UPSTATE NEW YORK MCAA CHAPTER

Upstate NY MCAA Installation Bulletin #4

Architectural Concrete Masonry

Single-Wythe Wall Checklist - The Top 5

Important Details to Consider for Protection from Moisture Penetration and Stains

> Upstate NY MCAA's Installation Bulletins are meant to be brief reminders on various aspects of masonry construction. They aren't intended to be a complete discussion of the topic. At the end of each Installation Bulletin are references that you can follow up for a broader understanding.

Masonry is a mature industry where the design details that contribute to attractive, great-performing buildings are understood. This is a list of five design considerations that, if followed, will significantly help protect your project from moisture damage and unsightly stains. While this list does not include all the "Code" and "Best Practice" considerations you will need to design your building, in our experience, these are some of the most crucial details. If your plans and specifications currently do not include them, we recommend that you consider adding them.

This document is specifically for CMU Walls with 8-inch high units. The appendix includes supplemental recommendations specifically for CMU Walls with 4-inch high units

Essential Details addressed in this document:

1. Integral water-repellent for CMU, a compatible integral water-repellent for the mortar, and a clear breathable post-applied water-repellent.
2. Flashing and weeps
3. Control joints and horizontal joint reinforcement for crack control
4. Coping with sealant at top of the wall
5. Cleaning and sample panels

The basis of these design recommendations is listed below:
The "Code," TMS 402/602 "Building Code Requirements and Specifications for Masonry Structures"
The "MDG," TMS's "Masonry Designers Guide-2016" helps designers apply the provisions of TMS 402/602
"NCMA TEK" Technical Publications from the National Concrete Masonry Association
"Upstate MCAA" Educational material from the Upstate New York Mason Contractors Association of America
At the end of this document are links and references that we recommend you read to achieve the best understanding of the considerations we are providing you.

1. Integral Water Repellents and Clear Breathable Water-Repellent Coatings

For Architectural Concrete Masonry Units, along with specifying compliance to ASTM C90 and the job-specific attributes of color, texture, and density (if pre-insulated), integral water repellents and post-applied clear breathable water-repellent coatings are essential parts of the system.

Integral water repellents significantly decrease the water absorption characteristics of both the CMU and the mortar. Mortar and CMU with integral water repellents also have significantly less tendency to wick water, so that water penetration through the surface of the assembly is far less likely to spread to adjoining sections of the wall.

While these integral water repellent admixtures limit the amount of water that can pass through units and mortar, they have negligible impact on moisture entering through cracks and voids in the wall. The National Concrete Masonry Association's crack control strategy is intended to control cracking; it does not eliminate it. The goal is to keep crack widths to less than 0.02" (discussed later in this document) so post-applied clear breathable coatings can bridge these cracks.

Suggested Specifications for Integral Water Repellents and Clear Breathable Water-Repellent Coatings

All Architectural Concrete Masonry Units shall comply with ASTM C 90-16a "Standard Specification for Load Bearing Concrete Masonry Units."

Architectural CMU shall be manufactured using integral water-repellents (IWRs). IWR CMU must comply with the "Spray Bar Test" as outlined in the National Concrete Masonry Association's TEK 19-7 "Characteristics of Concrete Masonry Units with Integral Water Repellent".

After the walls of Architectural CMU have been permanently capped by the roof coping and have been cleaned, apply a clear, breathable water-repellent. At a minimum, the coating must perform over a 0.02" wide crack.

Mortar used for structural applications shall comply with ASTM C270, Type S using ASTM C150 Portland cement/ASTM C207 Lime, or ASTM C1329 Mortar Cement. Mortar shall contain Integral Water-Repellent for Mortar that was tested with the IWR CMU and demonstrated to be compatible with no reduction in the bond between the CMU and the mortar per ASTM C1384.

