.
      a. Allow mortar to stand in dampened condition for one to 1-1/2 hours.
      b. Add water to bring mortar to a workable consistency prior to application.

G. Joint Sealing: Provide joint sealing as specified in Section 07901.

H. 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.

   1. Perform cleaning work when temperature and humidity conditions allow the surfaces to dry rapidly.
   2. Remove mortar droppings and other foreign substances from wall surfaces.
   3. Brush with stiff fiber brushes while washing, and immediately thereafter hose down with clean water.
   4. Free clean surfaces from traces of detergent, foreign streaks or stains.
   5. Protect materials during cleaning operations including adjoining construction.
   6. Use of muratic acid for cleaning is prohibited

I. Protection of Work: Protect work against damage from subsequent operations.

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

K. 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 by owner and architect.

## 3.03 WARRANTY

A. Cleaning Warranty:

   1. Cleaning procedures shall be warranted 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

B. Repair Warranty:

   1. Repair procedures, including repointing, shall be warranted 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.

END OF SECTION

SECTION 07175

WATER REPELLENTS

PART 1 - GENERAL

1.01 SUMMARY

A. General: Provide clear water repellent coating and anti-graffiti coating for exterior brick, stone, terracotta, and associated joints.

B. Performance Requirements:

1. Reduce absorption of water and waterborne contaminants into substrate.
2. Permit water vapor transmittance.
3. Anti-Graffiti coating to facilitate the removal of graffiti.
4. No change to slight darkening of substrate after application.

C. Provide Building and Occupant Protection.

1. General Protection: Protect persons, motor vehicles, adjacent surfaces, surrounding buildings, equipment, and landscape materials from chemicals used and runoff from cleaning 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.
2. Interior Protection: Protect the interior of buildings from the weather, cleaning, and repair operations at all times. Protect air intakes.
3. Worker Exposures: Exposure of workers to chemical substances shall not exceed the limits established by ACGIH 0100Doc, or those required by a more stringent applicable regulation.
5. Environmental Considerations: Minimize environmental pollution and damage that may occur as the result of construction operations. The environmental resources within the project boundaries and those affected outside the limits of permanent work must be protected during the entire duration of this contract. Comply with all applicable environmental Federal, State, and local laws and regulations. Any delays resulting from failure to comply with environmental laws and regulations will be the Contractor's responsibility.
6. Coordinate the work to minimize exposure of building occupants, other Contractor personnel, and visitors to mists and odors from surface preparation, cleaning, and repair operations.

D. Schedule: Entire building - all exposed exterior masonry.

1. Siloxane: Clay brick, concrete, and concrete block.
2. Silicone: Limestone, natural stone, and concrete block.
3. Silicone Elastomer: All surfaces to be protected against graffiti.

1.02 SUBMITTALS

A. Submit, for approval, product data:

1. Water absorption
2. Accelerated weathering
3. Resistance to chloride ion penetration
4. Moisture vapor transmission
5. Scaling resistance
6. Water Penetration and Leakage
7. Certificates for:
   a. Manufacturer's qualifications
   b. Applicator's qualifications
   c. Evidence of acceptable variation
   d. Warranty
8. Application instructions: Provide manufacturer's instructions including preparation, application, recommended equipment to be used, safety measures, and protection of completed application.
9. Manufacturer's material safety data sheets

1.03 QUALITY ASSURANCE

A. Qualifications: Provide products of acceptable manufacturer's which have been in satisfactory use in similar service for a minimum of five (5) years. Products shall be installed by an applicator with a minimum of five (5) years experience in projects of similar age, size, and scope using specified or similar treatment materials and manufacturer's approval for application. Provide (3) references.

B. Performance Requirements:

1. Water absorption: ASTM C 140. Comparison of treated and untreated specimens.
2. Moisture vapor transmission: ASTM E 96/E 96M. Comparison of treated and untreated specimens.
3. Water penetration and leakage through masonry: ASTM E 514/E 514M.Comply with governing codes and regulations.

C. Mock-ups / Sample Test Panels

1. The approved Sample Test Panel will serve as the standard of quality for all other water repellent coating work. Do not proceed with application until the sample panel has been approved by the Contracting Officer.
2. Prior to commencing work, including bulk purchase and delivery of material, apply water repellent treatment to a minimum 4 feet high by 4 feet long for EACH product!
   a. Determine optimum coverage rate for application.
   b. Water test after curing to verify sufficient coverage to repel moisture from surface.
   c. Verify that application of water repellent to substrate will not produce surface stains or discoloration.
3. The owner may purposely test an area by applying graffiti to the wall to field verify appropriate coverage.
4. Proceed with water repellent and anti-graffiti treatment work only after approval of mock-ups by the architect and owner.

D. Pre-Installation Meeting

1. Attend pre-installation meeting required prior to commencement of installation.
2. Review procedures and coordination required between water repellent treatment work and work of other trades which could affect work to be performed under this section of the work.
3. Convene additional pre-installation meeting prior to water repellent treatment application for coordination with work not previously coordinated including joint sealants.

E. Delivery, Storage, and Handling

1. Deliver materials in original sealed containers, clearly marked with the manufacturer's name, brand name, type of material, batch number, percent solids by weight and volume, and date of manufacturer. Store materials off the ground, in a dry area where the temperature will be not less10 degrees C 50 degrees F nor more than 29 degrees C 85 degrees F.

F. Safety and Toxic Materials: To protect personnel from overexposure to toxic materials, conform to the most stringent guidance of:

1. The coating manufacturer when using solvents or other chemicals.
2. Use impermeable gloves, chemical goggles or face shield, and other recommended protective clothing and equipment to avoid exposure of skin, eyes, and respiratory system.
3. Conduct work in a manner to minimize exposure of building occupants and the general public.
4. Threshold Limit Values (R) of the American Conference of Governmental Industrial Hygienists.
5. Manufacturer's material safety data sheets.

G. Environmental Conditions

1. Weather and Substrate Conditions: Do not proceed with application of water repellents under any of the following conditions, except with written recommendations of manufacturer.

   a. Ambient temperature is less than 4 degrees C 40 degrees F.

b. Substrate faces have cured less than one month.
c. Rain or temperature below 4 degrees C 40 degrees F are predicted for a period of 24 hours before or after treatment.
d. Earlier than three days after surfaces are wet.
e. Substrate is frozen or surface temperature is less than 4 degrees C 40 degrees F and falling.

2. Moisture Condition: Determine moisture content of substrate meets manufacturer's requirements prior to application of water repellent material.

H. Sequencing and Scheduling

1. Masonry Surfaces: Do not start water repellent coating until all joint tooling, pointing and masonry cleaning operations have been completed. Allow masonry to cure for at least 60 days under normal weather conditions before applying water repellent.

2. Sealants: Do not apply water repellents until the sealants for joints adjacent to surfaces receiving water repellent treatment have been installed and cured.

a. Water repellent work may precede sealant application only if sealant adhesion and compatibility have been tested and verified using substrate, water repellent, and sealant materials identical to those used in the work.
b. Provide manufacturers' test results of compatibility.

I. Inspections: Notify the manufacturer's representative a minimum of 72 hours prior to scheduled application of water repellents for field inspection. Inspect surfaces and obtain approval in writing from the manufacturer's representative prior to any application of any water repellent coating.

J. Surface to be Coated: Coat all exterior masonry (brick and stone) surfaces. This includes back faces of parapets, top of walls, edges and returns adjacent to windows and door frames and free standing walls.

PART 2 - PRODUCTS

2.02 MATERIALS

Water repellent solution shall be a clear, non-yellowing, deep-penetrating, VOC compliant solution. Material shall not stain or discolor and shall produce a mechanical and chemical interlocking bond with the substrate to the depth of the penetration.

Anti-Graffiti coating shall act as water repellant AND to protect masonry surfaces from repeated graffiti attacks wtiout altering the natural appearance of the materials. Graffiti removal to be fast and easy.

2.03 MANUFACTURERS:
ProSoCo , Diedrich Chemical, Hydrozo - Harris Specialty Chemicals, Chemical Products Industries, Inc, or Owner approved equal.

A. Siloxanes: Clear penetrating water repellent.

1. Composition: Oligomeric alkyl-alkoxy siloxanes with alcohol, ethanol, mineral spirits, or water.
2. Solids by weight: ASTM D 2369, 7.5 to 16.0 percent.
3. Appearance: White, milky liquid.
4. Average depth of penetration: Up to 10mm 3/8" deep depending on substrate.
5. Volatile Organic Content (VOC) after blending: Less than 175 grams per liter.
6. Density, activated: One kilogram per liter 8.4 pounds per gallon, plus or minus one percent.
7. Specific gravity, at 25 degrees C 78 degrees F: 0.996
8. Flash point, ASTM D 3278: Greater than 100 degrees C 212 degrees F.

B. Silicone: Clear water repellant.
1. Composition: Potassium methyl siliconate with mineral spirits or water
2. Solids by weight: ASTM D 5095 4.5 percent.
3. Appearance: Clear liquid.
4. Volatile Organic Content (VOC) after blending: Less than 175 grams per liter.
5. Density, activated: One kilogram per liter 8.4 pounds per gallon, plus or minus one percent.

6. Specific gravity, at 25 degrees C 78 degrees F: 1.02
7. Flash point, ASTM D 3278: Greater than 100 degrees C 212 degrees F.

B. Anti-Graffiti Repellant
1. Prosoco “Sure Klean Weather Seal Blok-Guard & Graffiti Control” or Owner Approved Equal During the Bidding Process.

2.04 PERFORMANCE CRITERIA

A. Siloxane

1. Dry time for recoat, if necessary: One to two hours depending on weather conditions.
2. Penetration: 10 mm 3/8 inch, depending on substrate.
3. Water penetration and leakage through masonry, ASTM E 514/E 514M, percentage reduction of leakage: 97.0 percent minimum.
4. Moisture vapor transmission, ASTM E 96/E 96M: 47.5 perms or 82 percent maximum compared to untreated sample.
5. Resistance to accelerated weathering, ASTM G 53. Testing 2,500 hours: No loss in repellency.
6. Resistance to chloride ion penetration, AASHTO T 259 and AASHTO T 260.
7. Scaling resistance,ASTM C 672/C 672M, non-air-entrained concrete: Zero rating, no scaling, 100 cycles treated concrete.

B. Silicoln

1. Water absorption test: ASTM C 642 and ASTM E 514/E 514M.
2. Moisture vapor transmission: ASTM D 1653, 28.33 perms or 51.61 percent maximum compared to untreated surfaces.
3. Scaling resistance: ASTM C 672/C 672M, non-air-entrained concrete, zero rating, no scaling, 100 cycles treated concrete.
4. Resistance to chloride ion penetration: AASHTO T 259 and AASHTO T 260.
5. Water penetration and leakage through masonry, ASTM E 514/E 514M percentage reduction of leakage: 97 percent minimum.
6. Resistance to accelerated weathering, ASTM G 53 testing 2,500 hours: No loss in repellency.
7. Drying time under normal conditions: Six hours per 24 degrees C 75 degrees F.

PART 3 - EXECUTION

3.02 EXAMINATION

A. Examine surfaces to be treated to ensure that:

1. All visible cracks, voids or holes have been repaired.
2. All mortar joints in masonry are tight and sound, have not been re-set or misaligned and show no cracks or spalling.
3. Moisture contents of walls does not exceed 15 percent when measured on an electronic moisture register, calibrated for the appropriate substrate.
4. Concrete surfaces are free of form release agents, curing compounds and other compounds that would prevent full penetration of the water repellent material.

Do not start water repellent treatment work until all deficiencies have been corrected, examined and found acceptable to the Contracting Officer and the water repellent treatment manufacturer. Do not apply treatment to damp, dirty, dusty or otherwise unsuitable surfaces. Comply with the manufacturer's recommendations for suitability of surface.

3.03 PREPARATION

A. Surface Preparation: Prepare substrates in accordance with water repellent treatment manufacturer's recommendation. Clean surfaces of dust, dirt, efflorescence, alkaline, and foreign matter detrimental to proper application of water repellent treatment.

B. Protection: Provide masking or protective covering for materials which could be damaged by water repellent treatment.

1. Protect glass, glazed products, and prefinished products from contact with water repellent

treatment.
2. Protect landscape materials with breathing type drop cloths: plastic covers are not acceptable.

C. Compatibility

1. Confirm treatment compatibility with each type of joint sealer within or adjacent to surfaces receiving water repellent treatment in accordance with manufacturer's recommendations.
2. When recommended by joint sealer manufacturer, apply treatment after application and cure of joint sealers. Coordinate treatment with joint sealers.
3. Mask surfaces indicated to receive joint sealers which would be adversely affected by water repellent treatment where treatment must be applied prior to application of joint sealers.

3.04 APPLICATION

In strict accordance with the manufacturers written requirements. Do not start application without the manufacturer's representative being present or his written acceptance of the surface to be treated.

A. Mixing: Mix water repellent material thoroughly in accordance with the manufacturer's recommendations. Mix, in quantities required for that days work, all containers prior to application. Mix each container the same length of time.

B. Spray Application: Spray apply water repellent material to exterior masonry surfaces using low-pressure airless spray equipment in strict accordance with manufacturer's printed application, instructions, and precautions. Maintain copies at the job site. Apply flood coat in an overlapping pattern allowing approximately 8 to 10 inch rundown on the vertical surface. Maintain a wet edge at all overlaps, both vertical and horizontal. Hold gun maximum 18 inches from wall.

1. For best results, apply to a visibly dry and absorbent surface.
2. Spray from the bottom up, creating a 6" to 8" rundown below the spray contact point.
3. Let the first application penetrate for 5-10 minutes. Resaturate. Less material will be needed for the second application.

C. Brush or Roller Application: Brush or roller apply water repellent material only at locations where overspray would affect adjacent materials and where not practical for spray applications.

1. Saturate uniformly.
2. Let protective treatment penetrate for 5 to 10 minutes.
3. Brush out heavy runs and drips that do not penetrate the surface.

D. Covered Surfaces: Coat all exterior masonry surfaces including back faces of parapets, tops of walls, edges and returns adjacent to window and door frames, window sills, and free-standing walls.

E. Rate of Application: Apply materials to exterior surfaces at the coverages recommended by the manufacturer and as determined from sample panel test. Increase or decrease application rates depending upon the surface texture and porosity of the substrate so as to achieve even appearance and total water repellency.

1. Dense Surfaces: Apply enough product in a single coat to completely wet the surface without creating drips, puddles or rundown. Do not overapply
2. Strengthening Deteriorated Surfaces: For maximum strengthening benefits, appl in as few as 1 and as many as 3 "cycles." Each cycle consists of 3 consecutive saturating applications applied at 5 to 10 minute intervals. Allow enough time between cycles (30 - 60 minutes) for penetration of the previous application.

F. Number of Coats: The sample panel test shall determine the number of coats required to achieve full coverage and protection.

G. Appearance: If unevenness in appearance, lines of work termination or scaffold lines exist, or detectable changes from the approved sample panel occur, the architect may require additional treatment at no additional cost to the owner. Apply any required additional treatment to a natural break off point.

H. Cleaning: Clean all runs, drips, and overspray from adjacent surfaces while the water repellent treatment is still wet in a manner recommended by the manufacturer.

3.05 FIELD QUALITY CONTROL

A. Inspection: Inspect the water repellent work with the Contractor, Architect, applicator or manufacturer's representative, and compare with test panel results approved by the Architect. Determine if the substrates are suitably protected by the water repellents. After coating has dried, test surfaces with water spray and Material Absorption Tube test; reapply to any areas showing water absorption.

3.06 FINAL CLEANING

A. Clean site of all unused water repellents, residues, rinse water, wastes, and effluents in accordance with environmental regulations.
B. Remove and dispose of all materials used to protect surrounding areas and non-masonry surfaces, following completion of the work of this section.
C. Repair, restore, or replace to the satisfaction of the Architect, all materials, landscaping, and non-masonry surfaces damaged by exposure to water repellents

3.07 WARRANTY
A. Provide a warranty, issued jointly by the manufacturer and the applicator of the water repellent treatment against moisture penetration through the treated structurally sound surface for a period of five (5) years.
B. Warranty to provide the material, labor, and equipment necessary to remedy the problem. At the satisfactory completion of the work, complete the warranty sign, and submit to the owner.

END OF SECTION

SECTION 07901

JOINT SEALANTS

PART 1 - GENERAL

1.01 SUMMARY

A. Provide elastomeric joint sealants, joint backer materials and accessories needed to ensure a complete and durable weather tight seal at all locations indicated. Section covers all sealant and caulking materials and their application, as indicated on the drawings, and wherever required for a watertight building envelope.

1. Sealant between stone units.
2. Sealant between dissimilar materials.
3. Sealant for control joints.

B. Provide Building and Occupant Protection.

1. General Protection: Protect persons, motor vehicles, adjacent surfaces, surrounding buildings, equipment, and landscape materials from chemicals used and runoff from cleaning 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.
2. Interior Protection: Protect the interior of buildings from the weather, cleaning, and repair operations at all times. Protect air intakes.
3. Worker Exposures: Exposure of workers to chemical substances shall not exceed the limits established by ACGIH 0100Doc, or those required by a more stringent applicable regulation.
4. Environmental Considerations: Minimize environmental pollution and damage that may occur as the result of construction operations. The environmental resources within the project boundaries and those affected outside the limits of permanent work must be protected during the entire duration of this contract. Comply with all applicable environmental Federal, State, and local laws and regulations. Any delays resulting from failure to comply with environmental laws and regulations will be the Contractor's responsibility.
5. Coordinate the work to minimize exposure of building occupants, other Contractor personnel, and visitors to mists and odors from surface preparation, cleaning, and repair operations.

C. Schedule: Refer to Drawings for extent.

1.02 SUBMITTALS

A. Submit for approval, shop drawings, product data, and samples.

1. Manufacturer's installation instructions for each product used.
2. Cured samples of exposed sealants for each color where required to match adjacent material.
3. Manufacturer's Literature and Data:

a. Caulking compound
b. Primers
c. Sealing compound, each type, including compatibility when different sealants are in contact with each other.
d. Certification from sealant manufacturers that their products are suitable for the use indicated and comply with specification requirements.
e. Report from sealant applicator summarizing results of pre-construction field adhesion testing.

1.03 QUALITY ASSURANCE

A. Submit documentation showing Contractor’s experience of 5 consecutive years in work of this type. Contractor shall be an experienced installer who has specialized in installing joint sealants similar in material, design, and extent to those indicated for this Project and whose work has resulted in joint-sealant installations with a record of successful in-service performance. A list of

similar jobs shall be provided identifying when, where, and for whom the work was done.

B. Use adequate numbers of skilled workmen thoroughly trained and experienced in the necessary crafts and completely familiar with the specified requirements and methods needed for proper performance of the work of this Section.

C. Source Limitations: Obtain each type of joint sealant through one source from a single manufacturer. Manufacturer shall instruct applicator in procedures for intersecting sealants

D. Product Testing: Obtain test results from a qualified testing agency based on testing current sealant formulations within a 12-month period. Perform work in accord with ASTM C 1193 guidelines except where more stringent requirements are indicated or specified.

E. Preconstruction compatibility and adhesion testing:

1. Submit to joint sealant manufacturer samples of actual materials that will contact or affect their joint sealants in the Work for compatibility and adhesion testing.
2. This testing will not be required where sealant manufacturer is able to furnish data acceptable to Architect based on previous testing for adhesion and compatibility to materials matching those of the Work.

F. Preconstruction field adhesion testing: Before installing elastomeric sealants, field test their adhesion to joint substrates in accordance with sealant manufacturer's recommendations:

1. In jobsite field samples prior to general installation, conduct field-tests for adhesion of joint sealants to actual joint substrates using proposed joint preparation methods recommended by manufacturer.
2. Conduct tests for each type of sealant and substrate.
3. Locate field-test joints where inconspicuous or as approved by Architect.
   a. Include areas typical of those requiring removal of existing sealants and utilize methods proposed for sealant removal that have been pre-approved by Architect.
4. Test method: Use manufacturer's standard field adhesion test methods and methods proposed for joint preparation to verify proper priming and joint preparation techniques required to obtain optimum adhesion of joint sealants to joint substrate.
5. Arrange for tests to take place with joint sealant manufacturer's technical representative present
6. Evaluate and report results of field adhesion testing.
7. Do not use joint preparation methods or sealants that produce less than satisfactory adhesion to joint substrates during testing.

G. Standard of acceptance: Joints installed during pre-construction field adhesion testing that are accepted by Architect shall be retained as standard of acceptability and incorporated into Work of that area during general installation.

H. Schedule applications of waterproofing, water repellents and preservative finishes after sealant installation unless sealant manufacturer approves otherwise in writing. Ensure that installed sealant is allowed to cure sufficiently prior to subsequent applications.

I. VOC: Acrylic latex and Silicon sealants shall have less than 50g/l VOC content.

J. Mockups: Before installing joint sealants, apply elastomeric sealants as follows to verify selections made under sample Submittals and to demonstrate aesthetic effects and qualities of materials and execution: At least one standard of minimum 5 feet in length shall be established for each type of joint type, sealant, and substrate indicating:

1. Old sealant removal and surface preparation prior to new sealant installation.

2. Location, size shape, color, and depth of joints complete with back-up material, primer, and new sealant. Mock-up may be part of finished work.

1.04 DELIVERY STORAGE AND HANDLING

A. Deliver materials in manufacturers' original unopened containers, with all labels intact and legible at time of use, with brand names, date of manufacture, shelf life, and material designation clearly marked thereon.

B. Carefully handle and store to prevent inclusion of foreign materials.

C. Do not subject to sustained temperatures exceeding 5 C (40 F) or less than 32 C (90 F).

D. Store materials in accord with manufacturer's recommendations with proper precautions to ensure fitness of material when installed

1.05 PROJECT CONDITIONS

A. Protect persons and property from injury and damage from cleaning operations. Coordinate the work to minimize exposure of building occupants, other Contractor personnel, and visitors to mists and odors from surface preparation, cleaning, and repair operations.

