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SECTION 011000 - SUMMARY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Project information.
   2. Work covered by Contract Documents.
   3. Contractor's use of site and premises.
   4. Coordination with occupants.
   5. Work restrictions.
   6. Specification and Drawing conventions.

B. Related Requirements:

   1. Section 015000 "Temporary Facilities and Controls" for limitations and procedures governing temporary use of Owner's facilities.
   2. Section 017300 "Execution" for coordination of Owner-installed products.

1.3 PROJECT INFORMATION

A. Project Identification: Spring Creek Masonry Repair and Door Replacement

B. Project Location: Spring Creek Elementary School
   5222 Spring Creek Road
   Rockford, Illinois 61107

C. Owner: Rockford School District #205.

D. Work Description: Examine exterior, masonry walls of schools. Repair masonry at areas indicated on drawings, including repointing mortar joints and repair, replacement, and re-anchoring of damaged masonry units. Other tasks as required to perform masonry repairs. Remove and replace select doors, hardware, and associated door frames. Repair of adjacent finishes. Other tasks as required to replace doors.

1.4 WORK RESTRICTIONS

A. Existing site conditions and restrictions:

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

B. Requirements for sequencing or scheduling:

1. Hours of access shall be as allowed by SD 205. Typically 6am to 5pm.
2. The Contractor and all Subcontractors shall notify the Owner's Representative prior to beginning work each day.
3. Protect existing work:
4. Protect existing building and surfaces to remain. Protect existing trees, shrubs, lawns, etc.
5. Repair damage to this contract work at no cost to Owner.
6. 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.
7. Warranty: Contractor is to guarantee all work for a minimum of one full year after final acceptance.
8. 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.

C. Smoking and Controlled Substance Restrictions: Use of tobacco products, alcoholic beverages, and other controlled substances on Owner's property is not permitted.

1.5 SPECIFICATION AND DRAWING CONVENTIONS

A. Specification Content: The Specifications use certain conventions for the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations. These conventions are as follows:

1. Imperative mood and streamlined language are generally used in the Specifications. The words "shall," "shall be," or "shall comply with," depending on the context, are implied where a colon (:) is used within a sentence or phrase.
2. Specification requirements are to be performed by Contractor unless specifically stated otherwise.

B. Division 00 Contracting Requirements: General provisions of the Contract, including General and Supplementary Conditions, apply to all Sections of the Specifications.

C. Division 01 General Requirements: Requirements of Sections in Division 01 apply to the Work of all Sections in the Specifications.

D. Drawing Coordination: Requirements for materials and products identified on Drawings are described in detail in the Specifications. One or more of the following are used on Drawings to identify materials and products:

1. Terminology: Materials and products are identified by the typical generic terms used in the individual Specifications Sections.
2. Abbreviations: Materials and products are identified by abbreviations scheduled on Drawings.
3. Keynoting: Materials and products are identified by reference keynotes referencing Specification Section numbers found in this Project Manual.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 011000

SECTION 012900 - PAYMENT PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements necessary to prepare and process Applications for Payment.

B. 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.

1.3 SCHEDULE OF VALUES

A. Coordination: Coordinate preparation of the schedule of values with preparation of Contractor's construction schedule.

   1. Coordinate line items in the schedule of values with items required to be indicated as separate activities in Contractor's construction schedule.
   2. Submit the schedule of values to Architect no later than seven days before the date scheduled for submittal of initial Applications for Payment.

B. Format and Content: Use Project Manual table of contents as a guide to establish line items for the schedule of values. Provide at least one line item for each Specification Section.

   1. Identification: Include the following Project identification on the schedule of values:

      a. Project name and location.
      b. Owner's name.
      c. Owner's Project number.
      d. Name of Architect.
      e. Architect's Project number.
      f. Contractor's name and address.
      g. Date of submittal.

2. Arrange schedule of values consistent with format of AIA Document G703.
3. Arrange the schedule of values in tabular form, with separate columns to indicate the following for each item listed:

    a. Related Specification Section or division.
    b. Description of the Work.
    c. Name of subcontractor.
    d. Name of manufacturer or fabricator.
    e. Name of supplier.
    f. Change Orders (numbers) that affect value.
    g. Dollar value of the following, as a percentage of the Contract Sum to nearest one-hundredth percent, adjusted to total 100 percent. Round dollar amounts to whole dollars, with total equal to Contract Sum.

4. Provide a breakdown of the Contract Sum in enough detail to facilitate continued evaluation of Applications for Payment and progress reports. Provide multiple line items for principal subcontract amounts in excess of five percent of the Contract Sum.
5. Provide a separate line item in the schedule of values for each part of the Work where Applications for Payment may include materials or equipment purchased or fabricated and stored, but not yet installed.
6. Overhead Costs, Proportional Distribution: Include total cost and proportionate share of general overhead and profit for each line item.
7. Temporary Facilities: Show cost of temporary facilities and other major cost items that are not direct cost of actual work-in-place as separate line items.
8. Closeout Costs. Include separate line items under Contractor and principal subcontracts for Project closeout requirements in an amount totaling five percent of the Contract Sum and subcontract amount.
9. Schedule of Values Revisions: Revise the schedule of values when Change Orders or Construction Change Directives result in a change in the Contract Sum. Include at least one separate line item for each Change Order and Construction Change Directive.

1.4 APPLICATIONS FOR PAYMENT

A. Each Application for Payment following the initial Application for Payment shall be consistent with previous applications and payments, as certified by Architect and paid for by Owner.

B. Payment Application Times: Per schedule provided at Pre- Construction Meeting.

C. Application for Payment Forms: Use AIA Document G702 and AIA Document G703 as form for Applications for Payment.

D. Pay Applications must consist of the following:
1. Application and Certificate of Payment 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 current 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 postdated. 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

E. 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.
7. Checks are mailed the day after each RPS205 board meeting, listed on the district website.
8. Contractor is advised to contact the RPS205 Project Manager for a Schedule.
9. Failure to follow the Pay Application Schedule will delay payment

F. Waivers of Mechanic's Lien: With each Application for Payment, submit waivers of mechanic's lien from entities lawfully entitled to file a mechanic's lien arising out of the Contract and related to the Work covered by the payment.

1. Submit partial waivers on each item for amount requested in previous application, after deduction for retainage, on each item.
2. When an application shows completion of an item, submit conditional final or full waivers.
3. Owner reserves the right to designate which entities involved in the Work must submit waivers.
4. Submit final Application for Payment with or preceded by conditional final waivers from every entity involved with performance of the Work covered by the application who is lawfully entitled to a lien.
5. Waiver Forms: Submit executed waivers of lien on forms acceptable to Owner.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 012900

SECTION 013100 - PROJECT MANAGEMENT AND COORDINATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative provisions for coordinating construction operations on Project, including, but not limited to, the following:

1. General coordination procedures.
2. RFIs.
3. Digital project management procedures.
4. Project meetings.

B. Each contractor shall participate in coordination requirements. Certain areas of responsibility are assigned to a specific contractor.

1.3 DEFINITIONS

A. RFI: Request for Information. Request from Owner, Architect, or Contractor seeking information required by or clarifications of the Contract Documents.

1.4 INFORMATIONAL SUBMITTALS

A. Subcontract List: Prepare a written summary identifying individuals or firms proposed for each portion of the Work, including those who are to furnish products or equipment fabricated to a special design.

1.5 GENERAL COORDINATION PROCEDURES

A. Coordination: Coordinate construction operations included in different Sections of the Specifications to ensure efficient and orderly installation of each part of the Work. Coordinate construction operations included in different Sections that depend on each other for proper installation, connection, and operation.

1. Schedule construction operations in sequence required to obtain the best results, where installation of one part of the Work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair.

3. Make adequate provisions to accommodate items scheduled for later installation.

B. Prepare memoranda for distribution to each party involved, outlining special procedures required for coordination. Include such items as required notices, reports, and list of attendees at meetings.

C. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:

1. Preparation of Contractor's construction schedule.
2. Preparation of the schedule of values.
3. Installation and removal of temporary facilities and controls.
4. Delivery and processing of submittals.
5. Progress meetings.
6. Preinstallation conferences.
7. Project closeout activities.
8. Startup and adjustment of systems.

1.6 REQUEST FOR INFORMATION (RFI)

A. General: Immediately on discovery of the need for additional information, clarification, or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified.

1. Architect will return without response those RFIs submitted to Architect by other entities controlled by Contractor.
2. Coordinate and submit RFIs in a prompt manner to avoid delays in Contractor's work or work of subcontractors.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:

1. Project name.
2. Owner name.
3. Owner's Project number.
4. Name of Architect.
5. Architect's Project number.
6. Date.
7. Name of Contractor.
8. RFI number, numbered sequentially.
9. RFI subject.
10. Specification Section number and title and related paragraphs, as appropriate.
11. Drawing number and detail references, as appropriate.
12. Field dimensions and conditions, as appropriate.
13. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
14. Contractor's signature.

15. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.

    a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. RFI Forms: AIA Document G716.

1. Attachments shall be electronic files in PDF format.

D. Architect's Action: Architect will review each RFI, determine action required, and respond. Allow seven days for Architect's response for each RFI.

1. Architect's action may include a request for additional information, in which case Architect's time for response will date from time of receipt by Architect of additional information.
2. Architect's action on RFIs that may result in a change to the Contract Time or the Contract Sum may be eligible for Contractor to submit Change Proposal according to Section 012600 "Contract Modification Procedures."

E. RFI Log: Prepare, maintain, and submit a tabular log of RFIs organized by the RFI number. Submit log weekly.

1. Project name.
2. Name and address of Contractor.
3. Name and address of Architect.
4. RFI number, including RFIs that were returned without action or withdrawn.
5. RFI description.
6. Date the RFI was submitted.
7. Date Architect's response was received.
8. Identification of related Minor Change in the Work, Construction Change Directive, and Proposal Request, as appropriate.
9. Identification of related Field Order, Work Change Directive, and Proposal Request, as appropriate.

F. On receipt of Architect's action, update the RFI log and immediately distribute the RFI response to affected parties. Review response and notify Architect within seven days if Contractor disagrees with response.

1.7 PROJECT MEETINGS

A. General: Schedule and conduct meetings and conferences at Project site unless otherwise indicated.

1. Attendees: Inform participants and others involved, and individuals whose presence is required, of date and time of each meeting. Notify Owner and Architect of scheduled meeting dates and times a minimum of 10 working days prior to meeting.
2. Agenda: Prepare the meeting agenda. Distribute the agenda to all invited attendees.

3. Minutes: Entity responsible for conducting meeting will record significant discussions and agreements achieved. Distribute the meeting minutes to everyone concerned, including Owner and Architect, within three days of the meeting.

B. Preconstruction Conference: Architect will schedule and conduct a preconstruction conference before starting construction, at a time convenient to Owner and Architect, but no later than 15 days after execution of the Agreement.

1. Attendees: Authorized representatives of Owner Architect, and their consultants; Contractor and its superintendent; major subcontractors; suppliers; and other concerned parties shall attend the conference. Participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.
2. Agenda: Discuss items of significance that could affect progress.
3. Minutes: Entity responsible for conducting meeting will record and distribute meeting minutes.

C. Progress Meetings: Conduct progress meetings at monthly intervals.

1. Coordinate dates of meetings with preparation of payment requests.
2. Attendees: In addition to representatives of Owner and Architect, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the meeting shall be familiar with Project and authorized to conclude matters relating to the Work.
3. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.
4. Minutes: Entity responsible for conducting the meeting will record and distribute the meeting minutes to each party present and to parties requiring information.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 013100

SECTION 013300 - SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Submittal schedule requirements.
2. Administrative and procedural requirements for submittals.

1.3 SUBMITTAL SCHEDULE

A. Submittal Schedule: Submit, as an action submittal, a list of submittals, arranged in chronological order by dates required by construction schedule. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or revisions to submittals noted by Architect and additional time for handling and reviewing submittals required by those corrections.

1.4 SUBMITTAL FORMATS

A. Submittal Information: Include the following information in each submittal:

1. Project name.
2. Date.
3. Name of Architect.
4. Name of Contractor.
5. Name of firm or entity that prepared submittal.
6. Names of subcontractor, manufacturer, and supplier.
7. Unique submittal number, including revision identifier. Include Specification Section number with sequential alphanumeric identifier and alphanumeric suffix for resubmittals.
8. Category and type of submittal.
9. Submittal purpose and description.
10. Number and title of Specification Section, with paragraph number and generic name for each of multiple items.
11. Drawing number and detail references, as appropriate.
12. Indication of full or partial submittal.
13. Location(s) where product is to be installed, as appropriate.
14. Other necessary identification.
15. Remarks.
16. Signature of transmitter.

B. Options: Identify options requiring selection by Architect.

C. Deviations and Additional Information: On each submittal, clearly indicate deviations from requirements in the Contract Documents, including minor variations and limitations; include relevant additional information and revisions, other than those requested by Architect on previous submittals. Indicate by highlighting on each submittal or noting on attached separate sheet.

D. Electronic Submittals: Prepare submittals as PDF package, incorporating complete information into each PDF file. Name PDF file with submittal number.

1.5 SUBMITTAL PROCEDURES

A. Prepare and submit submittals required by individual Specification Sections. Types of submittals are indicated in individual Specification Sections.

B. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
4. Coordinate transmittal of submittals for related parts of the Work specified in different Sections, so processing will not be delayed because of need to review submittals concurrently for coordination.

C. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Initial Review: Allow 15 days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. Architect will advise Contractor when a submittal being processed must be delayed for coordination.

D. Resubmittals: Make resubmittals in same form and number of copies as initial submittal.

1. Note date and content of previous submittal.
2. Note date and content of revision in label or title block, and clearly indicate extent of revision.
3. Resubmit submittals until they are marked with approval notation from Architect's action stamp.

E. Distribution: Furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, installers, authorities having jurisdiction, and others as necessary for performance of construction activities. Show distribution on transmittal forms.

F. Use for Construction: Retain complete copies of submittals on Project site. Use only final action submittals that are marked with approval notation from Architect's action stamp.

1.6 SUBMITTAL REQUIREMENTS

A. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.

1. If information must be specially prepared for submittal because standard published data are unsuitable for use, submit as Shop Drawings, not as Product Data.
2. Mark each copy of each submittal to show which products and options are applicable.
3. Include the following information, as applicable:

    a. Manufacturer's catalog cuts.
    b. Manufacturer's product specifications.
    c. Standard color charts.
    d. Statement of compliance with specified referenced standards.
    e. Notation of coordination requirements.
    f. Availability and delivery time information.

B. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.

1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:

    a. Identification of products.
    b. Schedules.
    c. Compliance with specified standards.
    d. Notation of coordination requirements.
    e. Notation of dimensions established by field measurement.
    f. Relationship and attachment to adjoining construction clearly indicated.
    g. Seal and signature of professional engineer if specified.

2. Paper Sheet Size: Except for templates, patterns, and similar full-size Drawings, submit Shop Drawings on sheets at least 8-1/2 by 11 inches (215 by 280 mm), but no larger than 30 by 42 inches (750 by 1067 mm).

    a. One electronic PDF copy of each submittal.

C. Samples: Submit Samples for review of type, color, pattern, and texture for a check of these characteristics with other materials.

1. Transmit Samples that contain multiple, related components, such as accessories together in one submittal package.
2. Identification: Permanently attach label on unexposed side of Samples that includes the following:

    a. Project name and submittal number.
    b. Generic description of Sample.

c. Product name and name of manufacturer.
d. Number and title of applicable Specification Section.
e. Specification paragraph number and generic name of each item.

3. Email Transmittal: Provide PDF transmittal. Include digital image file illustrating Sample Disposition: Maintain sets of approved Samples at Project site, available for quality-control comparisons throughout the course of construction activity. Sample sets may be used to determine final acceptance of construction associated with each set.

4. Samples for Initial Selection: Submit manufacturer's color charts consisting of units or sections of units, showing the full range of colors, textures, and patterns available.

   a. Number of Samples: Submit one full set(s) of available choices where color, pattern, texture, or similar characteristics are required to be selected from manufacturer's product line. Architect will return submittal with options selected.

1.7 CONTRACTOR'S REVIEW

A. Action Submittals and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Architect.

B. Contractor's Approval: Indicate Contractor's approval for each submittal with a uniform approval stamp. Include name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.

1.8 ARCHITECT'S REVIEW

A. Action Submittals: Architect will review each submittal, indicate corrections or revisions required, and return.

B. Submittals not required by the Contract Documents will be returned by Architect without action.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 013300

SECTION 015000 - TEMPORARY FACILITIES AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes requirements for temporary utilities, support facilities, and security and protection facilities.

B. Provided 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 may use designated toilet facilities in the building.
5. Materials storage: Exterior storage to be limited to areas on the site as directed by the
6. Owner's Representative. Interior material storage is not available.
7. Contractor parking and site access to be restricted to areas designated by SD205.

C. 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
3. operations. Collect waste daily and, when containers are full, legally dispose of waste
4. off-site.
5. Install project identification and other signs in locations approved by Owner to inform the
6. public and persons seeking entrance to Project.

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

PART 2 - PRODUCTS

2.1 MATERIALS

A. Fencing Windscreen Privacy Screen: Polyester fabric scrim with grommets for attachment to chain-link fence, sized to height of fence, in color selected by Architect from manufacturer's standard colors.

PART 3 - EXECUTION

3.1 TEMPORARY FACILITIES, GENERAL

A. Conservation: Coordinate construction with consideration given to conservation of energy, water, and materials. Coordinate use of temporary utilities to minimize waste. Coordinate requirements in subparagraph below with provisions in Section 017419 "Construction Waste Management and Disposal."

3.2 SUPPORT FACILITIES INSTALLATION

A. Comply with the following:

B. Parking: Use designated areas of Owner's existing parking areas for construction personnel.

C. Storage and Staging: Use designated areas of Project site for storage and staging needs.

D. Project Signs: Provide Project signs as indicated. Unauthorized signs are not permitted.

1. Identification Signs: Provide Project identification signs as indicated on Drawings.

E. Waste Disposal Facilities: Provide waste-collection containers in sizes adequate to handle waste from construction operations. Comply with requirements of authorities having jurisdiction. Comply with progress cleaning requirements in Section 017300 "Execution."

