# MASTER YOUR MASONRY SPEC

Presented by Philippe Ledent, PE, SE



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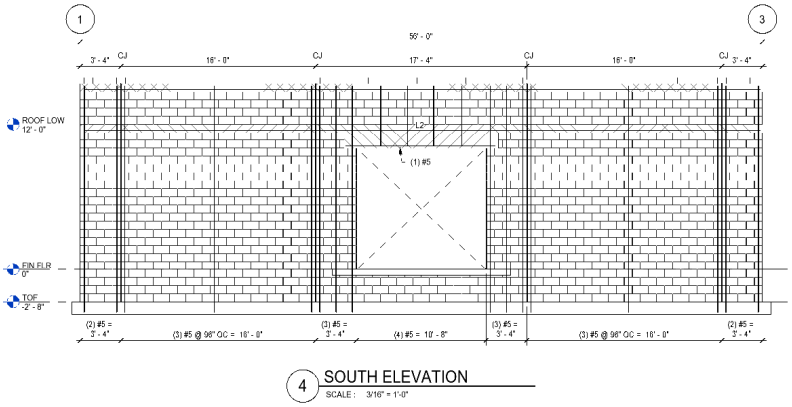
## SECTION 042200 CONCRETE UNIT MASONRY

- Poll Question 1: What is the maximum spacing of vertical reinforcement in CMU construction?

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# PART 2: PRODUCTS PERFORMANCE

- **2.2 Performance Requirements**
  A. Provide [**structural**] unit masonry that develops indicated net-area compressive strengths at 28 days.
     1. Determine net-area compressive strength of masonry from average net-area compressive strengths of masonry units and mortar types (unit-strength method) according to TMS 602/ACI 530.1/ASCE 6.
     2. Determine net-area compressive strength of masonry by testing masonry prisms according to ASTM C1314**.**

Only when required

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# PART 2: PRODUCTS PERFORMANCE

- **2.3 Unit Masonry, General**
  B. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated. Do not use units where such defects are exposed in the completed Work [**and will be within 20 feet vertically and horizontally of a walking surface**]

See MIM FAQs

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# PART 2: PRODUCTS PERFORMANCE

**Is there a recommended viewing distance for concrete masonry unit sample panels or for viewing CMU walls at completion?**

No; there is not a standardized means of assessing workmanship or appearance of completed masonry assemblies as noted by NCMA.

TMS 602 does not address a viewing distance for sample panels. TMS 602 Commentary states; "Sample panels should contain the full range of unit and mortar color. Each procedure, including cleaning and application of coatings and sealants, should be demonstrated on the sample panel. Certain elements of sample panels, such as the type of mortar joint, can have structural implications with the performance of masonry. Construct sample panels within the tolerances of Article 3.3F. The specifier has the option of permitting a segment of the masonry construction to serve as a sample panel or requiring a separate stand-alone panel."

There is a specified viewing distance in ASTM C90 for CMUs (Refer to **Is there a recommended viewing distance for concrete masonry units (CMUs)** for more information.). The MIM FAQ references NCMA FAQ 11-14. The NCMA FAQ points out that there is not a standardized means of assessing workmanship or appearance of completed masonry assemblies. The NCMA FAQ also states; "It is often interpreted that the 20-foot criterion above applies to units that are installed. While this requirement could be applied as such, its true intent is for assessing units prior to their installation – again, because this is a product standard." Based on this commentary discussion and since the industry has accepted the 20-foot rule for viewing the units, the MIM Generic Wall Design Committee recommends that it be applied to viewing the completed wall assembly.

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# PART 2: PRODUCTS PERFORMANCE

- **2.2 Performance Requirements**
  - C. Fire-Resistance Ratings: Comply with requirements for fire-resistance-rated assembly designs indicated
    - 1. Where fire-resistance-rated construction is indicated, units shall be listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction.

Not many CMU producers have UL ratings, and so the *Calculations Procedure* from IBC Section 703.3 is typically used for masonry.