B. Environmental Limitations: Do not proceed with installation of joint sealants under following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint sealant manufacturer or are below 4.4 C (40 F).
2. When joint substrates are wet.

C. Joint-Substrate Conditions:

1. Do not proceed with installation of joint sealants until contaminants capable of interfering with adhesion are removed from joint substrates.
2. Provide joints properly dimensioned to receive the approved sealant system.
3. Provide joint surfaces that are clean, dry, sound and free of voids, deformations, protrusions and contaminants which may inhibit application or performance of the joint sealant.
4. Where expansion joints having preformed joint fillers are scheduled to be sealed, provide a reservoir to accept the sealant such as by a molded breakaway joint cap or a removable block out.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Acceptable manufacturers: Pecora Corp., Sika Corp., Dow Corning, General Electric, Tremco or Owner approved equal

B. Compatibility: Provide joint sealants, joint fillers and accessory joint materials that are compatible with one another and with joint substrates under project conditions. Install joint sealants, joint fillers and related joint materials that are non-staining to visible joint surfaces and surrounding substrate surfaces.

C. Provide colors selected by Architect from manufacturer's full range of standard, and tintable colors.

1. Sealants used with exposed masonry (brick, stone, etc. shall match color of mortar joints.
2. Sealants used with terra-cotta shall match color of terra-cotta units, unless noted otherwise on the drawings.
3. Sealants used with pre-cast concrete shall match color of existing sealant to remain.
4. Sealants used against painted surfaces (frames, louvers, etc.) shall be color of the painted surface, and field paintable in the future.
5. Sealants used against pre-finished, colored surfaces shall be color of the pre-finished surface.
6. For other areas, contact architect for written approval of color(s).

D. Urethane Elastomeric Joint Sealants: Multi-part, nonsag, urethane sealant, for joints in vertical and horizontal surfaces, exterior use. Equal to Tremco Dymeric 240.

1. ASTM C920.
2. Type M.
3. Class 50.
4. Grade NS.
5. Shore A hardness of 35-40.

E. Urethane Elastomeric Joint Sealants: Single-part, nonsag, urethane sealant, for joints in vertical and horizontal surfaces, exterior use. Equal to Tremco Dymonic FC.

1. ASTM C920.
2. Type S.

3. Class 35.
4. Grade NS.
5. Shore A hardness of 25.

F. Silicone Elastomeric Joint Sealants: Single-part, neutral-curing, silicone sealant for joints in vertical and horizontal surfaces, modulus as required for application, exterior use. Equal to Tremco Spectrum 3.

1. ASTM C920.
2. Type S.
3. Class 50.
4. Grade NS.
5. Shore A hardness of 15.

G. Silicone Elastomeric Joint Sealants: Single-part neutral-curing, field tintable, silicone sealant for joints in vertical and horizontal surfaces, modulus as required for application, exterior use. Equal to Tremco Spectrum 4-TS.

1. ASTM C920.
2. Type M.
3. Class 50.
4. Grade NS.
5. Shore A hardness of 15.

H. Auxiliary Materials:

1. Joint cleaner for non-porous surfaces: Chemical cleaners acceptable to manufacturer of sealants and sealant backing material for substrates indicated. Cleaners to be free of oily residues and other substances capable of staining or harming joint substrates and adjacent non-porous surfaces and formulated to promote adhesion of sealant and substrates.
2. Joint primer: Stain-free type, as recommended by manufacturer for substrates, conditions and exposures indicated. Equal to Tremco Primer #171 or TREMprime Silicone Porous Primer for porous surfaces, or TREMprime Non-Porous Primer for metals or plastics
3. Bond breaker: Polyethylene tape or other adhesive plastic tape as recommended by sealant manufacturer to prevent sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint where such adhesion would result in sealant failure. Equal to.3M #226 or #481.
4. Joint backer: Provide sealant backings of material and type that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
   Closed cell or soft rod Polyethylene foam rod or other compatible non-waxing, non-extruding, non-staining resilient material in dimension 25 percent to 50 percent wider than joint width as recommended by sealant manufacturer for conditions and exposures indicated.

   a. Cylindrical Sealant Backings: ASTM C1330
   b. Type C: Closed-cell material with a surface skin.
   d. Elastomeric Tubing Sealant Backings: Neoprene, butyl, EPDM, or silicone tubing complying with ASTM D1056, nonabsorbent to water and gas, and capable of remaining resilient at temperatures down to minus 32 C (minus 26 F). Provide products with low compression set and of size and shape to provide a secondary seal, to control sealant depth, and otherwise contribute to optimum sealant performance.

5. Filler: Mineral fiber board: ASTM C612, Class 1, thickness same as joint width, depth to fill void completely behind back-up rod.

6. Masking tape: Non-staining, non-absorbent tape product compatible with joint sealants and adjacent joint surfaces that is suitable for masking.

7. Other Materials: Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor and approved by the sealant manufacturer as compatible, subject to review of the Architect.

PART 3 - EXECUTION

3.01 INSPECTION AND SURFACE CONDITIONS

A. Inspect substrate surface; report unsatisfactory conditions in writing. Coordinate for repair and resolution of unsound substrate materials. Applicator shall examine the areas and conditions under which work of this Section will be performed.

1. Verify conformance with manufacturer's requirements;
2. Inspect for bond breaker contamination and unsound materials at adherent faces of sealant.
3. Inspect for uniform joint widths and that dimensions are within tolerance established by sealant manufacturer.
4. Report unsatisfactory conditions in writing to the Architect;
5. Do not proceed until unsatisfactory conditions are corrected.
   * Beginning work means acceptance of substrates.

3.02 PREPARATION

A. Prepare surfaces to receive sealants in accord with sealant manufacturer's instructions and recommendations, and SWRI, except where more stringent requirements are indicated.

B. Thoroughly clean joint surfaces with methods approved by sealant manufacturer whether primers are required or not.

1. Clean porous joint substrate surfaces by brushing, grinding, blast cleaning, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove all traces of previous sealant and joint backer in manner not damaging to surrounding surfaces. Porous joint surfaces include the following: Concrete, Masonry, and Unglazed surfaces of ceramic tile

2. Clean nonporous surfaces with chemical cleaners or other means, approved by the sealant manufacturer, that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous surfaces include the following: Metal, Glass, Glazed surfaces/tile

3. Remove loose particles and dust by vacuuming or blowing out joints with oil-free

4. Remove paints from joint surfaces except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer.

5. Remove wax, oil, grease, dirt film residues, temporary protective coatings and other residues by wiping with cleaner recommended for that purpose. Use clean, white, lint-free cloths and change cloths frequently.

C. Provide joint backer material uniformly to depth required by sealant manufacturer for proper joint design using a blunt instrument. Install back-up material, to form joints enclosed on three sides as required for specified depth of sealant.

1. Fit securely by compressing backer material 25 percent to 50 percent so no displacement occurs during tooling.

2. Avoid stretching or twisting joint backer.

3. Where deep joints occur, install filler to fill space behind the back-up rod and position the rod at proper depth.

4. Cut fillers installed by others to proper depth for installation of back-up rod and sealants.

5. Install back-up rod, without puncturing the material, to a uniform depth, within plus or minus 3 mm (1/8 inch) for sealant depths specified.

6. Where space for back-up rod does not exist, install bond breaker tape strip at bottom (or back) of joint so sealant bonds only to two opposing surfaces.

7. Take all necessary steps to prevent three sided adhesion of sealants.

D. Provide bond-breaker where indicated or recommended by sealant manufacturer, adhering strictly to the manufacturers installation requirements.

E. Prime joint substrates where required: Apply primer prior to installation of back-up rod or bond breaker tape. Use and apply primer according to sealant manufacturers recommendations.

1. Confine primers to sealant bond surfaces; do not allow spillage or migration onto adjoining surfaces.

2. Use brush or other approved means that will reach all parts of joints.

3. Take all necessary steps to prevent three sided adhesion of sealants.

F. Taping: Use masking tape where required to prevent sealant or primer contact with adjoining surfaces that would be permanently stained or otherwise damaged by such contact or the cleaning methods required for removal.

1. Apply tape so as not to shift readily and remove tape immediately after tooling without disturbing joint seal.

2. Do not leave gaps between ends of sealant backings.

G. Sealant Depths and Geometry:

1. At widths up to 6 mm (1/4 inch), sealant depth equal to width.

2. At widths over 6 mm (1/4 inch), sealant depth 1/2 of width up to 13 mm (1/2 inch) maximum depth at center of joint with sealant thickness at center of joint approximately 1/2 of depth at adhesion surface.

3.03 INSTALLATION

A. General: For application of sealants, follow requirements of ASTM C1193 unless specified otherwise.

1. Apply sealants and caulking only when ambient temperature is between 5 C and 38 C (40 and 100 F).

2. Do not use sealant type listed by manufacture as not suitable for use in locations specified.

3. Apply caulking and sealing compound in accordance with manufacturer's printed instructions.

4. Avoid dropping or smearing compound on adjacent surfaces.

5. Apply compounds with nozzle size to fit joint width.

6. Test sealants for compatibility with each other and substrate. Use only compatible sealant.

B. Install sealants immediately after joint preparation.

C. Mix and apply multi-component sealants in accord with manufacturer's printed instructions.

D. Install sealants to fill joints completely from the back, without voids or entrapped air, using proven techniques, proper nozzles and sufficient force that result in sealants directly contacting and fully wetting joint surfaces.

E. Install sealants to uniform cross-sectional shapes with depths relative to joint widths that allow optimum sealant movement capability as recommended by sealant manufacturer.

F. Tool sealants in manner that forces sealant against back of joint, ensures firm, full contact at joint interfaces and leaves a finish that is smooth, uniform and free of ridges, wrinkles, sags, air pockets and embedded impurities.

1. Dry tooling is preferred; tooling liquids that are non-staining, non-damaging to adjacent surfaces and approved by sealant manufacturer may be used if necessary when care is taken to ensure that the liquid does not contact joint surfaces before the sealant.

2. Provide concave tooled joints unless otherwise indicated to provide flush tooling or recessed tooling.

3. Provide recessed tooled joints where the outer face of substrate is irregular.

G. Protect joint sealants from contact with contaminating substances and from damages. Cut out, remove and replace contaminated or damaged sealants, immediately, so that they are without contamination or damage at time of substantial completion.

H. Cleaning: Remove sealant from adjacent surfaces in accord with sealant and substrate manufacturer recommendations as work progresses.

1. Fresh compound accidentally smeared on adjoining surfaces: Scrape off immediately and rub clean with a solvent as recommended by the caulking or sealant manufacturer.

2. After filling and finishing joints, remove masking tape.

3. Leave adjacent surfaces in a clean and unstained condition

3.04 WARRANTY

A. Deliver to the Owner signed copies of the following written warranties against adhesive and cohesive failure of the sealant and against infiltration of water and air through the sealed joint for a period of 3 years from date of completion.

1. Manufacturer's standard warranty covering sealant materials;

2. Applicator's standard warranty covering workmanship.

END OF SECTION

THE BRICK INDUSTRY ASSOCIATION
TECHNICAL NOTES on Brick Construction
1850 Centennial Park Drive, Reston, Virginia 20191 | www.gobrick.com | 703-620-0010
8
January 2008

# Mortars for Brickwork

**Abstract:** This *Technical Note* addresses mortars for brickwork. The major ingredients of mortar are identified. Means of specifying mortar are covered. Mortar properties are described, as well as their effect on brickwork. Information is provided for selection of the appropriate materials for mortar and properties of mortars.

**Key Words:** hardened mortar properties, mortar, plastic mortar properties, specifications, Types of mortar.

## SUMMARY OF RECOMMENDATIONS:

### General
- Use mortar complying with ASTM C270
- For typical project requirements, use proportion specifications of ASTM C270
- Select mortar Type using recommendations of *Technical Note* 8B
- Use Type N mortar for normal use, including most veneer applications
- Avoid combining two air-entraining agents in mortar

### Mortar Materials
Cementitious:
- Use cement complying with ASTM C150 (portland cement), ASTM C595 (blended hydraulic cement), or ASTM C1157 (hydraulic cement) in combination with either hydrated lime complying with ASTM C207, Type S, or lime putty complying with ASTM C1489
- Use mortar cement complying with ASTM C1329
- Use masonry cement complying with ASTM C91

Aggregate:
- Use natural or manufactured sand complying with ASTM C144

Water:
- Use potable water free of deleterious materials

### Mortar Admixtures
- Use admixtures complying with ASTM C1384
- When using a bond enhancer admixture, do not use an air-entraining agent
- When using a set retarding admixture, do not retemper mortar
- Do not use water-repellent admixtures

### Pigments
- Use pigments complying with ASTM C979
- Use as little pigment as possible
- For metallic oxide pigments, limit quantity to 10 percent of cement content by weight
- For carbon black pigment, limit quantity to 2 percent of cement content by weight
- Avoid using pigments containing Prussian blue, cadmium lithopone and zinc and lead chromates
- Premix cement and coloring agents in large, controlled quantities
- Do not retemper colored mortar

## INTRODUCTION

Mortar is the bonding agent that integrates brick into a masonry assembly. Mortar must be strong, durable and capable of keeping the masonry intact, and it must help to create a water-resistant barrier. Also, mortar accommodates dimensional variations and physical properties of the brick when laid. These requirements are influenced by the composition, proportions and properties of mortar ingredients.

Because concrete and mortar contain the same principal ingredients, it is often erroneously assumed that good concrete practice is also good mortar practice. In reality, mortar differs from concrete in working consistencies, methods of placement and structural performance. Mortar is used to bind masonry units into a single element, developing a complete, strong and durable bond. Concrete, however, is usually a structural element in itself. Mortar is usually placed between absorbent masonry units and loses water upon contact with the units. Concrete is usually placed in nonabsorbent metal or wooden forms, which absorb little if any water. The importance of the water/cement ratio for concrete is significant, whereas for mortar it is less important. Mortar has a high water/cement ratio when mixed, but this ratio changes to a lower value when the mortar comes in contact with the absorbent units.

The most frequently used means of specifying mortar is ASTM C270, *Standard Specification for Mortar for Unit Masonry* [Ref. 1]. This standard contains information on specifying and using mortar. This *Technical Note* uses ASTM C270 as a basis and addresses the materials, properties and means of specifying mortars. The other *Technical Note* in this series addresses the selection and quality control of mortars.

# MATERIALS

Historically, mortar has been made from a variety of materials. Burned gypsum and sand were used to make mortar in ancient Egypt, while lime and sand were used extensively in this country before the 1900s. Currently, the basic dry ingredients for mortar include some type of cement, hydrated lime and sand. Each of these materials makes a definite contribution to mortar performance.

## Portland and Other Hydraulic Cements

Portland cement, a hydraulic cement, is the principal cementitious ingredient for cement-lime mortar. It contributes to durability, high strength and early setting of the mortar. Portland cement used in masonry mortar should conform to ASTM C150, *Standard Specification for Portland Cement* [Ref. 1]. Of the eight portland cement Types covered by ASTM C150, only three are recommended for use in masonry mortars:

**Type I** - For general use when the special properties of Types II and III are not required.
**Type II** - For use when moderate sulfate resistance or moderate heat of hydration is desired.
**Type III** - For use when high early strength is desired.

ASTM C270 permits the use of other hydraulic cements in mortar. Some of these materials may slow the strength gain or may affect the color of mortar. The material standards for these cements are ASTM C595, *Standard Specification for Blended Hydraulic Cements* [Ref. 1], such as portland blast-furnace slag cement, portland-pozzolan cement and slag cement; and ASTM C1157, *Standard Performance Specification for Hydraulic Cement* [Ref. 1]. The use of blended hydraulic cements is not recommended unless the mortar containing such cements meets the property specifications of ASTM C270.

Because high air entrainment can significantly reduce the bond between the mortar and brick or reinforcement, the use of air-entrained portland, blended hydraulic or hydraulic cements is not recommended. Most building codes have lower allowable flexural tensile stress values for mortar made with air-entrained cementitious materials.

## Masonry Cements

Masonry cements are proprietary cementitious materials for mortar. They are widely used because of their convenience and good workability. ASTM C91, *Standard Specification for Masonry Cement* [Ref. 1], defines masonry cement as “a hydraulic cement, primarily used in masonry and plastering construction, consisting of a mixture of portland or blended hydraulic cement and plasticizing materials (such as limestone, hydrated or hydraulic lime) together with other materials introduced to enhance one or more properties such as setting time, workability, water retention, and durability.” ASTM C91 provides specific criteria for physical requirements and performance properties of masonry cements. The constituents of masonry cement may vary depending on the manufacturer, local construction practices and climatic conditions.

Masonry cements are classified into three Types by ASTM C91: Types M, S and N. The current edition of ASTM C91 requires a minimum air content of 8 percent (by volume) and limits the maximum air content to 21 percent for Type N masonry cement and 19 percent for Types S and M masonry cements. Mortar prepared in the field will typically have an air content that is 2 to 3 percent lower than mortar tested under laboratory conditions.

In the model building codes, allowable flexural tensile stress values for masonry built with masonry cement mortar are lower than those for masonry built with non-air-entrained portland cement-lime mortar. Therefore, the use of masonry cement should be based on the requirements of the specific application.

## Mortar Cements

Mortar cements are hydraulic cements, consisting of a mixture of portland or blended hydraulic cement, plasticizing materials such as limestone or hydrated or hydraulic lime, and other materials intended to enhance one or more of the properties of mortar. In this respect, mortar cement is similar to masonry cement. However, ASTM C1329, *Standard Specification for Mortar Cement* [Ref. 1], includes requirements for maximum air content and minimum flexural bond strength that are not found in the masonry cement specification. Because of the strict controls on air content and the minimum strength requirement, mortar cement and portland cement-lime mortars are treated similarly in the *Building Code Requirements for Masonry Structures* (ACI 530-05/ASCE 5-05/TMS 402-05) [Ref. 5].

Three Types of mortar cements are specified in ASTM C1329: Types M, S and N. Physical requirements vary depending upon mortar cement Type. Air content for all three Types must be a minimum of 8 percent. The maximum air content is 14 percent for Types M and S and 16 percent for Type N. Flexural bond strength, as measured by the test method in ASTM C1072, *Standard Test Method for Measurement of Masonry Flexural Bond Strength* [Ref. 1], is also specified. The minimum flexural bond strength for these mortar cements is 115 psi (0.8 MPa) for Type M, 100 psi (0.7 MPa) for Type S and 70 psi (0.5 MPa) for Type N.

## Hydrated Lime and Lime Putty

Hydrated lime is a derivative of limestone that has been through two chemical reactions to produce calcium hydroxide. Lime contributes to extent of bond, workability, water retention and elasticity.

Hydrated lime in ASTM C207, *Standard Specification for Hydrated Lime for Masonry Purposes* [Ref. 1], is available in four Types. Only Type S hydrated lime should be used in mortar. Type N hydrated lime contains no limits on the quantity of unhydrated oxides. Types NA and SA lime contain air-entraining additives that reduce the extent of bond between the mortar and masonry units or reinforcement, and are therefore not recommended for mortar.

ASTM C1489, *Standard Specification for Lime Putty for Structural Purposes* [Ref. 1], is prepared from hydrated lime and is often used in restoration projects.

Because lime hardens only upon contact with carbon dioxide in the air, hardening occurs over a long period of time. However, if small hairline cracks develop, water and carbon dioxide that penetrate the joint will react with calcium hydroxide from the mortar and form calcium carbonate. The newly developed calcium carbonate will seal the cracks, limiting further water penetration. This process is known as autogenous healing.

## Aggregates

Aggregates (sand) act as a filler material in mortar, providing for an economical mix and controlling shrinkage. Either natural sand or manufactured sand may be used. Gradation limits are given in ASTM C144, *Standard Specification for Aggregates for Masonry Mortar* [Ref. 1].

Gradation can be easily and inexpensively altered by adding fine or coarse sands. Sometimes the most feasible method requires proportioning the mortar mix to suit the available sand, rather than requiring sand to meet a particular gradation. However, if the sand does not meet the grading requirement of ASTM C144, it can only be used provided the mortar meets the property specifications of ASTM C270.

## Water

Water that is clean, potable and free of deleterious acids, alkalis or organic materials is suitable for masonry mortars.

## Admixtures

Admixtures are sometimes used in mortar to obtain a specific mortar color, increase workability, decrease setting time, increase setting time, increase flexural bond strength or act as a water repellent [Ref. 2]. Admixtures to achieve a desired color of the mortar are the most widely used. Although some admixtures are harmless, some are detrimental to mortar and the resulting brickwork. Because the properties of both plastic and hardened mortars are highly dependent on mortar ingredients, the use of admixtures should not be considered unless their effect on the mortar is known. Admixtures also should be examined for their effect on the masonry, masonry units and items embedded in the brickwork. For example, admixtures containing chlorides promote corrosion of embedded metal anchors and therefore should not be used. ASTM C1384, *Standard Specification for Admixtures for Masonry Mortars* [Ref. 1], provides methods to evaluate the effect of admixtures on mortar properties. The admixtures represented in ASTM C1384 are as follows:

**Bond Enhancers.** Bond enhancers improve flexural bond strength, surface density and freeze-thaw resistance. They are typically used to increase bond strength to smooth, dense surface units and applications such as copings and pavers. Bond enhancers should not be used with air-entraining agents.

**Set Accelerators.** Set accelerators shorten the time required for cement hydration to occur and typically reduce the setting time by 30 to 40 percent. They are typically used to reduce the time required for cold weather protective measures. Set accelerators typically increase short-term compressive strengths and may affect color.

**Set Retarders.** Set retarders increase the board life of fresh mortar by increasing the time required for cement hydration to occur. They are typically used in conjunction with hot weather protective measures or to aid in reducing the rapid suction associated with high initial rate of absorption (IRA) brick. Mortar with set retarders should not be retempered, and severely retarded mortar may require moist curing to maintain hydration. Set retarders typically reduce short-term compressive strength and may affect color.