F. Lifts and Hoists: Provide facilities necessary for hoisting materials and personnel.

1. Subparagraph below could be important for cost-plus contracts.

2. Truck cranes and similar devices used for hoisting materials are considered "tools and equipment" and not temporary facilities.

3.3 SECURITY AND PROTECTION FACILITIES INSTALLATION

A. Protection of Existing Facilities: Protect existing vegetation, equipment, structures, utilities, and other improvements at Project site and on adjacent properties, except those indicated to be removed or altered. Repair damage to existing facilities.

1. Where access to adjacent properties is required in order to affect protection of existing facilities, obtain written permission from adjacent property owner to access property for that purpose.

B. Environmental Protection: Provide protection, operate temporary facilities, and conduct construction as required to comply with environmental regulations and that minimize possible air, waterway, and subsoil contamination or pollution or other undesirable effects.

3.4 MOISTURE AND MOLD CONTROL

A. Moisture and Mold Protection: Protect stored materials and installed Work in accordance with Moisture and Mold Protection Plan.

B. Exposed Construction Period: Before installation of weather barriers, when materials are subject to wetting and exposure and to airborne mold spores, protect as follows:

1. Protect porous materials from water damage.

2. Protect stored and installed material from flowing or standing water.

3. Keep porous and organic materials from coming into prolonged contact with concrete.

4. Remove standing water from decks.

5. Keep deck openings covered or dammed.

3.5 OPERATION, TERMINATION, AND REMOVAL

1. Supervision: Enforce strict discipline in use of temporary facilities. To minimize waste and abuse, limit availability of temporary facilities to essential and intended uses.

B. Termination and Removal: Remove each temporary facility when need for its service has ended, when it has been replaced by authorized use of a permanent facility, or no later than Substantial Completion. Complete or, if necessary, restore permanent construction that may have been delayed because of interference with temporary facility. Repair damaged Work, clean exposed surfaces, and replace construction that cannot be satisfactorily repaired.

END OF SECTION 015000

SECTION 017300 - EXECUTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes general administrative and procedural requirements governing execution of the Work, including, but not limited to, the following:

1. Construction layout.
2. Installation of the Work.
3. Cutting and patching.
4. Progress cleaning.
5. Protection of installed construction.

B. Related Requirements:

1. Section 013300 "Submittal Procedures" for submitting surveys.
2. Section 017700 "Closeout Procedures" for submitting final property survey with Project Record Documents, recording of Owner-accepted deviations from indicated lines and levels, replacing defective work, and final cleaning.

1.3 DEFINITIONS

A. Cutting: Removal of in-place construction necessary to permit installation or performance of subsequent work.

B. Patching: Fitting and repair work required to restore construction to original conditions after installation of subsequent work.

1.4 QUALITY ASSURANCE

A. Cutting and Patching: Comply with requirements for and limitations on cutting and patching of construction elements.

1. Structural Elements: When cutting and patching structural elements, or when encountering the need for cutting and patching of elements whose structural function is not known, notify Architect of locations and details of cutting and await directions from Architect before proceeding. Shore, brace, and support structural elements during cutting and patching. Do not cut and patch structural elements in a manner that could change their load-carrying capacity or increase deflection.

2. Operational Elements: Do not cut and patch operating elements and related components in a manner that results in reducing their capacity to perform as intended or that results in increased maintenance or decreased operational life or safety.

3. Other Construction Elements: Do not cut and patch other construction elements or components in a manner that could change their load-carrying capacity, that results in reducing their capacity to perform as intended, or that results in increased maintenance or decreased operational life or safety.

4. Visual Elements: Do not cut and patch construction in a manner that results in visual evidence of cutting and patching. Do not cut and patch exposed construction in a manner that would, in Architect's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.

B. Manufacturer's Installation Instructions: Obtain and maintain on-site manufacturer's written recommendations and instructions for installation of specified products and equipment.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Comply with requirements specified in other Sections.

B. In-Place Materials: Use materials for patching identical to in-place materials. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.

C. Cleaning Agents: Use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examination and Acceptance of Conditions: Before proceeding with each component of the Work, examine substrates, areas, and conditions, with Installer or Applicator present where indicated, for compliance with requirements for installation tolerances and other conditions affecting performance. Record observations.

B. Written Report: Where a written report listing conditions detrimental to performance of the Work is required by other Sections, include the following:

1. Description of the Work, including Specification Section number and paragraph, and Drawing sheet number and detail, where applicable.
2. List of detrimental conditions, including substrates.
3. List of unacceptable installation tolerances.
4. Recommended corrections.

C. Proceed with installation only after unsatisfactory conditions have been corrected. Proceeding with the Work indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Field Measurements: Take field measurements as required to fit the Work properly. Recheck measurements before installing each product. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

B. Review of Contract Documents and Field Conditions: Immediately on discovery of the need for clarification of the Contract Documents, submit a request for information to Architect in accordance with requirements in Section 013100 "Project Management and Coordination."

3.3 CONSTRUCTION LAYOUT

A. Verification: Before proceeding to lay out the Work, verify layout information shown on Drawings, in relation to the property survey and existing benchmarks and existing conditions. If discrepancies are discovered, notify Architect promptly.

3.4 INSTALLATION

A. Locate the Work and components of the Work accurately, in correct alignment and elevation, as indicated.

1. Make vertical work plumb and make horizontal work level.

B. Comply with manufacturer's written instructions and recommendations for installing products in applications indicated.

C. Install products at the time and under conditions that will ensure satisfactory results as judged by Architect. Maintain conditions required for product performance until Substantial Completion.

D. Conduct construction operations, so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy of type expected for Project.

E. Sequence the Work and allow adequate clearances to accommodate movement of construction items on-site and placement in permanent locations.

F. Tools and Equipment: Select tools or equipment that minimizes production of excessive noise levels.

G. Templates: Obtain and distribute to the parties involved templates for Work specified to be factory prepared and field installed. Check Shop Drawings of other portions of the Work to confirm that adequate provisions are made for locating and installing products to comply with indicated requirements.

H. Attachment: Provide blocking and attachment plates and anchors and fasteners of adequate size and number to securely anchor each component in place, accurately located and aligned with other portions of the Work. Where size and type of attachments are not indicated, verify size and type required for load conditions with manufacturer.

1. Mounting Heights: Where mounting heights are not indicated, mount components at heights directed by Architect.
2. Allow for building movement, including thermal expansion and contraction.
3. Coordinate installation of anchorages. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

I. Joints: Make joints of uniform width. Where joint locations in exposed Work are not indicated, arrange joints for the best visual effect, as judged by Architect. Fit exposed connections together to form hairline joints.

J. Repair or remove and replace damaged, defective, or nonconforming Work.

3.5 CUTTING AND PATCHING

A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.

B. Temporary Support: Provide temporary support of Work to be cut.

C. Protection: Protect in-place construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of Project that might be exposed during cutting and patching operations.

D. Adjacent Occupied Areas: Where interference with use of adjoining areas or interruption of free passage to adjoining areas is unavoidable, coordinate cutting and patching in accordance with requirements in Section 011000 "Summary."

E. Cutting: Cut in-place construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction. If possible, review proposed procedures with original Installer; comply with original Installer's written recommendations.

1. In general, use hand or small power tools designed for sawing and grinding, not hammering and chopping. Cut holes and slots neatly to minimum size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.

F. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other Work. Patch with durable seams that are as invisible as practicable, as judged by Architect. Provide materials and comply with installation requirements specified in other Sections, where applicable.

1. Inspection: Where feasible, test and inspect patched areas after completion to demonstrate physical integrity of installation.

2. Exterior Building Enclosure: Patch components in a manner that restores enclosure to a weathertight condition and ensures thermal and moisture integrity of building enclosure.

G. Cleaning: Clean areas and spaces where cutting and patching are performed. Remove paint, mortar, oils, putty, and similar materials from adjacent finished surfaces.

3.6 PROGRESS CLEANING

A. Clean Project site and work areas daily, including common areas. Enforce requirements strictly. Dispose of materials lawfully.

1. Comply with requirements in NFPA 241 for removal of combustible waste materials and debris.
2. Do not hold waste materials more than seven days during normal weather or three days if the temperature is expected to rise above 80 deg F (27 deg C).
3. Containerize hazardous and unsanitary waste materials separately from other waste. Mark containers appropriately and dispose of legally, according to regulations.
4. Coordinate progress cleaning for joint-use areas where Contractor and other contractors are working concurrently.

B. Site: Maintain Project site free of waste materials and debris.

C. Work Areas: Clean areas where Work is in progress to the level of cleanliness necessary for proper execution of the Work.

1. Remove liquid spills promptly.
2. Where dust would impair proper execution of the Work, broom-clean or vacuum the entire work area, as appropriate.

D. Installed Work: Keep installed work clean. Clean installed surfaces according to written instructions of manufacturer or fabricator of product installed, using only cleaning materials specifically recommended. If specific cleaning materials are not recommended, use cleaning materials that are not hazardous to health or property and that will not damage exposed surfaces.

E. Concealed Spaces: Remove debris from concealed spaces before enclosing the space.

F. Exposed Surfaces: Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration at time of Substantial Completion.

G. Waste Disposal: Do not bury or burn waste materials on-site. Do not wash waste materials down sewers or into waterways.

H. During handling and installation, clean and protect construction in progress and adjoining materials already in place. Apply protective covering where required to ensure protection from damage or deterioration at Substantial Completion.

I. Clean and provide maintenance on completed construction as frequently as necessary through the remainder of the construction period. Adjust and lubricate operable components to ensure operability without damaging effects.

J. Limiting Exposures: Supervise construction operations to ensure that no part of the construction, completed or in progress, is subject to harmful, dangerous, damaging, or otherwise deleterious exposure during the construction period.

3.7 PROTECTION AND REPAIR OF INSTALLED CONSTRUCTION

A. Provide final protection and maintain conditions that ensure installed Work is without damage or deterioration at time of Substantial Completion.

B. Repair Work previously completed and subsequently damaged during construction period. Repair to like-new condition.

C. Protection of Existing Items: Provide protection and ensure that existing items to remain undisturbed by construction are maintained in condition that existed at commencement of the Work.

D. Comply with manufacturer's written instructions for temperature and relative humidity.

END OF SECTION 017300

SECTION 017419 - CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for the following:

1. Disposing of nonhazardous demolition and construction waste.

1.3 DEFINITIONS

A. Construction Waste: Building, structure, and site improvement materials and other solid waste resulting from construction, remodeling, renovation, or repair operations. Construction waste includes packaging.

B. Demolition Waste: Building, structure, and site improvement materials resulting from demolition operations.

C. Disposal: Removal of demolition or construction waste and subsequent salvage, sale, recycling, or deposit in landfill, incinerator acceptable to authorities having jurisdiction, or designated spoil areas on Owner’s property.

1.4 MATERIALS OWNERSHIP

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

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with transportation and disposal regulations of authorities having jurisdiction.

1.6 WASTE MANAGEMENT PLAN

A. General: Develop a waste management plan according to requirements in this Section. Plan shall consist of waste identification, waste reduction work plan, and cost/revenue analysis. Indicate quantities by weight or volume, but use same units of measure throughout waste management plan.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 PLAN IMPLEMENTATION

A. General: Implement approved waste management plan. Provide handling, containers, storage, signage, transportation, and other items as required to implement waste management plan during the entire duration of the Contract.

B. Site Access and Temporary Controls: Conduct waste management operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

1. Designate and label specific areas on Project site necessary for separating materials that are to be salvaged and recycled.
2. Comply with Section 015000 "Temporary Facilities and Controls" for controlling dust and dirt, environmental protection, and noise control.

3.2 DISPOSAL OF WASTE

A. General: Remove waste materials from Project site and legally dispose of them in a landfill or incinerator acceptable to authorities having jurisdiction.

B. Burning: Do not burn waste materials.

END OF SECTION 017419

SECTION 017700 - CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for Contract closeout, including, but not limited to, the following:

1. Substantial Completion procedures.
2. Final completion procedures.
3. Warranties.
4. Final cleaning.

1.3 DEFINITIONS

A. List of Incomplete Items: Contractor-prepared list of items to be completed or corrected, prepared for the Architect's use prior to Architect's inspection, to determine if the Work is substantially complete.

1.4 SUBSTANTIAL COMPLETION PROCEDURES

A. Contractor's List of Incomplete Items: Prepare and submit a list of items to be completed and corrected (Contractor's "punch list"), indicating the value of each item on the list and reasons why the Work is incomplete.

B. Submittals Prior to Substantial Completion: Complete the following a minimum of 10 days prior to requesting inspection for determining date of Substantial Completion. List items below that are incomplete at time of request.

1. Certificates of Release: Obtain and submit releases from authorities having jurisdiction, permitting Owner unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
2. Submit closeout submittals specified in other Division 01 Sections, including Project Record Documents, operation and maintenance manuals, damage or settlement surveys, property surveys, and similar final record information.
3. Submit closeout submittals specified in individual Sections, including specific warranties, workmanship bonds, maintenance service agreements, final certifications, and similar documents.

C. Procedures Prior to Substantial Completion: Complete the following a minimum of 10 days prior to requesting inspection for determining date of Substantial Completion. List items below that are incomplete at time of request.

1. Advise Owner of pending insurance changeover requirements.
2. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.
3. Complete final cleaning requirements.

D. Inspection: Submit a written request for inspection to determine Substantial Completion a minimum of 10 days prior to date the Work will be completed and ready for final inspection and tests. On receipt of request, Architect will either proceed with inspection or notify Contractor of unfulfilled requirements. Architect will prepare the Certificate of Substantial Completion after inspection or will notify Contractor of items, either on Contractor's list or additional items identified by Architect, that must be completed or corrected before certificate will be issued.

1. Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.
2. Results of completed inspection will form the basis of requirements for Final Completion.

1.5 FINAL COMPLETION PROCEDURES

A. Submittals Prior to Substantial Completion: Before requesting inspection for Substantial Completion, submit 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.

A. Submittals Prior to Final Completion: Before requesting final inspection for determining Final Completion, complete the following:

1. Submit a final Application for Payment in accordance with Section 012900 "Payment Procedures."
2. Certified List of Incomplete Items: Submit certified copy of Architect's Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed and dated by Architect. Certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance.
3. Certificate of Insurance: Submit evidence of final, continuing insurance coverage complying with insurance requirements.

B. Inspection: Submit a written request for final inspection to determine acceptance a minimum of 10 days prior to date the Work will be completed and ready for final inspection and tests. On receipt of request, Architect will either proceed with inspection or notify Contractor of unfulfilled requirements. Architect will prepare a final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.

1. Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.

1.6 LIST OF INCOMPLETE ITEMS

A. Organization of List: Include name and identification of each space and area affected by construction operations for incomplete items and items needing correction including, if necessary, areas disturbed by Contractor that are outside the limits of construction.

1.7 SUBMITTAL OF PROJECT WARRANTIES

A. Time of Submittal: Submit written warranties on request of Architect for designated portions of the Work where warranties are indicated to commence on dates other than date of Substantial Completion, or when delay in submittal of warranties might limit Owner's rights under warranty.

B. Organize warranty documents into an orderly sequence based on the table of contents of Project Manual.

C. Provide additional copies of each warranty to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cleaning Agents: Use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.

PART 3 - EXECUTION

3.1 FINAL CLEANING

A. General: Perform final cleaning. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and Federal and local environmental and antipollution regulations.

B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.

1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a designated portion of Project:

    a. Clean Project site of rubbish, waste material, litter, and other foreign substances.
    b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.

c. Rake grounds that are not planted, mulched, or paved to a smooth, even-textured surface.
d. Remove tools, construction equipment, machinery, and surplus material from Project site.
e. Clean exposed exterior finishes to a dirt-free condition, free of stains, films, and similar foreign substances.
f. Leave Project clean and ready for occupancy.

3.2 REPAIR OF THE WORK

A. Complete repair and restoration operations required by Section 017300 "Execution" before requesting inspection for determination of Substantial Completion.

END OF SECTION 017700

SECTION 017839 - PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for Project Record Documents, including the following:

1. Record Drawings.
2. Record specifications.
3. Record Product Data.
4. Miscellaneous record submittals.

B. Related Requirements:

1. Section 017300 "Execution" for final property survey.
2. Section 017700 "Closeout Procedures" for general closeout procedures.

1.3 CLOSEOUT SUBMITTALS

A. Record Drawings: Comply with the following:

1. Number of Copies: Submit one set(s) of marked-up record prints.

1) Submit PDF electronic files of scanned Record Prints and set(s) of file prints.

B. Record Specifications: Submit annotated PDF electronic files of Project's Specifications, including addenda and Contract modifications.

C. Record Product Data: Submit annotated PDF electronic files and directories of each submittal.

1. Where record Product Data are required as part of operation and maintenance manuals, submit duplicate marked-up Product Data as a component of manual.

D. Miscellaneous Record Submittals: See other Specification Sections for miscellaneous record-keeping requirements and submittals in connection with various construction activities. Submit annotated PDF electronic files and directories of each submittal.

E. Reports: Submit written report indicating items incorporated into Project Record Documents concurrent with progress of the Work, including revisions, concealed conditions, field changes, product selections, and other notations incorporated.

1.4 RECORD DRAWINGS

A. Record Prints: Maintain one set of marked-up paper copies of the Contract Drawings and Shop Drawings, incorporating new and revised drawings as modifications are issued.

1. Preparation: Mark record prints to show the actual installation, where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to provide information for preparation of corresponding marked-up record prints.

2. Content: Types of items requiring marking include, but are not limited to, the following:

    a. Dimensional changes to Drawings.
    b. Revisions to details shown on Drawings.
    c. Changes made by Change Order or Construction Change Directive.
    d. Changes made following Architect's written orders.
    e. Details not on the original Contract Drawings.
    f. Field records for variable and concealed conditions.