2. Flashing and Weeps

Partially reinforced single-wythe walls should be considered drainage walls and detailed such that any water that penetrates the outside surface be collected and diverted back to the exterior. Page 4-28 of the "TMS Masonry Designers Guide" states, **"Flashing should collect water that penetrates the outside wythe of masonry. The specified flashing and weep systems shall be installed to direct that water to the exterior of the wall without allowing it to flow behind or under the flashing and into the building interior. The weeps should provide a conduit for that collected water to travel to the exterior. Typically flashing is installed at all interruptions in the vertical plane of a masonry drainage wall, such as tops of the foundation, above shelf angles, over openings, and above bond beams."** Flashing should also be designed above openings and below openings at sill locations.

Fully grouted walls are barrier walls that require no flashing/weeps within the wall because voids and cavities within the wall where moisture can collect are filled solid. Barrier walls still require copings and flashing at sills and over openings.

Suggested Specifications for Flashing and Weeps

Flashing For Partially Reinforced Single-Wythe CMU Drainage Walls

Install CMU pan flashing at all interruptions in the vertical plane of a masonry drainage wall. The locations are noted on the plans at the following locations: Tops of the foundation, above shelf angles, over openings, and above bond beams.

Flashing pans are to have a sloped design to direct moisture to the integrated weep spout, designed to be built into mortar bed joints to expel moisture. Follow manufacturer's installation directions.
The basis of design is BlockFlash by Mortar Net

Flashing for Sills and Openings

Install flashing, weeps, and drip edge at sill locations and louvers as detailed on the plans.

3. Crack Control - Control Joints and Horizontal Reinforcement

While clay masonry can expand approximately one inch per 100 linear feet, concrete masonry can shrink approximately 1 ¼ inches per 100 linear feet. The physics of both clay and concrete masonry are well understood. When the "Code" and industry best practices are followed, cracks in the wall will be controlled to an average width of less than 0.02 inches and be uniformly distributed. These have no negative effect on the structural or moisture penetration performance of the wall when proper post-applied coatings are used.

There are two aspects to controlling cracks:

Control joints that reduce stresses by creating smaller panels in the wall.

Horizontal reinforcement that limits crack width by holding the cracks that form tightly together.

Control Joints (CJ)

The "Code" requires the design professional to indicate the control joint locations on the plans.

Crack control recommendations are different for single-wythe 4" high CMU, 8" high CMU, and CMU veneers. The recommendations listed below are for CMU walls with 8-inch high units and are based on NCMA TEK 10-02D "Control Joints for Concrete Masonry Walls—Empirical Method". (Designers can consult NCMA TEK-03, Control Joints for Concrete Masonry Walls—Alternative Engineered Method for other options.)

Control joints for CMU walls with 8-inch high units according to Table 1 of NCMA TEK 10-02 D should have a maximum control joint spacing, the lesser of:

Length to height ratio of 1 ½: 1

Maximum spacing of 25 ft;. Upstate NY MCAA recommends using modular dimensions to avoid cutting the units.

Note: See Appendix for CMU walls with 4-inch high units

TEK 10-2D gives the example of a 20 ft tall warehouse with walls 100 ft. long using 8-inch high CMU.

Table 1 recommends a length to height ratio of 1½: 1, which corresponds to 1½ x 20 ft = 30 ft.

However, 30 ft exceeds the 25 ft maximum, so the control joints should be placed at corners and no more than 25 ft apart.

Mason contractors will bid your project based on an estimate of how many blocks they can lay per day. For half bond walls, when your design is laid out for the control joint to align at the head joint of full 16-inch long CMU and 8-inch long CMU, the masons will not have to stop and saw cut the CMU at control joints. This facilitates the mason laying more blocks per day and you can expect the mason contractor to quote your project more competitively than a design that requires sawing at control joints, openings, and corners. Control joint spacing, corners, and the lengths between openings are key factors whether your masonry bid will be under or over budget.

For BIM software that provides dimensional control and avoids cutting CMU, see Masonry IQ (https://3diqinc.com/).

CJs at corners: Control joints located near corners should be placed a maximum of ½ the control joint spacing of the walls. For example, if the CJ spacing of the walls is 24 ft, CJs should be placed within 12 ft of corners. Control joints should be positioned so the CJ is aligned at the head joint of the block. The reference is TEK 10-02D Figure 3.