**Water Repellents.** Water repellent admixtures are typically used in conjunction with concrete masonry units where the admixture is added to both the mortar and to the concrete masonry units. When water-repellent admixtures are used in the mortar alone, they may inhibit bond and are not recommended for use with brick.

**Workability Enhancers.** Workability enhancers add viscosity to mortar mixes, allowing easier placement of mortar on masonry units. The benefits of workability enhancers are subjective, and their use is more to suit the liking of the mason. They should be reviewed to ensure that there are no deleterious effects on the mortar.

## Colored Mortar

Colored mortars may be obtained through the use of colored aggregates or suitable pigments. The use of colored aggregates is preferable when the desired mortar color can be obtained. White sand, ground granite, marble or stone usually have permanent color and do not weaken the mortar. For white joints, use white sand, ground limestone or ground marble with white portland cement and lime.

Most pigments that conform to ASTM C979, *Standard Specification for Pigments for Integrally Colored Concrete* [Ref. 1], are suitable for mortar. Mortar pigments must be sufficiently fine to disperse throughout the mix, capable of imparting the desired color when used in permissible quantities, and must not react with other ingredients to the detriment of the mortar. These requirements are generally met by metallic oxide pigments. Carbon black and ultramarine blue also have been used successfully as mortar colors. Avoid using organic colors and, in particular, those colors containing Prussian blue, cadmium lithopone and zinc and lead chromates. Paint pigments may not be suitable for mortars.

Use as little pigment as is needed to produce the desired results; an excess may seriously impair strength and durability. The maximum permissible quantity of most metallic oxide pigments is 10 percent of the cement content by weight. Although carbon black is a very effective coloring agent, it will greatly reduce mortar strength when used in greater proportions. Therefore, limit carbon black to 2 percent of the cement content by weight.

For best results, use cement and coloring agents premixed in large, controlled quantities. Premixing large quantities will ensure more uniform color than can be obtained by mixing smaller batches in the field. A consistent mixing sequence is essential for color consistency when mixing smaller batches in the field. Further, use the same source of mortar materials throughout the project.

Color uniformity varies with the amount of mixing water, the moisture content of the brick when laid and whether the mortar is retempered. The time and degree of tooling and cleaning techniques also will influence final mortar color. Color permanence depends upon the quality of pigments and the weathering and efflorescing qualities of the mortar.

# SPECIFYING MORTAR

Masonry mortars are classified by ASTM C270 into four Types: M, S, N and O. Each mortar Type consists of aggregate, water and one or more of the four cementitious materials (portland or hydraulic cement, mortar cement, masonry cement and lime) listed in the previous section.

There are two methods of specifying mortar by Type in ASTM C270: proportion specifications and property specifications. A cement-lime mortar, a mortar cement mortar, or a masonry cement mortar is permitted. The type of cementitious material desired should be specified.

## Proportion Specifications

The proportion specifications require that mortar materials be mixed according to given volumetric proportions. If mortar is specified by this method, no laboratory testing is required, either before or during construction. Table 1 lists proportion requirements of the various mortar Types. Note that masonry cement and mortar cement may be used alone to produce Type M, S, N or O mortars. Additionally, Type N mortar cement or masonry cement may be combined with portland cement to produce a Type M or Type S mortar.

**TABLE 1**
**Proportion Specification Requirements**

Note: Two air-entraining materials shall not be combined in mortar

| Mortar | Type | Proportions by Volume (Cementitious Materials) | | | | | | | | Aggregate Ratio (Measured in Damp, Loose Conditions) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Portland or Blended Cement | Mortar Cement | | | Masonry Cement | | | Hydrated Lime or Lime Putty | |
| | | | M | S | N | M | S | N | | |
| Cement – Lime | M | 1 | … | … | … | … | … | … | ¼ | Not less than 2¼ and not more than 3 times the sum of the separate volumes of cementitious materials |
| | S | 1 | … | … | … | … | … | … | over ¼ to ½ | |
| | N | 1 | … | … | … | … | … | … | over ½ to 1¼ | |
| | O | 1 | … | … | … | … | … | … | over 1¼ to 2½ | |
| Mortar Cement | M | 1 | … | … | 1 | … | … | … | … | |
| | M | … | 1 | … | … | … | … | … | … | |
| | S | ½ | … | … | 1 | … | … | … | … | |
| | S | … | … | 1 | … | … | … | … | … | |
| | N | … | … | … | 1 | … | … | … | … | |
| | O | … | … | … | 1 | … | … | … | … | |
| Masonry Cement | M | 1 | … | … | … | … | … | 1 | … | |
| | M | … | … | … | … | 1 | … | … | … | |
| | S | ½ | … | … | … | … | … | 1 | … | |
| | S | … | … | … | … | … | 1 | … | … | |
| | N | … | … | … | … | … | … | 1 | … | |
| | O | … | … | … | … | … | … | 1 | … | |

The volumetric proportions given in Table 1 can be converted to weight proportions using assumed weights per cubic foot (cubic meter) for the materials as follows:

| | |
|---|---|
| Portland cement | 94 lb (1506 kg) |
| Masonry, mortar and blended cements | Varies, use weight printed on bag |
| Hydrated lime | 40 lb (641 kg) |
| Lime putty | 80 lb (1281 kg) |
| Sand, damp and loose | 80 lb (1281 kg) of dry sand |

## Property Specifications

The property specifications require a mortar mix of the materials to be used for construction to meet the specified properties under laboratory testing conditions. If mortar is specified by the property specifications, compressive strength, water retention and air content tests must be performed prior to construction on mortar mixed in the laboratory with a controlled amount of water. The material quantities determined from the laboratory testing are

then used in the field with the amount of water determined by the mason. Table 2 lists property requirements of the various mortar Types. Properties of field-mixed mortar cannot be compared to the requirements of the property specifications because of the different amounts of water used in the mortars, the use of different mixers and the different curing conditions. Field sampling of mortar, where specified, is typically performed for tracking project consistency from beginning to end. It is not to be used for compliance with property specifications. Additional information about this type of quality assurance testing can be found in *Technical Note* 8B.

**TABLE 2**
**Property Specification Requirements[1]**

| Mortar | Type | Average Compressive Strength at 28 Days, min. psi (MPa) | Water Retention, min. % | Air Content, max. % | Aggregate Ratio (Measured in Damp, Loose Conditions) |
|---|---|---|---|---|---|
| Cement – Lime | M | 2500 (17.2) | 75 | 12 | Not less than 2¼ and not more than 3½ times the sum of the separate volumes of cementitious materials |
| | S | 1800 (12.4) | 75 | 12 | |
| | N | 750 (5.2) | 75 | 14[2] | |
| | O | 350 (2.4) | 75 | 14[2] | |
| Mortar Cement | M | 2500 (17.2) | 75 | 12 | |
| | S | 1800 (12.4) | 75 | 12 | |
| | N | 750 (5.2) | 75 | 14[2] | |
| | O | 350 (2.4) | 75 | 14[2] | |
| Masonry Cement | M | 2500 (17.2) | 75 | 18 | |
| | S | 1800 (12.4) | 75 | 18 | |
| | N | 750 (5.2) | 75 | 20[3] | |
| | O | 350 (2.4) | 75 | 20[3] | |

1. Laboratory prepared mortar only.
2. When structural reinforcement is incorporated in cement-lime or mortar-cement mortar, the maximum air content shall be 12 percent.
3. When structural reinforcement is incorporated in masonry-cement mortar, the maximum air content shall be 18 percent.

## Proportion vs. Property Specifications

The specifier should indicate in the project specifications whether the proportion or the property specifications are to be used. If the specifier does not indicate which should be used, then the proportion specifications govern by default. The specifier also should confirm that the mortar Types selected and the materials indicated in the project specifications are consistent with the structural design requirements of the masonry.

Mortar prepared by the proportion specifications is not to be compared to mortar of the same Type prepared by the property specifications. A mortar that is mixed according to the proportion specification will have a higher laboratory compressive strength than that of the corresponding mortar Type under the property specification [Ref. 7].

# PHYSICAL PROPERTIES OF MORTAR

Mortars have two distinct, important sets of properties: those in the plastic state and those in the hardened state. The plastic properties help to determine the mortar's compatibility with brick and its construction suitability. Properties of plastic mortar include workability, water retention, initial flow and flow after suction. Properties of hardened mortars help determine the performance of the finished brickwork. Hardened properties include flexural bond strength, durability, extensibility and compressive strength. Properties of plastic mortar are more important to the mason, while the properties of hardened mortar are more important to the designer and owner.

## Workability

Workability is the most important physical property of plastic mortar. A mortar is workable if its consistency allows it to be spread with little effort and if it will readily adhere to vertical masonry surfaces. This results in good extent of bond between the mortar and the brick, which provides resistance to water penetration. Although experienced masons are good judges of the workability of a mortar and have developed various methods to determine suitability, there is no standard laboratory or field test for measuring this property.

Water retention, flow and resistance to segregation affect workability. In turn, these are affected by properties of the mortar ingredients. Because of this complex relationship, quantitative estimates of workability are difficult to obtain. Until a test is developed, the requirements for water retention and aggregate gradation must be relied upon to provide a quantitative measure of workability.

## Water Content

Water content is possibly the most misunderstood aspect of masonry mortar, probably due to the similarity between mortar and concrete materials. Many designers mistakenly base mortar specifications on the assumption that mortar requirements are similar to concrete requirements, especially with regard to the water/cement ratio. Many specifications incorrectly require mortar to be mixed with the minimum amount of water consistent with workability. Often, retempering of the mortar is prohibited. These provisions result in mortars that have higher compressive strengths but lower bond strengths. Mixing mortar with the maximum amount of water consistent with workability will provide maximum bond strength within the capacity of the mortar. As a result, water content normally should be determined by the mason or bricklayer to produce the best workability. Retempering is permitted, but only to replace water lost by evaporation. This is usually controlled by the requirement that all mortar be used within 2½ hours after initial mixing, or as determined for hot weather construction.

## Water Retention

Water retention is the ability of a mortar to hold water when placed in contact with absorbent masonry units. The laboratory value of water retention is the ratio of flow after suction to the initial flow, expressed in a percentage. Flow after suction, as described in ASTM C91, is determined by subjecting the mortar to a vacuum and remeasuring the flow of the mortar. A mortar that has low water retention will lose moisture more rapidly. This is used in conjunction with the IRA of the brick to select mortar materials and Type.

In general, the following will increase water retention:

1. Addition of sand fines within allowable gradation limits.
2. Use of highly plastic lime (Type S lime).
3. Increased air content.
4. Use of hydraulic cement containing very fine pozzolans.

## Initial Flow

Initial flow is essentially a measure of the mortar's water content. It can be measured by either of two methods: ASTM C109, *Standard Test Method for Compressive Strength of Hydraulic Cement Mortars* [Ref. 1], or ASTM C780, *Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry* [Ref. 1].

In ASTM C109, a truncated cone of mortar is formed on a flow table, which is then mechanically raised 1 in. (25.4 mm) and dropped 25 times in 15 seconds. During this test, the mortar will flow, increasing the diameter of the mortar specimen. The initial flow is the ratio of the increase in diameter from the initial 4 in. (102 mm) cone base diameter, expressed in a percentage. Flow rates are laboratory tests.

In ASTM C780, a 3½ in. (89 mm) high hollow cylinder is filled with mortar, and a cone-shaped plunger, whose point is placed at the top of the cylinder, is dropped into the mortar. The depth of the cone penetration into the mortar is measured in millimeters. The greater the penetration of the cone into the mortar, the greater its flow or water content. Cone penetration can be measured in the laboratory or in the field.

Laboratory mortars are mixed to have an initial flow of only 105 to 115 percent. Construction mortars normally have initial flows in the range of 130 to 150 percent (sometimes higher in hot weather) to produce workability satisfactory to the mason. Requirements for laboratory-prepared mortar should not be applied to field-prepared mortar. Test results of laboratory-prepared mortar should not be compared to test results of field-prepared mortar without considering the initial flow of each. The lower initial flow requirements for laboratory mortars were set to allow for more consistent test results on most available laboratory equipment, and to compensate for water absorbed by the units.

## Extensibility and Plastic Flow

Extensibility is another term for maximum tensile strain at failure. It reflects the maximum elongation possible under tensile forces. High-lime mortars exhibit greater plastic flow than low-lime mortars. Plastic flow, or creep, acting with extensibility will impart some flexibility to the masonry, permitting slight movement. Where greater resiliency for movement is desirable, the lime content may be increased while still satisfying other requirements.

## Flexural Bond Strength

Flexural bond strength is perhaps the most important physical property of hardened mortar. For veneer applications, the bond strength of mortar to brick units provides the ability to transfer lateral loads to veneer anchors. For loadbearing applications, the bond influences the overall strength of the wall for resisting lateral and flexural loads. Variables that affect the bond strength include texture of the brick, suction of the brick, air content of the mortar, water retention of the mortar, pressure applied to the joint during forming, mortar proportions and methods of curing.

**Brick Texture.** The texture of a brick affects the mechanical bond between the brick and mortar [Ref. 8]. Mortar bond is greater to roughened surfaces, such as wire-cut surfaces, than to smooth surfaces, such as die-skin surfaces. Sanded and coated surfaces can reduce the bond strength depending upon the amount and type of material on the surface and its adherence to the surface.

**Brick IRA (Suction).** The laboratory-measured initial rate of absorption (IRA) of brick indicates the brick's suction and whether it should be considered for wetting before use. It is the IRA at the time of laying that influences bond strength. In practically all cases, mortar bonds best to brick with an IRA less than 30 g/min/30 in.$^2$ (30 g/min/194 cm$^2$) when laid. If the brick's IRA exceeds this value, then the brick should be wetted three to 24 hours before laying. Wetted brick should be surface dry when they are laid in mortar.

Several researchers have shown that IRA appears to have little influence on bond strength when the appropriate mortar is used [Refs. 3, 4 and 9].

**Air Content.** Available information indicates a definite relationship between air content and bond strength of mortar. Provided that other parameters are held constant, as air content is increased, compressive strength and bond strength are reduced, while workability and resistance to freeze-thaw deterioration are increased [Ref. 10].

**Water Content.** Mortar with a high water content, or flow, at the time of use is beneficial because it can satisfy the suction of the brick and can allow greater control of the mortar for the bricklayer. For all mortars, and with minor exceptions for all brick suction rates, bond strength increases as flow increases. However, excessive water can reduce both workability and bond strength.

The time lapse between spreading mortar and placing brick will affect mortar flow, particularly when mortar is spread on brick with high suction rates, or when construction takes place during hot, dry weather. In such cases, mortar will have less flow by the time brick are placed than when it was first spread. Conceivably, bond to brick placed on this mortar could be materially reduced. For highest bond strength, reduce the time interval between spreading the mortar and laying brick on top of it to a minimum.

Because not all mortar is used immediately after mixing, some of its water may evaporate while it is on the mortar board. The addition of water to mortar (retempering) to replace water lost by evaporation should be encouraged, when necessary. Although compressive strength may be slightly reduced and mortar color lightened if mortar is retempered, bond strength may be lowered if it is not. ASTM C270 requires that all mortar be used within 2½ hours after mixing since the mortar will begin to set. This time may be affected by hot or cold weather, as discussed in *Technical Note* 1.

**Materials and Proportions.** There is no precise combination of materials that will always produce optimum bond. Mortars made with cement-lime and mortar cement cementitious materials typically have higher flexural bond strengths than do masonry cement mortars [Refs. 3, 4, 6]. Building codes prescribe the same bond strength values to Type S and M mortars [Ref. 5].

**Test Methods.** Because many variables affect bond, it may be desirable to achieve reproducible results from a small-scale laboratory test. The bond wrench test, ASTM C1072, *Standard Test Method for Measurement of Masonry Flexural Bond Strength* [Ref. 1], appears to fulfill this need. It evaluates the flexural bond strength of each

joint in a masonry prism. The apparatus shown in Figure 1 consists of a stack-bonded prism clamped in a stationary frame. A cantilevered arm is clamped to the top brick over the joint to be tested. The free end of the cantilevered arm is loaded until failure, which occurs when the clamped brick is “wrenched” off. The bond wrench test has replaced previous tests of full-sized wall specimens and prisms in which only one joint was tested.

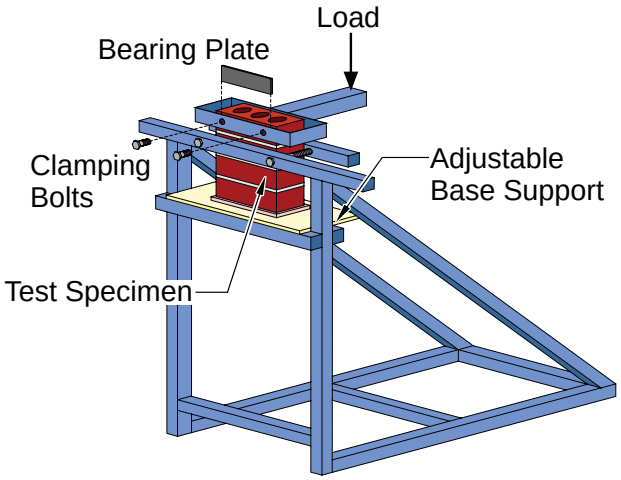



**Figure 1**
**Bond Wrench Test Apparatus**

In general, to increase the flexural bond strength:

1. Bond mortar to a wire-cut or roughened surface rather than a die-skin surface.
2. Wet brick with an IRA greater than 30 grams/min/30 in.² (30 g/min/194 cm²) when laid.
3. Use Type S portland cement-lime mortar, Type S mortar cement or Type S masonry cement mortar with air content in the low to mid-range of ASTM C91 limits.
4. Mix mortar to the maximum flow compatible with workmanship. Use maximum mixing water and permit retempering.

## Compressive Strength

As with concrete, the compressive strength of mortar primarily depends upon the cement content and the water/cement ratio. However, because compressive strength of masonry mortar is less important than bond strength, workability and water retention, the latter properties should be given principal consideration in mortar selection. The water/cement ratio of mortar as mixed in the field is reduced due to absorption of water by the adjacent brick.

**Proportions.** Compressive strength increases with an increase in cement content of mortar and decreases with an increase in water content, lime content or over-sanding. Occasionally air entrainment is introduced to obtain higher flows with lower water content. The reasoning here is that lower water/cement ratios will provide higher compressive strengths. However, this generally proves futile since compressive strength decreases with an increase in air content.

**Test Methods.** Compressive strength is measured by testing 2 in. (51 mm) mortar cubes or 2 in. (51 mm) or 3 in. (76 mm) diameter cylinders. Procedures for molding and testing cubes appear in ASTM C109, and procedures for molding and testing both cubes and cylinders appear in ASTM C780.

## Durability

The durability of mortar in unsaturated masonry is not a serious problem. The durability of mortar is shown in the number of masonry structures that have been in service for many years.

In general, mortar contains sufficient entrapped and entrained air to resist freeze-thaw damage. Though increasing air content may theoretically increase the durability of masonry mortar, a decrease in bond strength, compressive strength and other desirable properties will result. For this reason, the use of air-entraining admixtures to increase air content is not recommended.

## Volume Change

Volume changes in mortars can result from four causes: chemical reactions in hardening, temperature changes, wetting and drying, and unsound ingredients that chemically expand. Differential volume change between brick and mortar in a given wythe has no significant effect on performance. However, total volume change can be significant.

Volume change caused by cement hydration (hardening) is often termed shrinkage and depends upon curing conditions, mix proportions and water content. Mortars hardened in contact with brick exhibit considerably less shrinkage than those hardened in nonabsorbent molds. An increase in water content will cause an increase in

shrinkage during hardening of mortar if the excess water is not removed. Change in temperature will lead to expansion or contraction of mortar. Thermal expansion and contraction of masonry and means to accommodate the expected movement are discussed in the *Technical Note* 18 Series.

Mortar swells as its moisture content increases and shrinks as it decreases. Moisture content changes with normal cycles of wetting and drying. The magnitude of volume change due to this effect is smaller than that from shrinkage. Unsound ingredients or impurities such as unhydrated lime oxides or gypsum can cause significant volume change and are thus limited by ASTM C207.

## Efflorescence

Efflorescence is a crystalline deposit of water-soluble salts on the surface of masonry. Mortar may be a major contributor to efflorescence since it is a primary source of calcium hydroxide. This chemical can produce efflorescence on its own and can react with carbon dioxide in the air or solutions from the brick to form insoluble compounds. Mortar can contain other soluble constituents, including alkalis, sulfates and magnesium hydroxide.

Currently there is no standard test method to determine the efflorescence potential of mortar or of a brick/mortar combination. Researchers have concluded that mortars will effloresce under any standard test.

# RECOMMENDED MORTAR USES

Selection of a particular mortar Type and materials is usually a function of the needs of the finished masonry element. Type N mortar is recommended for normal use and in most veneer applications. In applications where high lateral strength is required, mortar with high flexural bond strength should be chosen. For loadbearing walls and reinforced brick masonry, high compressive strength may be the governing factor. In some projects, considerations of durability, color and flexibility may be of utmost concern. Factors that improve one property of mortar often do so at the expense of others. For this reason, when selecting a mortar, evaluate properties of each Type and materials and choose the combination that will best meet the particular end-use requirements. No single mortar Type is best for all purposes. Refer to *Technical Note* 8B for more information on selection of mortar Type.

# GREEN BUILDING/SUSTAINABILITY

Sustainability or “Green Building” is a movement to use resources efficiently, create healthier environments and enhance the quality of buildings while minimizing social and environmental impacts on future generations. For further information about the sustainability of brick masonry, refer to *Technical Note* 48.