3. Mark the Contract Drawings and Shop Drawings completely and accurately. Use personnel proficient at recording graphic information in production of marked-up record prints.
4. Mark record prints with erasable, red-colored pencil. Mark important additional information that was either shown schematically or omitted from original Drawings.
5. Note Construction Change Directive numbers, alternate numbers, Change Order numbers, and similar identification, where applicable.

B. Format: Identify and date each Record Drawing; include the designation "PROJECT RECORD DRAWING" in a prominent location.

1. Format: Annotated PDF electronic file.

1.5 RECORD SPECIFICATIONS

A. Preparation: Mark Specifications to indicate the actual product installation, where installation varies from that indicated in Specifications, addenda, and Contract modifications.
1. Mark copy with the proprietary name and model number of products, materials, and equipment furnished, including substitutions and product options selected.
2. Record the name of manufacturer, supplier, Installer, and other information necessary to provide a record of selections made.
3. For each principal product, indicate whether Record Product Data has been submitted in operation and maintenance manuals instead of submitted as Record Product Data.
4. Note related Change Orders, Record Product Data, and Record Drawings where applicable.

B. Format: Submit record specifications as annotated PDF electronic file.

1.6 RECORD PRODUCT DATA

A. Recording: Maintain one copy of each submittal during the construction period for Project Record Document purposes. Post changes and revisions to Project Record Documents as they occur; do not wait until end of Project.

B. Preparation: Mark Product Data to indicate the actual product installation where installation varies substantially from that indicated in Product Data submittal.

1. Include significant changes in the product delivered to Project site and changes in manufacturer's written instructions for installation.
2. Note related Change Orders, Record Specifications, and Record Drawings where applicable.

C. Format: Submit Record Product Data as annotated PDF electronic file.

1. Include Record Product Data directory organized by Specification Section number and title, electronically linked to each item of Record Product Data.

1.7 MISCELLANEOUS RECORD SUBMITTALS

A. Assemble miscellaneous records required by other Specification Sections for miscellaneous record keeping and submittal in connection with actual performance of the Work. Bind or file miscellaneous records and identify each, ready for continued use and reference.

B. Format: Submit miscellaneous record submittals as PDF electronic file.

1. Include miscellaneous record submittals directory organized by Specification Section number and title, electronically linked to each item of miscellaneous record submittals.

1.8 MAINTENANCE OF RECORD DOCUMENTS

A. Maintenance of Record Documents: Store Record Documents in the field office apart from the Contract Documents used for construction. Do not use Project Record Documents for construction purposes. Maintain Record Documents in good order and in a clean, dry, legible condition, protected from deterioration and loss. Provide access to Project Record Documents for Architect's reference during normal working hours.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 017839

SECTION 024119 - SELECTIVE DEMOLITION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Demolition and removal of selected portions of building or structure.

B. Related Requirements:

1. Section 017300 "Execution" for cutting and patching procedures.

1.3 DEFINITIONS

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

B. Existing to Remain: Existing items 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.

1.4 MATERIALS OWNERSHIP

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

B. All surplus salvaged materials, including hardware, door frames, fire extinguishers, light fixtures, window blinds, and others not indicated to be relocated or reused shall be turned over to Owner for first refusal.

C. No surplus salvage materials shall be taken by Contractor or sold to the public.

1.5 FIELD CONDITIONS

A. Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted.

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

C. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.

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. Maintain fire-protection facilities in service during selective demolition operations.

1.6 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. 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

2.1 PERFORMANCE REQUIREMENTS

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

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

PART 3 - EXECUTION

3.1 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.

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

3.2 UTILITY SERVICES AND MECHANICAL/ELECTRICAL SYSTEMS

A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.

B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.

1. Owner will arrange to shut off indicated services/systems when requested by Contractor.
2. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
3. Electrical, mechanical, plumbing and telephone systems deleted by new construction shall be removed to the furthest termination point unless otherwise noted in Drawings.

3.3 PREPARATION

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

1. Comply with requirements for access and protection specified in Section 015000 "Temporary Facilities and Controls."

B. Temporary Facilities: 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.
3. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.
4. Cover and protect furniture, furnishings, and equipment that have not been removed.
5. Comply with requirements for temporary enclosures, dust control, heating, and cooling specified in Section 015000 "Temporary Facilities and Controls."

3.4 SELECTIVE DEMOLITION, GENERAL

A. General: 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. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.

2. 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.
3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
4. 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.
5. Maintain adequate ventilation when using cutting torches.
6. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
7. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
8. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
9. Dispose of demolished items and materials promptly.

B. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Architect, items may be removed to a suitable, protected storage location during selective demolition and cleaned and reinstalled in their original locations after selective demolition operations are complete.

3.5 DISPOSAL OF DEMOLISHED MATERIALS

A. General: Except for items or materials indicated to be reused, or otherwise indicated to remain Owner's property, remove demolished materials from Project site and legally dispose of them in an EPA-approved landfill.

1. 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.

B. Burning: Do not burn demolished materials.

C. Disposal: Transport demolished materials off Owner's property and legally dispose of them.

3.6 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 024119

SECTION 040100 - 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.

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

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

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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 re-pointing to demonstrate/select appropriate mortar mix and method. As directed install test brick to demonstrate match.

D. 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.

E. 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.

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 only as required to perform masonry repair work.

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1. 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 cleanedMa

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.

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. 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 mortar before repointing in order to provide a match with the new repointing mortar.
2. Repointing: Repointing work shall be 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 masonry materials only if surfaces are extensively deteriorated (surface missing to a depth of 1 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.

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. 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

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

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

J. 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 061053 - ROUGH CARPENTRY

PART 1 - GENERAL

1.01 SUMMARY

A. Wood blocking and nailers.

B. Related Requirements:

1. Section 07620 Sheet Metal Work

1.03 SUBMITTALS

A. Product Data: Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.

B. Evaluation Reports: For wood-preservative-treated wood, from ICC-ES.

PART 2 - PRODUCTS

2.01 WOOD PRODUCTS

A. General

1. Factory mark each piece of lumber with grade stamp of grading agency.
2. Dress lumber, S4S, unless otherwise indicated.

B. Maximum Moisture Content of Lumber: 19 percent unless otherwise indicated.

C. Framing Lumber: Worked and graded in accordance with American Lumber Standard PS 20 (U.S. Dep. Comm.), S4S, seasoned to moisture content not exceeding 19% and stamped “S-DRY.”

1. Rough Frames, Nailers and Blocking, etc.: #1 Common Southern Yellow Pine, or equivalent SPF, or Douglas Fir.

D. Nailers and Blocking:

1. Factory mark each piece of lumber with grade stamp of grading agency.
2. Dress lumber, S4S, unless otherwise indicated.
3. Maximum Moisture Content of Lumber: 19 percent unless otherwise indicated.
4. For blocking not used for attachment of other construction, Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.
5. For blocking and nailers used for attachment of other construction, select and cut lumber to eliminate knots and other defects that will interfere with attachment of other work.

2.03 WOOD-PRESERVATIVE-TREATED LUMBER

A. Preservative Treatment by Pressure Process: AWPA U1; Use Category UC2 for interior construction. Use Category UC3b for exterior construction.

1. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium.

B. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Do not use material that is warped or that does not comply with requirements for untreated material.

C. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.

D. Application: Treat all rough carpentry unless otherwise indicated.

2.4 FASTENERS

A. General: Fasteners shall be of size and type indicated and shall comply with requirements specified in this article for material and manufacture.

1. Where rough carpentry is pressure-preservative treated provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M.

B. Nails, Brads, and Staples: ASTM F 1667.

C. Power-Driven Fasteners: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Wood Framing: Comply with recommendations of NFPA "National Design Specifications for Wood Construction." Place work accurately, level, plumb and true.

B. Nailers and Blocking: Execute in a manner to achieve greatest stability.

1. General: Use 2x wood studs spaced 16" o.c.
2. Plates: Joints in top plates shall be lapped at least 6"
3. Nailers and Blocking:
   a. Provide wherever shown and where required for attachment of work of other trades. Cut and fit as required for true line and level of work to be attached.
   b. Attach to substrates as required to support applied loading. Bolts and nuts shall be countersunk flush with surfaces, unless shown otherwise.

3.03 PROTECTION

A. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

B. Protect rough carpentry from weather. If, despite protection, rough carpentry becomes wet enough that moisture content exceeds that specified, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label

END OF SECTION

SECTION 079200 - 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

SECTION 081113 - HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes hollow metal work.

1.02 RELATED REQUIREMENTS

A. Drawings and general provisions of the contract including General and Supplementary Conditions and Division 01 Specification Sections apply to this section.

B. Section 087100 “Door Hardware”

1.03 DEFINITIONS

A. Minimum Thickness: Minimum thickness for base metal without coatings according to HAAMM-HMMA 803 or SDI A250.8.

1.04 COORDINATION

A. Coordinate anchorage installation for hollow-metal frames. Furnish setting drawings, templates, and directions for installing anchorage, including sleeves, concrete inserts, anchor bolts, and items with integral anchors. Deliver such items to Project Site in time for installation.

1.05 SUBMITTALS

A. Product Data: Submit manufacturer’s product data, including installation instructions, core descriptions, and finishes.

B. Shop Drawings: Include the following:

1. Elevations of each door type.
2. Details of doors, including vertical-edge and horizontal edge details and metal thicknesses.
3. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
4. Locations of reinforcement and preparations for hardware.
5. Details of each different wall opening condition.
6. Details of anchorages, joints, field splices, and connections.
7. Details of accessories.
8. Details of moldings, removable stops, and glazing.
9. Details of conduit and preparations for power, signal, and control systems.

C. Samples for Initial Selection: For units with factory-applied color / finishes.

D. Samples for Verification:

1. For each type of exposed finish required, prepared on Samples of not less than 3 by 5 inches (75 by 127 mm) .

2. Prepare Samples approximately 12 by 12 inches (305 by 305 mm) to demonstrate compliance with requirements for quality of materials and construction:
    a. Doors: Show vertical edge, top, and bottom construction; core construction; and hinge and other applied hardware reinforcement. Include separate section showing glazing if applicable.
    b. Frames: Show profile, corner joint, floor and wall anchors, and silencers. Include separate section showing fixed hollow metal panels and glazing if applicable.

E. Schedule: Provide a schedule of hollow metal work prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with final Door Hardware Schedule.

1.06 QUALITY ASSURANCE

A. Installer to be experienced in the installation of hollow metal doors and frames, in new/retrofit construction as applicable, for not less than 5 years in the jurisdiction of the project..

1.07 DELIVERY, STORAGE AND HANDLING

A. Deliver hollow metal work palletized, packaged, or crated to provide protection during transit and Project site storage. Do not use non-vented plastic.

    1. Provide additional protection to prevent damage to factory finished units.

B. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.

C. Store hollow metal work vertically under cover at Project site with head up. Place on minimum 4 inch - (102 mm) high wood blocking. Provide minimum 1/4 inch (6 mm) space between each stacked door to permit air circulation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the WORK include, but are not limited to the following:
    1. Apex Industries, Inc.
    2. Ceco Door Products; an Assa Abloy Group company.
    3. Curries Company ; an Assa Abloy Group company.
    4. Steelcraft: an Ingersoll-Rand Company.

B. Source Limitations: Obtain hollow-metal work from single source from single manufacturer.

2.02 REGULATORY REQUIREMENTS

A. Fire-Rated Assemblies: Complying with NFPA 80 and listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for fire protection ratings indicated, based on

testing at positive pressure according to NFPA 252 or UL 10C.

1. Smoke-Control and Draft-Control Assemblies: Provide an assembly with gaskets listed and labeled for smoke and draft control by a qualified testing agency acceptable to authorities having jurisdiction, based on testing according to UL 1784 and installed in compliance with NFPA 105.

B. Fire-Rated, Borrowed-Light Assemblies: Complying with NFPA 80 and listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction for fire-protection ratings indicated, based on testing according to NFPA 257 or UL 9.

2.3 INTERIOR DOORS AND FRAMES

A. Construct interior doors and frames to comply with the standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.

B. Heavy Duty Doors and Frames: SDI A250.8, Level 2.

1. Physical Performance: Level B according to SDI A250.4.
2. Doors:

    a. Type: As indicated in the Door and Frame Schedule.
    b. Thickness: 1 3/4 inches (44.5 mm) .
    c. Face: Un-coated, cold rolled steel sheet, minimum thickness of 0.042 inch (1.0 mm).
    d. Edge Construction: Model 1, Full Flush
    e. Core: Manufacturer's standard kraft-paper honeycomb, polystyrene, polyurethane, polyisocyanurate, mineral board, or vertical steel stiffener core at manufacturer's discretion.

3. Frames:

    a. Materials: Un-coated steel sheet, minimum thickness of 0.053 inch (1.3 mm) .
    b. Construction: Knocked down.

4. Exposed Finish: Prime.

2.4 EXTERIOR HOLLOW METAL DOORS AND FRAMES

A. Construct exterior doors and frames to comply with the standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.

B. Heavy Duty Doors and Frames: SDI A250.8, Level 2.

1. Physical Performance: Level B according to SDI A250.4.
2. Doors:

    a. Type: As indicated in the Door and Frame Schedule.
    b. Thickness: 1 3/4 inches (44.5 mm.)

c. Face: Metallic-coated steel sheet, minimum thickness of 0.042 inch (1.0 mm) , with minimum A40 (ZF120) coating.
d. Edge Construction: Model 1, Full Flush.
e. Core: Manufacturer's standard kraft-paper honeycomb, polystyrene, polyurethane, polyisocyanurate, mineral-board, or vertical steel-stiffener core at manufacturer's discretion.

3. Frames:

a. Materials: Metallic-coated steel sheet, minimum thickness of 0.053 inch (1.3 mm) , with minimum A40 (ZF120) coating.
b. Construction: Knocked down.

4. Exposed Finish: Prime.

2.5 FRAME ANCHORS

A. Jamb Anchors:

1. Masonry Type: Adjustable strap and stirrup or T-shaped anchors to suit frame size, not less than 0.042 inch (1.0 mm) thick, with corrugated or perforated straps not less than 2 inches (51 mm) wide by 10 inches (254 mm) long; or wire anchors not less than 0.177 inch (4.5 mm) thick.
2. Stud Wall Type: Designed to engage stud, welded to back of frames; not less than 0.042 inch (1.0 mm) thick.
3. Compression Type for Drywall Slip on Frames: Adjustable compression anchors.
4. Post-installed Expansion Type for In Place Concrete or Masonry: Minimum 3/8 inch - (9.5 mm) diameter bolts with expansion shields or inserts. Provide pipe spacer from frame to wall, with throat reinforcement plate, welded to frame at each anchor location.

B. Floor Anchors: Formed from same material as frames, minimum thickness of 0.042 inch (1.0 mm) , with clip type anchors, with two holes to receive fasteners.

2.6 MATERIALS

A. Cold Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B; suitable for exposed applications.

B. Frame Anchors: ASTM A 879/A 879M, Commercial Steel (CS), 04 Z (12G) coating designation; mill phosphatized.

1. For anchors built into exterior walls, steel sheet complying with ASTM A 1008/A 1008M or ASTM A 1011/A 1011M, hot-dip galvanized according to ASTM A 153/A 153M, Class B.

C. Inserts, Bolts, and Fasteners: Hot-dip galvanized according to ASTM A 153/A 153M.

D. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion resistant materials, with clips or other accessory devices for attaching hollow-metal frames of type indicated.

E. Grout: ASTM C 476, except with a maximum slump of 4 inches (102 mm) , as measured according to ASTM C 143/C 143M.

F. Mineral-Fiber Insulation: ASTM C 665, Type I (blankets without membrane facing); consisting of fibers manufactured from slag or rock wool; with maximum flame spread and smoke developed indexes of 25 and 50, respectively; passing ASTM E 136 for combustion characteristics.

G. Glazing : Comply with requirements in Section 088000 "Glazing."

2.7 FABRICATION

A. Fabricate hollow-metal work to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for metal thickness. Where practical, fit and assemble units in manufacturer's plant. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.

B. Hollow-Metal Doors:

1. Steel-Stiffened Door Cores: Provide minimum thickness 0.026 inch (0.66 mm) , steel vertical stiffeners of same material as face sheets extending full-door height, with vertical webs spaced not more than 6 inches (152 mm) apart. Spot weld to face sheets no more than 5 inches (127 mm) o.c. Fill spaces between stiffeners with glass- or mineral-fiber insulation.
2. Fire Door Cores: As required to provide fire-protection ratings indicated.
3. Vertical Edges for Single-Acting Doors: Bevel edges 1/8 inch in 2 inches (3.2 mm in 51 mm) .
4. Top Edge Closures: Close top edges of doors with flush closures of same material as face sheets.
5. Bottom Edge Closures: Close bottom edges of doors where required for attachment of weather stripping with end closures or channels of sam e material as face sheets.
6. Exterior Doors: Provide weep hole openings in bottoms of exterior doors to permit moisture to escape. Seal joints in top edges of doors against water penetration.
7. Astragals: Provide overlapping astragal on one leaf of pairs of doors where required by NFPA 80 for fire-performance rating or where indicated. Extend minimum 3/4 inch (19 mm) beyond edge of door on which astragal is mounted or as required to comply with published listing of qualified testing agency.

C. Hollow-Metal Frames: Where frames are fabricated in sections due to shipping or handling limitations, provide alignment plates or angles at each joint, fabricated of same thickness metal as frames.

1. Sidelight Frames: Provide closed tubular members with no visible face seams or joints, fabricated from same material as door frame. Fasten members at crossings and to jambs by butt welding.
2. Provide countersunk, flat-head or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
3. Grout Guards: Weld guards to frame at back of hardware mortises in frames to be grouted.
4. Floor Anchors: Weld anchors to bottoms of jambs with at least four spot welds per anchor; however, for slip on drywall frames, provide anchor clips or countersunk holes at bottoms

of jambs.