CJs at openings: For openings of up to 6 ft in width that are not wrapped with reinforcement, a CJ should be placed on one side of the opening. For openings wider than 6 ft CJs are recommended on both sides. Alternatively, "control joints at openings wrapped in reinforcement" provides options to add reinforcing and reduce the number of control joints at openings. This is sometimes helpful depending on the type of lintel. The reference is TEK 10-02D, Figure 2.

In addition, control joints should be located as shown in Figure 1a:

- at changes in wall height
- at changes in wall thickness, such as at pipe and duct chases and pilasters
- at (above) movement joints in foundations and floors
- at (above and below) movement joints in roofs and floors that bear on a wall,

Control joints are such a critical part of your design, completely understanding NCMA TEK 10-02D "Control Joints for Concrete Masonry Walls—Empirical Method" is important.

Horizontal Joint Reinforcement (HJR) for 8"-high CMU

Concrete masonry walls rely on horizontal reinforcement to limit the crack widths to less than 0.02 inches. While reinforcing bars are perfectly suited to satisfy the horizontal steel requirements for crack control, horizontal joint reinforcing is more commonly used on the east coast.

The length to height ratio used for the control joint spacing in Table 1 on page 7 of NCMA TEK 10-02D, is based on horizontal reinforcement having an equivalent area of not less than 0.025 inches per foot of masonry height. The table shows that two 9-gauge wires per course spaced a maximum of 16 inches on center satisfies this requirement for 8" high CMU walls.

For CMU walls:

- LADDER-type HJR should be used so the cross rods don't interfere with the grouting process or the vertical bars. In addition, under normal circumstances, the wire diameter should not exceed 9 gauge.
- HJR should not extend through control joints unless specifically detailed on the plans.
- HJR segments must lap a minimum of 8 inches for 9-gauge wire.
- All exterior applications must use hot-dipped joint reinforcement, stainless steel, or sometimes epoxy-coated HJR.

Suggested Specifications for Control Joints and Horizontal Joint Reinforcing for Crack Control

Form control joints in CMU by installing a preformed control-joint gasket designed to fit into a standard sash CMU. Keep head joints free and clear of mortar, unless specified otherwise.

Control joint to be rubber material complying with ASTM D2000 M2AA-805, with a durometer hardness of 80.
Alternate control joints are shown on NCMA TEK-02D, Figure 3.

Masonry - Joint Reinforcement for Single-Wythe Masonry to comply with ASTM A951.

Note to the designer, decide if you will wrap openings with reinforcement. If you are, select details from Figure 2 of NCMA TEK 10-02D. Also, check with your engineer if Masonry Chords for Diaphragms are designed, chord reinforcement usually should continue through control joints. This must be noted on the plans.

1. Exterior Walls: Hot-dip galvanized carbon steel, 1.5 oz. per sq. ft.
2. Wire size for side rods: 0.148-inch (9 gauge) diameter.
3. Wire size for cross rods: 0.148-inch (9 gauge) diameter.
4. Ladder design with perpendicular cross rods spaced not more than 16" O.C.

Install HJR spaced vertically (from one bed joint to another) a maximum of 16 inches on center.

Lap sections of HJR a minimum of 8 inches for 9-gauge wire.

Interrupt HJR at control joints unless otherwise indicated on the plans.

Provide reinforcement not more than 8 inches above and below wall openings and extend a minimum of 12 inches beyond the openings.

Cover requirements for joint reinforcement are ½ in. to the inside (non-weather-exposed) face and at least 5/8 in. to the exterior face of a wall that is exposed to earth or weather.

4. Top Of Wall Protection and Coping

The most severe staining of masonry walls has resulted from water entering the tops of walls. There are two primary causes:

1. Failing to protect the tops of walls during construction until the permanent coping is in place.
2. Inadequate permanent coping, coping that is not effectively sealed at the top or does not extend down the face of the CMU a minimum of 4".