While materials used to make mortar are readily abundant and produce a durable material, sustainability can be improved further by using recycled products such as blast furnace slag cement and cements with fly ash in the mortar to partially replace portland cement. Blast furnace slag is a by-product from the production of iron. The waste from the production is processed to produce slag cement. When slag cement is used in mortar, it typically makes the cement hydration process more efficient, increases long-term compressive strength, produces a tighter pore structure and increases workability of mortar during placement. Fly ash comes from coal-fired plants used in generating electrical power. It can replace a portion of the cement in mortar materials. Fly ash increases strength and durability by increasing density.

# SUMMARY

Mortar requirements differ from concrete requirements, principally because the primary function of mortar is to bond masonry units into an integral element. Properties of both plastic and hardened mortars are important. Plastic properties determine construction suitability; hardened properties determine performance of finished elements. When selecting a mortar, evaluate all properties, and then select the mortar providing the best results overall for the particular requirements.

> *The information and suggestions contained in this* Technical Note *are based on the available data and the combined experience of engineering staff and members of the Brick Industry Association. The information contained herein must be used in conjunction with good technical judgment and a basic understanding of the properties of brick masonry. Final decisions on the use of the information contained in this* Technical Note *are not within the purview of the Brick Industry Association and must rest with the project architect, engineer and owner.*

# REFERENCES


1. *Annual Book of ASTM Standards*, ASTM International, West Conshohocken, PA, 2007:

   Volume 4.01
   C91 "Standard Specification for Masonry Cement"
   C109 "Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)"
   C150 "Standard Specification for Portland Cement"
   C207 "Standard Specification for Hydrated Lime for Masonry Purposes"
   C595 "Standard Specification for Blended Hydraulic Cements"
   C1157 "Standard Performance Specification for Hydraulic Cement"
   C1489 "Standard Specification for Lime Putty for Structural Purposes"
   C1329 "Standard Specification for Mortar Cement"

   Volume 4.02
   C979 "Standard Specification for Pigments for Integrally Colored Concrete"

   Volume 4.05
   C144 "Standard Specification for Aggregate for Masonry Mortar"
   C270 "Standard Specification for Mortar for Unit Masonry"
   C780 "Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry"
   C1072 "Standard Test Method for Measurement of Masonry Flexural Bond Strength"
   C1384 "Standard Specification for Admixtures for Masonry Mortars"

2. Beall, Christine, "A Guide to Mortar Admixtures," *Magazine of Masonry Construction*, October 1989, pp. 436-438.

3. Borchelt, J.G., Melander, J.M., and Nelson, R.L., "Bond Strength and Water Penetration of High IRA Brick and Mortar," *Proceedings of the Eighth North American Masonry Conference*, The Masonry Society, Boulder, CO, June 1999, pp. 304-315.

4. Borchelt, J.G., and Tann, J.A., "Bond Strength and Water Penetration of Low IRA Brick and Mortar," *Proceedings of the Seventh North American Masonry Conference*, The Masonry Society, Boulder, CO, June 1996, pp. 206-216.

5. *Building Code Requirements for Masonry Structures* (ACI 530-05/ASCE 5-05/TMS 402-05), The Masonry Society, Boulder, CO, 2005.

6. Matthys, J.H., "Brick Masonry Flexural Bond Strength Using Conventional Masonry Mortar," *Proceedings of the Fifth Canadian Masonry Symposium*, University of Vancouver, Vancouver, BC, 1992, pp. 745-756.

7. Melander, J.M., and Conway, J.T., "Compressive Strengths and Bond Strengths of Portland Cement-Lime Mortars," *Masonry, Design and Construction, Problems and Repair,* ASTM STP 1180, American Society for Testing and Materials, Philadelphia, PA, 1993, pp. 105-120.

8. Ribar, J.W., and Dubovoy, V.S., "Investigation of Masonry Bond and Surface Profile of Brick," *Masonry: Materials, Design, Construction and Maintenance,* ASTM STP 992, American Society for Testing and Materials, Philadelphia, PA, 1988, pp. 33-37.

9. Wood, S.L., "Flexural Bond Strength of Clay Brick Masonry," *The Masonry Society Journal*, Vol. 13, No. 2, The Masonry Society, Boulder, CO, February 1995, pp. 45-55.

10. Wright, B.T., Wilkin, R.D., and John, G.W., "Variables Affecting the Strength of Masonry Mortars," *Masonry, Design and Construction, Problems and Repair*, ASTM STP 1180, American Society for Testing and Materials, Philadelphia, PA, 1993, pp. 197-210.

THE BRICK INDUSTRY ASSOCIATION
TECHNICAL NOTES on Brick Construction
1850 Centennial Park Drive, Reston, Virginia 20191 | www.gobrick.com | 703-620-0010
20
June 2006

# Cleaning Brickwork

**Abstract:** This *Technical Note* addresses cleaning of brickwork and brick pavements. Methods for removal of efflorescence and a variety of specific stains are discussed, that if followed, should result in the successful cleaning of brickwork.

**Key Words:** abrasive blasting, acid, bucket and brush cleaning, cleaning, efflorescence, poultice, pressurized water, stains.

## SUMMARY OF RECOMMENDATIONS:

### During Construction:
- Use bricklaying techniques that reduce mortar smears during construction
- Use construction practices that prevent debris from splashing onto brickwork and minimize water penetration into unfinished masonry

### Prior to Cleaning:
- Match the cleaning method and cleaning solution to the type of brick
- Protect adjacent materials that may be damaged by cleaning
- Remove large mortar tags using wooden paddles or non-metallic tools
- Test the cleaning method and materials on a 20 $ft^2$ (2 $m^2$) sample area and allow wall to dry before evaluation
- Determine the environmental impact and appropriate removal method of cleaning effluent

### For All Cleaning Methods:
- Select the gentlest effective cleaning method
- Follow the brick manufacturer's recommended cleaning procedure
- Do not use unbuffered muriatic acid
- Clean new masonry as soon as possible after mortar hardens, typically 7 days. More aggressive cleaning methods, such as abrasive blasting, may require a longer mortar curing time prior to cleaning
- Clean from the top of the wall section to the bottom
- For consistent results, do not overlap areas being cleaned

### Bucket and Brush Cleaning:
- Saturate the area to be cleaned and brickwork below with water prior to applying cleaning solution and keep wet until final rinse
- Mix and apply cleaning solution according to manufacturer's instructions
- Do not allow cleaning solution to dry on brickwork
- After cleaning, thoroughly rinse the area being cleaned and the area below with water

### Pressurized Water Cleaning:
- Determine appropriate water pressure, nozzle type and distance between wall and nozzle by trial cleaning; maintain consistently throughout cleaning
- Saturate the area to be cleaned and brickwork below with water prior to applying cleaning solution, and keep wet until final rinse
- Apply cleaning solution according to manufacturer's instructions with a low-pressure sprayer, 30 to 50 psi (200 to 350 kPa) using a 50º fan-shaped sprayer, or by brush
- Do not use high pressure to apply cleaning solution
- Do not allow cleaning solution to dry on brickwork
- Thoroughly rinse using a maximum water pressure of 200 to 300 psi (1,400 to 2,100 kPa) with a 25º to 50º fan-shaped tip

### Abrasive Blasting:
- Do not use abrasive blasting on brick with a sand finish or decorative surface coating
- Brickwork should be dry and well cured prior to abrasive cleaning
- Determine appropriate air pressure, abrasive, distance and angle between wall and nozzle by trial cleaning; maintain consistently throughout cleaning

### Efflorescence Control:
- Allow one year of weathering to naturally remove new building bloom
- Remove light efflorescence by dry brushing or with a stiff fiber brush and water
- Before attempting to clean recurring efflorescence, identify and correct the source of water penetration and allow the brickwork to dry
- Remove stubborn accumulations with a proprietary cleaner according to the manufacturer's instructions

## INTRODUCTION

The final appearance of brickwork depends primarily on the attention given to masonry surfaces during construction and the cleaning process. Recommended cleaning methods and materials vary depending on the type of brick, mortar, construction and reason for cleaning. For example, cleaning the newly constructed brickwork of an entire building requires a different approach than removing stains from an isolated portion of an existing wall.

An effective general approach to ensuring clean brickwork includes the following steps before the cleaning operation begins:

- Reduce the need to clean through detailing and construction techniques that reduce water penetration and staining.

- Account for any special considerations, such as decorative coatings or finishes, water repellents, mortar type, mortar color or historic significance.
- Repair leaks contributing to staining.
- Identify the stain or discoloration and select appropriate cleaning materials and methods that will produce desired results.
- Clean a sample test area or panel, carefully following brick manufacturer's directions, and allow to dry before evaluating and applying to larger areas.

The selection of effective cleaning solutions, as well as the use of consistent and appropriate cleaning procedures throughout the job, are essential to successful cleaning and cannot be overemphasized. Improper cleaning practices can cause a host of problems that, in severe cases, cannot be repaired.

This *Technical Note* does not address specific safety issues related to various methods of cleaning brick masonry. It should be noted however that cleaning agents and processes may be hazardous and may cause injury if used carelessly. Cleaning operations should only be performed by persons familiar with and equipped to handle the safety risks associated with the work.

# CLEANING NEW BRICKWORK

Brickwork is often cleaned soon after construction is completed to remove mortar smears and construction dirt that detract from the appearance of the masonry. With new construction, keeping the masonry clean as it is erected can be very cost-effective by eliminating the need for extensive cleaning after construction. When it is determined that brickwork needs to be cleaned, the brick cube identification card and other pertinent manufacturer information should be consulted first to ascertain the recommended cleaning procedures for the brick. As discussed under **Suggested Cleaning Methods** below, recommended cleaning materials and methods vary with the type of brick.

## Keeping Brickwork Clean During Construction

Some general practices that can be used to construct a cleaner wall are:

- Protect site-stored brick from mud. Store brick off the ground under protective covering.
- Erect scaffolding far enough away from the wall to allow mortar droppings to fall to the ground. Scaffold boards closest to the wall should be angled away from the wall or removed at the end of the day to remove excess mortar droppings and prevent rain from splashing mortar and dirt directly onto the completed masonry.
- Protect the base of the wall from rain-splashed mud and mortar splatter. Use straw, sand, sawdust, plastic sheeting or fabric spread out on the ground, extending 3 to 4 ft (0.9 to 1.2 m) from the wall surface and 2 to 3 ft (0.6 to 0.9 m) up the wall. Keep this protection in place until final landscaping.
- Cover wall openings and tops of walls with a waterproof membrane at the end of the workday and at other work stoppages to prevent mortar joint wash out and entry of water into the completed masonry.
- Protect newly constructed brickwork from adjacent construction practices that may cause staining, such as placing concrete or spraying curing agent.

It is always advisable for masons to keep brickwork as free from mortar smears as possible. Masons should also be careful to prevent excessive mortar droppings from contacting the face of the wall or falling into the air space. In addition to the bricklaying techniques described in *Technical Note* 7B, the practices below should be followed:

- After spreading mortar, but before laying brick, the trowel edge should be used to cut mortar even with the wall face, preventing excessive extrusion of mortar onto the face of the wall as the brick are laid.
- After tooling joints, excess mortar and dust should be brushed from the surface, preferably using a medium-soft bristle or fiber brush. Brushes with steel bristles are not recommended as they may leave behind small particles which can rust. Brushing is preferable to bagging or sacking. Avoid any motion that will result in rubbing or pressing mortar particles into the brick faces.

- Large clumps of mortar that adhere to brickwork should be allowed to become firm, then removed by hand with wooden paddles, a loose brick or nonmetallic tools.

## Trial Cleaning

Before cleaning, it is beneficial to test potential cleaning procedures and solutions on a sample area of about 20 ft² (2 m²), or large enough to evaluate the selected cleaning procedure. Although not common for small residential projects, trial cleaning on larger, more complex projects not only serves as a means to determine whether mortar or stains can be removed, but helps to identify the most effective procedures that cause the least damage to the masonry. Optimal concentrations of cleaning products and unexpected problems can also be determined through trial cleaning. Once approved, the test area can serve as a standard for the appearance of the brickwork after cleaning.

Reactions between cleaning solutions and certain minerals found in some brick or their surface coatings may cause stains. Thus, it is safer to test a small area before subjecting the entire project to the cleaning procedure. Ideally, a portion of the sample panel can be tested, leaving the building and the rest of the sample panel undamaged in case the brickwork is adversely affected. If trial cleaning must be performed on a building, select an inconspicuous location. Trial cleaning should be performed at temperature and humidity conditions that closely approximate the conditions that will be experienced during cleaning.

Judge the effectiveness of a cleaning agent or procedure by inspecting both brick and mortar in the trial area after it has dried sufficiently, usually about one week. Approval of the trial area should precede application to any additional areas.

## Suggested Cleaning Methods

Generally, the cleaning method that effectively cleans the brickwork while being the gentlest, or least harmful to the masonry is the most appropriate. Commonly used cleaning methods for new masonry include bucket and brush hand cleaning and pressurized water cleaning.

Always consult brick manufacturers for recommendations on cleaning specific brick. When more than one type or color of brick is used, the brick manufacturer can aid in identifying a cleaning method that will be safe for all of the brickwork. Table 1 suggests appropriate cleaning methods for various brick types, which can be used when guidelines are not available from the brick manufacturer. These are general recommendations and may not be effective on all brick described in each category. The use of colored mortars may require special consideration, as noted in Table 1.

**Special Considerations.** Air temperature, temperature of masonry and wind conditions affect the drying time and reaction rate of cleaning solutions. Chemical cleaning solutions are generally more effective when the outdoor temperature is 50 ºF (10 ºC) or above. To avoid harming the masonry or increasing the risk of efflorescence, cleaning methods that involve water should not be used during freezing weather or when it is expected.

Do not allow cleaning solutions to dry on brickwork. In hot weather, the cleaning crew can avoid this by working on small or shaded areas. The size of the work area should be determined after a trial run. For consistent results, avoid overlapping work areas.

Some chemicals used to clean brickwork and their fumes may be harmful. Use protective clothing and accessories, proper ventilation and exercise safe handling procedures. Comply with federal, state or local laws regulating the use and disposal of chemicals and cleaning wastewater. Strictly observe the cleaner manufacturer's material safety data sheet and recommended handling requirements.

Brick texture may also influence the effectiveness of cleaning operations. Mortar stains and smears are generally easier to remove from brick with smooth textures because less surface area is exposed. These brick include die skin extruded brick, glazed brick, water-struck molded brick and dry-pressed brick. They are easier to presoak and rinse because their unbroken surfaces are more likely to display poor rinsing, acid staining and poor removal of mortar smears. Mortar and dirt tend to penetrate deeper into textures. Brick that are wire-cut, coated or textured extruded brick and sand-struck molded brick provide additional surface area for water and acid absorption. Use of pressurized water may assist in complete rinsing of rough textured brick.

**General Cleaning Procedure.** The following general cleaning procedure is applicable to a variety of cleaning methods and is commonly used for new brickwork as well as removing stains from existing masonry.

**TABLE 1**
**Quick Guide for Cleaning Brickwork**

| Brick Category | Cleaning Method | Remarks |
|---|---|---|
| Red and Red Flashed | Bucket and Brush Hand Cleaning<br>Pressurized Water<br>Abrasive Blasting | Water, detergents, emulsifying agents, or suitable proprietary compounds may be used. |
| White, Tan, Buff, Gray, Pink, Brown, Black, Specks and Spots | Bucket and Brush Hand Cleaning<br>Pressurized Water<br>Abrasive Blasting | Clean with water, detergents, emulsifying agents, or suitable proprietary compounds. Unbuffered muriatic acid solutions tend to cause stains in brick containing manganese and vanadium. Light colored brick are more susceptible to "acid burn" and stains, compared to darker units. |
| Sand Finish or Surface Coating | Bucket and Brush Hand Cleaning | Clean with water and scrub brush using light pressure. Stubborn mortar stains may require use of cleaning solutions. Abrasive blasting is not recommended. Cleaning may affect appearance.<br>See **Brick Category** for additional remarks based on brick color. |
| Glazed Brick | Bucket and Brush Hand Cleaning<br>Pressurized Water | Wipe glazed surface with soft cloth within a few minutes of laying units. Use a soft sponge or brush plus ample water supply for final washing. Use detergents where necessary and proprietary cleaners only for very difficult mortar stain. Consult brick and cleaner manufacturer before use of proprietary cleaners on salt glazed or metallic glazed brick. Do not use abrasive powders. Do not use metal cleaning tools or brushes. |
| Colored Mortars | Method is generally controlled by **Brick Category** | Many manufacturers of colored mortars do not recommend chemical cleaning solutions. Unbuffered acids and some proprietary cleaners tend to bleach colored mortars. Mild detergent solutions are generally recommended. |

1. Decide when to clean. Mortar must harden prior to cleaning. It is generally best to schedule cleaning at least seven days after brickwork is completed. In some cases it may be possible to clean earlier; however, effects on the masonry and influencing factors such as weather conditions and the type of brick and mortar should be carefully considered. Prolonged time periods between the completion of the masonry and cleaning should be avoided. After one month, mortar smears and splatters left on brickwork become increasingly difficult to remove.

2. Remove larger clumps of mortar using wooden paddles or nonmetallic tools. Metal tools may damage the brickwork or leave behind fragments that oxidize and cause rust stains.

3. Select the proper cleaning solution. There are many types of proprietary cleaners available that are formulated to remove specific stains or for use with a particular type of brick. Be careful to select cleaning products suitable for the brick, mortar and adjacent materials and follow the cleaner manufacturer's recommended instructions. Each product being considered should be evaluated as discussed previously in **Trial Cleaning**.

   Do not use unbuffered muriatic acid. Use of unbuffered muriatic acid solutions tend to cause further stains and damage mortar joints. Many proprietary cleaners contain acids, however, their formulations include other chemicals that make them safer, easier to use properly and more environmentally responsible.

4. Protect adjacent materials and nearby plants. Mask or otherwise protect windows, doors, and materials such as sealants, metal, glass, wood, limestone, cast stone, concrete masonry and ornamental trim from cleaning solutions. Cleaning chemicals may also damage plants and grass. It may be necessary to prevent the cleaning solution and run-off from contacting plants or the surrounding soil.

5. Saturate the area to be cleaned. Flush with water from the top down. Saturated brick masonry will not absorb the cleaning solution or dissolved mortar particles. Areas below the area being cleaned should also be saturated and kept wet until after the final rinse to prevent streaking and absorption of the run-off from above.

6. Apply the cleaning solution. For proprietary compounds, follow the manufacturer's instructions for application, dwell time and cleaning technique. Wooden paddles or other non-metallic tools may be used to remove stubborn particles.

7. Rinse thoroughly. Flush walls with large amounts of clean water from top to bottom before cleaned surfaces can dry. Failure to completely flush the wall of cleaning solution and dissolved matter may result in the formation of "white scum."

Individual cleaning methods and procedures may vary slightly from this general procedure; where appropriate such variations are noted in succeeding sections of this *Technical Note*.

**Bucket and Brush Hand Cleaning.** This is a popular but misunderstood method used to clean brick masonry. Its popularity is due to the simplicity of execution and the availability of proprietary cleaning compounds. This cleaning method is applicable to virtually all brick types. The least aggressive method of cleaning is the bucket and brush method with clean water only. If a cleaning solution is used, it should be matched to the specific brick. The **General Cleaning Procedure** given above is applicable to bucket and brush cleaning with the following amendments:

- In Step 1, cleaning can often begin 24 hours after the masonry is completed if only clean water without chemicals is used.
- In Step 6, use a long handled stiff fiber brush or other type as recommended by the cleaning solution manufacturer. Do not use metal brushes which may damage mortar joints or result in further staining. Depend on the chemical reaction of the cleaner rather than the scrubbing action of the brush. If stubborn mortar smears are not removed, reapplication is often more effective than hard scrubbing.

**Pressurized Water Cleaning.** Cleaning contractors often utilize pressurized water because it is less labor intensive than bucket and brush cleaning and permits large areas to be cleaned much faster. Pressurized water cleaning permits the operator to spray clean water on a wall over 100 ft (30 m) from the tank and compressor. However, the method requires more skill than the bucket and brush method, as consistent results depend on maintaining a consistent pressure, water flow rate, distance from the wall and angle between the water jet and the wall. It is also important to use uniform horizontal strokes. The effects of pressurized water cleaning on each project or type of brick should be carefully considered as excessive pressure may damage brick surfaces, erode mortar joints and remove finishes or other surface coatings, resulting in a different appearance. Nozzle pressures less than 300 psi (2,100 kPa) are typically recommended. The brick manufacturer should be consulted before use of pressurized water to clean brick.

With the following modifications, the **General Cleaning Procedure** described previously is applicable to pressurized water cleaning:

- In Step 3, when selecting a cleaning solution, verify its compatibility with the equipment to be used. Mix proprietary cleaners in accordance with the manufacturer's instructions.
- In Step 5, a maximum pressure of 30 to 50 psi (200 to 350 kPa) with a 25º to 50º fan-shaped nozzle is recommended when using a sprayer to presoak the wall.
- In Step 6, the cleaning solution should be applied by a low-pressure sprayer, (30 to 50 psi [200 to 350 kPa]), with a 50º fan-shaped sprayer nozzle, or by brush. Cleaning solutions applied under high pressure can be driven into the masonry and become the source of future staining.
- In Step 7, use a 25º to 50º fan-shaped nozzle and a maximum water pressure of 200 to 300 psi (1,400 to 2,100 kPa) to flush the cleaning solution from the brickwork. If trial cleaning or prior experience with the selected brick has established that no damage will result, higher pressures may be used.

# Improper Cleaning

Cleaning failures generally fall into one of the following categories:

- **Failure to thoroughly saturate the brick masonry surface with water before and after application of chemical or detergent cleaning solutions.** Dry masonry permits absorption of the cleaning solution and may result in "white scum," efflorescence, manganese or vanadium stains. Saturating the surface prior to cleaning reduces the masonry's absorption rate, permitting the cleaning solution to stay on the surface

of the brickwork rather than being absorbed. Likewise, thorough rinsing reduces the potential for stains caused by cleaning solution residue.