5. Jamb Anchors: Provide number and spacing of anchors as follows:

    a. Masonry Type: Locate anchors not more than 16 inches (406 mm) from top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c., to match coursing, and as follows:

        1) Two anchors per jamb up to 60 inches (1524 mm) high.
        2) Three anchors per jamb from 60 to 90 inches (1524 to 2286 mm) high.
        3) Four anchors per jamb from 90 to 120 inches (2286 to 3048 mm) high.
        4) Four anchors per jamb plus one additional anchor per jamb for each 24 inches (610 mm) or fraction thereof above 120 inches (3048 mm) high.

    b. Stud Wall Type: Locate anchors not more than 18 inches (457 mm) f rom top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c. and as follows:
        1) Three anchors per jamb up to 60 inches (1524 mm) high.
        2) Four anchors per jamb from 60 to 90 inches (1524 to 2286 mm) high.
        3) Five anchors per jamb from 90 to 96 inches (2286 to 2438 mm) high.
        4) Five anchors per jamb plus one additional anchor per jamb for each 24 inches (610 mm) or fraction thereof above 96 inches (2438 mm) high.

    c. Compression Type: Not less than two anchors in each frame.

    d. Post-installed Expansion Type: Locate anchors not more than 6 inches (152 mm) from top and bottom of frame. Space anchors not more than 26 inches (660 mm) o.c.

6. Head Anchors: Two anchors per head for frames more than 42 inches (1067 mm) wide and mounted in metal stud partitions.

7. Door Silencers: Except on weather stripped frames, drill stops to receive door silencers as follows. Keep holes clear during construction.

    a. Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
    b. Double-Door Frames: Drill stop in head jamb to receive two door silencers.

8. Terminated Stops: Terminate stops 6 inches (152 mm) above finish floor with a 90 degree angle cut, and close op en end of stop with steel sheet closure. Cover opening in extension of frame with welded steel filler plate, with welds ground smooth and flush with frame.

D. Fabricate concealed stiffeners and edge channels from either cold-rolled or hot-rolled steel sheet.

E. Hardware Preparation: Factory prepare hollow-metal work to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping according to SDI A250.6, the Door Hardware Schedule, and templates.

1. Reinforce doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.
2. Comply with applicable requirements in SDI A250.6 and BHMA A156.115 for preparation of hollow-metal work for hardware.

F. Stops and Moldings: Provide stops and moldings around glazed lites and louvers where indicated. Form corners of stops and moldings with mitered hairline joints.

1. Single Glazed Lites: Provide fixed stops and moldings welded on secure side of hollow-metal work.
2. Multiple Glazed Lites: Provide fixed and removable stops and moldings so that each glazed lite is capable of being removed independently.
3. Provide fix ed frame moldings on outside of exterior and on secure side of interior doors and frames.
4. Provide loose stops and moldings on inside of hollow-metal work.
5. Coordinate rabbet width between fixed and removable stops with glazing and installation types indicated.

2.8 STEEL FINISHES

A. Prime Finish: Clean, pre-treat, and apply manufacturer's standard primer.

1. Shop Primer: Manufacturer's standard, fast-curing, lead-free and chromate-free primer complying with SDI A250 .10; recommended by primer manufacturer for substrate; compatible with substrate and field applied coatings despite prolonged exposure.

2.9 ACCESSORIES

A. Mullions and Transom Bars: Join to adjacent members by welding or rigid mechanical anchors.

B. Grout Guards: Formed from same material as frames, not less than 0.016 inch (0.4 mm) thick.

PART 3 - EXECUTION

3.02 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for embedded and built-in anchors to verify actual locations before frame installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have be en corrected.

3.03 PREPARATION

A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces.

B. Drill and tap doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.

3.04 INSTALLATION

A. General: Install hollow-metal work plumb, rigid, properly aligned, and securely fastened in place. Comply with Drawings and manufacturer's written instructions.

B. Hollow-Metal Frames: Install hollow-metal frames of size and profile indicated. Comply with SDI A250.11 or NAAMMHMMA 840 as required by standards specified.

1. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, leaving surfaces smooth and undamaged.

    a. At fire-rated openings, install frames according to NFPA 80.
    b. Where frames are fabricated in sections because of shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces.
    c. Install frames with removable stops located on secure side of opening.
    d. Install door silencers in frames before grouting.
    e. Remove temporary braces necessary for installation only after frames have been properly set and secured.
    f. Check plumb, square, and twist of frames as walls are constructed. Shim as necessary to comply with installation tolerances.
    g. Field apply bituminous coating to backs of frames that will be filled with grout containing anti-freezing agents.

2. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, and secure with post-installed expansion anchors.

    a. Floor anchors may be set with power actuated fasteners instead of post-installed expansion anchors if so indicated and approved on Shop Drawings.

3. Metal-Stud Partitions: Solidly pack mineral fiber insulation inside frames.
4. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout.
5. Concrete Walls: Solidly fill space between frames and concrete with mineral fiber insulation.
6. In Place Concrete or Masonry Construction: Secure frames in place with post-installed expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
7. In Place Metal Partitions: Secure slip on drywall frames in place according to manufacturer's written instructions.
8. Installation Tolerances: Adjust hollow-metal door frames for squareness, alignment, twist, and plumb to the following tolerances:

    a. Squareness: Plus or minus 1/16 inch (1.6 mm) , measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
    b. Alignment: Plus or minus 1/16 inch (1.6 mm) , measured at jambs on a horizontal line parallel to plane of wall.
    c. Twist: Plus or minus 1/16 inch (1.6 mm) , measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
    d. Plumbness: Plus or minus 1/16 inch (1.6 mm) , measured at jambs at floor.

C. Hollow-Metal Doors: Fit hollow-metal doors accurately in frames, within clearances specified below. Shim as necessary.

1. Non Fire-Rated Steel Doors:
   a. Between Door and Frame Jambs and Head: 1/8 inch (3.2 mm) plus or minus 1/32 inch (0.8 mm) .
   b. Between Edges of Pairs of Doors: 1/8 inch (3.2 mm) to 1/4 inch (6.3 mm) plus or minus 1/32 inch (0.8 mm) .
   c. At Bottom of Door : 5/8 inch (15.8 mm) plus or minus 1/32 inch (0.8 mm) .
   d. Between Door Face and Stop: 1/16 inch (1.6 mm) to 1/8 inch (3.2 mm) plus or minus 1/32 inch (0.8 mm) .

2. Secure stops with countersunk flat-head or oval-head machine screws spaced uniformly n ot more than 9 inches (230 mm) o.c. and not more than 2 inches (51 mm) o.c. from each corner.

D. Glazing: Comply with installation requirements in Section 088000 "Glazing" and with hollow-metal manufacturer's written instructions.

1. Secure stops with countersunk flat-head or oval-head machine screws spaced uniformly not more than 9 inches (230 mm) o.c. and not more than 2 inches (51 mm) o.c. from each corner.

3.04 ADJUSTING AND CLEANING

A. Final Adjustments: Check and readjust operating hardware items immediately before final inspection. Leave work in complete and proper operating condition. Remove and replace defective work, including hollow-metal work that is warped, bowed, or otherwise unacceptable.

B. Remove grout and other bonding material from hollow-metal work immediately after installation.

C. Prime Coat Touch up: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touch up of compatible air drying, rust-inhibitive primer.

END OF SECTION

SECTION 084113 - ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Storefront framing.
2. Manual-swing entrance doors.

B. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

C. Shop Drawings: For aluminum-framed entrances and storefronts. Include plans, elevations, sections, full-size details, and attachments to other work.

1. Include details of provisions for assembly expansion and contraction and for draining moisture occurring within the assembly to the exterior.
2. Include full-size isometric details of each type of vertical-to-horizontal intersection of aluminum-framed entrances and storefronts, showing the following:

a. Joinery, including concealed welds.
b. Anchorage.
c. Expansion provisions.
d. Glazing.
e. Flashing and drainage.

3. Show connection to and continuity with adjacent thermal, weather, air, and vapor barriers.

D. Fabrication Sample: Of each vertical-to-horizontal intersection of assemblies, made from 12-inch (300-mm) lengths of full-size components and showing details of the following:

1. Joinery, including concealed welds.
2. Anchorage.
3. Expansion provisions.
4. Glazing.
5. Flashing and drainage.

E. Entrance Door Hardware Schedule: Prepared by or under supervision of supplier, detailing fabrication and assembly of entrance door hardware, as well as procedures and diagrams. Coordinate final entrance door hardware schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of entrance door hardware.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance Data: For aluminum-framed entrances and storefronts to include in maintenance manuals.

B. Maintenance Data for Structural Sealant: For structural-sealant-glazed storefront to include in maintenance manuals. Include ASTM C1401 recommendations for post-installation-phase quality-control program.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1. Do not change intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If changes are proposed, submit comprehensive explanatory data to Architect for review.

1.5 MOCKUPS

A. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.
1. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of aluminum-framed entrances and storefronts that do not comply with requirements or that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures, including, but not limited to, excessive deflection.
b. Noise or vibration created by wind and thermal and structural movements.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
d. Water penetration through fixed glazing and framing areas.
e. Failure of operating components.

2. Warranty Period: Five years from date of Substantial Completion.

B. Special Finish Warranty: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of factory-applied finishes within specified warranty period.

1. Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Hunter units when tested according to ASTM D2244.
b. Chalking in excess of a No. 8 rating when tested according to ASTM D4214.
c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain all components of aluminum-framed entrance and storefront system, including framing and accessories, from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. General Performance: Comply with performance requirements specified, as determined by testing of aluminum-framed entrances and storefronts representing those indicated for this Project without failure due to defective manufacture, fabrication, installation, or other defects in construction.

1. Aluminum-framed entrances and storefronts shall withstand movements of supporting structure, including, but not limited to, twist, column shortening, long-term creep, and deflection from uniformly distributed and concentrated live loads.
2. Failure also includes the following:

a. Thermal stresses transferring to building structure.
b. Glass breakage.
c. Noise or vibration created by wind and thermal and structural movements.
d. Loosening or weakening of fasteners, attachments, and other components.
e. Failure of operating units.

B. Deflection of Framing Members: At design wind pressure, as follows:

1. Deflection Normal to Wall Plane: Limited to edge of glass in a direction perpendicular to glass plane not exceeding 1/175 of the glass edge length for each individual glazing lite or an amount that restricts edge deflection of individual glazing lites to 3/4 inch (19.1 mm), whichever is less.
2. Deflection Parallel to Glazing Plane: Limited to 1/360 of clear span or 1/8 inch (3.2 mm), whichever is smaller.

C. Structural: Test according to ASTM E330/E330M as follows:

1. When tested at positive and negative wind-load design pressures, storefront assemblies, including entrance doors, do not evidence deflection exceeding specified limits.
2. When tested at 150 percent of positive and negative wind-load design pressures, storefront assemblies, including entrance doors and anchorage, do not evidence material failures, structural distress, or permanent deformation of main framing members exceeding 0.2 percent of span.
3. Test Durations: As required by design wind velocity, but not less than 10 seconds.

D. Air Infiltration: Test according to ASTM E283 for infiltration as follows:

1. Fixed Framing and Glass Area:

    a. Maximum air leakage of 0.06 cfm/sq. ft. (0.30 L/s per sq. m) at a static-air-pressure differential of.

2. Entrance Doors:

    a. Single Doors: Maximum air leakage of 0.5 cfm/sq. ft. (2.54 L/s per sq. m) at a static-air-pressure differential of 1.57 lbf/sq. ft. (75 Pa).

E. Water Penetration under Static Pressure: Test according to ASTM E331 as follows:

1. No evidence of water penetration through fixed glazing and framing areas, including entrance doors, when tested according to a minimum static-air-pressure differential of 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft. (300 Pa).
2. Maximum Water Leakage: According to AAMA 501.1. Water leakage does not include water controlled by flashing and gutters, or water that is drained to exterior.

F. Energy Performance: Certify and label energy performance according to NFRC as follows:

1. Thermal Transmittance (U-factor): Fixed glazing and framing areas as a system shall have U-factor of not more than 0.57 Btu/sq. ft. x h x deg F (3.23 W/sq. m x K) as determined according to NFRC 100.
2. Solar Heat Gain Coefficient (SHGC): Fixed glazing and framing areas as a system shall have SHGC of no greater than 0.40 as determined according to NFRC 200.
3. Condensation Resistance: Fixed glazing and framing areas as a system shall have an NFRC-certified condensation resistance rating of no less than 35 as determined according to NFRC 500.

G. Noise Reduction: Test according to ASTM E90, with ratings determined by ASTM E1332, as follows.

1. Outdoor-Indoor Transmission Class: Minimum 34.

H. Blast Resistance:

1. Hazard Rating: No Break according to ASTM F2912.
2. Performance Condition: 1 according to GSA-TS01.

I. Ballistics Resistance: Listed and labeled as Level 1 when tested according to UL 752.

J. Thermal Movements: Allow for thermal movements resulting from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.3 STOREFRONT SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Commercial Architectural Products, Inc.
2. EFCO Corporation.
3. Kawneer North America, an Arconic company.

B. Framing Members: Manufacturer's extruded- or formed-aluminum framing members of thickness required and reinforced as required to support imposed loads.

1. Exterior Framing Construction: Thermally broken.
2. Glazing System: Retained mechanically with gaskets on four sides.
3. Glazing Plane: Front.
4. Finish: Color anodic finish.
5. Fabrication Method: Field-fabricated stick system.
6. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
7. Steel Reinforcement: As required by manufacturer.

C. Backer Plates: Manufacturer's standard, continuous backer plates for framing members, if not integral, where framing abuts adjacent construction.

D. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

2.4 ENTRANCE DOOR SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Commercial Architectural Products, Inc.
2. EFCO Corporation.
3. Kawneer North America, an Arconic company.

B. Entrance Doors: Manufacturer's standard glazed entrance doors for manual-swing or automatic operation.

1. Door Construction: 1-3/4-inch (44.5-mm) overall thickness, with minimum 0.125-inch-(3.2-mm-) thick, extruded-aluminum tubular rail and stile members. Mechanically fasten corners with reinforcing brackets that are deeply penetrated and fillet welded or that incorporate concealed tie rods.

a. Thermal Construction: High-performance plastic connectors separate aluminum members exposed to the exterior from members exposed to the interior.

2. Door Design: Medium stile; 3-1/2-inch (88.9-mm) nominal width.
3. Glazing Stops and Gaskets: Beveled, snap-on, extruded-aluminum stops and preformed gaskets.

a. Provide nonremovable glazing stops on outside of door.

2.5 ENTRANCE DOOR HARDWARE

A. General: Provide entrance door hardware and entrance door hardware sets indicated in "Entrance Door Hardware Sets" Article for each entrance door, to comply with requirements in this Section.

1. Entrance Door Hardware Sets: Provide quantity, item, size, finish or color indicated, and products complying with BHMA standard referenced.
2. Sequence of Operation: Provide electrified door hardware function, sequence of operation, and interface with other building control systems indicated.
3. Opening-Force Requirements:

a. Egress Doors: Not more than 15 lbf (67 N) to release the latch and not more than 30 lbf (133 N) to set the door in motion and not more than 15 lbf (67 N) to open the door to its minimum required width.
b. Accessible Interior Doors: Not more than 5 lbf (22.2 N) to fully open door.

B. Designations: Requirements for design, grade, function, finish, quantity, size, and other distinctive qualities of each type of entrance door hardware are indicated in "Entrance Door Hardware Sets" Article. Products are identified by using entrance door hardware designations as follows:
1. References to BHMA Standards: Provide products complying with these standards and requirements for description, quality, and function.

C. Pivot Hinges: BHMA A156.4, Grade 1.

D. Butt Hinges: BHMA A156.1, Grade 1, radius corner.

1. Nonremovable Pins: Provide setscrew in hinge barrel that, when tightened into a groove in hinge pin, prevents removal of pin while entrance door is closed.
2. Exterior Hinges: Stainless steel, with stainless-steel pin.
3. Quantities:

a. For doors up to 87 inches (2210 mm) high, provide three hinges per leaf.

E. Continuous-Gear Hinges: BHMA A156.26.

F. Mortise Auxiliary Locks: BHMA A156.5, Grade 1.

G. Automatic and Self-Latching Flush Bolts: BHMA A156.3, Grade 1.

H. Panic Exit Devices: BHMA A156.3, Grade 1, listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for panic protection, based on testing according to UL 305.

I. Cylinders: BHMA A156.5, Grade 1.

1. Keying: Match to Owner's master key system. Permanently inscribe each key with a visual key control number and include notation "DO NOT DUPLICATE" to be furnished by Owner.

J. Strikes: Provide strike with black-plastic dust box for each latch or lock bolt; fabricated for aluminum framing.

K. Operating Trim: BHMA A156.6.

L. Removable Mullions: BHMA A156.3 extruded aluminum.

1. When used with panic exit devices, provide removable mullions listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for panic protection, based on testing according to UL 305. Use only mullions that have been tested with exit devices to be used.

M. Closers: BHMA A156.4, Grade 1, with accessories required for a complete installation, sized as required by door size, exposure to weather, and anticipated frequency of use; adjustable to comply with field conditions and requirements for opening force.

N. Door Stops: BHMA A156.16, Grade 1, floor or wall mounted, as appropriate for door location indicated, with integral rubber bumper.

O. Weather Stripping: Manufacturer's standard replaceable components.

1. Compression Type: Made of ASTM D2000 molded neoprene or ASTM D2287 molded PVC.

P. Weather Sweeps: Manufacturer's standard exterior-door bottom sweep with concealed fasteners on mounting strip.

Q. Thresholds: BHMA A156.21 raised thresholds beveled with a slope of not more than 1:2, with maximum height of 1/2 inch (12.7 mm).

R. Finger Guards: Manufacturer's standard collapsible neoprene or PVC gasket anchored to frame hinge-jamb at center-pivoted doors.

2.6 GLAZING

A. Glazing Gaskets: Manufacturer's standard sealed-corner pressure-glazing system of black, resilient elastomeric glazing gaskets, setting blocks, and shims or spacers.