**703.3 Methods for determining fire resistance.**

The application of any of the methods listed in this section shall be based on the fire exposure and acceptance criteria specified in ASTM E119 or UL 263. The required *fire resistance* of a building element, component or assembly shall be permitted to be established by any of the following methods or procedures:

1. *Fire-resistance* designs documented in approved sources.
2. Prescriptive designs of fire-resistance-rated building elements, components or assemblies as prescribed in Section 721.
3. Calculations in accordance with Section 722.
4. Engineering analysis based on a comparison of building element, component or assemblies designs having *fire-resistance ratings* as determined by the test procedures set forth in ASTM E119 or UL 263.
5. Alternative protection methods as allowed by Section 104.11.
6. *Fire-resistance* designs certified by an approved agency.

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# PART 2: PRODUCTS PERFORMANCE

Most commonly, the *equivalent thickness method* is used for masonry construction as discussed in IBC 722.3.2.

- Note: Fully grouted masonry will have an *equivalent thickness* equal to the specified thickness. Partially grouted masonry will have an *equivalent thickness* equal to that of a hollow unit.

**722.3.2 Concrete masonry walls.**

The *fire-resistance rating* of walls and partitions constructed of concrete masonry units shall be determined from Table 722.3.2. The rating shall be based on the equivalent thickness of the masonry and type of aggregate used.

**TABLE 722.3.2 MINIMUM EQUIVALENT THICKNESS (inches) OF BEARING OR NONBEARING CONCRETE MASONRY WALLS[a, b, c, d]**

| TYPE OF AGGREGATE | FIRE-RESISTANCE RATING (hours) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1/2 | 3/4 | 1 | 1 1/4 | 1 1/2 | 1 3/4 | 2 | 2 1/4 | 2 1/2 | 2 3/4 | 3 | 3 1/4 | 3 1/2 | 3 3/4 | 4 |
| Pumice or expanded slag | 1.5 | 1.9 | 2.1 | 2.5 | 2.7 | 3.0 | 3.2 | 3.4 | 3.6 | 3.8 | 4.0 | 4.2 | 4.4 | 4.5 | 4.7 |
| Expanded shale, clay or slate | 1.8 | 2.2 | 2.6 | 2.9 | 3.3 | 3.4 | 3.6 | 3.8 | 4.0 | 4.2 | 4.4 | 4.6 | 4.8 | 4.9 | 5.1 |
| Limestone, cinders or unexpanded slag | 1.9 | 2.3 | 2.7 | 3.1 | 3.4 | 3.7 | 4.0 | 4.3 | 4.5 | 4.8 | 5.0 | 5.2 | 5.5 | 5.7 | 5.9 |
| Calcareous or siliceous gravel | 2.0 | 2.4 | 2.8 | 3.2 | 3.6 | 3.9 | 4.2 | 4.5 | 4.8 | 5.0 | 5.3 | 5.5 | 5.8 | 6.0 | 6.2 |

For SI: 1 inch = 25.4 mm.

a. Values between those shown in the table can be determined by direct interpolation.
b. Where combustible members are framed into the wall, the thickness of solid material between the end of each member and the opposite face of the wall, or between members set in from opposite sides, shall be not less than 93 percent of the thickness shown in the table.
c. Requirements of ASTM C55, ASTM C73, ASTM C90 or ASTM C744 shall apply.
d. Minimum required equivalent thickness corresponding to the hourly fire-resistance rating for units with a combination of aggregate shall be determined by linear interpolation based on the percent by volume of each aggregate used in manufacture.

**Table 2—Equivalent Thicknesses of Concrete Masonry Units, in. (mm)**

| Nominal width, in. (mm) | Based on typical hollow units[A] | | Based on percent solid (75%) | (100%) |
|---|---|---|---|---|
| 4 (102) | 2.7 (69) | [73.8] | 2.7 (69) | 3.6 (91) |
| 6 (152) | 3.1 (79) | [55.0] | 4.2 (107) | 5.6 (142) |
| 8 (203) | 4.0 (102) | [53.0] | 5.7 (145) | 7.6 (193) |
| 10 (254) | 4.5 (113) | [46.3] | 7.2 (183) | 9.6 (244) |
| 12 (305) | 5.1 (129) | [44.0] | 8.7 (221) | 11.6 (295) |
| 14 (356) | 5.5 (139 | [40.2] | 10.2 (259) | 13.6 (345) |
| 16 (406) | 6.0 (152) | [38.4] | 11.7 (297) | 15.6 (396) |

[A] Values in brackets [ ] are percent solid values based on typical two-core concrete masonry units.