- **Use of improper chemical cleaning solutions.** Improperly mixed or overly concentrated acid solutions can etch the brick or dissolve cementitious materials from mortar joints. Unbuffered acid has a tendency to discolor masonry units, particularly lighter shades, producing an appearance frequently termed “acid burn” and can also promote the development of vanadium and manganese stains.
- **Excessively aggressive cleaning methods.** Cleaning methods such as abrasive blasting and high pressure water cleaning, that remove stains from the masonry by abrasion, can etch mortar joints and remove the outer surface of brick, resulting in permanent damage.
- **Failure to protect windows, doors, and trim.** Many cleaning agents, particularly acid solutions, have a corrosive effect on metal. If permitted to come in contact with metal frames, the solutions may cause pitting of the metal or staining of the masonry surface and trim materials such as limestone, concrete masonry and cast stone.

# CLEANING EXISTING MASONRY (STAIN REMOVAL)

Bucket and brush hand cleaning and pressurized water cleaning discussed above in **Suggested Cleaning Methods**, are also used to remove stains from existing masonry. Besides these, poultices, additional proprietary solutions and a variety of abrasive blasting methods are among the techniques typically used to remove dirt or specific stains from existing masonry [Ref 3]. These are described briefly below.

It is always advisable to collect as much information as possible before attempting to clean existing masonry. In some cases, water repellents may have been applied to the masonry or other unexpected treatments or conditions may interfere with cleaning. In these instances, professional guidance should be sought in determining how to address these conditions to achieve successful cleaning.

## Using a Poultice

A poultice is a paste made with a solvent or reagent and an inert material. It works by dissolving a stain and absorbing or pulling it into the poultice. Poultices tend to prevent stains from spreading during treatment and pull stains out of the pores of brick. Poultices are normally used for stains affecting small areas of brickwork.

Poultices for cleaning masonry can be purchased commercially or made on site. The inert material used in the poultice may be talc, whiting, fuller’s earth, diatomaceous earth, bentonite or other clay. The solution or solvent used depends upon the nature of the stain to be removed. Enough of the solution or solvent is added to a small quantity of the inert material to make a smooth paste. The paste is smeared onto the stained area with a trowel or spatula, to make a coating at least 1/8 in. (3 mm) thick. When dried, the remaining powder, which now contains the staining material, is scraped, brushed or washed off. Repeated applications may be necessary.

If the solvent used in preparing a poultice is an acid, do not use whiting as the inert material. Whiting is a carbonate which reacts with acids to give off carbon dioxide. While this is not dangerous, it will make a foamy mess and destroy the power of the acid.

## Abrasive Blasting

Abrasive methods are not generally recommended for cleaning brickwork. Attempting to remove dirt or stains by abrasion is risky because the outer surface of the masonry may also be removed, resulting in permanent damage and increased water penetration. Abrasive cleaning may also roughen the surface of masonry, which increases its tendency to hold dirt and makes future cleaning more difficult. Sanded, coated, glazed and slurry-finished brick should not be cleaned by abrasive blasting.

It is possible to safely clean brick masonry by abrasive blasting, however a gentler abrasive than sand and a highly qualified operator are typically required, in conjunction with proper specifications and job inspection. In limited instances, abrasive blasting is the only method that will remove persistent stains. This method is sometimes preferred over conventional wet cleaning since it eliminates the problem of chemical reactions with vanadium salts and other materials used in manufacturing brick.

Abrasive blasting involves an air compressor, blasting tank, blasting hose, nozzle, and protective clothing, a hood and a respirator for the operator. The air compressor should be capable of producing 60 to 100 psi (400 to 700

kPa) at a minimum air flow capacity of 125 $ft^3$ (3.5 $m^3$) per minute. The inside orifice or bore of the nozzle may vary from $^3/_{16}$ to $^5/_{16}$ in. (4.8 to 7.9 mm) in diameter. The sandblast machine (tank) should be equipped with controls to regulate the flow of abrasive materials to the nozzle at a minimum rate of 300 lb/hr (0.004 kg/s).

Methods for cleaning masonry using abrasives may be executed at high or low pressures and with dry abrasives or abrasives added to a stream of water. Abrasives should be selected based on the degree of cutting or cleaning desired and the amount of change in the surface of the masonry that is permissible. Silica sands, crushed quartz, crushed granite and white urn sand (round particles) are among the harder abrasives at approximately 6 on Moh's Scale. Softer abrasives include crushed nut shells, dry ice, baking soda and others. If used these minerals should have a gradation appropriate for the intended use [Ref. 2].

Dry abrasive blasting (sandblasting) at high pressure is perhaps the best known of these methods, but has a significant potential to damage masonry. In addition, the dust it creates can be harmful if inhaled, which poses health and safety concerns.

Wet sand cleaning depends on water-cushioned abrasive action for its effectiveness. It is similar to sandblasting, with the addition of water into the air stream, which eliminates dust. It is often suggested when abrasion of the surface is permissible. Such instances may include removal of paint or other surface coatings.

Wet aggregates delivered at low pressure through a special nozzle are sometimes used on soft brick and soft stone materials, and are particularly effective on surfaces with flutings, carvings and other ornamentation. Wet aggregate cleaning is a gentle but thorough process, employing a mixture of water and a friable aggregate free from silica, with a scouring action that cleans effectively with less surface damage than sandblasting or wet sand cleaning.

The **General Cleaning Procedure** can also be followed for abrasive blasting with the following modifications:

- In Step 3, select abrasives that are clean, dust free and sufficiently hard. Test clean several areas at varying distances from the wall and several angles that afford the best cleaning job without damaging brick and mortar joints. Workers should be instructed to direct abrasive at the brick and not directly at the mortar joints.
- Omit Steps 5 through 7.

# REMOVING EFFLORESCENCE

The removal of efflorescing salts is relatively easy compared to some other stains. Refer to *Technical Notes* 23 Series for a detailed discussion on efflorescence. Efflorescing salts are water soluble and generally will disappear of their own accord with normal weathering. This is particularly true of "new building bloom," which tends to occur shortly after construction is completed (or during construction) due to normal water loss during post-construction drying.

Before efflorescence is removed, any leaks should be repaired and the brickwork should be allowed to dry. White efflorescence can often be removed by dry brushing or with a stiff fiber brush and water. Heavy accumulations or stubborn deposits of white efflorescence may be removed with a proprietary cleaner. It is imperative that the manufacturer's instructions are carefully followed.

# REMOVING SPECIFIC STAINS

Whether a stain results from chemical reactions within a brick, or external materials being spilled, splattered on, or absorbed by brickwork, each is an individual case and must be treated accordingly. When using any cleaner, it is advisable to consult the brick manufacturer for cleaning advice, follow the instructions of the cleaner manufacturer, and trial clean in an inconspicuous area before using on an entire project.

There are a variety of proprietary cleaners that effectively remove most of the common substances that stain brickwork, including bronze and copper stains, efflorescence, graffiti, iron stains (rust), lime run, manganese stain, moss, oil and tar stains, paint, smoke and vanadium stain. When available, these are preferred over site-mixed or "homemade" cleaning solutions because they are generally safer, easier to control and more consistent, resulting in successful cleaning. In some cases these cleaners have been developed in conjunction with brick manufacturers.

In addition to proprietary cleaners, many stains can be removed by scrubbing with kitchen cleansers, bleach or other household chemicals. A combination, such as is found in some kitchen cleansers, may prove most effective. The sections below list some non-proprietary alternatives for removal of common stains. Further information on causes and prevention of stains is contained in the *Technical Notes* 23 Series.

## Brick Dust

Dust produced from the cutting of brick sometimes adheres to the surface of brickwork. Compressed air, such as from a portable cylinder, has been found effective in removing this dust.

## Dirt and Mud

Dirt can be difficult to remove, particularly from a textured brick. In addition to proprietary cleaners, scouring powder and a stiff bristle brush are effective if the texture is not too rough. For very rough textures, pressurized water cleaning can be effective.

## Egg Splatter

Brickwork vandalized with raw eggs has been successfully cleaned by prewetting the stain, applying a saturated solution of oxalic acid crystals dissolved in water and rinsing with water. Mix the solution in a non-metallic container and apply with a brush.

If the egg splatter is to be removed from brick that contain vanadium (typically light colored units), a solution of 1.5 oz (10 g) washing soda (sodium carbonate) per gal (1 L) of water should be applied to the brickwork following the oxalic acid solution. Without this neutralizing solution, cleaning with oxalic acid may cause more severe staining.

## Manganese (Brown) Stain

Besides specially formulated proprietary compounds, manganese stains have been effectively removed and their return prevented by carefully mixing a solution of acetic acid (80 percent or stronger), hydrogen peroxide (30 to 35 percent) and water in the following proportions by volume: 1 part acetic acid, 1 part hydrogen peroxide, and 6 parts water. After wetting the brickwork, brush or spray on the solution. Do not scrub. The reaction is usually very rapid and the stain quickly disappears. After the reaction is complete, rinse the wall thoroughly with water.

Caution: Although this solution is very effective, it is a dangerous solution to mix and use. Acetic acid-hydrogen peroxide may also be available in a premixed form known as peracetic acid.

An alternate treatment sometimes suggested for new and mild manganese stains is oxalic acid crystals and water. Mix 1 lb of crystals (0.45 kg) to 1 gal (3.79 L) of water. The neutralizing wash mentioned above in **Egg Splatter** should be considered when oxalic acid is applied to brown or light colored brick.

## Oil and Tar Stains

Oil and tar stains may be effectively removed by commercially available oil and tar removers. For heavy tar stains, mix the agents with kerosene to remove the tar, and then water to remove the kerosene. After application, the stains can be hosed off. When used in a steam cleaning apparatus, cleaners have been known to remove tar without the use of kerosene.

Where the area to be cleaned is small, or minimal cleanup is desired, a poultice using naphtha or trichloroethylene is most effective in removing oil stains.

Dry ice or compressed carbon dioxide may be applied to make tar brittle. Then, light tapping with a small hammer and prying with a putty knife generally will be enough to remove thick tar splatters.

## Organic Growth

Occasionally, an exterior masonry surface remains in a constantly damp condition, thus encouraging moss, algae, lichen or other organic growth. Applications of household bleach, ammonium sulfate or weed killer, in accordance with furnished directions, have been used successfully for the removal of such growths.

## Paint and Graffiti

Commercial and proprietary paint removers and organic solvents are most effective at softening or dissolving paint so that it can be removed with a scraper and a stiff bristle brush or rinsed away with water. For very old dried paint, organic solvents may not be effective, in which case the paint must be removed by sandblasting or scrubbing with a non-metallic abrasive pad. Graffiti that has penetrated into masonry is best removed by a poultice, paste or gel that can cling to the masonry, extending its working time on the stain.

## Smoke

Scrubbing with scouring powder (particularly one containing bleach) and a stiff bristle brush is often effective.

## Vanadium (Green) Stain

Applying a solution of potassium or sodium hydroxide, consisting of 0.5 lb (0.23 kg) hydroxide to 1 qt (0.95 L) water or 2 lb (0.91 kg) per gal (3.79 L) to brickwork is an alternative treatment for vanadium stains. The solution should be allowed to remain for two or three days and then washed off. Use a hose to wash off any white residue remaining on the brickwork after this treatment.

Sodium hypochlorite, the active ingredient in household bleaches, can also be used to remove mild vanadium stains. Spray or brush onto the stain, and then rise off after the stain disappears.

Oxalic acid is another chemical known to remove vanadium stains. A mixture of 3 to 6 oz (20 to 40 g) oxalic acid per gal (1 L) of water (preferably warm) should be applied to the brickwork, followed by the neutralizing wash described in **Egg Splatter.** More severe staining may result if the oxalic acid solution is applied without the neutralizing wash.

## Welding Splatter

When metal is welded too close to brick stored on site or completed brickwork, molten metal may splash onto the brick and melt into the surface. A mixture of 1 lb (0.45 kg) oxalic crystals and 0.5 lb (0.23 kg) of ammonium biflouride per gal (3.79 L) of water is particularly effective in removing welding splatters. This mixture should be used with caution as it generates dangerous hydroflouric acid, which can also etch brick and glass.

Scrape as much of the metal as possible from the brick. Apply the mixture in a poultice, and remove when it is dried. If the stain has not disappeared, use sandpaper to remove as much as possible and apply a fresh poultice. For stubborn stains, several applications may be necessary.

## Stains of Unknown Origin

Stains of unknown origin can be a real challenge. Laboratory tests of unknown stains maybe necessary to determine their composition. Then the appropriate method may be implemented to clean the brickwork. The application of a cleaning agent without identifying the initial stain may result in stains that are more difficult to remove. The visual characteristics of a stain may be the first clues as to its source. Identification of stains is discussed further in *Technical Note* 23.

# CLEANING HISTORIC STRUCTURES

Improper cleaning can cause irreparable damage to historic brickwork. Therefore, cleaning of structures with historic significance should be overseen by a restoration specialist. Before a historic structure is cleaned, consider the purpose of cleaning: to improve the appearance; to slow deterioration; or to provide a clean surface for evaluation or further treatments. With historic structures, it is imperative to use the least harmful cleaning method that will achieve the desired results. Cleaning methods and materials must be carefully matched to the substance to be cleaned, the type of soiling/staining to be removed and the desired results.

These issues are discussed in detail in “Assessing Cleaning and Water-Repellent Treatments for Historic Masonry Buildings” [Ref. 4].

# CLEANING BRICK PAVING

Cleaning of brick pavements is essentially the same as for brickwork in walls and other applications. The methods described above can be used successfully to remove stains that also affect pavements such as efflorescence, hardened mortar, plant life, oil and tar, etc. However, after construction is complete, dirt and stains resulting from

deicing salts or materials tracked onto or spilled on pavements typically build up more quickly than other brick applications. Frequent sweeping and washing with clean water will help reduce the need for more aggressive cleaning methods and solutions.

Fresh mortar stains can be removed from existing or mortarless pavements before they set by covering the pavement with clean, slightly damp, washed sand and sweeping toward the edges. When the surface is almost clean, sweeping with dry sand should remove remaining residue.

Chewing gum can usually be removed from brick pavements by wire brushes, carefully applied high pressure water or freezing each piece of gum with compressed carbon dioxide or dry ice, and then scraping or chiseling it off the pavement. Food stains and tire marks are typically removed by scrubbing with a detergent or proprietary cleaner.

## SUMMARY

Testing of cleaning procedures and chemicals as suggested in this *Technical Note* is strongly recommended. Such testing should be performed under conditions of temperature and humidity that closely approximate the conditions under which the brick masonry will be cleaned. Cleaning solutions recommended by the brick or cleaning agent manufacturer should also be trial tested before being committed to an entire project. The effects of any cleaning process on people and the environment should be carefully evaluated before cleaning begins.

The recommendations in this *Technical Note* should be used as a guide for successful cleaning of brick masonry. Due to the diverse nature of cleaning solutions, procedures and problems, the Brick Industry Association cannot accept responsibility for the final success or effectiveness of these procedures.

In conclusion, nothing is quite as effective as careful attention exercised during construction to keep brickwork relatively clean. If this is successful, it will eliminate the need for costly cleaning procedures.

> *The information and suggestions contained in this* Technical Note *are based on the available data and the combined experience of engineering staff and members of the Brick Industry Association. The information contained herein must be used in conjunction with good technical judgment and a basic understanding of the properties of brick masonry. Final decisions on the use of the information contained in this* Technical Note *are not within the purview of the Brick Industry Association and must rest with the project architect, engineer and owner.*

## REFERENCES


1. Clay Paving Design and Construction, Clay Brick and Paver Institute, Baulkham Hills BC, Australia, 2003.
2. "Good Practice for Cleaning New Brickwork," Brick SouthEast, Charlotte, NC, 2003.
3. Grimm, C.T., “Cleaning Masonry - A Review of the Literature”, Construction Research Center, University of Texas at Arlington, Arlington, TX, 1988.
4. Mack, R.C. and Anne Grimmer, “Assessing Cleaning and Water-Repellent Treatments for Historic Masonry Buildings,” Preservation Briefs No. 1, National Park Service, Washington, DC, 2000.

Technical Notes on Brick Construction

31B REVISED

Reissued* May 1987

Brick Industry Association 11490 Commerce Park Drive, Reston, Virginia 20191

# STRUCTURAL STEEL LINTELS

**Abstract:** The design of structural steel lintels for use with brick masonry is too critical an element to be left to "rule-of-thumb" designs. Too little concern for loads, stresses and serviceability can lead to problems. Information is provided so that structural steel lintels for use in brick masonry walls may be satisfactorily designed.

**Key Words:** **beams** (supports); **brick**; **buildings**; **deflection**; **design**; lintels; **loads** (forces); **masonry**; structural steel; **walls**.

## INTRODUCTION

A lintel is a structural member placed over an opening in a wall. In the case of a brick masonry wall, lintels may consist of reinforced brick masonry, brick masonry arches, precast concrete or structural steel shapes. Regardless of the material chosen for the lintel, its prime function is to support the loads above the opening, and it must be designed properly. To eliminate the possibility of structural cracks in the wall above these openings, the structural design of the lintels should not involve the use of "rule-of-thumb" methods, or the arbitrary selection of structural sections without careful analysis of the loads to be carried and calculation of the stresses developed. Many of the cracks which appear over openings in masonry walls are due to excessive deflection of the lintels resulting from improper or inadequate design.

This *Technical Notes* presents the considerations to be addressed if structural steel lintels are to be used. It also provides a procedure for the structural design of these lintels. For information concerning reinforced brick masonry lintels, see *Technical Notes* 17H and for brick masonry arches, see *Technical Notes* 31, 31A and 31C Revised.

## CONSIDERATIONS

### General

When structural steel lintels are used, there are several considerations which must be addressed in order to have a successful design. These include loading, type of lintel, structural design, material selection and maintenance, moisture control around the opening, provisions to avoid movement problems and installation of the lintel in the wall.

### Types

There are several different types of structural steel lintels used in masonry. They vary from single angle lintels in cavity or veneer walls, to steel beams with plates in solid walls, to shelf angles in brick veneer panel walls. Most building codes permit steel angle lintels to be used for openings up to 8 ft 0 in. (2.4 m). Openings larger than this are usually required to have fire protected lintels.

**Loose Angle Lintels.** Loose angle lintels are used in brick veneer and cavity wall constructions where the lintel is laid in the wall and spans the opening. This type of lintel has no lateral support. Figure 1a shows this condition.

**Combination Lintels.** In solid masonry walls, single loose angle lintels are usually not capable of doing the job. Therefore, combination lintels are required. These combination lintels can take many forms, from a clustering of steel angles, such as shown in Figs. 1b and 1c, to a combination of steel beam and plates, as shown in Figs. 1d and 1e.

*Angle Lintels* - In solid masonry walls, it is usually satisfactory to use multiple steel angles as a lintel. These angles are usually placed back to back, as shown in Figs. 1b and 1c.

*Steel Beam/Plate Lintels* - In solid walls with large superimposed loads, or in walls where the openings are greater than 8 ft 0 in. (2.4 m), it may be necessary to use lintels composed of steel beams with attached or suspended plates, as shown in Figs. 1d and 1e. This permits the beam to be fully encased in masonry, and fire-protected.

**Shelf Angles.** In panel walls systems, the exterior wythe of brickwork may be supported by shelf angles rigidly attached to the structural frame. These shelf angles, in some cases, also act as lintels over openings in the masonry. This condition is shown in Fig.1f.

*Originally published in Nov/Dec 1981, this *Technical Notes* has been reviewed and reissued.

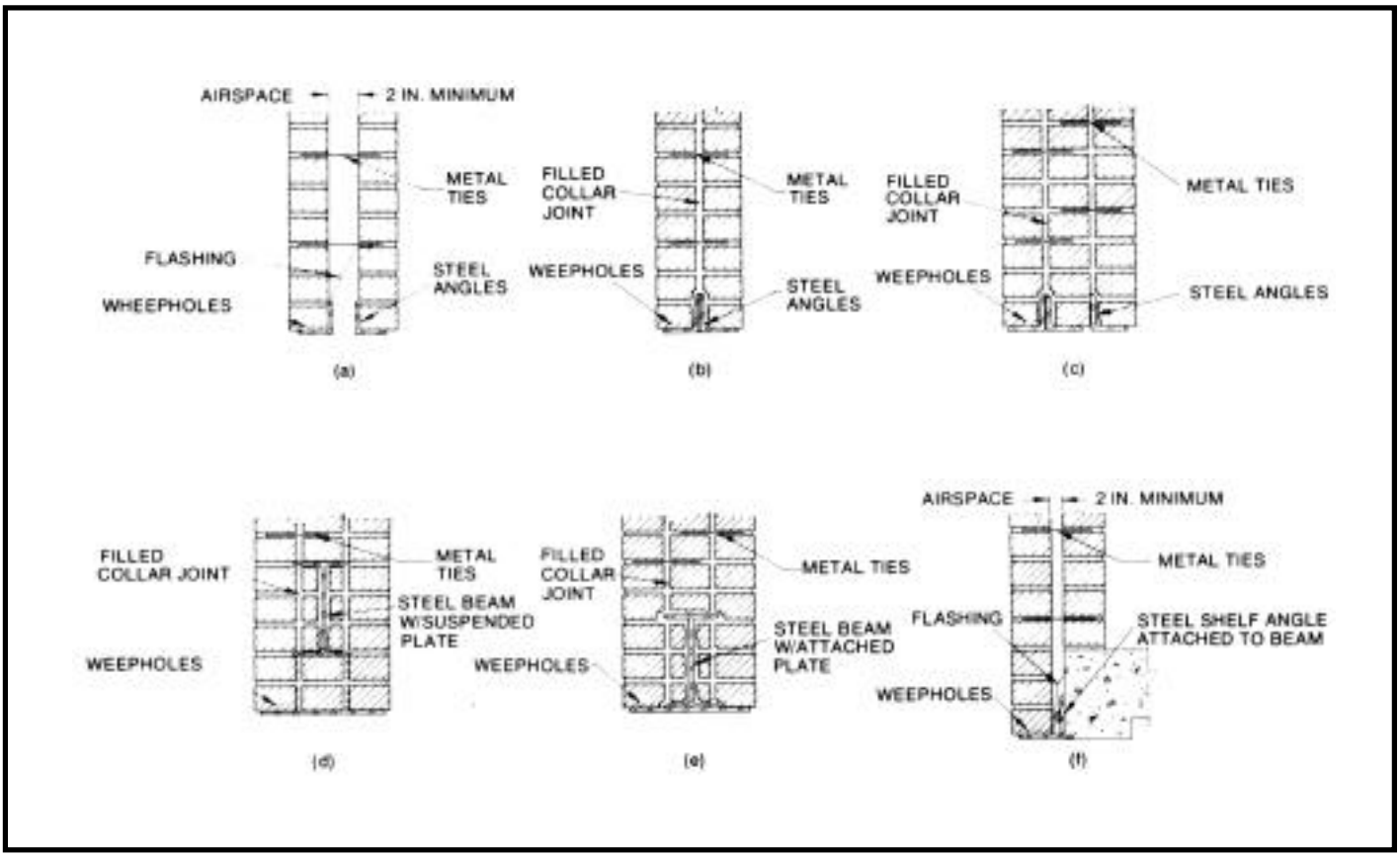



**Fig. 1**
**Types of Structural Steel Lintels**

## Design

The proper design of the structural steel lintel is very important, regardless of the type used. The design must meet the structural requirements and the serviceability requirements in order to perform successfully. Design loads, stresses and deflections will be covered in a later section of this *Technical Notes*.