2.7 MATERIALS

A. Sheet and Plate: ASTM B209 (ASTM B209M).

B. Extruded Bars, Rods, Profiles, and Tubes: ASTM B221 (ASTM B221M).

C. Extruded Structural Pipe and Tubes: ASTM B429/B429M.

D. Structural Profiles: ASTM B308/B308M.

E. Steel Reinforcement:

1. Structural Shapes, Plates, and Bars: ASTM A36/A36M.
2. Cold-Rolled Sheet and Strip: ASTM A1008/A1008M.
3. Primer: Manufacturer's standard zinc-rich, corrosion-resistant primer complying with SSPC-PS Guide No. 12.00; applied immediately after surface preparation and pretreatment. Select surface preparation methods according to recommendations in SSPC-SP COM, and prepare surfaces according to applicable SSPC standard.

2.8 ACCESSORIES

A. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.

1. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.
2. Reinforce members as required to receive fastener threads.
3. Use exposed fasteners with countersunk Phillips screw heads, fabricated from 300 series stainless steel.

B. Anchors: Three-way adjustable anchors with minimum adjustment of 1 inch (25.4 mm) that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.

1. Concrete and Masonry Inserts: Hot-dip galvanized cast-iron, malleable-iron, or steel inserts complying with ASTM A123/A123M or ASTM A153/A153M requirements.

C. Concealed Flashing: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding flashing compatible with adjacent materials.

D. Rigid PVC Filler.

2.9 FABRICATION

A. Form or extrude aluminum shapes before finishing.

B. Fabricate components that, when assembled, have the following characteristics:

1. Profiles that are sharp, straight, and free of defects or deformations.
2. Accurately fitted joints with ends coped or mitered.

3. Physical and thermal isolation of glazing from framing members.
4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
5. Provisions for field replacement of glazing from interior.
6. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.

C. Storefront Framing: Fabricate components for assembly using shear-block system.

D. Entrance Door Frames: Reinforce as required to support loads imposed by door operation and for installing entrance door hardware.

1. At interior and exterior doors, provide compression weather stripping at fixed stops.

E. Entrance Doors: Reinforce doors as required for installing entrance door hardware.

1. At exterior doors, provide weather sweeps applied to door bottoms.

F. Entrance Door Hardware Installation: Factory install entrance door hardware to the greatest extent possible. Cut, drill, and tap for factory-installed entrance door hardware before applying finishes.

G. After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.

2.10 ALUMINUM FINISHES

A. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.
1. Color: As selected by Architect from full range of industry colors and color densities.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare surfaces that are in contact with structural sealant according to sealant manufacturer's written instructions, to ensure compatibility and adhesion. Preparation includes, but is not limited to, cleaning and priming surfaces.

3.3 INSTALLATION

A. General:

1. Comply with manufacturer's written instructions.
2. Do not install damaged components.
3. Fit joints to produce hairline joints free of burrs and distortion.
4. Rigidly secure nonmovement joints.
5. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
6. Seal perimeter and other joints watertight unless otherwise indicated.

B. Metal Protection:

1. Where aluminum is in contact with dissimilar metals, protect against galvanic action by painting contact surfaces with materials recommended by manufacturer for this purpose or by installing nonconductive spacers.
2. Where aluminum is in contact with concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.

C. Set continuous sill members and flashing in full sealant bed, as specified in Section 079200 "Joint Sealants," to produce weathertight installation.

D. Install components plumb and true in alignment with established lines and grades.

E. Install glazing as specified in Section 088000 "Glazing."

F. Install weatherseal sealant according to Section 079200 "Joint Sealants" and according to sealant manufacturer's written instructions to produce weatherproof joints. Install joint filler behind sealant as recommended by sealant manufacturer.

G. Entrance Doors: Install doors to produce smooth operation and tight fit at contact points.

1. Exterior Doors: Install to produce weathertight enclosure and tight fit at weather stripping.
2. Field-Installed Entrance Door Hardware: Install surface-mounted entrance door hardware according to entrance door hardware manufacturers' written instructions using concealed fasteners to greatest extent possible.

3.4 ERECTION TOLERANCES

A. Erection Tolerances: Install aluminum-framed entrances and storefronts to comply with the following maximum tolerances:

1. Plumb: 1/8 inch in 10 feet (3.2 mm in 3 m); 1/4 inch in 40 feet (6.35 mm in 12.2 m).
2. Level: 1/8 inch in 20 feet (3.2 mm in 6 m); 1/4 inch in 40 feet (6.35 mm in 12.2 m).
3. Alignment:

a. Where surfaces abut in line or are separated by reveal or protruding element up to 1/2 inch (12.7 mm) wide, limit offset from true alignment to 1/16 inch (1.6 mm).

b. Where surfaces are separated by reveal or protruding element from 1/2 to 1 inch (12.7 to 25.4 mm) wide, limit offset from true alignment to 1/8 inch (3.2 mm).
c. Where surfaces are separated by reveal or protruding element of 1 inch (25.4 mm) wide or more, limit offset from true alignment to 1/4 inch (6 mm).

4. Location: Limit variation from plane to 1/8 inch in 12 feet (3.2 mm in 3.6 m); 1/2 inch (12.7 mm) over total length.

3.5 MAINTENANCE SERVICE

A. Entrance Door Hardware:

1. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for Owner's continued adjustment, maintenance, and removal and replacement of entrance door hardware.
2. Initial Maintenance Service: Beginning at Substantial Completion, provide six months' full maintenance by skilled employees of entrance door hardware Installer. Include quarterly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper entrance door hardware operation at rated speed and capacity. Use parts and supplies that are the same as those used in the manufacture and installation of original equipment.

END OF SECTION 084113

SECTION 087100 - DOOR HARDWARE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes:

1. Mechanical door hardware for the following:

a. Swinging doors.

2. Cylinders for door hardware specified in other Sections.

B. Related Sections:

1. Section 081113 "Hollow Metal Doors and Frames" for astragals provided as part of labeled fire-rated assemblies and for door silencers provided as part of hollow-metal frames.
2. Section 084113 "Aluminum-Framed Entrances and Storefronts" for installation of entrance door hardware, including cylinders.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction and installation details, material descriptions, dimensions of individual components and profiles, and finishes.

B. Other Action Submittals:

1. Door Hardware Schedule: Prepared by or under the supervision of Installer, detailing fabrication and assembly of door hardware, as well as installation procedures and diagrams. Coordinate final door hardware schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.

a. Submittal Sequence: Submit door hardware schedule concurrent with submissions of Product Data, Samples, and Shop Drawings. Coordinate submission of door hardware schedule with scheduling requirements of other work to facilitate the fabrication of other work that is critical in Project construction schedule.
b. Format: Comply with scheduling sequence and vertical format in DHI's "Sequence and Format for the Hardware Schedule." Double space entries, and number and date each page.

c. Format: Use same scheduling sequence and format and use same door numbers as in the Contract Documents.
d. Content: Include the following information:

1) Identification number, location, hand, fire rating, size, and material of each door and frame.
2) Locations of each door hardware set, cross-referenced to Drawings on floor plans and to door and frame schedule.
3) Complete designations, including name and manufacturer, type, style, function, size, quantity, function, and finish of each door hardware product.
4) Description of electrified door hardware sequences of operation and interfaces with other building control systems.
5) Fastenings and other pertinent information.
6) Explanation of abbreviations, symbols, and codes contained in schedule.
7) Mounting locations for door hardware.
8) List of related door devices specified in other Sections for each door and frame.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each type of door hardware to include in maintenance manuals. Include final hardware and keying schedule.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.6 QUALITY ASSURANCE

A. Architectural Hardware Consultant Qualifications: A person who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project and who is currently certified by DHI as follows:

1. For door hardware, an Architectural Hardware Consultant (AHC).

B. Source Limitations: Obtain each type of door hardware from a single manufacturer.

C. Fire-Rated Door Assemblies: Where fire-rated door assemblies are indicated, provide door hardware rated for use in assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure according to NFPA 252 or UL 10C, unless otherwise indicated.

D. Accessibility Requirements: For door hardware on doors in an accessible route, comply with the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines.

1. Provide operating devices that do not require tight grasping, pinching, or twisting of the wrist and that operate with a force of not more than 5 lbf (22.2 N).
2. Comply with the following maximum opening-force requirements:

    a. Interior, Non-Fire-Rated Hinged Doors: 5 lbf (22.2 N) applied perpendicular to door.
    b. Sliding or Folding Doors: 5 lbf (22.2 N) applied parallel to door at latch.
    c. Fire Doors: Minimum opening force allowable by authorities having jurisdiction.

3. Bevel raised thresholds with a slope of not more than 1:2. Provide thresholds not more than 1/2 inch (13 mm) high.
4. Adjust door closer sweep periods so that, from an open position of 70 degrees, the door will take at least 3 seconds to move to a point 3 inches (75 mm) from the latch, measured to the leading edge of the door.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Inventory door hardware on receipt and provide secure lock-up for door hardware delivered to Project site.

B. Tag each item or package separately with identification coordinated with the final door hardware schedule, and include installation instructions, templates, and necessary fasteners with each item or package.

C. Deliver keys to manufacturer of key control system for subsequent delivery to Owner.

D. Deliver keys and permanent cores to Owner by registered mail or overnight package service.

1.8 COORDINATION

A. Coordinate layout and installation of floor-recessed door hardware with floor construction. Cast anchoring inserts into concrete.

B. Installation Templates: Distribute for doors, frames, and other work specified to be factory prepared. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing door hardware to comply with indicated requirements.

C. Security: Coordinate installation of door hardware, keying, and access control with Owner's security consultant.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of door hardware that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Structural failures including excessive deflection, cracking, or breakage.

b. Faulty operation of doors and door hardware.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.

2. Warranty Period: Three years from date of Substantial Completion, unless otherwise indicated.

a. Exit Devices: Two years from date of Substantial Completion.
b. Manual Closers: 10 years from date of Substantial Completion.
c. Concealed Floor Closers: 10 years from date of Substantial Completion.

1.10 MAINTENANCE SERVICE

A. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions for Owner's continued adjustment, maintenance, and removal and replacement of door hardware.

B. Maintenance Service: Beginning at Substantial Completion, provide six months' full maintenance by skilled employees of door hardware Installer. Include quarterly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper door and door hardware operation. Provide parts and supplies that are the same as those used in the manufacture and installation of original products.

PART 2 - PRODUCTS

2.1 SCHEDULED DOOR HARDWARE

A. Provide door hardware for each door as scheduled on Drawings to comply with requirements in this Section.

1. Door Hardware Sets: Provide quantity, item, size, finish or color indicated, and products complying with BHMA designations referenced.
2. Sequence of Operation: Provide electrified door hardware function, sequence of operation, and interface with other building control systems indicated.

B. Designations: Requirements for design, grade, function, finish, size, and other distinctive qualities of each type of door hardware are indicated in Part 3 "Door Hardware Schedule" Article. Products are identified by using door hardware designations, as follows:
1. References to BHMA Designations: Provide products complying with these designations and requirements for description, quality, and function.

2.2 HINGES

A. Hinges: BHMA A156.1.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Baldwin Hardware Corporation.
b. Hager Companies.
c. IVES Hardware; an Ingersoll-Rand company.
d. McKinney Products Company; an ASSA ABLOY Group company.
e. Stanley Commercial Hardware; Div. of The Stanley Works.

2.3 MECHANICAL LOCKS AND LATCHES

A. Lock Throw: Comply with testing requirements for length of bolts required for labeled fire doors, and as follows:

1. Mortise Locks: Minimum 3/4-inch (19-mm) latchbolt throw.

B. Lock Backset: 2-3/4 inches (70 mm), unless otherwise indicated.

C. Lock Trim:
1. Levers: Cast.
2. Knobs: Cast.
3. Escutcheons (Roses): Cast.
4. Dummy Trim: Match lever lock trim and escutcheons.
5. Operating Device: Lever with escutcheons (roses).

D. Strikes: Provide manufacturer's standard strike for each lock bolt or latchbolt complying with requirements indicated for applicable lock or latch and with strike box and curved lip extended to protect frame; finished to match lock or latch.

1. Flat-Lip Strikes: For locks with three-piece antifriction latchbolts, as recommended by manufacturer.
2. Extra-Long-Lip Strikes: For locks used on frames with applied wood casing trim.
3. Aluminum-Frame Strike Box: Manufacturer's special strike box fabricated for aluminum framing.
4. Rabbet Front and Strike: Provide on locksets for rabbeted meeting stiles.

E. Mortise Locks: BHMA A156.13; Operational Grade 1; stamped steel case with steel or brass parts; Series 1000.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Adams Rite Manufacturing Co.; an ASSA ABLOY Group company.
b. Arrow USA; an ASSA ABLOY Group company.
c. Best Access Systems; Div. of Stanley Security Solutions, Inc.
d. Corbin Russwin Architectural Hardware; an ASSA ABLOY Group company.
e. Falcon Lock; an Ingersoll-Rand company.
f. SARGENT Manufacturing Company; an ASSA ABLOY Group company.
g. Schlage Commercial Lock Division; an Ingersoll-Rand company.
h. Yale Security Inc.; an ASSA ABLOY Group company.

F. Push-Pull Latches: Mortise, BHMA A156.13; Grade 1; with paddle handles that retract latchbolt; capable of being mounted vertically or horizontally.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Adams Rite Manufacturing Co.; an ASSA ABLOY Group company.
b. Corbin Russwin Architectural Hardware; an ASSA ABLOY Group company.
c. Glynn-Johnson; an Ingersoll-Rand company.
d. IVES Hardware; an Ingersoll-Rand company.
e. Rockwood Manufacturing Company.
f. SARGENT Manufacturing Company; an ASSA ABLOY Group company.

2.4 MANUAL FLUSH BOLTS

A. Manual Flush Bolts: BHMA A156.16; minimum 3/4-inch (19-mm) throw; designed for mortising into door edge.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Adams Rite Manufacturing Co.; an ASSA ABLOY Group company.
b. Door Controls International, Inc.
c. Hiawatha, Inc.
d. IVES Hardware; an Ingersoll-Rand company.

2.5 EXIT DEVICES AND AUXILIARY ITEMS

A. Exit Devices and Auxiliary Items: BHMA A156.3.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Adams Rite Manufacturing Co.; an ASSA ABLOY Group company.
b. Arrow USA; an ASSA ABLOY Group company.
c. Corbin Russwin Architectural Hardware; an ASSA ABLOY Group company.
d. Door Controls International, Inc.
e. Dor-O-Matic; an Ingersoll-Rand company.
f. K2 Commercial Hardware; a Black & Decker Corp. company.
g. Monarch Exit Devices & Panic Hardware; an Ingersoll-Rand company.
h. Precision Hardware, Inc.; Division of Stanley Security Solutions, Inc.
i. SARGENT Manufacturing Company; an ASSA ABLOY Group company.
j. Von Duprin; an Ingersoll-Rand company.
k. Yale Security Inc.; an ASSA ABLOY Group company.

2.6 LOCK CYLINDERS

A. Lock Cylinders: Tumbler type, constructed from brass or bronze, stainless steel, or nickel silver.

1. Manufacturer: Same manufacturer as for locking devices.

B. Construction Cores: Provide construction cores that are replaceable by permanent cores. Provide 10 construction master keys.

2.7 KEYING

A. Keying System: Factory registered, complying with guidelines in BHMA A156.28, Appendix A. Incorporate decisions made in keying conference.

1. Keyway to be Sargent LL with blank cylinders and two (2) blank keys.

2. Keyed Alike: Key all cylinders to same change key.

B. Keys: Nickel silver.

1. Stamping: Permanently inscribe each key with a visual key control number and include the following notation:

a. Notation: "DO NOT DUPLICATE."

C. Operating Trim: BHMA A156.6; bronze, unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Burns Manufacturing Incorporated.
b. Hager Companies.
c. Hiawatha, Inc.
d. IVES Hardware; an Ingersoll-Rand company.
e. Rockwood Manufacturing Company.

2.8 ACCESSORIES FOR PAIRS OF DOORS

A. Coordinators: BHMA A156.3; consisting of active-leaf, hold-open lever and inactive-leaf release trigger; fabricated from steel with nylon-coated strike plates; with built-in, adjustable safety release; and with internal override.

B. Carry-Open Bars: BHMA A156.3; prevent the inactive leaf from opening before the active leaf; provide polished brass or bronze carry-open bars with strike plate for inactive leaves of pairs of doors unless automatic or self-latching bolts are used.

C. Astragals: BHMA A156.22.

2.9 SURFACE CLOSERS

A. Surface Closers: BHMA A156.4; rack-and-pinion hydraulic type with adjustable sweep and latch speeds controlled by key-operated valves and forged-steel main arm. Comply with manufacturer's written recommendations for size of door closers depending on size of door, exposure to weather, and anticipated frequency of use. Provide factory-sized closers, adjustable to meet field conditions and requirements for opening force.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Arrow USA; an ASSA ABLOY Group company.
    b. Corbin Russwin Architectural Hardware; an ASSA ABLOY Group company.
    c. K2 Commercial Hardware; a Black & Decker Corp. company.
    d. LCN Closers; an Ingersoll-Rand company.
    e. Norton Door Controls; an ASSA ABLOY Group company.
    f. Rixson Specialty Door Controls; an ASSA ABLOY Group company.
    g. SARGENT Manufacturing Company; an ASSA ABLOY Group company.
    h. Yale Security Inc.; an ASSA ABLOY Group company.

2.10 MECHANICAL STOPS AND HOLDERS

A. Wall- and Floor-Mounted Stops: BHMA A156.16; polished cast brass, bronze, or aluminum base metal.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Door Controls International, Inc.
    b. Hager Companies.
    c. Hiawatha, Inc.
    d. IVES Hardware; an Ingersoll-Rand company.
    e. Rockwood Manufacturing Company.
    f. Stanley Commercial Hardware; Div. of The Stanley Works.