TMS 602 Article 1.8B requires that the top of unfinished masonry work be covered to protect it from moisture intrusion. Exposed masonry construction should be covered at the end of each day and whenever work is not in progress. Excessive moisture entering the masonry during construction can saturate the masonry and may takes months to dry out. Such prolonged wetting promotes efflorescence and linear shrinkage cracks.

The time lag between when the mason finishes installing the wall and when the roofing contractor permanently caps the wall is a period when serious staining problems occur most often. Perhaps the most effective way to ensure that completed walls remain covered, after the mason has left the project, is to install an inexpensive membrane at the top of the wall upon completion- EPDM is inexpensive, can be glued to the top of the wall, and left in place below the blocking. Bolts and embeds should be sealed to ensure moisture cannot enter the wall from the top. Use a type of flashing that will not breakdown and stain the wall. This simple step can prevent the majority of problems mason contractors will ultimately have to deal with when moisture related staining from uncovered walls begins to occur.

The cap flashing at the top of the roof should be sloped to prevent water from draining onto the exposed surface of the masonry and should extend at least 4 inches down the face of the masonry, with a sloped drip, and sealed on both sides. A smooth texture is preferred under the cap to ensure a tight fit between the masonry surface and cap that might be hindered by uneven concrete masonry units such as split-face or split-rib units. Sealing the fit between the cap flashing and the wall is strongly recommended because wind-driven rain can push moisture up a wall 1 inch for every 10 mph of wind speed. Sealing will help prevent water penetration at the top of metal-capped walls.

Coping details can be found on the website video: Upstate New York Mason Contractors Association of America Coping and caps and starts at the 10:54 mark of the video. http://www.upstatenymcaa.com/flashing-for-masonry-part-3/

Suggested Specifications For Top Of Wall Protection

Exposed masonry construction should be covered at the end of each day and whenever work is not in progress. This includes walls, projections and sills. In addition, to ensure completed walls remain covered until the permanent coping is in place, the mason contractor shall be responsible to supply and install EPDM and mastic on the top of the completed masonry wall. EPDM to be secured by the masons with the mastic recommended by the manufacturer. Seal bolts and embeds. Use an EPDM that will not breakdown with UV exposure and stain the wall.

5. Sample Panels & Cleaning

Article 3.8 of TMS 402/602 "Building Code Requirements and Specifications for Masonry Structures", "Clean exposed masonry surfaces of stains, efflorescence, mortar and grout droppings and debris using methods that do not damage the masonry."

Given there has never been a masonry wall completed without some stains left on the wall, what is the meaning of "clean" and how is it decided if the wall is clean enough? The answer is the sample panel.

TMS 402/602 "Building Code Requirements and Specifications for Masonry Structures" on page S-29 states, "The acceptable standard for the work is established by the accepted panel."

Sample panels are a particular type of submittal with one of its functions being verification of aesthetics. The sample panel establishes the acceptable standard of quality for the project and as such defines what clean means.

Suggested specification: Sample Panels for Aesthetics
The sample panel will be used to determine the acceptable standard for masonry work. All individual product submittals including colors should be approved before the sample panel is constructed.

The architect should design the sample panel so that it contains a reasonable representation of the full range of the approved unit color and mortar color and texture so that each procedure, including cleaning and application of coatings, can be demonstrated on the sample panel. The size of the sample panel should be a minimum of 4 ft long x 4 ft high; the actual size and details should be specified by the architect and incorporate the masonry in the bond and color pattern specified. The sample panel shall contain flashing/weeps where specified. Any changes proposed by the mason contractor should be approved by the architect before its construction.

Build a freestanding sample panel at a location where the future masonry walls and the sample panel can be viewed together. The sample panel is to be built by the mason contractor awarded the job, from the masonry units manufactured for this specific project.

Clean one-half of the exposed face of the panel using the same means and methods that will be used to clean the exposed masonry walls of stains, efflorescence, mortar, grout dropping, and debris, without damage to the masonry. Apply the specified clear, post-applied water repellents to the half of the sample panel that has been cleaned and allowed to dry.