## Materials

The proper specification of materials for steel lintels is important for both structural and serviceability requirements. If materials are not properly selected and maintained, problems can occur.

**Selection.** The steel for lintels, as a minimum, should comply with ASTM A 36. Steel angle lintels should be at least 1/4 in. (6 mm) thick with a horizontal leg of at least 3 1/2 in. (90 mm) for use with nominal 4 in. (100 mm) thick brick, and 3 in. (75 mm) for use with nominal 3 in. (75 mm) thick brick.

**Maintenance.** For harsh climates and exposures, consideration should be given to the use of galvanized steel lintels. If this is not done, then the steel lintels will require periodic maintenance to avoid corrosion.

## Moisture Control

Proper consideration must always be given to moisture control wherever there are openings in masonry walls. There must always be a mechanism to channel the flow of water, present in the wall, to the outside.

**Flashing and Weepholes.** Even where galvanized or stainless steel angles are used for lintels in cavity and veneer walls, continuous flashing should be installed over the angle. It should be placed between the steel and the exterior masonry facing material to collect and divert moisture to the outside through weepholes. Regardless of whether flashing is used, weepholes should be provided in the facing at the level of the lintel to permit the escape of any accumulated moisture. See *Technical Notes* 7A for further information on flashing and weepholes.

## Movement Provisions

Because of the diversity of movement characteristics of different materials, it is necessary to provide for differential movement of the materials. This is especially true at locations where a number of different materials come together. *Technical Notes* 18 Series provides additional information on differential movement.

**Expansion Joints.** Expansion joints in brick masonry are very important in preventing unnecessary and unwanted cracking. There are two types of expansion joints which will need to be carefully detailed when lintels are involved: vertical and horizontal.

*Vertical* - Vertical expansion joints are provided to permit the horizontal movement of the brick masonry. Where these expansion joints are interrupted by lintels, the expansion joint should go around the end of the lintel and then continue down the wall.

*Horizontal* - In multi-story walls where the lintels are a continuation of shelf angles supporting masonry panels, horizontal expansion joints to accommodate vertical movement must be provided. Often a simple soft joint below the shelf angle is all that is needed. See *Technical Notes* 18A, 21 Rev, and 28B Rev for typical details.

**Installation**

The installation of steel lintels in masonry walls is a conventional construction operation, familiar to most members of the building team. The walls are built to the height of the opening, the lintel is placed over the opening, and the masonry work is continued. One item of special construction that must be noted is temporary shoring.

**Temporary Shoring.** If the steel lintel is being designed assuming in-plane arching of the masonry above, then the lintel must be shored until the masonry has attained sufficient strength to carry its own weight. This shoring period should not be less than 24 hr. This minimum time period should be increased to three days when there are imposed loads to be supported. If the masonry is being built in cold weather construction conditions, the length of cure should be increased. If the lintel is designed for the full uniform load of the masonry and other superimposed loads ignoring any inherent arching action, then no shoring is required.

## STRUCTURAL DESIGN

**General**

The structural design of steel lintels is relatively simple. The computations are the same as for steel beams in a building frame, but because of the low elasticity of the masonry, and the magnitude and eccentricity of the loading, the design should not be taken lightly. A proper design must consider the loads, stresses, and serviceability of the system. If these are not properly taken into account, problems of cracking and spalling could occur.

**Loads**

The determination of imposed loads is an important factor. Fig. 2 shows an example of a lintel design situation. On the left is an elevation showing an opening in a wall with planks and a beam bearing on the wall. On the right is a graphic illustration of the distribution of the superimposed loads.

**Uniform Loads.** The triangular wall area (ABC) in Fig. 2b above the opening has sides at 45-deg angles to the base. Arching action of a masonry wall will carry the dead weight of the wall and the superimposed loads outside this triangle, provided that the wall above Point B (the top of the triangle) is sufficient to provide resistance to arching thrusts. For most lintels of ordinary wall thickness, loads and spans, a depth of 8 to 16 in. (200 mm to 400 mm) above the apex is sufficient. If stack bonded masonry is used, horizontal joint reinforcement must be provided to ensure the arching action.

Providing arching action occurs, the dead weight of the masonry wall, carried by the lintel, may be safely assumed as the weight of masonry enclosed within the triangular area (ABC). To the dead load of the wall must be added the uniform live and dead loads of the floor bearing on the wall above the opening and below the apex of the 45-deg triangle. Again, providing arching occurs, such loads above the apex may be neglected. In Fig. 2b, D is greater than L/2, so the floor load may be ignored, but, in order to use this assumed loading, temporary shoring must be provided until the masonry has cured sufficiently to assure the arching action.

If arching action is not assumed and temporary shorting is not to be used, the steel lintel must be designed for the full weight of the masonry and other superimposed live and dead loads above the opening. There could be quite a substantial difference in the final lintel sizes required in each case.

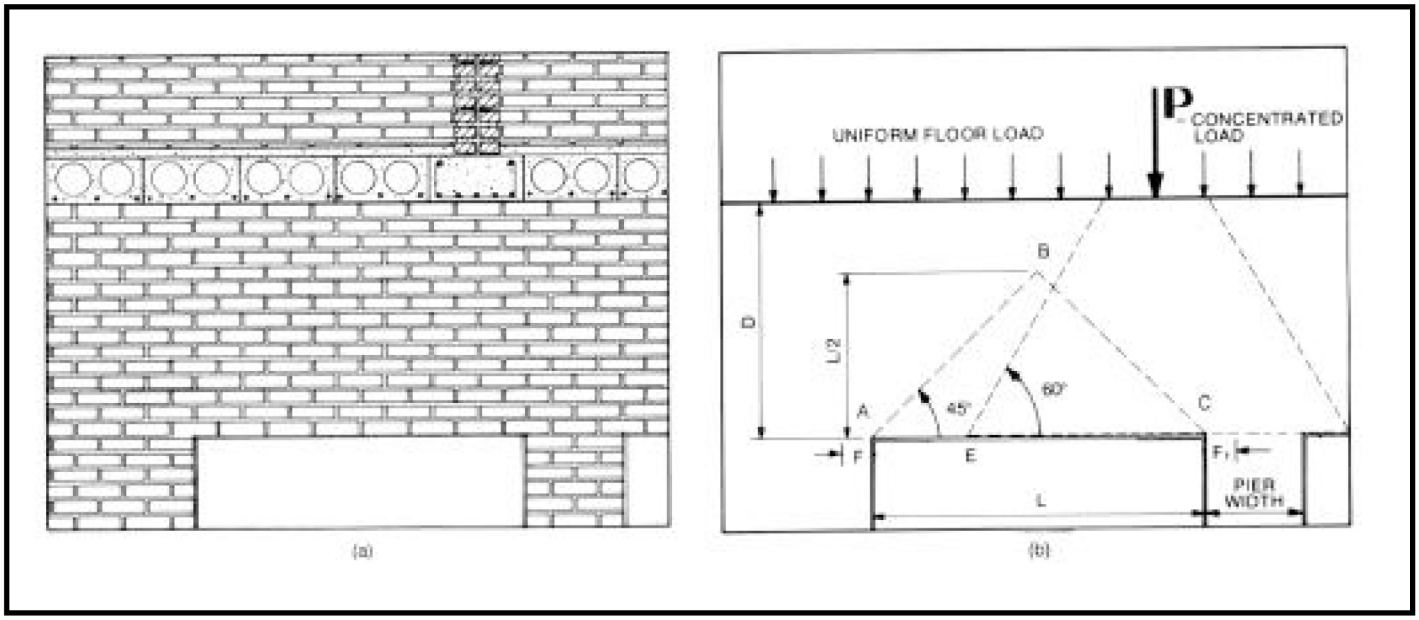



**Fig. 2**
**Lintel Load Determination**

**Concentrated Loads.** Concentrated loads from beams, girders, or trusses, framing into the wall above the opening, must also be taken into consideration. Such loads may be distributed over a wall length equal to the base of the trapezoid and whose summit is at the point of load application and whose sides make an angle of 60 deg with the horizontal. In Fig. 2b, the portion of the concentrated load carried by the lintel would be distributed over the length, EC, and would be considered as a partially distributed uniform load. Arching action of the masonry is not assumed when designing for concentrated loads. Again, if stack bonded masonry is used, horizontal joint reinforcement must be provided to assure this distribution.

**Stresses**

After the loads have been determined, the next step in the design of the lintel is the design for stresses. Which stresses need to be checked will depend upon the type and detailing of the lintel.

**Flexure.** In a simply supported member loaded through its shear center, the maximum bending moment due to the triangular wall area (ABC) above the opening can be determined by:

$$M_{max} = \frac{WL}{6}$$

where:

$M_{max}$ = maximum moment (ft---lb)

W = total load on lintel (lb)

L = span of lintel, center to center of end bearing (ft)

As an alternative, the designer may wish to calculate an equivalent uniform load by taking 2/3 of the maximum height of the triangle times the unit weight of the masonry as the uniform load across the entire lintel. If this is done, the maximum bending moment equation becomes:

$$M_{max} = \frac{wL^2}{8}$$

where:

w = equivalent uniformly distributed load per unit of length (lb per ft).

To this bending moment should be added the bending moment caused by the concentrated loading, if any. Where such loads are located far enough above the lintel to be distributed as shown in Fig. 2b, the bending moment formula for a partially distributed uniform load may be used. Such formulae may be found in the " Manual of Steel Construction," by the American Institute of Steel Construction (AISC). Otherwise, concentrated load bending moments should be used.

The next step is the selection of the required section. The angle, or other structural steel shape, should be selected by first determining the required section modulus. This becomes:

$$S = \frac{12M_{max}}{F_b}$$

where:

S = section modulus ($in^3$)

$F_b$ = allowable stress in bending of steel (psi)

The allowable stress, $F_b$, for ASTM A 36 structural steel is 22,000 psi (150 MPa) for members laterally supported. Solid brick masonry walls under most conditions provide sufficient lateral stiffness to permit the use of the full 22,000 psi (150 MPa). This is especially true when floors or roofs frame into the wall immediately above the lintel. The design for non-laterally supported lintels should be in accordance with the AISC *Specification for the Design, Fabrication and Erection of Structural Steel for Buildings*.

Using the design property tables in the AISC Manual, a section having an elastic section modulus equal to, or slightly greater than, the required section modulus is selected. Whenever possible, within the limitations of minimum thickness of steel and the length of outstanding leg required the lightest section having the required section modulus should be chosen.

**Combined Flexure and Torsion.** In some cases, the design for flexure will need to be modified to include the effects of torsion. This is the case in cavity and veneer walls where the load on the angle is not through the shear center.

In some situations, such as veneers, panel or curtain walls, the lintel may be supporting only the triangular portion of masonry directly over the opening. If this is the case, then the torsional stresses will usually be negligible compared to the flexural stresses, and can be safely ignored.

If, on the other hand, there are imposed uniform loads within the triangle or imposed concentrated loads above the lintel, then a detailed, combined stress analysis will be necessary. The design of a lintel subjected to combined flexure and torsion should be in accordance with the AISC *Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.*

**Shear.** Shear is a maximum at the end supports, and for steel lintels it is seldom critical. However, the computation of the unit shear is a simple calculation and should not be neglected. The allowable unit shear value for ASTM A 36 structural steel is 14,500 psi (100 MPa). To calculate the shear:

$$v_{max} = \frac{R_{max}}{A_s}$$

where:

$V_{max}$ = the actual maximum unit shear (psi)

$R_{max}$ = maximum reaction (lb)

$A_s$ = area of steel section resisting shear (sq. in.)

**Bearing.** In order to determine the overall length of a steel lintel, the required bearing area must be determined. The stress in the masonry supporting each end of the lintel should not exceed the allowable unit stress for the type of masonry used. For allowable bearing stresses, see "Building Code Requirements for Engineered Brick Masonry," BIA; "American Standard Building Code Requirements for Masonry," ANSI A41.1-1953 (R 1970); or the local building code. The reaction at each end of the lintel will be one-half the total uniform load on the lintel, plus a proportion of any concentrated load or partially distributed uniform load. The required area may be found by:

$$A_b = \frac{R_{max}}{f_m}$$

where:

$A_b$ = required bearing area (sq in.)

$f_m$ = allowable compressive stress in masonry (psi)

In addition, any stresses due to rotation from bending or torsion of the angle at its bearing must be taken into account.

Since in selecting the steel section, the width of the section was determined, that width divided into the required bearing area, $A_b$, will determine the length of bearing required, F and $F_1$, in Fig. 2b. This length should not be less than 3 in. (75 mm).

If the openings are close together, the piers between these openings must be investigated to determine whether the reactions from the lintels plus the dead and live loads acting on the pier exceed the allowable unit compressive stress of the masonry. This condition will not normally occur where the loads are light, such as in most one and two-story structures.

## Serviceability

In addition to the stress analysis for the lintel, a serviceability analysis is also important. Different types of lintels have different problems of deflection and rotation, and each must be analyzed separately to assure its proper performance.

**Deflection Limitations.** After the lintel has been designed for stresses, it should be checked for deflection. Lintels supporting masonry should be designed so that their deflection does not exceed 1/600 of the clear span nor more than 0.3 in (8 mm) under the combined superimposed live and dead loads.

For uniform loading, the deflection can be found by:

$$\Delta_t = \frac{5wL^4 (1728)}{384\ EI}$$

where:

$\Delta_t$ = total maximum deflection (in.)

E = modulus of elasticity of steel (psi)

I = moment of inertia of section (in.$^4$)

For loadings other than uniform, such as concentrated loads and partially distributed loads, deflection formulae may be found in the AISC Manual.

**Torsional Limitations.** In cases where torsion is present, the rotation of the lintel can be as important as its deflection. The rotation of the lintel should be limited to 1/16 in. (1.5 mm) maximum under the combined superimposed live and dead loads. As mentioned before, all additional bearing stresses due to angle rotation must be taken into account in the design for bearing.

## Design Aids

In order to facilitate the design of steel angle lintels, several design aids are included. These design aids are not all-inclusive, but should give the designer some help in designing lintels for typical applications. Conditions beyond the scope of these tables should be thoroughly investigated.

Table 1 contains tabulated load values to assist the designer in the selection of the proper size angle lintel, governed either by moment or deflection under uniform load. Shear does not govern in any of the listed cases. The deflection limitation in Table 1 is 1/600 of the span, or 0.3 in. (8 mm), whichever is less. Lateral support is assumed in all cases.

Table 2 lists the allowable bearing stresses taken from ANSI A41.1-1953 (R 1970). In all cases, allowable bearing stresses set by local jurisdictions in their building codes will govern.

Table 3 lists end reactions and required length in bearing, which may control for steel angle lintels.

## SUMMARY

This *Technical Notes* is concerned primarily with the design of structural steel lintels for use in brick masonry walls. It presents the considerations which must be addressed for the proper application of this type of masonry support system. Other *Technical Notes* address the subjects of reinforced brick masonry lintels and brick masonry arches.

The information and suggestions contained in this *Technical Notes* are based on the available data and the experience of the technical staff of the Brick Institute of America. The information and recommendations contained herein, if followed with the use of good technical judgment, will avoid many of the problems discussed. Final decisions on the use of details and materials as discussed are not within the purview of the Brick Institute of America, and must rest with the project designer, owner, or both.

**TABLE 1**

**Allowable Uniform Superimposed Load (lb per ft) for ASTM A 36 Structural Steel Angle Lintels** [1,2,3,4,5,6]

| Horizontal Leg (in) | Angle Size (in x in x in) | Weight per ft (lb) | Span in Feet (Center to Center of Required Bearing | | | | | | Resisting Moment (ft-lb) | Elastic Section Modulus ($in^3$) | Moment of Inertia ($in^4$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 3 | 4 | 5 | 6 | 7 | 8 | | | |
| 2 1/2 | 2 x 2 1/2 x 1/4 | 3.6 | 352 | 146 | 73 | | | | 458 | 0.25 | 0.372 |
| | 2 1/2 x 2 1/2 x 1/4 | 4.1 | 631 | 279 | 141 | 80 | | | 715 | 0.39 | 0.703 |
| | 5/16 | 5.0 | 777 | 336 | 170 | 96 | | | 880 | 0.48 | 0.849 |
| | 3/8 | 5.9 | 923 | 390 | 197 | 112 | | | 1045 | 0.57 | 0.984 |
| | 3 x 2 1/2 x 1/4 | 4.5 | 908 | 467 | 237 | 135 | 83 | | 1027 | 0.56 | 1.17 |
| | 3 1/2 x 2 1/2 x 1/4 | 4.9 | 1233 | 692 | 366 | 210 | 130 | 86 | 1393 | 0.76 | 1.80 |
| | 5/16 | 6.1 | 1509 | 846 | 446 | 255 | 158 | 104 | 1705 | 0.93 | 2.19 |
| | 3/8 | 7.2 | 1769 | 992 | 521 | 298 | 185 | 122 | 1998 | 1.09 | 2.56 |
| 3 1/2 | 2 1/2 x 3 1/2 x 1/4 | 4.9 | 664 | 308 | 155 | 88 | | | 752 | 0.41 | 0.777 |
| | 3 x 3 1/2 x 1/4 | 5.4 | 956 | 518 | 263 | 150 | 92 | | 1082 | 0.59 | 1.30 |
| | 3 1/2 x 3 1/2 x 1/4 | 5.8 | 1281 | 718 | 409 | 234 | 145 | 95 | 1448 | 0.79 | 2.01 |
| | 5/16 | 7.2 | 1590 | 891 | 498 | 285 | 177 | 116 | 1797 | 0.98 | 2.45 |
| | 3/8 | 8.5 | 1865 | 1046 | 583 | 334 | 207 | 136 | 2108 | 1.15 | 2.87 |
| | 4 x 3 1/2 x 1/4 | 6.2 | 1672 | 938 | 594 | 341 | 212 | 140 | 1888 | 1.03 | 2.91 |
| | 5/16 | 7.7 | 2046 | 1147 | 726 | 417 | 260 | 172 | 2310 | 1.26 | 3.56 |
| | 5 x 3 1/2 x 5/16 | 8.7 | 3153 | 1770 | 1130 | 779 | 487 | 324 | 3557 | 1.94 | 6.60 |
| | 3/8 | 10.4 | 3721 | 2089 | 1333 | 918 | 574 | 381 | 4198 | 2.29 | 7.78 |
| | 6 x 3 1/2 x 3/8 | 11.7 | 5268 | 2958 | 1889 | 1308 | 958 | 638 | 5940 | 3.24 | 12.90 |

[1] Allowable loads to the left of the heavy line are governed by moment, and to the right by deflection.

[2] $F_b$ = 22,000 psi (150 MPa)

[3] Maximum deflection limited to L/600

[4] Lateral support is assumed in all cases.

[5] For angles laterally unsupported, allowable load must be reduced.

[6] For angles subjected to torsion, make special investigation.

**TABLE 2**

**Allowable Compressive Stresses (psi) in Masonry** [1]

| Type of Wall | Type of Mortar | | | |
|---|---|---|---|---|
| | M | S | N | O |
| Solid walls of brick or solid units of clay when average compressive strength of unit is as follows: | | | | |
| 8000 plus psi | 400 | 350 | 300 | 200 |
| 4500 to 8000 psi | 250 | 225 | 200 | 150 |
| 2500 to 4500 psi | 175 | 160 | 140 | 110 |
| 1500 to 2500 psi | 125 | 115 | 100 | 75 |
| Grouted solid masonry of brick and other solid units of clay | | | | |
| 4500 plus psi | 350 | 275 | 200 | - |
| 2500 to 4500 psi | 275 | 215 | 155 | - |
| 1500 to 2500 psi | 225 | 175 | 125 | - |
| Masonry of hollow units | 85 | 75 | 70 | - |

1 Adapted from "American Standard Building Code Requirements for Masonry," National Bureau of Standards, ANSI A41. 1-1953 (R 1970).