2.11 DOOR GASKETING

A. Door Gasketing: BHMA A156.22; air leakage not to exceed 0.50 cfm per foot (0.000774 cu. m/s per m) of crack length for gasketing other than for smoke control, as tested according to ASTM E 283; with resilient or flexible seal strips that are easily replaceable and readily available from stocks maintained by manufacturer.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Hager Companies.

b. Pemko Manufacturing Co.; an ASSA ABLOY Group company.
c. Reese Enterprises, Inc.

2.12 THRESHOLDS

A. Thresholds: BHMA A156.21; fabricated to full width of opening indicated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Hager Companies.
b. Pemko Manufacturing Co.; an ASSA ABLOY Group company.
c. Reese Enterprises, Inc.
d. Rixson Specialty Door Controls; an ASSA ABLOY Group company.

2.13 METAL PROTECTIVE TRIM UNITS

A. Metal Protective Trim Units: BHMA A156.6; fabricated from 0.050-inch- (1.3-mm-) thick aluminum; with manufacturer's standard machine or self-tapping screw fasteners.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Hiawatha, Inc.
b. IPC Door and Wall Protection Systems, Inc.; Div. of InPro Corporation.
c. IVES Hardware; an Ingersoll-Rand company.
d. Rockwood Manufacturing Company.

2.14 FABRICATION

A. Manufacturer's Nameplate: Do not provide products that have manufacturer's name or trade name displayed in a visible location except in conjunction with required fire-rated labels and as otherwise approved by Architect.

B. Base Metals: Produce door hardware units of base metal indicated, fabricated by forming method indicated, using manufacturer's standard metal alloy, composition, temper, and hardness. Furnish metals of a quality equal to or greater than that of specified door hardware units and BHMA A156.18.

C. Fasteners: Provide door hardware manufactured to comply with published templates prepared for machine, wood, and sheet metal screws. Provide screws that comply with commercially recognized industry standards for application intended, except aluminum fasteners are not permitted. Provide Phillips flat-head screws with finished heads to match surface of door hardware, unless otherwise indicated.

1. Concealed Fasteners: For door hardware units that are exposed when door is closed, except for units already specified with concealed fasteners. Do not use through bolts for

installation where bolt head or nut on opposite face is exposed unless it is the only means of securely attaching the door hardware. Where through bolts are used on hollow door and frame construction, provide sleeves for each through bolt.

2. Fire-Rated Applications:

    a. Wood or Machine Screws: For the following:

        1) Hinges mortised to doors or frames.
        2) Strike plates to frames.
        3) Closers to doors and frames.

    b. Steel Through Bolts: For the following unless door blocking is provided:

        1) Surface hinges to doors.
        2) Closers to doors and frames.
        3) Surface-mounted exit devices.

3. Spacers or Sex Bolts: For through bolting of hollow-metal doors.
4. Fasteners for Wood Doors: Comply with requirements in DHI WDHS.2, "Recommended Fasteners for Wood Doors."
5. Gasketing Fasteners: Provide noncorrosive fasteners for exterior applications and elsewhere as indicated.

2.15 FINISHES

A. Provide finishes complying with BHMA A156.18 as indicated in door hardware schedule.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine doors and frames, with Installer present, for compliance with requirements for installation tolerances, labeled fire-rated door assembly construction, wall and floor construction, and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Steel Doors and Frames: For surface applied door hardware, drill and tap doors and frames according to ANSI/SDI A250.6.

3.3 INSTALLATION

A. Mounting Heights: Mount door hardware units at heights to comply with the following unless otherwise indicated or required to comply with governing regulations.

1. Standard Steel Doors and Frames: ANSI/SDI A250.8.
2. Custom Steel Doors and Frames: HMMA 831.

B. Install each door hardware item to comply with manufacturer's written instructions. Where cutting and fitting are required to install door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing. Do not install surface-mounted items until finishes have been completed on substrates involved.

1. Set units level, plumb, and true to line and location. Adjust and reinforce attachment substrates as necessary for proper installation and operation.
2. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.

C. Hinges: Install types and in quantities indicated in door hardware schedule but not fewer than the number recommended by manufacturer for application indicated or one hinge for every 30 inches (750 mm) of door height, whichever is more stringent, unless other equivalent means of support for door, such as spring hinges or pivots, are provided.

D. Lock Cylinders: Install construction cores to secure building and areas during construction period.

1. Replace construction cores with permanent cores as directed by Owner.
2. Furnish permanent cores to Owner for installation.

E. Key Control System: Tag keys and place them on markers and hooks in key control system cabinet, as determined by final keying schedule.

F. Thresholds: Set thresholds for exterior doors and other doors indicated in full bed of sealant complying with requirements specified in Section 079200 "Joint Sealants."

G. Stops: Provide floor stops for doors unless wall or other type stops are indicated in door hardware schedule. Do not mount floor stops where they will impede traffic.

H. Perimeter Gasketing: Apply to head and jamb, forming seal between door and frame.

I. Meeting Stile Gasketing: Fasten to meeting stiles, forming seal when doors are closed.

J. Door Bottoms: Apply to bottom of door, forming seal with threshold when door is closed.

3.4 FIELD QUALITY CONTROL

A. Independent Architectural Hardware Consultant: Owner will engage a qualified independent Architectural Hardware Consultant to perform inspections and to prepare inspection reports.

1. Independent Architectural Hardware Consultant will inspect door hardware and state in each report whether installed work complies with or deviates from requirements, including whether door hardware is properly installed and adjusted.

3.5 ADJUSTING

A. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.

1. Spring Hinges: Adjust to achieve positive latching when door is allowed to close freely from an open position of 30 degrees.
2. Electric Strikes: Adjust horizontal and vertical alignment of keeper to properly engage lock bolt.
3. Door Closers: Adjust sweep period to comply with accessibility requirements and requirements of authorities having jurisdiction.

B. Occupancy Adjustment: Approximately six months after date of Substantial Completion, Installer's Architectural Hardware Consultant shall examine and readjust each item of door hardware, including adjusting operating forces, as necessary to ensure function of doors, door hardware, and electrified door hardware.

3.6 CLEANING AND PROTECTION

A. Clean adjacent surfaces soiled by door hardware installation.

B. Clean operating items as necessary to restore proper function and finish.

C. Provide final protection and maintain conditions that ensure that door hardware is without damage or deterioration at time of Substantial Completion.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain door hardware and door hardware finishes.

3.8 DOOR HARDWARE SCHEDULE

A. Refer to Drawings.

END OF SECTION 087100

SECTION 088000 - GLAZING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes:

1. Glass for windows, doors, interior borrowed lites, and storefront framing.
2. Glazing sealants and accessories.

1.3 DEFINITIONS

A. Glass Manufacturers: Firms that produce primary glass, fabricated glass, or both, as defined in referenced glazing publications.

B. Glass Thicknesses: Indicated by thickness designations in millimeters according to ASTM C 1036.

C. IBC: International Building Code.

D. Interspace: Space between lites of an insulating-glass unit.

1.4 COORDINATION

A. Coordinate glazing channel dimensions to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Glass Samples: For each type of glass product other than clear monolithic vision glass; 12 inches (300 mm) square.

C. Glazing Schedule: List glass types and thicknesses for each size opening and location. Use same designations indicated on Drawings.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications for Insulating-Glass Units with Sputter-Coated, Low-E Coatings: A qualified insulating-glass manufacturer who is approved and certified by coated-glass manufacturer.

B. Installer Qualifications: A qualified installer who employs glass installers for this Project who are certified under the National Glass Association's Certified Glass Installer Program.

C. Mockups: Build mockups to demonstrate aesthetic effects and to set quality standards for materials and execution.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect glazing materials according to manufacturer's written instructions. Prevent damage to glass and glazing materials from condensation, temperature changes, direct exposure to sun, or other causes.

B. Comply with insulating-glass manufacturer's written instructions for venting and sealing units to avoid hermetic seal ruptures due to altitude change.

1.8 FIELD CONDITIONS

A. Environmental Limitations: Do not proceed with glazing when ambient and substrate temperature conditions are outside limits permitted by glazing material manufacturers and when glazing channel substrates are wet from rain, frost, condensation, or other causes.

1. Do not install glazing sealants when ambient and substrate temperature conditions are outside limits permitted by sealant manufacturer or are below 40 deg F (4.4 deg C).

1.9 WARRANTY

A. Manufacturer's Special Warranty for Insulating Glass: Manufacturer agrees to replace insulating-glass units that deteriorate within specified warranty period. Deterioration of insulating glass is defined as failure of hermetic seal under normal use that is not attributed to glass breakage or to maintaining and cleaning insulating glass contrary to manufacturer's written instructions. Evidence of failure is the obstruction of vision by dust, moisture, or film on interior surfaces of glass.

1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide product indicated in glass schedules or comparable product by one of the following:

1. AGC Glass Company North America, Inc.
2. Cardinal Glass Industries.
3. General Glass International.
4. Guardian Industries Corp.
5. Oldcastle BuildingEnvelope.
6. Pilkington North America Inc.
7. PPG Industries, Inc.
8. Schott North America, Inc.
9. Trulite Glass & Aluminum Solutions.

2.2 PERFORMANCE REQUIREMENTS

A. General: Installed glazing systems shall withstand normal thermal movement and wind and impact loads (where applicable) without failure, including loss or glass breakage attributable to the following: defective manufacture, fabrication, or installation; failure of sealants or gaskets to remain watertight and airtight; deterioration of glazing materials; or other defects in construction.

B. Structural Performance: Glazing shall withstand the following design loads within limits and under conditions indicated determined according to the IBC and ASTM E 1300.

1. Design Wind Pressures: Withstand 100 mph winds.
2. Maximum Lateral Deflection: For glass supported on all four edges, limit center-of-glass deflection at design wind pressure to not more than 1/50 times the short-side length or 1 inch (25 mm), whichever is less.
3. Differential Shading: Design glass to resist thermal stresses induced by differential shading within individual glass lites.

C. Safety Glazing: Where safety glazing is indicated, provide glazing that complies with 16 CFR 1201, Category II.

D. Thermal and Optical Performance Properties: Provide glass with performance properties specified, as indicated in manufacturer's published test data, based on procedures indicated below:

1. For monolithic-glass lites, properties are based on units with lites 6 mm thick.
2. For laminated-glass lites, properties are based on products of construction indicated.
3. For insulating-glass units, properties are based on units of thickness indicated for overall unit and for each lite.
4. U-Factors: Center-of-glazing values, according to NFRC 100 and based on LBL's WINDOW 5.2 computer program, expressed as Btu/sq. ft. x h x deg F (W/sq. m x K).
5. Solar Heat-Gain Coefficient and Visible Transmittance: Center-of-glazing values, according to NFRC 200 and based on LBL's WINDOW 5.2 computer program.
6. Visible Reflectance: Center-of-glazing values, according to NFRC 300.

2.3 GLASS PRODUCTS, GENERAL

A. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below unless more stringent requirements are indicated. See these publications for glazing terms not otherwise defined in this Section or in referenced standards.

1. GANA Publications: "Laminated Glazing Reference Manual" and "Glazing Manual."
2. AAMA Publications: AAMA GDSG-1, "Glass Design for Sloped Glazing," and AAMA TIR A7, "Sloped Glazing Guidelines."
3. IGMA Publication for Sloped Glazing: IGMA TB-3001, "Guidelines for Sloped Glazing."
4. IGMA Publication for Insulating Glass: SIGMA TM-3000, "North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial and Residential Use."

B. Safety Glazing Labeling: Where safety glazing is indicated, permanently mark glazing with certification label of the SGCC. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.

C. Insulating-Glass Certification Program: Permanently marked either on spacers or on at least one component lite of units with appropriate certification label of IGCC.

D. Thickness: Where glass thickness is indicated, it is a minimum. Provide glass that complies with performance requirements and is not less than the thickness indicated.

1. Minimum Glass Thickness for Exterior Lites: 6 mm.
2. Thickness of Tinted Glass: Provide same thickness for each tint color indicated throughout Project.

E. Strength: Where annealed float glass is indicated, provide annealed float glass, heat-strengthened float glass, or fully tempered float glass as needed to comply with "Performance Requirements" Article. Where heat-strengthened float glass is indicated, provide heat-strengthened float glass or fully tempered float glass as needed to comply with "Performance Requirements" Article. Where fully tempered float glass is indicated, provide fully tempered float glass.

2.4 GLASS PRODUCTS

A. Fully Tempered Float Glass: ASTM C 1048, Kind FT (fully tempered), Condition A (uncoated) unless otherwise indicated, Type I, Class 1 (clear) or Class 2 (tinted) as indicated, Quality-Q3.

1. Fabrication Process: By horizontal (roller-hearth) process with roll-wave distortion parallel to bottom edge of glass as installed unless otherwise indicated.

2.5 INSULATING GLASS

A. Insulating-Glass Units: Factory-assembled units consisting of sealed lites of glass separated by a dehydrated interspace, qualified according to ASTM E 2190.

1. Sealing System: Dual seal, with manufacturer's standard polyisobutylene and silicone primary and secondary sealants.
2. Spacer: Manufacturer's standard spacer material and construction Thermally broken aluminum.
3. Desiccant: Molecular sieve or silica gel, or a blend of both.

2.6 GLAZING SEALANTS

A. General:

1. Compatibility: Compatible with one another and with other materials they contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.
2. Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.
3. Colors of Exposed Glazing Sealants: As selected by Architect from manufacturer's full range.

B. Glazing Sealant: Neutral-curing silicone glazing sealant complying with ASTM C 920, Type S, Grade NS, Class 100/50, Use NT.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Dow Corning Corporation; 790.
   b. GE Advanced Materials - Silicones; SilPruf LM SCS2700.
   c. Pecora Corporation; 890NST.
   d. Sika Corporation U.S.; Sikasil WS-290.
   e. Tremco Incorporated; Spectrem 1.

2.7 GLAZING TAPES

A. Back-Bedding Mastic Glazing Tapes: Preformed, butyl-based, 100 percent solids elastomeric tape; nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod as recommended in writing by tape and glass manufacturers for application indicated; and complying with ASTM C 1281 and AAMA 800 for products indicated below:

1. AAMA 804.3 tape, where indicated.
2. AAMA 806.3 tape, for glazing applications in which tape is subject to continuous pressure.
3. AAMA 807.3 tape, for glazing applications in which tape is not subject to continuous pressure.

2.8 MISCELLANEOUS GLAZING MATERIALS

A. General: Provide products of material, size, and shape complying with referenced glazing standard, with requirements of manufacturers of glass and other glazing materials for application indicated, and with a proven record of compatibility with surfaces contacted in installation.

B. Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.

C. Setting Blocks: Elastomeric material with a Shore, Type A durometer hardness of 85, plus or minus 5.

D. Spacers: Elastomeric blocks or continuous extrusions of hardness required by glass manufacturer to maintain glass lites in place for installation indicated.

E. Edge Blocks: Elastomeric material of hardness needed to limit glass lateral movement (side walking).

F. Cylindrical Glazing Sealant Backing: ASTM C 1330, Type O (open-cell material), of size and density to control glazing sealant depth and otherwise produce optimum glazing sealant performance.

2.9 FABRICATION OF GLAZING UNITS

A. Fabricate glazing units in sizes required to fit openings indicated for Project, with edge and face clearances, edge and surface conditions, and bite complying with written instructions of product manufacturer and referenced glazing publications, to comply with system performance requirements.

1. Allow for thermal movements from ambient and surface temperature changes acting on glass framing members and glazing components.

a. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

B. Clean-cut or flat-grind vertical edges of butt-glazed monolithic lites to produce square edges with slight chamfers at junctions of edges and faces.

C. Grind smooth and polish exposed glass edges and corners.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine framing, glazing channels, and stops, with Installer present, for compliance with the following:

1. Manufacturing and installation tolerances, including those for size, squareness, and offsets at corners.

2. Presence and functioning of weep systems.
3. Minimum required face and edge clearances.
4. Effective sealing between joints of glass-framing members.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean glazing channels and other framing members receiving glass immediately before glazing. Remove coatings not firmly bonded to substrates.

B. Examine glazing units to locate exterior and interior surfaces. Label or mark units as needed so that exterior and interior surfaces are readily identifiable. Do not use materials that leave visible marks in the completed Work.

3.3 GLAZING, GENERAL

A. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.

B. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass includes glass with edge damage or other imperfections that, when installed, could weaken glass, impair performance, or impair appearance.

C. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.

D. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.

E. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.

F. Provide spacers for glass lites where length plus width is larger than 50 inches (1270 mm).

1. Locate spacers directly opposite each other on both inside and outside faces of glass. Install correct size and spacing to preserve required face clearances, unless gaskets and glazing tapes are used that have demonstrated ability to maintain required face clearances and to comply with system performance requirements.
2. Provide 1/8-inch (3-mm) minimum bite of spacers on glass and use thickness equal to sealant width. With glazing tape, use thickness slightly less than final compressed thickness of tape.

G. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and according to requirements in referenced glazing publications.

H. Set glass lites in each series with uniform pattern, draw, bow, and similar characteristics.

I. Set glass lites with proper orientation so that coatings face exterior or interior as specified.

J. Where wedge-shaped gaskets are driven into one side of channel to pressurize sealant or gasket on opposite side, provide adequate anchorage so gasket cannot walk out when installation is subjected to movement.

K. Square cut wedge-shaped gaskets at corners and install gaskets in a manner recommended by gasket manufacturer to prevent corners from pulling away; seal corner joints and butt joints with sealant recommended by gasket manufacturer.

3.4 GASKET GLAZING (DRY)

A. Cut compression gaskets to lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.

B. Insert soft compression gasket between glass and frame or fixed stop so it is securely in place with joints miter cut and bonded together at corners.

C. Installation with Drive-in Wedge Gaskets: Center glass lites in openings on setting blocks, and press firmly against soft compression gasket by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.

D. Installation with Pressure-Glazing Stops: Center glass lites in openings on setting blocks, and press firmly against soft compression gasket. Install dense compression gaskets and pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.