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# PART 2: PRODUCTS PERFORMANCE

- **2.4 Concrete Masonry Units**
  - C. Integral Water Repellent: Provide units made with integral water repellent [**for exposed units**] [**and**] [**where indicated**].
    1. Integral Water Repellent: Liquid polymeric, integral water-repellent admixture that does not reduce flexural bond strength. Units made with integral water repellent, when tested according to ASTM E514/E514M as a wall assembly made with mortar containing integral water-repellent manufacturer's mortar additive, with test period extended to 24 hours, shall show no visible water or leaks on the back of the specimen.

Integral Water Repellent (IWR) is critical to the performance of single-wythe masonry and should be specified in both the mortar and the CMU. Ensure IWR in the mortar is compatible with the IWR in the block.

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# PART 2: PRODUCTS
# MORTAR AND GROUT MATERIALS

- **2.6 Mortar and Grout Materials**

  MIM's reference specification includes the following:

  A. Mortar:
     1. Comply with ASTM C270, Type [**S**] [**N**] [**M**].
     2. [**Use any cementitious materials permitted by ASTM C270.**] [**Do not use masonry cement or air-entrained Portland cement and lime in cementitious materials when masonry is partially grouted and structure is in Seismic Design Category D, E, or F.**]
     3. Admixtures: Comply with ASTM C1384 to enhance the following property(ies): [**water repellency**] [**set retarding**] [**set accelerating**] [**bond**] [**workability**].
     4. Pigmented Mortar: Comply with ASTM 979, which is referenced from ASTM C270. Use colored cement product or select and proportion pigments with other ingredients to product selected color. Do not add pigments to colored cement products. Comply with TMS 602 Article 2.6 A.2 for maximum permitted amount of pigments.

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# PART 2: PRODUCTS
# CONCRETE MASONRY UNITS

- Poll Question 2: What is the minimum net area compressive strength of concrete masonry ($f'_m$)?

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# PART 2: PRODUCTS
# CONCRETE MASONRY UNITS

- **2.4 Concrete Masonry Units**
  - E. CMUs: ASTM C90
    - 1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of [**2150 psi**] [**2800 psi**] [**3050 psi**] <**Insert value**>

**Table 2 — Compressive strength of masonry based on the compressive strength of concrete masonry units and type of mortar used in construction**

| Net area compressive strength of concrete masonry, psi (MPa) | Net area compressive strength of concrete masonry units, psi (MPa) | |
|---|---|---|
| | Type M or S mortar | Type N mortar |
| 1,700 (11.72) | --- | 1,900 (13.10) |
| 1,900 (13.10) | 1,900 (13.10) | 2,350 (14.82) |
| 2,000 (13.79) | 2,000 (13.79) | 2,650 (18.27) |
| 2,250 (15.51) | 2,600 (17.93) | 3,400 (23.44) |
| 2,500 (17.24) | 3,250 (22.41) | 4,350 (28.96) |
| 2,750 (18.96) | 3,900 (26.89) | ----- |
| 3,000 (20.69) | 4,500 (31.03) | ----- |

[1]For units of less than 4 in. (102 mm) nominal height, use 85 percent of the values listed.

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# PART 2: PRODUCTS
# CONCRETE MASONRY UNITS

- Almost all equations in TMS 402 are a function of $f'_m$ and so understanding the actual strength of units used is important.
- $f'_m$ will have a minimal impact on vertical reinforcement spacing in walls, however.

| Wall Height | 8" CMU Partial Grout With Bars Centered – Reinforcement Spacing | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 psi | | | 2500 psi | | | 3000 psi | | |
| | #5 | #6 | #7 | #5 | #6 | #7 | #5 | #6 | #7 |
| **10' - 0"** | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| **12' - 0"** | 112 | 120 | 120 | 112 | 120 | 120 | 112 | 120 | 120 |
| **14' - 0"** | 88 | 120 | 120 | 88 | 120 | 120 | 88 | 120 | 120 |
| **16' - 0"** | 64 | 96 | 120 | 64 | 96 | 120 | 64 | 96 | 120 |
| **18' - 0"** | 56 | 72 | 104 | 56 | 80 | 104 | 56 | 80 | 104 |
| **20' - 0"** | 40 | 64 | 88 | 48 | 64 | 88 | 48 | 64 | 88 |

Note: These values are for flexure-only and do not include axial load from self weight, axial load will in many cases result in greater rebar spacings.