**TABLE 3**

**End Reaction[1] and Required Length of Bearing[2] for Structural Angle Lintels**

| 2 1/2" Leg Horizontal | | | | |
|---|---|---|---|---|
| $f_m$ | Length of Bearing | | | |
| psi | 3 | 4 | 5 | 6 |
| 400 | 3000 | 4000 | 5000 | 6000 |
| 350 | 2625 | 3500 | 4375 | 5250 |
| 300 | 2250 | 3000 | 3750 | 4500 |
| 275 | 2063 | 2750 | 3438 | 4125 |
| 250 | 1875 | 2500 | 3125 | 3750 |
| 225 | 1688 | 2250 | 2813 | 3375 |
| 215 | 1613 | 2150 | 2688 | 3225 |
| 200 | 1500 | 2000 | 2500 | 3000 |
| 175 | 1313 | 1750 | 2188 | 2625 |
| 160 | 1200 | 1600 | 2000 | 2400 |
| 155 | 1163 | 1550 | 1938 | 2325 |
| 150 | 1125 | 1500 | 1875 | 2250 |
| 140 | 1050 | 1400 | 1750 | 2100 |
| 125 | 938 | 1250 | 1563 | 1875 |
| 115 | 863 | 1150 | 1438 | 1725 |
| 110 | 825 | 1100 | 1375 | 1650 |
| 100 | 750 | 1000 | 1250 | 1500 |
| 85 | 638 | 850 | 1063 | 1275 |
| 75 | 563 | 750 | 938 | 1125 |
| 70 | 525 | 700 | 875 | 1050 |

| 31/2" Leg Horizontal | | | | |
|---|---|---|---|---|
| $f_m$ | Length of Bearing | | | |
| psi | 3 | 4 | 5 | 6 |
| 400 | 4200 | 5600 | 7000 | 8400 |
| 350 | 3675 | 4900 | 6125 | 7350 |
| 300 | 3150 | 4200 | 5250 | 6300 |
| 275 | 2888 | 3850 | 4813 | 5775 |
| 250 | 2625 | 3500 | 4375 | 5250 |
| 225 | 2363 | 3150 | 3938 | 4725 |
| 215 | 2258 | 3010 | 3763 | 4515 |
| 200 | 2100 | 2800 | 3500 | 4200 |
| 175 | 1838 | 2450 | 3063 | 3675 |
| 160 | 1680 | 2240 | 2800 | 3360 |
| 155 | 1628 | 2170 | 2713 | 3255 |
| 150 | 1575 | 2100 | 2625 | 3150 |
| 140 | 1470 | 1960 | 2450 | 2940 |
| 125 | 1313 | 1750 | 2188 | 2625 |
| 115 | 1208 | 1610 | 2013 | 2415 |
| 110 | 1155 | 1540 | 1925 | 2310 |
| 100 | 1050 | 1400 | 1750 | 2100 |
| 85 | 893 | 1190 | 1488 | 1785 |
| 75 | 788 | 1050 | 1313 | 1575 |
| 70 | 735 | 980 | 1225 | 1470 |

[1] End Reaction in lbs.

[2] Length of Bearing in inches.

## REFERENCES


1. *AISC, Manual of Steel Construction*, American Institute of Steel Construction, Inc., New York, New York, Eighth Edition, 1980.
2. AISC, *Specification for the Design, Fabrication and Erection of Structural Steel for Buildings*, American Institute of Steel Construction, Inc., New York, New York, 1978.
3. ANSI, *American Standard Building Code Requirements for Masonry*, ANSI A41.1-1953 (R 1970), American National Standards Institute, New York, New York.
4. BIA, *Building Code Requirements for Engineered Brick Masonry*, Brick Institute of America, McLean, Virginia, 1969.

THE BRICK INDUSTRY ASSOCIATION
TECHNICAL NOTES on Brick Construction
1850 Centennial Park Drive, Reston, Virginia 20191 | www.gobrick.com | 703-620-0010
46
December 2005

# Maintenance of Brick Masonry

**Abstract:** Even though one of the major advantages of brick masonry construction is durability, periodic inspections and maintenance can extend the life of brickwork in structures. This *Technical Note* discusses the benefits and elements of suggested inspection programs and describes specific maintenance procedures including replacement of sealant joints, grouting of mortar joint faces, repointing of mortar joints, removal of plant growth, repair of weeps, replacement of brick, installation of a dampproof course, installation of flashing in existing walls and replacement of wall ties.

**Key Words:** anchors, cleaning, dampproof course, efflorescence, flashing, inspection, maintenance, moisture penetration, mortar, repointing, sealant, ties, weeps.

## SUMMARY OF RECOMMENDATIONS:

- Perform periodic inspections, preferably each season
- Determine moisture source before attempting repairs to correct moisture penetration
- Remove and replace torn, deteriorated or inelastic sealants
- When repairing mortar joints, surface grout hairline cracks and repoint damaged or deteriorating mortar joints
- Repoint with prehydrated Type N, O or K mortar, mixed drier than for conventional masonry work
- Remove ivy and plant growth that contributes to moisture penetration or deterioration of brickwork
- Exercise care in opening existing or drilling new weeps, to ensure that flashing is not damaged
- Install a dampproof course if missing or required
- Install remedial anchors and ties in accordance with manufacturer's recommendations
- Inspect masonry and correct all deficiencies before application of external coatings

## INTRODUCTION

This *Technical Note* discusses maintenance of brick masonry with an emphasis on preventing moisture penetration. All buildings are unique and may experience different problems. A given solution may not remedy similar problems on all buildings. It is therefore suggested that a repair method which will effectively suit the particular needs of a building be selected when a problem occurs.

Generally, if brickwork is properly designed, detailed and constructed, it is very durable and requires little maintenance. However, many of the other components incorporated in the brickwork such as caps, copings, sills, lintels and sealant joints may require periodic inspection and repair. Neglecting maintenance of these components may lead to deterioration of other elements in the wall.

Maintenance of buildings may be broken into two general categories: 1) general inspection to identify potential problems with the performance of exterior walls; and 2) specific maintenance to correct problems which may develop. This *Technical Note* addresses both general and specific maintenance procedures. A checklist is provided for general inspections and specific repair techniques are described.

## GENERAL INSPECTION

A thorough inspection and maintenance program may help extend the life of a building. It is a good idea to become familiar with the materials used in a building and how they perform over a given time period. Table 1 lists various building materials and the estimated time before repair may be needed, given normal exposure. These times are based on brickwork in vertical applications, constructed of proper materials and workmanship and exposed to normal weathering conditions in the United States. Sills, parapets, chimneys and copings which experience more severe exposures may require repairs at shorter intervals.

Periodic inspections should be performed to determine

**TABLE 1**
**Estimated Time to Repair of Materials**

| Material | Use | Estimated Time to Repair (Years) |
|---|---|---|
| Brick | Walls | 100+ |
| Sealant | Joints | 5-20 |
| Metal | Coping/Flashing | 20-75 |
| Metal | Anchors & Ties | 15+ |
| Mortar | Walls | 25+ |
| Plastic | Flashing | 5-25 |
| **Finishes** | | |
| Paint | Appearance | 3-5 |
| Water Repellents | Dampproofing | 5-10 |
| Stucco | Appearance | 5-10 |

the condition of the various materials used on a building. These inspections can be performed monthly, yearly, biennially, or any time period deemed appropriate. “Seasonal” inspection periods are recommended so that the behavior of building materials in various weather conditions can be noted. Inspection records, including conditions and comments, should be kept to identify changes in materials, potential problems and needed repair. Table 2 is a suggested checklist of conditions that may require maintenance or repair. It is not all-inclusive; however, it may establish a guideline for use during inspections.

Conditions that may necessitate maintenance or repair actions include efflorescence, spalling, deteriorating mortar joints, interior moisture damage and mold. Once one or more of these conditions becomes evident, the origin of the problem should be determined and action taken to correct both the cause and visible effect of the condition. Table 3 lists various conditions affecting brickwork and their most probable sources. The items checked in the table represent each source that should be considered when such conditions are observed in brick masonry.

**TABLE 2**

**Brick Masonry Inspection Checklist**

| LOCATION | | ITEM OR CONDITION | BUILDING ELEVATION | | | |
|---|---|---|---|---|---|---|
| | | | NORTH | SOUTH | EAST | WEST |
| Above Grade | Masonry | Cracked Units | | | | |
| | | Loose Units | | | | |
| | | Spalled Units | | | | |
| | | Hairline Cracks in Mortar | | | | |
| | | Deteriorated Mortar Joints | | | | |
| | | Missing or Clogged Weeps | | | | |
| | | Plant Growth | | | | |
| | | Deteriorated/Torn Sealants | | | | |
| | | Out-of-Plumb | | | | |
| | | Efflorescence | | | | |
| | | Stains | | | | |
| | | Water Penetration | | | | |
| | Flashing/ Counter-flashing | Damaged | | | | |
| | | Open Lap Joints | | | | |
| | | Missing | | | | |
| | | Stains | | | | |
| | Caps/ Copings/ Sills | Inadequate Slope | | | | |
| | | Cracked Units | | | | |
| | | Hairline Cracks in Mortar | | | | |
| | | Loose Joints | | | | |
| | | Open Joints | | | | |
| | | Out-of-Plumb | | | | |
| | | Drips Needed | | | | |
| Below Grade | Foundation Walls | Deteriorated Mortar Joints | | | | |
| | | Cracks | | | | |
| | | Separation from Flooring | | | | |
| | | Inadequate Drainage | | | | |
| | | Water Penetration | | | | |
| | Retaining Walls | Spalled Units | | | | |
| | | Deteriorated Mortar Joints | | | | |
| | | Cracks | | | | |
| | | Out-of-Plumb | | | | |
| | | Dampness | | | | |
| | | Inadequate Drainage | | | | |
| | Other Elements | Roof Overhangs | | | | |
| | | Gutters/Leaders | | | | |
| | | Seal at Adjacent Materials | | | | |
| | | Grade/Drainage | | | | |

# SPECIFIC MAINTENANCE

After investigating all of the possible contributors the actual cause(s) of distress conditions may be determined through the process of elimination. Often the source will be self-evident as with deteriorated and missing materials; however, in instances such as improper flashing or differential movement the source may be hidden and determined only through building diagnostics. In any case, it is suggested to first visually inspect for the self-evident source before performing a more extensive investigation as it may save time and money in detecting the cause. Such a process should always be followed if the condition involves water penetration. Once the source is determined, measures can be taken to effectively remedy the moisture penetration source and its effects on the brickwork.

**TABLE 3**

**Possible Sources and Effects of Masonry Distress**

| Observed Condition \ Potential Cause of Condition | Incompletely Filled Mortar Joints See *Technical Note* 7B | Missing/Clogged Weeps | Plant Growth | Deteriorated/Torn Sealants | Capillary Rise | Missing/Damaged Flashing See *Technical Notes* 7 Series | Differential Movement See *Technical Notes* 18 Series | Previous Acid Cleaning See *Technical Note* 20 | Previous Sandblasting See *Technical Note* 20 |
|---|---|---|---|---|---|---|---|---|---|
| Cracked Units | ■ | | ■ | | | | ■ | | |
| Spalled Units | ■ | ■ | | ■ | ■ | ■ | ■ | | |
| Deteriorated Mortar | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ |
| Mildew/Algae Growth | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| Efflorescence See TN 23 Series | ■ | ■ | | ■ | ■ | ■ | | ■ | |
| Moisture Related Stains | ■ | ■ | | ■ | ■ | ■ | | | |
| Corrosion of Backing Materials | ■ | ■ | | ■ | ■ | ■ | | ■ | |
| Damaged Interior Finshes | ■ | ■ | | ■ | ■ | ■ | ■ | | |

## Removing Efflorescence

Generally, efflorescence is water-soluble and easily removed by natural weathering or by scrubbing with a brush and water. Proprietary cleaners formulated specifically for use on brickwork are effective in removing stubborn efflorescence (see *Technical Note* 20).

Use solutions specifically manufactured to remove efflorescence from brickwork. Improper acid cleaning procedures such as insufficient prewetting, rinsing and strong acid concentrations may cause additional staining, etched mortar joints and increase moisture penetration in brickwork. Stains caused by improper cleaning are not water-soluble, but can be removed by proprietary cleaners.

All cleaning procedures should first be tried at different concentrations in an inconspicuous area to judge their effectiveness and potential harm to the brickwork. Additional recommendations and cleaning methods for brick masonry are presented in *Technical Note* 20. After cleaning, the mortar joints should be inspected. Repointing or grouting of the joints, as discussed later in this *Technical Note*, may be necessary.

## Sealant Replacement

Missing or deteriorated sealants in and between brickwork and other materials such as windows, door frames and expansion joints may be a source of moisture penetration. The sealant joints in these areas should be inspected closely to discover areas where the sealant is missing, or was installed but has deteriorated, torn or lost elasticity. Deteriorated sealants should be carefully cut out and the opening cleaned of all existing sealant material. The clean joint should then be properly primed and filled with a backer rod (bond breaker tape if the joint is too small to accommodate a backer rod) and a full bead of high-quality, elastic sealant compatible with adjacent materials.

## Mortar Joint Repair

Repair of cracked or deteriorating mortar joints is very effective in reducing the amount of water that enters exterior masonry. Cracks in brickwork that are more than a few millimeters in width or that are suspected to have been caused by settlement or other structural problems (for example, cracks that continue through multiple brick units and mortar joints, or follow a stepped or diagonal pattern along mortar joint) are beyond the scope of this *Technical Note*. These cracks often require professional investigation to determine the cause and appropriate method of repair.

**Grouting of Hairline Cracks.** If the mortar joints develop small “hairline” cracks, surface grouting may be an effective measure to fill them. The impact of surface grouting on brickwork aesthetics should be considered before work begins as the appearance of the mortar joints will change somewhat. A recommended grout mixture is 1 part portland cement, $^1/_3$ part hydrated lime and $1^1/_3$ parts fine sand (passing a No. 30 sieve). The joints to be grouted should be dampened. To ensure good bond, the brickwork must absorb all surface water. Clean water is added to the dry ingredients to obtain a fluid consistency. The grout mixture should be applied to the joints with a stiff fiber brush to force the grout into the cracks. Two coats are usually required to effectively reduce moisture penetration. Tooling the joints after the grout application may help compact and force the grout into the cracks. The use of a template or masking tape may be effective in keeping the brick faces clean.

**Repointing Mortar Joints.** Moisture may penetrate mortar which has softened, deteriorated or developed visible

cracks, as shown in Photo 1. When this is the case, repointing (sometimes referred to as tuckpointing) may be necessary to reduce moisture penetration. Repointing is the process of removing damaged or deteriorated mortar to a uniform depth and placing new mortar in the joint, as shown in Photo 2 and Figure 1.

Prior to undertaking a repointing project, the following should be considered: 1) The potential for power tools to damage the brick surrounding the mortar being cut out. 2) Repointing operations should only be performed by qualified and experienced repointing craftsmen. An individual who is an excellent mason may not be a good repointing craftsman. Skills should be tested and evaluated prior to the selection of the contractor or craftsman. 3) When repointing for historic preservation purposes, refer to *Preservation Brief 2: Repointing Mortar Joints in Historic Masonry Buildings.* [Ref. 7]

The deteriorated mortar should be removed, by means of a toothing chisel or a special pointer's grinder, to a uniform depth (refer to Figure 1b) that is twice the joint width or until sound mortar is reached. Care must be taken not to damage the brick edges. Remove all dust and debris from the joint by brushing, blowing with air or rinsing with water.

Repointing mortar should be carefully selected and properly proportioned. For best results, the original mortar constituents and proportions should be duplicated. If this is not possible, select a mortar that is similar or lower in compressive strength. Type N, O and K mortar are generally recommended, as mortars with higher cement contents may be too strong for proper performance. Proper proportions for Type K mortars are 1 part portland cement, 4 parts hydrated lime and 11¼ to 15 parts fine sand. Refer to *Technical Note* 8 for material proportions of Type N and O mortar.

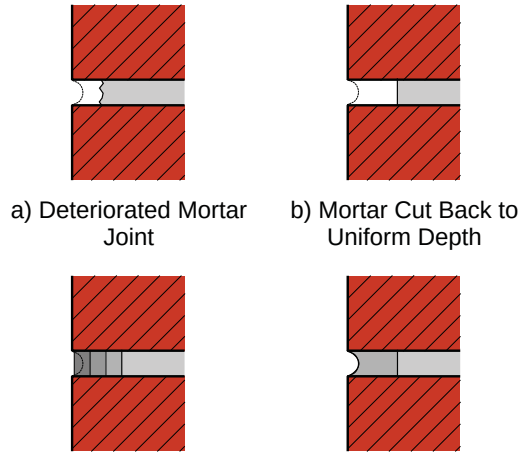
The repointing mortar should be prehydrated to reduce excessive shrinkage. The proper prehydration process is as follows: All dry ingredients should be thoroughly mixed. Only enough clean water should be added to the dry mix to produce a damp consistency which will retain its shape when formed into a ball. The mortar should be mixed to this dampened condition 1 to 1½ hr before adding water for placement.

The joints to be repointed should be dampened, but to ensure a good bond, the brickwork must absorb all surface water before repointing mortar is placed. Water should be added to the prehydrated mortar to bring it to a workable consistency (somewhat drier than conventional mortar). The mortar should be packed tightly into the joints in thin layers (¼ in. [6.4 mm] maximum), as shown in Figure 1c. The joints should be tooled to match the original profile after the last layer of mortar is "thumbprint" hard, as in Figure 1d. As it may be difficult to determine which joints allow moisture to penetrate, it is advisable to repoint all mortar joints in the affected wall area.

If only portions of the wall area are repointed, the repointing mortar should match the color of the existing mortar. Mortar materials should be mixed and the color matched to existing mortar that has been wetted. Several mix proportions can be made and placed on extra brick. Selection is made after the mortar specimens

**Photo 1**
**Mortar Joints in Need of Repointing**

**Photo 2**
**Repointing Mortar Joints**



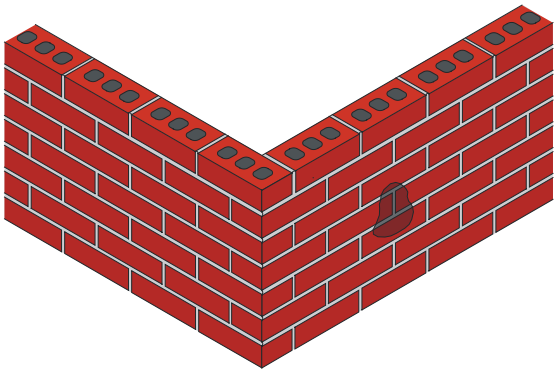
a) Deteriorated Mortar Joint

b) Mortar Cut Back to Uniform Depth

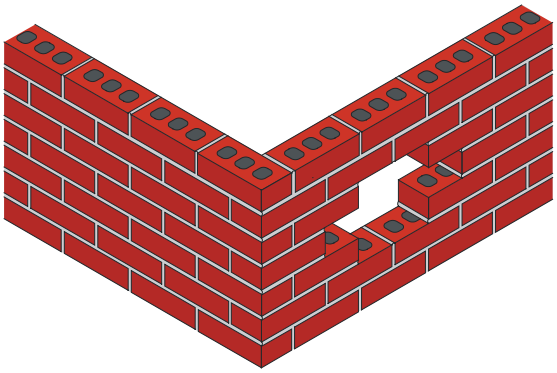
c) Pack Pointing Mortar in Thin Layers

d) Tool Joint to Match Original Profile

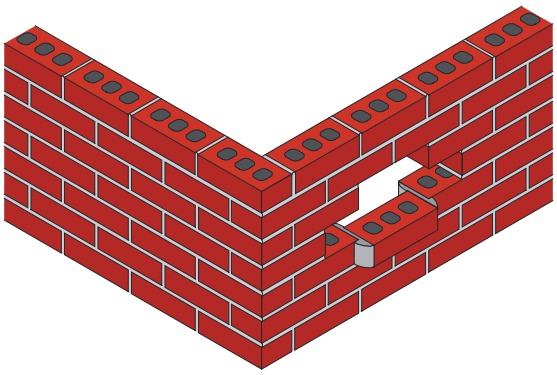
**Figure 1**
**Repointing Mortar Joints**



a) Damaged Brick



b) Remove Brick and Mortar



c) Butter Replacement Brick and Carefully Shove into Place

**Figure 2**
**Replacement of Deteriorated Brick**

are dried and compared to dry existing mortar.

## Plant Removal

Certain types of plant growth may contribute to moisture penetration. For example, ivy shoots, sometimes referred to as "suckers", penetrate voids in mortar and may conduct moisture into these voids. If this is the case, ivy removal may be necessary.

To effectively remove ivy and similar plants, the vines should be carefully cut away from the wall. The vines should never be pulled from the wall as this could damage the brickwork. After cutting, the shoots will remain. These suckers should be left in the wall until they dry up and shrivel. This usually takes 2 to 3 weeks. Care should be taken not to allow the suckers to rot as this could make them difficult to remove. Once the shoots dry, the wall should be dampened and scrubbed with a stiff fiber brush and water. Laundry detergent or weed killer may be added to the water in small concentrations to aid in the removal of the shoots. If these additives are used, the wall must be thoroughly rinsed with clean water before and after scrubbing.

To determine how the wall will appear once the ivy is removed, it is suggested that a small portion of the ivy (5-10 ft² [0.5 to 1.0 m²]) be removed from an inconspicuous area first. Repointing of the mortar joints may be necessary if the mortar has cracked or deteriorated.

## Opening Weeps

Weeps should be inspected to ensure that they are open and appropriately spaced so that moisture within the walls is able to escape to the exterior. If weeps are clogged, they can be cleaned out by probing with a thin dowel or stiff wire. If the weeps were not properly spaced, drilling new weeps may be necessary. *Technical Note* 7 outlines suggested types and spacing of weeps.

Since weeps are placed directly above flashing, care must be exercised to not damage the flashing when probing or drilling. The use of a stopper to limit the depth of penetration of the probe or drill bit may be effective in reducing the possibility of damaging the flashing where it turns up inside of the brick wythe.

## Replacement of Brick

Moisture may penetrate brick that are broken or heavily spalled. When this occurs, it may be necessary to replace the affected units. The procedure shown in Figure 2 is suggested for removing and replacing brick.