E. Install gaskets so they protrude past face of glazing stops.

3.5 CLEANING AND PROTECTION

A. Immediately after installation remove nonpermanent labels and clean surfaces.

B. Protect glass from contact with contaminating substances resulting from construction operations. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains.

C. Remove and replace glass that is damaged during construction period.

D. Wash glass on both exposed surfaces not more than four days before date scheduled for inspections that establish date of Substantial Completion. Wash glass as recommended in writing by glass manufacturer.

3.6 MONOLITHIC GLASS SCHEDULE

A. Glass Type GL-1: Clear fully tempered float glass.

1. Minimum Thickness: 6 mm.
2. Safety glazing required.

3.7 LAMINATED GLASS SCHEDULE

A. Glass Type GL-2: Clear laminated glass with two plies of fully tempered float glass.

1. Minimum Thickness of Each Glass Ply: 6 mm.
2. Interlayer Thickness: 0.060 inch (1.52 mm).
3. Safety glazing required.

3.8 INSULATING GLASS SCHEDULE

A. Glass Type GL-3: Low-E-coated, clear insulating glass.

1. Overall Unit Thickness: 1 inch (25 mm).
2. Minimum Thickness of Each Glass Lite: 6 mm.
3. Outdoor Lite: Fully tempered float glass.
4. Interspace Content: Air.
5. Indoor Lite: Fully tempered float glass.
6. Low-E Coating: Pyrolytic on second surface.
7. Winter Nighttime U-Factor: 0.35 maximum.
8. Summer Daytime U-Factor: 0.35 maximum.
9. Visible Light Transmittance: 60 percent minimum.
10. Solar Heat Gain Coefficient: 0.34 maximum.
11. Safety glazing required.

END OF SECTION 088000

SECTION 099113 - EXTERIOR PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes surface preparation and the application of paint systems on exterior substrates.

B. Related Requirements:

1. Section 099123 "Interior Painting" for surface preparation and the application of paint systems on interior substrates.

C. ACTION SUBMITTALS

D. Product Data: For each type of product. Include preparation requirements and application instructions.

E. Samples for Initial Selection: For each type of topcoat product.

F. Samples for Verification: For each type of paint system and each color and gloss of topcoat.

1. Submit Samples on rigid backing, 8 inches (200 mm) square.
2. Step coats on Samples to show each coat required for system.
3. Label each coat of each Sample.
4. Label each Sample for location and application area.

G. Product List: For each product indicated, include the following:

1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
2. Printout of current "MPI Approved Products List" for each product category specified, with the proposed product highlighted.
3. VOC content.

1.3 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Paint: 5 percent, but not less than 1 gal. (3.8 L) of each material and color applied.

1.4 QUALITY ASSURANCE

A. Mockups: Apply mockups of each paint system indicated and each color and finish selected to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Architect will select one surface to represent surfaces and conditions for application of each paint system specified in Part 3.

a. Vertical and Horizontal Surfaces: Provide samples of at least 100 sq. ft. (9 sq. m).
b. Other Items: Architect will designate items or areas required.

2. Final approval of color selections will be based on mockups.

a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to Owner.

3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).

1. Maintain containers in clean condition, free of foreign materials and residue.
2. Remove rags and waste from storage areas daily.

1.6 FIELD CONDITIONS

A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).

B. Do not apply paints in snow, rain, fog, or mist; when relative humidity exceeds 85 percent; at temperatures less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Benjamin Moore & Co.
2. PPG Architectural Finishes, Inc.
3. Sherwin-Williams Company (The).

2.2 PAINT, GENERAL

A. Material Compatibility:

1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.

B. VOC Content: Provide materials that comply with VOC limits of authorities having jurisdiction.

C. Colors: As selected by Architect from manufacturer's full range.

1. 10 percent of surface area will be painted with deep tones.

D. Locations: Paint all previously-painted surfaces within project scope, as well as surfaces indicated to be painted in Drawings.

2.3 SOURCE QUALITY CONTROL

A. Testing of Paint Materials: Owner reserves the right to invoke the following procedure:

1. Owner will engage the services of a qualified testing agency to sample paint materials. Contractor will be notified in advance and may be present when samples are taken. If paint materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
2. Testing agency will perform tests for compliance with product requirements.
3. Owner may direct Contractor to stop applying paints if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying paint materials from Project site, pay for testing, and repaint surfaces painted with rejected materials. Contractor will be required to remove rejected materials from previously painted surfaces if, on repainting with complying materials, the two paints are incompatible.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:

1. Concrete: 12 percent.
2. Masonry (Clay and CMU): 12 percent.
3. Wood: 15 percent.
4. Portland Cement Plaster: 12 percent.

5. Gypsum Board: 12 percent.

C. Portland Cement Plaster Substrates: Verify that plaster is fully cured.

D. Exterior Gypsum Board Substrates: Verify that finishing compound is sanded smooth.

E. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.

F. Proceed with coating application only after unsatisfactory conditions have been corrected.

1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations in "MPI Manual" applicable to substrates and paint systems indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.

1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection.

C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.

1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.

D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.

E. Masonry Substrates: Remove efflorescence and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces or mortar joints exceeds that permitted in manufacturer's written instructions.

F. Steel Substrates: Remove rust, loose mill scale, and shop primer if any. Clean using methods recommended in writing by paint manufacturer but not less than the following:

1. SSPC-SP 2, "Hand Tool Cleaning."
2. SSPC-SP 3, "Power Tool Cleaning."
3. SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
4. SSPC-SP 11, "Power Tool Cleaning to Bare Metal."

G. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.

H. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.

I. Aluminum Substrates: Remove loose surface oxidation.

J. Wood Substrates:

1. Scrape and clean knots. Before applying primer, apply coat of knot sealer recommended in writing by topcoat manufacturer for exterior use in paint system indicated.
2. Sand surfaces that will be exposed to view, and dust off.
3. Prime edges, ends, faces, undersides, and backsides of wood.
4. After priming, fill holes and imperfections in the finish surfaces with putty or plastic wood filler. Sand smooth when dried.

K. Plastic Trim Fabrication Substrates: Remove dust, dirt, and other foreign material that might impair bond of paints to substrates.

3.3 APPLICATION

A. Apply paints according to manufacturer's written instructions and recommendations in "MPI Manual."

1. Use applicators and techniques suited for paint and substrate indicated.
2. Paint surfaces behind movable items same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed items with prime coat only.
3. Paint both sides and edges of exterior doors and entire exposed surface of exterior door frames.
4. Paint entire exposed surface of window frames and sashes.
5. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
6. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.

B. Tint undercoats same color as topcoat, but tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Provide sufficient difference in shade of undercoats to distinguish each separate coat.

C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.

D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

E. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:

1. Paint the following work where exposed to view:

a. Equipment, including panelboards and switch gear.
b. Uninsulated metal piping.
c. Uninsulated plastic piping.
d. Pipe hangers and supports.
e. Metal conduit.
f. Plastic conduit.
g. Tanks that do not have factory-applied final finishes.

3.4 FIELD QUALITY CONTROL

A. Dry Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry film thickness.

1. Contractor shall touch up and restore painted surfaces damaged by testing.
2. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.6 EXTERIOR PAINTING SCHEDULE (Basis-of-Design: The Sherwin Williams Co.)

A. Concrete Substrates, Nontraffic Surfaces:

1. Latex System:

a. Prime Coat: S-W Loxon Masonry Primer, A24W8300
b. Intermediate Coat: S-W Resilience Exterior Acrylic Latex, K44Series
c. Topcoat: Latex, S-W Resilience Exterior Acrylic Latex, K44 Series.

B. Clay-Masonry Substrates:

1. Latex System:

a. Prime Coat: S-W Loxon Masonry Primer, A24W8300

b. Intermediate Coat S-W Resilience Exterior Acrylic Latex, K44Series
c. Topcoat: S-W Resilience Exterior Acrylic Latex, K44Series.

C. CMU Substrates:

1. Latex System:

a. Prime Coat: S-W Heavy Duty Block Filler, B42W46
b. Intermediate Coat: S-W Conflex XL High Build Exterior Coating, A5-450 Series.
c. Topcoat: S-W Conflex XL High Build Exterior Coating, A5-450 Series.

D. Steel Substrates:

1. Alkyd System:

a. Prime Coat: S-W Kem Kromik Universal Primer, B50Z Series.
b. Intermediate Coat: S-W Pro Industrial Waterbased Urethane Alkyd, B53 Series.
c. Topcoat: S-W Pro Industrial Waterbased Urethane Alkyd, B53 Series.

2. Aluminum Paint System:

a. Prime Coat: S-W Kem Kromik Universal Primer, B50Z Series.
b. Intermediate Coat: S-W Industrial Aluminum Paint, B59S4
c. Topcoat: S-W Industrial Aluminum Paint, B59S4

E. Wood Substrates: Including wood trim, architectural woodwork.

1. Latex System:

a. Prime Coat: S-W Exterior Latex Wood Primer, B42W8041
b. Intermediate Coat: S-W Resilience Exterior Acrylic Latex, K44Series
c. Topcoat: S-W Resilience Exterior Acrylic Latex, K44Series.

F. Plastic Trim Fabrication Substrates:

1. Latex System:

a. Prime Coat: S-W Extreme Bond Primer, B51W150.
b. Intermediate Coat: S-W Resilience Exterior Acrylic Latex, K44Series
c. Topcoat: S-W Resilience Exterior Acrylic Latex, K44Series.

G. Portland Cement Plaster Substrates:

1. Latex System:

a. Prime Coat: S-W Loxon Masonry Primer, A24W8300
b. Intermediate Coat: S-W Resilience Exterior Acrylic Latex, K44Series.
c. Topcoat: S-W Resilience Exterior Acrylic Latex, K44Series.

H. Cementitious Wood Fiber Panel Substrates (Tectum):

1. Dry Fall, S-W Pro Industrial Waterborne Acrylic Dryfall, B42 Series.

END OF SECTION 099113

SECTION 099123 - INTERIOR PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, as provided by the Owner, apply to this Section.

1.2 SUMMARY

A. Section includes surface preparation and the application of paint systems on interior substrates:

1. Concrete masonry units (CMU).
2. Ceramic tile / glazed CMU / structural glazed tile.
3. Steel.
4. Galvanized metal.
5. Wood.
6. Gypsum board.
7. Plaster.

B. For any item solely identified in the bid documents as “Basis of Design”, “Owner Approved Equal” products may be considered.

1.3 DEFINITIONS

A. Gloss Level 1: Not more than 5 units at 60 degrees and 10 units at 85 degrees, according to ASTM D 523, a matte flat finish.

B. Gloss Level 2: Not more than 10 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523, a high-side sheen flat, velvet-like finish.

C. Gloss Level 3: 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523, an eggshell finish.

D. Gloss Level 4: 20 to 35 units at 60 degrees and not less than 35 units at 85 degrees, according to ASTM D 523, a satin-like finish.

E. Gloss Level 5: 35 to 70 units at 60 degrees, according to ASTM D 523, a semi-gloss finish.

F. Gloss Level 6: 70 to 85 units at 60 degrees, according to ASTM D 523, a gloss finish.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include preparation requirements and application instructions.

B. Samples for Initial Selection: For each type of topcoat product.

C. Samples for Verification: For each type of paint system and in each color and gloss of topcoat.

1. Submit Samples on rigid backing, 8 inches (200 mm) square.
2. Step coats on Samples to show each coat required for system.
3. Label each coat of each Sample.
4. Label each Sample for location and application area.

D. Product List: For each product indicated, include the following:

1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
2. VOC content.

1.5 CLOSEOUT SUBMITTALS

A. Coating Maintenance Manual: Provide coating maintenance manual including area summary with finish schedule, area detail designating location where each product/color/finish was used, product data pages, material safety data sheets, care and cleaning instructions, touch-up procedures, and color samples of each color and finish used. Use same designations indicated on drawings / schedules.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Paint: For each facility where work is performed, Provide 1 gal. (3.8 L) of each coating type in each color applied.

1.7 QUALITY ASSURANCE

A. Mockups: Apply mockups of each paint system indicated and each color and finish selected to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Owner will select one surface to represent surfaces and conditions for application of each paint system specified in Part 3.

a. Vertical and Horizontal Surfaces: Provide samples of at least 100 sq. ft. (9 sq. m).
b. Other Items: Architect will designate items or areas required.

2. Final approval of color selections will be based on mockups.

a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to Owner.

3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion and accepted by Owner.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Handling: Deliver products to Project site in an undamaged condition in manufacturer's original sealed containers, complete with labels and instructions for handling, storing, unpacking, protecting, and installing. Packaging shall bear the manufacturer's label with the following information:

1. Product name and type (description).
2. Batch date.
3. Color number.
4. VOC content.
5. Environmental handling requirements.
6. Surface preparation requirements.
7. Application instructions.

B. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).

1. Maintain containers in clean condition, free of foreign materials and residue.
2. Remove rags and waste from storage and work areas daily.

1.9 FIELD CONDITIONS

A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).

B. Do not apply paints when relative humidity exceeds 85 percent; at temperatures less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.

C. Lead Paint: It is not expected that lead paint will be encountered in the Work.

1. If suspected lead paint is encountered, do not disturb; immediately notify Owner.

D. Lead Paint: Lead paint **may be** present in buildings and structures to be painted. A report on the presence of lead paint is on file for review and use. Examine report to become aware of locations where lead paint is present.

1. Do not disturb lead paint or items suspected of containing hazardous materials except under procedures specified.
2. Where applicable, perform preparation for painting of substrates known to include lead paint in accordance with EPA Renovation, Repair and Painting Rule and additional requirements of authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide products indicated in construction documents or Owner-approved equal from one of the following:
1. Sherwin-Williams Company.
2. Benjamin Moore & Co.

3. Glidden Professional, Division of PPG Architectural Finishes, Inc.
4. PPG Architectural Finishes, Inc.
5. Pratt & Lambert.

B. Source Limitations: Obtain paint materials from single source from single listed manufacturer.

1. Manufacturer's designations listed on a separate color schedule are for color reference only and do not indicate prior approval.

2.2 PAINT, GENERAL

A. Material Compatibility:

1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.

B. VOC Content: Comply with current State of Illinois Regulations regarding VOC (Volatile Organic Compounds).

C. Colors: Match Owner's final approved samples as indicated in construction documents.

2.3 SOURCE QUALITY CONTROL

A. Testing of Paint Materials: Owner reserves the right to invoke the following procedure:

1. Owner will engage the services of a qualified testing agency to sample paint materials. Contractor will be notified in advance and may be present when samples are taken. If paint materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
2. Testing agency will perform tests for compliance with product requirements.
3. Owner may direct Contractor to stop applying coatings if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying paint materials from Project site, pay for testing, and repaint surfaces painted with rejected materials. Contractor will be required to remove rejected materials from previously painted surfaces if, on repainting with complying materials, the two paints are incompatible. Contractor responsible for substrate damage identified, resulting from removal of rejected materials based on compliance testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers. Where acceptability of substrate conditions is in question, apply samples and

perform in-situ testing to verify compatibility, adhesion, and film integrity of new paint application.

1. Applicator to report, in writing, conditions that may affect application, appearance, or performance of paint.

B. Substrate Conditions:

1. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:

   a. Masonry (Clay and CMU): 12 percent.
   b. Wood: 15 percent.
   c. Gypsum Board: 12 percent.
   d. Plaster: 12 percent.

2. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.
3. Plaster Substrates: Verify that plaster is fully cured.
4. Existing finished surfaces: Verify existing finish is adequate or made ready to receive new finish.

C. Proceed with coating application only after unsatisfactory conditions have been corrected; application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Patch and prepare surfaces to create like-new finish conditions.

B. Comply with manufacturer's written instructions and recommendations in "MPI Manual" applicable to substrates indicated.

C. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.

1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.

D. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, tape and incompatible paints and encapsulants.

1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.

E. Concrete Masonry Units (CMU): Clean all CMU with Simple Green or “Owner-approved equal” product.

F. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.

G. Masonry Substrates: Remove efflorescence and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces or mortar joints exceed that permitted in manufacturer's written instructions.

H. Ceramic Tile, Structural Glazed Tile, Glazed CMU:
   1. The vitreous substrate must be structurally sound. Clean greasy, oily surfaces with hot soapy solution like Spic & Span. Followed by xylene solvent wipe.
   2. Lightly sand all surfaces paying particular attention to grout joints. Vacuum dust.

I. Steel Substrates: Remove rust, loose mill scale, and shop primer, if any. Clean using methods recommended in writing by paint manufacturer but not less than the following:

   1. SSPC-SP 2, "Hand Tool Cleaning."
   2. SSPC-SP 3, "Power Tool Cleaning."
   3. SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
   4. SSPC-SP 11, "Power Tool Cleaning to Bare Metal."

J. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.

K. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal fabricated from coil stock by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.

L. Wood Substrates:

   1. Scrape and clean knots, and apply coat of knot sealer before applying primer.
   2. Sand surfaces that will be exposed to view, and dust off.
   3. Prime edges, ends, faces, undersides, and backsides of wood.
   4. After priming, fill holes and imperfections in the finish surfaces with putty or plastic wood filler. Sand smooth when dried.

3.3 APPLICATION

A. Apply one coat of primer and two coats of finish paint.

B. Apply paints according to manufacturer's written instructions and to recommendations in "MPI Manual."

   1. Use applicators and techniques suited for paint and substrate indicated.
   2. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
   3. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces. All operable parts must be in full operable condition when painting is complete and dry.
   4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
   5. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.

C. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Tint undercoats to match color of topcoat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.

D. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.

E. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

3.4 FIELD QUALITY CONTROL

A. Dry Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry film thickness.

1. Contractor shall touch up and restore painted surfaces damaged by testing.
2. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project Site.