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# PART 2: PRODUCTS
# CONCRETE MASONRY UNITS

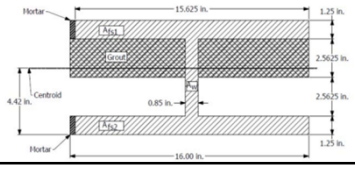
ASTM C90 has changed in the last few revisions to include requirements for *Normalized Web Area*. This allows for newer unit configurations, but an additional web shear strength must be performed.

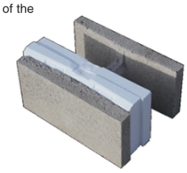
**TABLE 1 Minimum Face Shells and Web Requirements[A]**

| Nominal Width (W) of Units, in. (mm) | Face Shell Thickness ($t_{fs}$), min, in. (mm)[B,C] | Webs | |
|---|---|---|---|
| | | Web Thickness[C] ($t_w$), min, in. (mm) | Normalized Web Area ($A_{nw}$), min, in.$^2$/ft$^2$ (mm$^2$/m$^2$)[D] |
| 3 (76.2) and 4 (102) | ¾ (19) | ¾ (19) | 6.5 (45,140) |
| 6 (152) | 1 (25) | ¾ (19) | 6.5 (45,140) |
| 8 (203) and greater | 1¼ (32) | ¾ (19) | 6.5 (45,140) |

[A]Average of measurements on a minimum of 3 units when measured as described in Test Methods C140/C140M.
[B]When this standard is used for units having split surfaces, a maximum of 10 % of the split surface is permitted to have thickness less than those shown, but not less than ¾ in. (19.1 mm). When the units are to be solid grouted, the 10 % limit does not apply and Footnote C establishes a thickness requirement for the entire faceshell.
[C]When the units are to be solid grouted, minimum face shell and web thickness shall be not less than ⅝ in. (16 mm).
[D]Minimum normalized web area does not apply to the portion of the unit to be filled with grout. The length of that portion shall be deducted from the overall length of the unit for the calculation of the minimum web cross-sectional area.

What is your *effective depth* (*d*)?



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# PART 2: PRODUCTS
# REINFORCEMENT

The lock down type is recommended and will not move during construction.

**Wire-Bond Core Lock Double Rebar Positioner**

- **2.7 Reinforcement**

Uncoated includes epoxy coated and galvanization.

A. Uncoated Steel Reinforcing Bars: ASTM A615 or ASTM A996, Grade 60.

B. Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells to hold reinforcing bars in the center of cells. Units are formed from 0.148-inch steel wire, hot-dip galvanized after fabrication. Provide units designed for number of bars indicated.

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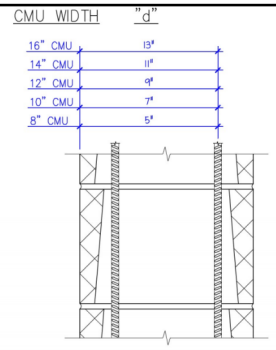
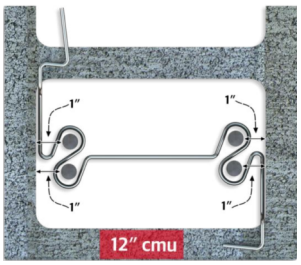
# PART 2: PRODUCTS REINFORCEMENT

- Rebar positioners are <u>not</u> required by the TMS 402/602.
- If you choose to specify rebar positioners, be mindful that in doing so it will dictate your *effective depth* (*d*) used in structural analysis.
  - TMS 402 equations are a function of *d* and changing it will affect your analysis!
  - In most cases, rebar positioners will place the center of the bar 2-5/8" from the outside face of the wall if doubly reinforced.