The mortar that surrounds the affected units should be cut out carefully to avoid damaging adjacent brickwork, as shown in Figure 2b. For ease of removal, the brick to be removed can be broken. Once the units are removed, all of the surrounding mortar should be carefully chiseled out, and all dust and debris should be swept out with a brush. If the units are located in the exterior wythe of a drainage wall, care must be exercised to prevent debris from falling into the air space, which could block weeps and interfere with moisture drainage.

The brick surfaces in the wall should be dampened before new units are placed, but the masonry should absorb all surface moisture to ensure a good bond. The appropriate surfaces of the surrounding brickwork and the

replacement brick should be buttered with mortar. The replacement brick should be centered in the opening and pressed into position, refer to Figure 2c. The excess mortar should be removed with a trowel. Pointing around the replacement brick will help to ensure full head and bed joints. When the mortar becomes “thumbprint” hard, the joints should be tooled to match the original profile.

Mortar proportions are selected as discussed in the section on Repointing. Matching the existing mortar color is important to keep the replacement location from being different in appearance. Similarly, replacement brick must match the color, texture and size of the existing brick. Locating a matching brick may take considerable effort.

## Installation of a Dampproof Course

Moisture may migrate upward through brickwork by capillary action. This condition appears as a rising water line or “tide mark” on the wall and is referred to as “rising damp”.

Model building codes require the use of a dampproofing material on below grade masonry walls and flashing above grade. If these are omitted or improperly installed, rising damp may occur. The insertion of a dampproof course at a level above the ground, but below the first floor, may stop the rising moisture. The installation procedure can take one of two forms. One form is the injection of a synthetic chemical that forms a continuous dampproof barrier into an existing brick course. Holes are drilled into the course of brick and the synthetic material is injected. The other form of installation is the insertion of flashing through the brick wythe. One or more brick courses are removed, flashing is inserted, and the brick is replaced. Recommendations for brick removal and replacement are discussed in the following section.

## Installation of Flashing

Flashing that has been omitted, damaged or improperly installed may permit moisture to penetrate to the building interior. If this is the case, a difficult procedure of removing brick, installing flashing and replacing the units may be required.

To install continuous flashing in existing walls, alternate sections of masonry in 2 to 5 ft (610 mm to 1.52 m) lengths should be removed. The flashing is installed in these sections and the masonry replaced, refer to Photo 3. Alternately, temporary braces can be installed as longer sections of brickwork are removed, as shown in Photo 4. The flashing can then be placed in these sections. The lengths of flashing should be lapped a minimum of 6 in. (152 mm) and be completely sealed to function properly. See *Technical Note* 7 for other flashing installation recommendations. The opening is then filled as discussed under Replacement of Brick. The replaced masonry should be properly cured (5 to 7 days) before the intermediate masonry sections or supports are removed.

**Photo 3**
**Flashing Installed in Alternating Sections**

**Photo 4**
**Flashing Installation Using Temporary Support**

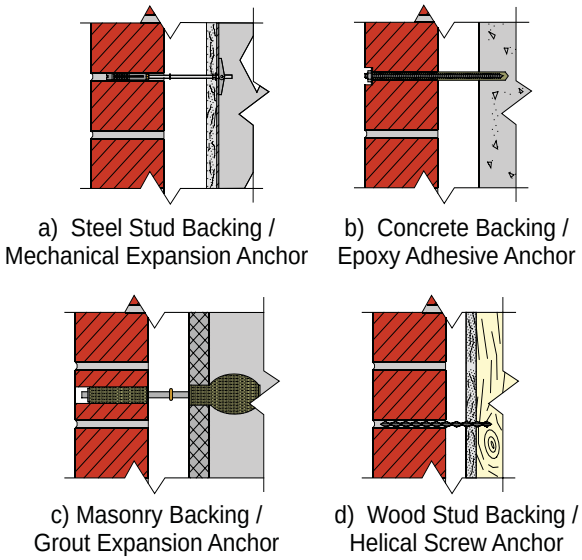



**Figure 3**
**Masonry Re-Anchoring Systems**

## Installation of Wall Ties and Anchors

In instances where masonry walls have been constructed without a sufficient number of connectors or the existing connectors have failed, "retrofit" anchors may be used to attach the wythes or veneer and transfer lateral loads. Installing anchors in such a wall improves its strength and reduces the potential for cracking. Installation of most retrofit anchors involves drilling small holes in the masonry, usually in a mortar joint, through which the anchors are attached to the substrate. Generally, mechanical expansion, helical screws, grout- or epoxy-adhesive systems, shown in Figure 3, are used to make the connection. Because the installation methods and limitations of each product are unique, consultation with the manufacturer is essential to assure proper application, detailing, installation, inspection, and performance.

## Coatings and Water Repellents

The use of external coatings on brick masonry should be considered only after completing repair and replacement of brick, mortar joints and other building elements, and careful consideration of the possible consequences. Properly designed and constructed brickwork can be expected to satisfactorily resist water penetration without the application of water repellents or external coatings. However, they may be used successfully to correct some deficiencies. For example, some coatings are helpful in reducing the amount of water absorbed by barrier walls and masonry subject to extreme exposures such as chimneys, parapets, copings and sills.

External coatings are most effective in reducing water penetration when their intended use corresponds with the nature of the existing water penetration problem. Water repellents and coatings should not be considered equivalent to essential, code-required details that resist water penetration. Use of coatings for reasons outside their intended application rarely reduces water penetration and may lead to more serious problems.

Only water repellents that permit evaporation and the passage of water vapor, such as siloxanes and silanes, should be used on exterior brickwork. Film-forming coating should not be applied to exterior brickwork. *Technical Notes* 6 and 6A and manufacturer's literature should be consulted before any coating is applied to brickwork.

## SUMMARY

This *Technical Note* has presented maintenance procedures for brick masonry. Routine inspection of the building is suggested to determine the condition of the brickwork and related materials. If distress is noted, appropriate maintenance tasks should be performed. If the problem is moisture related, the source of moisture should be determined and corrected before other repairs are initiated.

> *The information and suggestions contained in this* Technical Note *are based on the available data and the combined experience of engineering staff and members of the Brick Industry Association. The information contained herein must be used in conjunction with good technical judgment and a basic understanding of the properties of brick masonry. Final decisions on the use of the information contained in this* Technical Note *are not within the purview of the Brick Industry Association and must rest with the project architect, engineer and owner.*

## REFERENCES


1. *Brick Brief*, "Ivy on Brickwork", Brick Industry Association, Reston, VA, July 2005.
2. *Brick Brief*, "Repointing (Tuck-Pointing) Brick Masonry", Brick Industry Association, Reston, VA, July 2005.
3. Grimmer, Anne E., "A Glossary of Historic Masonry Deterioration Problems and Preservation Treatments", Department of the Interior, National Park Service, Preservation Assistance Division, Washington, D.C., 1984.
4. Higgins, L.R., *Maintenance Engineering Handbook*, Fifth Edition, McGraw-Hill Publishing Company, New York, NY, 1995.
5. Kreh, Richard T., Sr., *Masonry Skills*, Fifth Edition, Delmar Learning, Clifton Park, NY, 2003.
6. *Old House Journal*, No. 5, Vol. XIII, Brooklyn, NY, June 1985.
7. *Preservation Briefs No. 2*, "Repointing Mortar Joints in Historic Masonry Buildings", Heritage Preservation Services, U.S. Department of the Interior, Washington, D.C., October 1998.

# Cold Weather Masonry Construction

## Introduction

As cold weather arrives, builders must take precautions when doing masonry construction. By changing procedures, equipment, or supplies, mason contractors can avoid seasonal delays associated with cold weather. This permits better utilization of a mason contractor's resources, particularly manpower. Successful masonry construction can proceed despite cold temperatures by following an effective cold weather construction program.

The *Specification for Masonry Structures* (ACI 530.1-08/ASCE 6-08/TMS 602-08) contains minimum requirements for cold weather masonry construction. When ambient temperature falls below 40°F (4.4°C), cold weather construction applies. As the temperature of mortar materials falls below normal:

- water requirement to reach a given consistency is reduced
- a given amount of air-entraining agent yields more entrained air
- initial and final set of the mortar are significantly delayed
- heat-liberating reaction rates between portland cement and water are substantially reduced, becoming minimal as mortar temperature drops below 40°F (4.4°C)
- strength gain rates are reduced

**Figure 1. Masonry construction can proceed through winter months if an effective cold weather construction program is adopted. *(IMG12504)***

Cold masonry units lower the temperature of mortar placed in contact with those units. Not only does this slow reaction rates between cement and water and reduce strength gain rates, it delays tooling and setting times. If the units are cold enough, the temperature of the mortar may drop below freezing and result in disruptive expansion of the mortar as water in the mortar freezes. Wet or ice-covered unit surfaces prevent development of good bond between mortar and unit.

**Figure 2. Masonry materials stored at the project need to be protected from rain, snow, and ice. *(IMG12505)***

In addition to affecting the performance of masonry materials, cold weather may also affect the productivity and workmanship of masons. During cold weather, masons must first ensure their personal comfort and safety, then attend to normal construction tasks and any additional materials preparation, handling, and protection of masonry. These extra activities consume more time as temperatures continue to drop.

The goal of a cold weather construction plan is to eliminate or minimize the undesirable effects of cold temperatures on materials and people in a cost-effective manner. The mason contractor must evaluate the effectiveness and practicality of techniques in the context of specific project and weather conditions encountered. Depending on the severity of weather, one or more of the following strategies can be considered:

- optimize the selection of masonry materials for cold weather performance
- protect materials
- heat materials
- protect or enclose work areas
- heat work areas and in-place work

## Masonry Materials

**Selection.** Masonry units are typically selected on the basis of aesthetic or structural properties rather than consideration of performance in cold weather construction. Mortar type is also generally determined by structural or other performance criteria. However, knowledge of how mortar and unit properties interact in cold weather enables the mason contractor to modify construction procedures to accommodate the specified materials.

The initial water content of mortar required for workability is in the range of 11% to 16%. Mortar used to lay units stiffens as mixing water contained in the mortar is absorbed by units, evaporates, or reacts with the portland cement in the mortar. To avoid disruptive expansion upon freezing, water content of mortar needs to be below 6%. Units having high initial rates of absorption (suction) will accelerate stiffening by drawing water from the mortar. Low absorption or wet units remove very little water from the mortar.

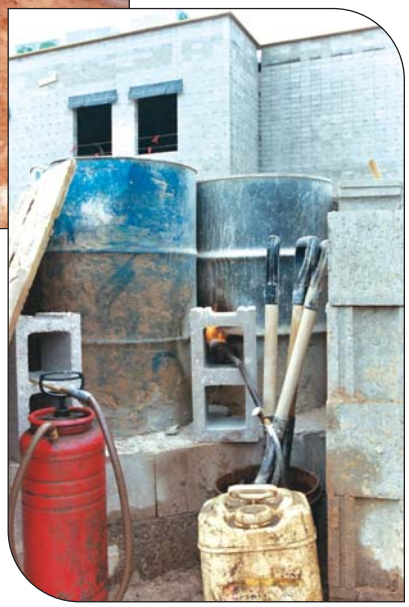
Likewise, the water-retentive properties of mortar affect its rate of moisture loss and stiffening. Mortars having high lime content or fine sands tend to have higher water demands and higher water retentivity than higher strength mortars or mortars made using well-graded sands. Although air entrainment increases water retentivity, it also reduces initial water demand required to achieve a workable consistency and has been shown to reduce susceptibility of mortar to damage by early freezing.

The rate at which portland cement reacts with water is primarily influenced by the temperature of the mortar or grout. The use of higher fineness cements (such as ASTM C 150 Type III) or accelerators increases reaction rates. *These materials can be used in mortar to augment, but not substitute for, other cold weather construction practices.*

Accelerators are sometimes mistakenly called "antifreeze" admixtures. Their function is not to reduce the freezing point of mortar, but to increase the rates of early-age strength development. Thus, they don't eliminate the need to protect mortar from freezing, but may limit the amount of time that protection is required. Calcium chloride (at a limit of 2% by mass of cement) is commonly used in concrete as an accelerator, but its use in mortar is prohibited by the *Specification for Masonry Structures* because it contributes to corrosion of embedded metal such as wall ties, anchors, and joint reinforcement. Only non-chloride based accelerators, as verified by the admixture manufacturer, should be allowed.

ASTM C 270 indicates that admixtures are not to be used unless specified. Therefore, unless project specifications call for the use of an accelerator, the mason must request permission from the specifier in order to use one.

**Protection, Storage, and Heating**. All masonry materials should be protected from rain, snow, and ice. Masonry units and packaged mortar materials should be securely wrapped with canvas or polyethylene tarpaulins and stored above the reach of moisture migrating from the ground. Sand piles should also be covered and care taken to avoid contamination of the sand with mud and clay.

**Figures 3a and 3b. Sand can be heated over fire in a pipe, and water can be heated in metal drums. *(IMG12506, IMG12507)***

Masonry materials may need to be heated prior to use to assure cement hydration in mortar. At temperatures of less than 40°F (4.4°C), cement hydration necessary for strength development is minimal. At temperatures of 120°F (48.9°C) or higher, flash set is imminent. When mixed, the mortar should be in the range of 40°F to 120°F (4.4°C to 48.9°C) and kept above freezing until used in masonry. If ambient temperatures are falling below freezing, a minimum grout temperature of 70°F (21.1°C) is recommended at the time of grout placement.

**Figure 4. A temporary shelter protects the mortar preparation area from rain and snow. *(IMG24817)***

Water can be heated in barrels or tubs. It is the easiest material to heat and it can store much more heat (per unit mass) than the other materials used in mortar. Although recommendations vary as to the highest temperature to which water should be heated, the *Specification for Masonry Structures* places a maximum of 140°F (60°C) because higher temperatures pose a safety hazard and could result in flash set. To avoid flash set, heated water should be combined with cold sand in the mixer before adding cement.

Sand is typically delivered to the project and used in a damp loose condition. Even though sand piles are covered, it may be necessary to heat sand to thaw frozen lumps when temperatures fall below freezing. Generally, sand is heated to about 50°F (10°C), although higher temperatures are permissible as long as the sand is not scorched and as long as resultant mortar or grout temperatures do not exceed 120°F (48.9°C). Sand piles can be heated with electric heating pads, by placing sand over a heated pipe, or by using steam heating systems.

Masonry units should not have any visible ice on bedding surfaces when used, nor should the temperature of masonry units be less than 20°F (- 6.7°C) to avoid rapid lowering of mortar or grout temperatures. Better productivity is often attained by using units that have a minimum temperature of 40°F (4.4°C). Masonry units are usually heated on pallets in an enclosure or stored in a heated area. The units should be kept dry, although very high-absorption fired-clay brick may need to be wetted, but not saturated, prior to use.

## Table 1. Cold Weather Construction Requirements

| **Ambient temperature** | **Cold weather procedures for work in progress** |
|---|---|
| Above 40°F (4.4°C) | No special requirements. |
| Below 40°F (4.4°C) | Do not lay glass unit masonry. |
| 32°F to 40°F (0°C to 4.4°C) | Heat sand or mixing water to produce mortar temperature between 40°F and 120°F (4.4°C and 48.9°C) at the time of mixing.<br>Heat materials for grout only if they are below 32°F (0°C). |
| 25°F to 32°F (-3.9°C to 0°C) | Heat sand or mixing water to produce mortar temperature between 40°F and 120°F (4.4°C and 48.9°C) at the time of mixing. Keep mortar above freezing until used in masonry.<br>Heat materials to produce grout temperature between 70°F and 120°F (21.1°C and 48.9°C) at the time of mixing. Keep grout temperature above 70°F (21.1°C) at the time of placement. |
| 20°F to 25°F (-6.7°C to -3.9°C) | In addition to requirements for 25°F to 32°F (-3.9°C to 0°C), heat masonry surfaces under construction to 40°F (4.4°C) and use wind breaks or enclosures when the wind velocity exceeds 15 mph (24 km/h).<br>Heat masonry to a minimum of 40°F (4.4°C) prior to grouting. |
| 20°F (-6.7°C) and below | In addition to all of the above requirements, provide an enclosure and auxiliary heat to keep air temperature above 32°F (0°C) within the enclosure. |
| **Ambient temperature (minimum for grouted; mean daily for ungrouted)** | **Cold weather procedures for newly completed masonry** |
| Above 40°F (4.4°C) | No special requirements, except for the following:<br>Maintain glass unit masonry above 40°F (4.4°C) for the first 48 hours after construction.<br>Maintain autoclaved aerated concrete (AAC) above 32°F (0°C) for the first 24 hours after thin-bed mortar application. |
| 25°F to 40°F (-3.9°C to 4.4°C) | Cover newly constructed masonry with a weather-resistive membrane for 24 hours after being completed. |
| 20°F to 25°F (-6.7°C to -3.9°C) | Cover newly constructed masonry with weather-resistive insulating blankets (or equal protection) for 24 hours after being completed.<br>Extend the time period to 48 hours for grouted masonry, unless the only cement used in the grout is ASTM C 150 Type III. |
| 20°F (-6.7°C) and below | Keep newly constructed masonry above 32°F (0°C) for at least 24 hours after being completed.<br>Use heated enclosures, electric heating blankets, infrared lamps, or other acceptable methods.<br>Extend the time period to 48 hours for grouted masonry, unless the only cement used in the grout is ASTM C 150 Type III. |

## Protecting Work Areas and Construction

**Figure 5. Enclosure and heating of a work area protects materials, workers, and installed masonry from severe weather. *(IMG12508)***

Wind breaks, heated wall coverings, and plain or heated enclosures are used to maintain adequate mortar temperatures and to improve the comfort and efficiency of masons and laborers. The level of protection required will depend on the severity of weather encountered. The *Specification for Masonry Structures* defines certain cold weather construction requirements as summarized in Table 1. It includes provisions needed during the work day while masonry is being laid, as well as protection requirements for newly constructed masonry. Several means of implementing these provisions are available to the mason contractor. Regional climatic differences and project-specific factors must be taken into account when selecting the most effective methods of protection for a given project. Basic principles required for satisfactory cold weather masonry construction described here and in the reference documents are well established. The use of innovative construction and protection techniques based on these established principles can improve the effectiveness and efficiency of a cold weather construction program.

## References


1. *All-Weather Concrete Masonry Construction*, NCMA TEK 3-1C, National Concrete Masonry Association, Herndon, Virginia, 2002.
2. *Cold and Hot Weather Construction*, BIA Technical Notes 1, Brick Industry Association, Reston, Virginia, June 2006.
3. *Concrete Masonry Handbook for Architects, Engineers, Builders*, Farny, J. A., Melander, J. M., and Panarese, W. C., EB008, Portland Cement Association, 2008, pages 128–137.
4. *Recommended Practices & Guide Specifications for Cold Weather Masonry Construction*, International Masonry Industry All Weather Council, Washington, D.C., twelfth printing, 1993. (Available from PCA as LT107.)
5. *Specification for Masonry Structures and Commentary (ACI 530.1-08/ASCE 6-08/ TMS 602-08)*, Masonry Standards Joint Committee, comprising the American Concrete Institute, Farmington Hills, Michigan, the Structural Engineering Institute of the American Society of Civil Engineers, Reston, Virginia, and The Masonry Society, Boulder, Colorado, 2008.
6. *Hot & Cold Weather Masonry Construction*, Masonry Industry Council, Lombard, Illinois, 1999. (Available from PCA as LT232.)


## Related Publications

Readers of this publication may also be interested in the following publications available for purchase from the Portland Cement Association. To order, write or call Customer Service, Portland Cement Association, 5420 Old Orchard Road, Skokie, Illinois 60077-1083, phone 847.966.6200 or 800.868.6733, fax 847.966.9666, or at www.cement.org.

*Concrete Masonry Handbook*, EB008
*Mortars for Masonry Walls*, IS040
*Masonry Cement Mortars*, IS181
*Trowel Tips: Efflorescence*, IS239
*Trowel Tips: Tuckpointing*, IS240
*Trowel Tips: Mortar Sand*, IS241
*Trowel Tips: Field Testing Mortar*, IS242
*Trowel Tips: Hot Weather Masonry Construction*, IS243
*Trowel Tips: Cleaning Masonry*, IS244
*Trowel Tips: Workmanship Part I, Preparing for Quality*, IS245
*Trowel Tips: Workmanship Part II, Imparting Quality to Masonry*, IS246
*Trowel Tips: Mortar Color*, IS247
*Recommended Practices for Laying Concrete Block*, PA043
*Recommended Practices & Guide Specifications for Cold Weather Masonry Construction*, LT107
*Hot & Cold Weather Masonry Construction*, LT232

WARNING: Contact with wet (unhardened) concrete, mortar, cement, or cement mixtures can cause SKIN IRRITATION, SEVERE CHEMICAL BURNS (THIRD DEGREE), or SERIOUS EYE DAMAGE. Frequent exposure may be associated with irritant and/or allergic contact dermatitis. Wear waterproof gloves, a long-sleeved shirt, full-length trousers, and proper eye protection when working with these materials. If you have to stand in wet concrete, use waterproof boots that are high enough to keep concrete from flowing into them. Wash wet concrete, mortar, cement, or cement mixtures from your skin immediately. Flush eyes with clean water immediately after contact. Indirect contact through clothing can be as serious as direct contact, so promptly rinse out wet concrete, mortar, cement, or cement mixtures from clothing. Seek immediate medical attention if you have persistent or severe discomfort.




**Portland Cement Association**
5420 Old Orchard Road
Skokie, Illinois 60077-1083
847.966.6200 Fax 847.966.9781

500 New Jersey Avenue NW, 7th Floor
Washington, DC 20001-2066
202.408.9494 Fax 202.408.0877
**www.cement.org**


An organization of cement companies to improve and extend the uses of portland cement and concrete through market development, engineering, research, education, and public affairs work.