B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

3.6 INTERIOR PAINTING SCHEDULE

A. CMU Substrates:

1. Water-Based Light Industrial Coating System:

a. Block filler: Latex, interior/exterior: S-W PrepRite Block Filler, B25W25, at 100 to 200 sq. ft. per gal (2.4 to 4.9 sq. m per l). (Use if unpainted CMU.)
b. Primer: S-W Protective & Marine Coatings, DTM Acrylic Coating (not required above 6’-0” above finished floor).
a. Topcoat: Light industrial coating, interior, water based, eggshell: S-W Pro Industrial Pre-Catalyzed Water-based Epoxy, K45-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat.

B. Ceramic Tile, Glazed CMU:
1. Two Step System:
a. Step One: Pre-primer / Tack Coat S-W 5531.

b. Step Two: S-W Protective & Marine Coatings, Water-based Tile-clad Epoxy finish (Part A & Part B).

C. Metal Substrates (Aluminum, Steel, Galvanized Steel, Hollow Metal Frames and Doors):

1. Latex System:

a. Prime Coat: Primer, rust-inhibitive, water-based alkyd: S-W Pro Industrial Pro-Cryl Universal Primer, B66-310 Series, at 5.0 to 10 mils wet, 2.0 to 4.0 mils dry.
b. Intermediate Coat: Water-based acrylic, interior, matching topcoat.
c. Topcoat: Water-based acrylic, semi-gloss: S-W Pro Industrial Acrylic Semi-Gloss Coating, B66-650 Series, at 2.5 to 4.0 mils dry, per coat.
d. Topcoat: Water-based acrylic, gloss: S-W Pro Industrial Acrylic Gloss Coating, B66-660 Series, at 2.5 to 4.0 mils dry, per coat.

2. Water-Based Dry-Fall System:

a. Top Coat: Dry-fall latex, flat: S-W Pro Industrial Waterborne Acrylic Dryfall Flat, B42-80 Series, at 6.0 mils wet, 1.7 mils dry.
b. Top Coat: Dry-fall latex, eggshell: S-W Pro Industrial Waterborne Acrylic DryFall Eg-Shel, B42-2 Series, at 6.0 mils wet, 1.9 mils dry.
c. Top Coat: Dry-fall latex, semi-gloss: S-W Pro Industrial Waterborne Acrylic DryFall Semi-Gloss, B42-80 Series, at 5.8 mils wet, 2.3 mils dry.

3. Water-Based Light Industrial Coating System:

a. Prime Coat: Primer, water based: S-W Pro Industrial Pro-Cryl Universal Primer, B66-310 Series, at 5.0 to 10.0 mils wet, 2.0 to 4.0 mils dry.
b. Intermediate Coat: Light industrial coating, interior, water based, matching topcoat.
c. Topcoat: Light industrial coating, interior, water based, eggshell: S-W Pro Industrial Pre-Catalyzed Water Based Epoxy, K45-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat.

D. Wood Substrates: Including exposed wood items not indicated to receive shop-applied finish.

1. Latex System:

a. Prime Coat: Primer sealer, latex, interior: S-W PrepRite ProBlock Primer Sealer, B51-620 Series, at 4.0 mils wet, 1.4 mils dry.
b. Intermediate Coat: Latex, interior, matching topcoat.
a. Topcoat: Latex, interior, eggshell: S-W ProMar 200 Zero VOC Latex Eg-Shel, B20-2600 Series, at 4.0 mils wet, 1.7 mils dry, per coat.
b. Topcoat: Latex, interior, semi-gloss: S-W ProMar 200 Zero VOC Latex Semi-Gloss, B31-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat.
c. Topcoat: Latex, interior, gloss: S-W ProMar 200 Latex Gloss, B11-2200 Series, at 4.0 mils wet, 1.5 mils dry, per coat.

2. Water-Based Light Industrial Coating System:

a. Prime Coat: Primer sealer, latex, interior: S-W PrepRite ProBlock Primer Sealer, B51-620 Series, at 4.0 mils wet, 1.4 mils dry.
b. Intermediate Coat: Light industrial coating, interior, water based, matching topcoat.
c. Topcoat: Light industrial coating, interior, water based, eggshell: S-W Pro Industrial Pre-Catalyzed Water Based Epoxy, K45-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat.

E. Gypsum Board, Plaster and Spray-Texture Ceiling Substrates:

1. Water-Based Light Industrial Coating System:

a. Primer: Protective & Marine Coatings, DTM Acrylic Coating
b. Intermediate Coat: Light industrial coating, interior, water based, matching topcoat.
c. Topcoat: Light industrial coating, interior, water based, eggshell: S-W Pro Industrial Pre-Catalyzed Waterbased Epoxy, K45-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat.

END OF SECTION 099123

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TECHNICAL NOTES on Brick Construction
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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.

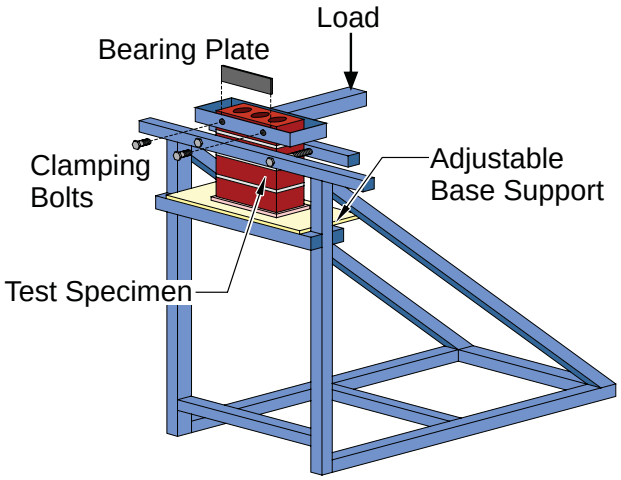

Figure 1
Bond Wrench Test Apparatus

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.*

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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 Pressurized Water 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 Pressurized Water 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. See **Brick Category** for additional remarks based on brick color.
Glazed Brick	Bucket and Brush Hand Cleaning 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 ⅛ 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.*

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Technical Notes on Brick Construction

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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.

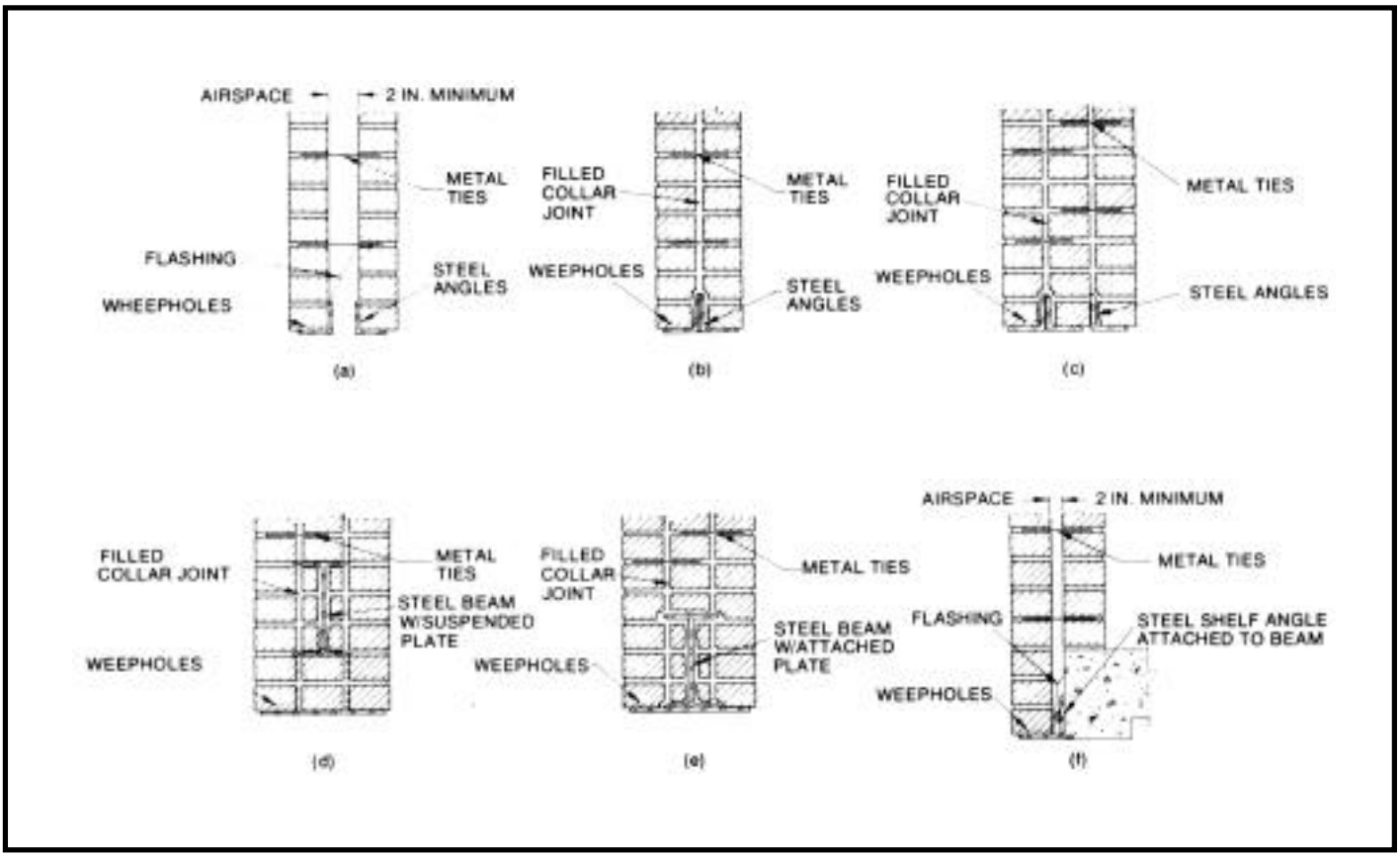

Fig. 1
Types of Structural Steel Lintels

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.

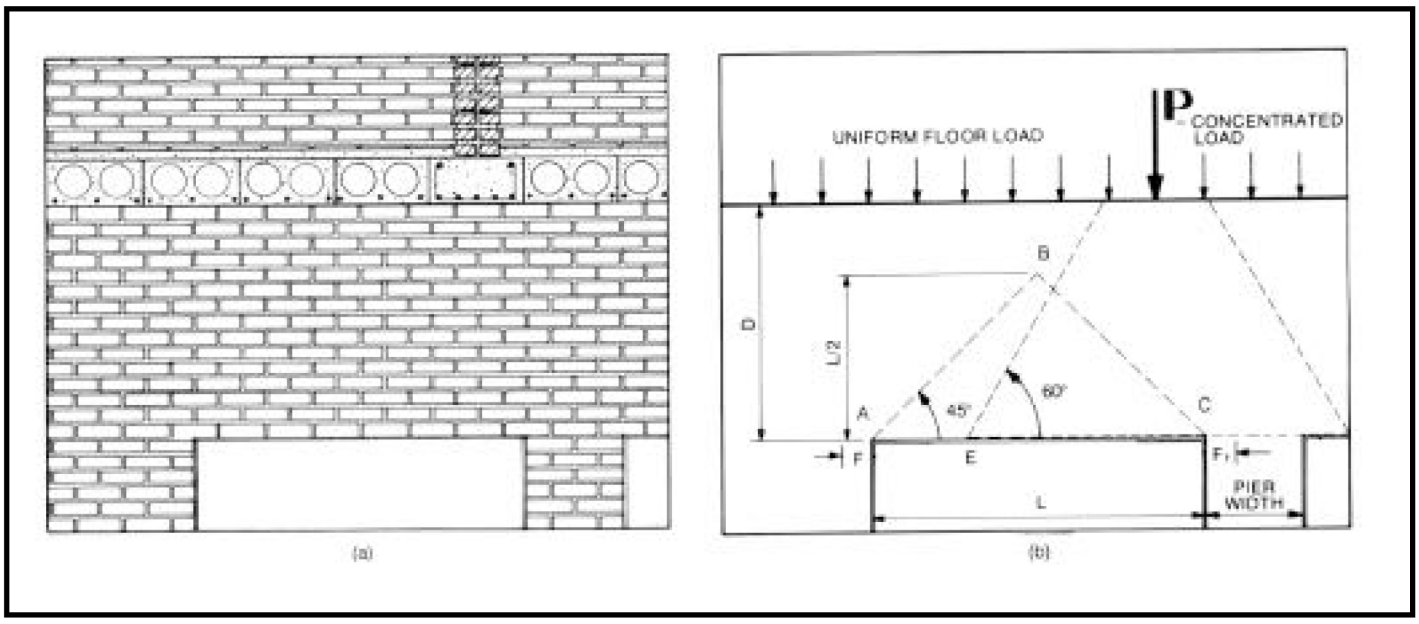

Fig. 2
Lintel Load Determination

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:

Δ_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.

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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, ⅓ part hydrated lime and 1⅓ 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

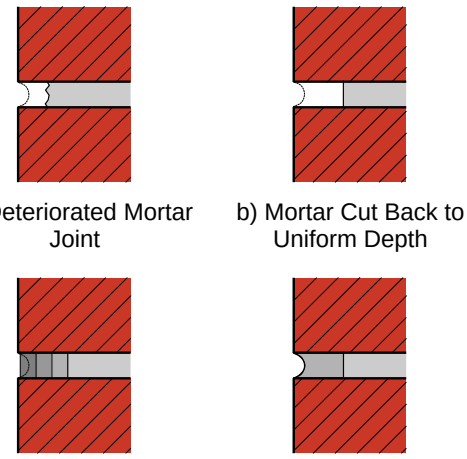
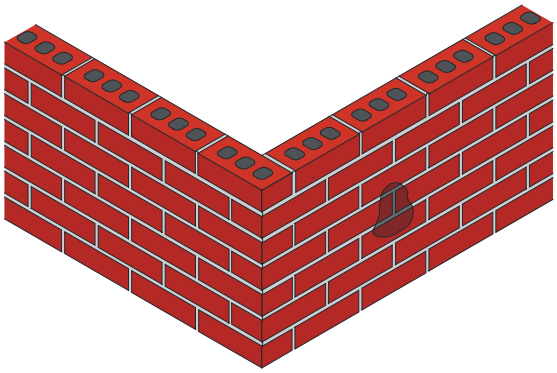
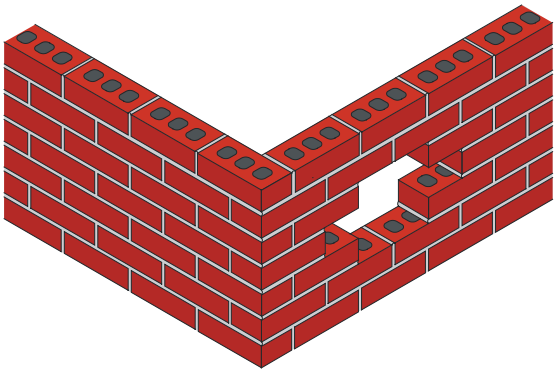


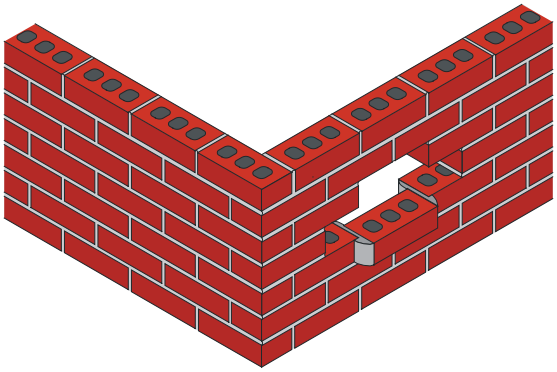
Figure 1
Repointing Mortar Joints



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.

Photo 3
Flashing Installed in Alternating Sections

Photo 4
Flashing Installation Using Temporary Support

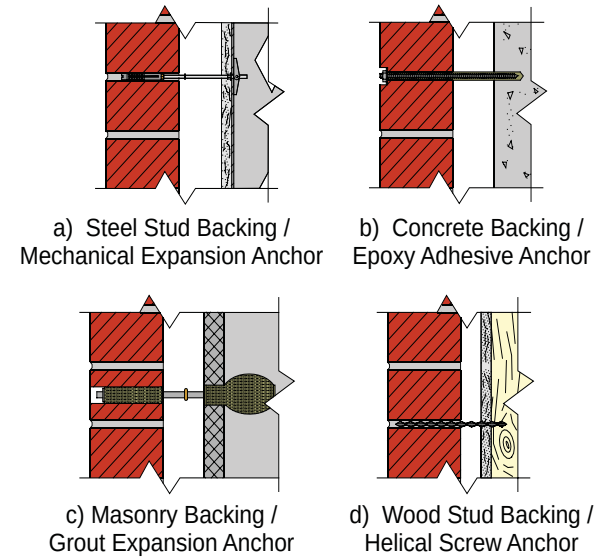


Figure 3
Masonry Re-Anchoring Systems

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.

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.*

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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.

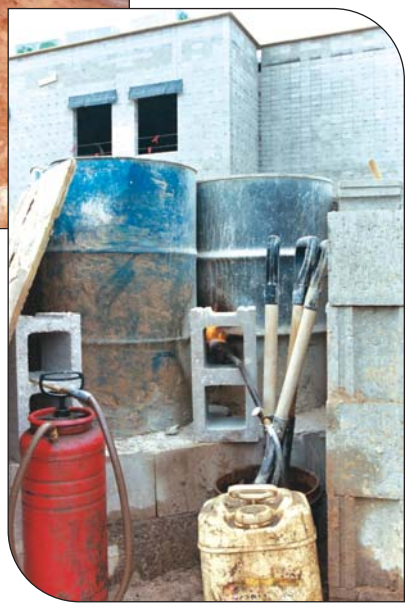
Likewise, the water-retentive properties of mortar affect its rate of moisture loss and stiffening. Mortars having high lime content or fine sands tend to have higher water demands and higher water retentivity than higher strength mortars or mortars made using well-graded sands. Although air entrainment 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. 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. 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). 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: Maintain glass unit masonry above 40°F (4.4°C) for the first 48 hours after construction. 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. 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. Use heated enclosures, electric heating blankets, infrared lamps, or other acceptable methods. 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

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