Notify the architect at least one week in advance of the date when the sample panel will be completed, and the mortar has dried to its final color. Build the sample far enough in advance of actual construction so there is time to make any final adjustments that the architect chooses. After the sample panel is approved for quality and allowable tolerances in writing by the architect, the construction of the project masonry can begin. Disputes over quality or tolerances should refer to the sample panel.

References
Understanding these details is particularly important for the design of a masonry structure. Please review the following references and contact us with any questions you have or if you would like additional information:

Integral Water Repellents and Clear Breathable Water-Repellent Coatings

NCMA TEK 19-02B, “Design for Dry Single-Wythe Concrete Masonry Walls”
https://ncma.org/resource/design-for-dry-single-wythe-walls/

NCMA TEK 19-7 “Characteristics of Concrete Masonry Units with Integral Water Repellent”
https://ncma.org/resource/characteristics-of-concrete-masonry-units-with-integral-water-repellent/

Flashing and Weeps

The Masonry Society, Masonry Designers’ Guide 2016 Page 4-28
https://masonrysociety.org/

Upstate New York Mason Contractors Association of America, Flashing for Masonry Part 3
http://www.upstatenymcaa.com/flashing-for-masonry-part-3

NCMA TEK 19-05A “Flashing Details for Concrete Masonry Walls”

https://ncma.org/resource/flashing-details-for-concrete-masonry-walls/

Block Flash for in-wall flashing
https://mortarnet.com/blockflash/

Crack Control

NCMA TEK 10-02D "Control Joints for Concrete Masonry Walls—Empirical Method".
https://ncma.org/resource/control-joints-for-concrete-masonry-empirical-method/

Upstate New York Mason Contractors Association of America- Masonry Chords for Diaphragms
http://www.upstatenymcaa.com/masonry-chords-for-diaphragms/

Upstate New York Mason Contractors Association of America-coping details
http://www.upstatenymcaa.com/flashing-for-masonry-part-3/

Coping Details

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Sample Panels & Cleaning

TMS 602 "*Specifications for Masonry Structures*" Article 1.6 D Samples panels on page S-29
TMS 602 "*Specifications for Masonry Structures*" Article 3.8 Cleaning on page S-81

There are always design considerations on projects that would cause a change in recommendations, so please consider these as general guidelines.

If you would like additional information, please do not hesitate to contact the Upstate New York Mason Contractors Association of America MCAA**.**

Appendix for Single-Wythe CMU Walls with 4-inch high units.

These recommendations modify the recommendations provided for CMU Walls with 8-inch high units. All other recommendations apply unless noted below.

3. Crack Control-Control Joints and Horizontal Reinforcement
   Control joints for 4-inch high units according to Table 1 of NCMA TEK 10-02 D should have a maximum control joint spacing, the lesser of:
   - Length to height ratio of 1 ½: 1
   - Maximum spacing of 20 ft

   For Example, a 20 ft tall warehouse with walls 100 ft long using 4-inch high CMU:
   Table 1 recommends a length to height ratio of 1½: 1, which corresponds to 1½ x 20 ft = 30 ft.
   However, 30 ft exceeds the 20 ft maximum, so the control joints should be placed no more than 20 ft apart.

Horizontal Joint Reinforcement (HJR) for 4-inch high CMU

When using 4-inch high CMU, the length to height ratio used for the control joint spacing in Table 1 on page 7 of NCMA TEK 10-02D, is based on horizontal reinforcement having an equivalent area of not less than 0.034 inches per foot of masonry height. This is greater than what is required for an 8-inch high CMU because the wall is subject to greater shrinkage due to a higher proportion of mortar. Table 2B on page 8 of TEK 10-02D shows that two 9-gauge wires per course spaced a maximum of 12 inches on center satisfies this requirement for 4-inch high CMU.

Install HJR spaced vertically (from one bed joint to another) a maximum of 12 inches on center.