WALL SECTION–DOUBLE REINFORCING
"d" = NOMINAL UNIT THICKNESS MINUS 3.00 INCHES

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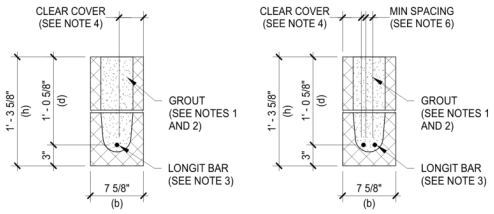
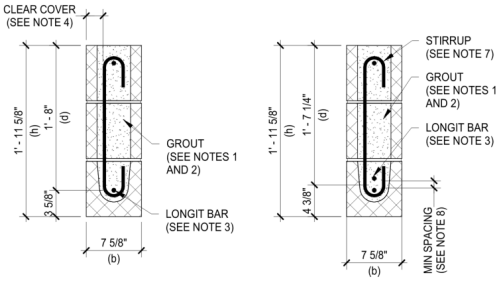
# PART 2: PRODUCTS REINFORCEMENT

In terms of the *effective depth* (*d*) for masonry lintels, make sure to account for the shape of the CMU molds and proper clearances.




8" LINTEL (PREFERRED)
SCALE : 1" = 1'-0"




8" LINTEL WITH STIRRUPS
SCALE : 1" = 1'-0"

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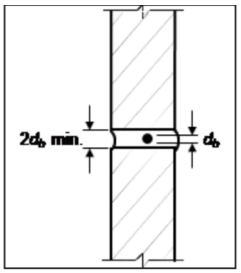
**Table CC-6.1.2 — Physical properties of steel reinforcing wire and bars**

| Designation | Diameter, in. (mm) | Area, in.$^2$ (mm$^2$) | Perimeter, in. (mm) |
|---|---|---|---|
| Wire | | | |
| W1.1 (11 gage) (MW7) | 0.121 (3.1) | 0.011 (7.1) | 0.380 (9.7) |
| W1.7 (9 gage) (MW11) | 0.148 (3.8) | 0.017 (11.0) | 0.465 (11.8) |
| W2.1 (8 gage) (MW13) | 0.162 (4.1) | 0.020 (12.9) | 0.509 (12.9) |
| W2.8 (3/16 in. wire) (MW18) | 0.187 (4.8) | 0.027 (17.4) | 0.587 (14.9) |
| W4.9 (1/4 in. wire) (MW32) | 0.250 (6.4) | 0.049 (31.6) | 0.785 (19.9) |
| Bars | | | |
| No. 3 (M#10) | 0.375 (9.5) | 0.11 (71.0) | 1.178 (29.9) |
| No. 4 (M#13) | 0.500 (12.7) | 0.20 (129) | 1.571 (39.9) |
| No. 5 (M#16) | 0.625 (15.9) | 0.31 (200) | 1.963 (49.9) |
| No. 6 (M#19) | 0.750 (19.1) | 0.44 (284) | 2.356 (59.8) |
| No. 7 (M#22) | 0.875 (22.2) | 0.60 (387) | 2.749 (69.8) |
| No. 8 (M#25) | 1.000 (25.4) | 0.79 (510) | 3.142 (79.8) |
| No. 9 (M#29) | 1.128 (28.7) | 1.00 (645) | 3.544 (90.0) |
| No. 10 (M#32) | 1.270 (32.3) | 1.27 (819) | 3.990 (101) |
| No. 11 (M#36) | 1.410 (35.8) | 1.56 (1006) | 4.430 (113) |




# PART 2: PRODUCTS REINFORCEMENT

**2.7 Reinforcement**

C. Masonry-Joint Reinforcement, General: Ladder type complying with ASTM A951

3. Wire Size for Side Rods: **[0.148-inch] [0.187-inch]** diameter.
4. Wire Size for Cross Rods: **[0.148-inch] [0.187-inch]** diameter.

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# PART 2: PRODUCTS REINFORCEMENT

Although 3/16" joint reinforcement could still require a 3/8" bed joint, it is not advisable because:

- The height of a masonry unit is permitted to vary from the specified height and the height difference is accommodated by varying the bed joint thickness.
- Joint reinforcement is not manufactured to be perfectly flat along its length.
- Mortar joint thickness may be one-quarter inch and still meet the TMS 602 tolerances.

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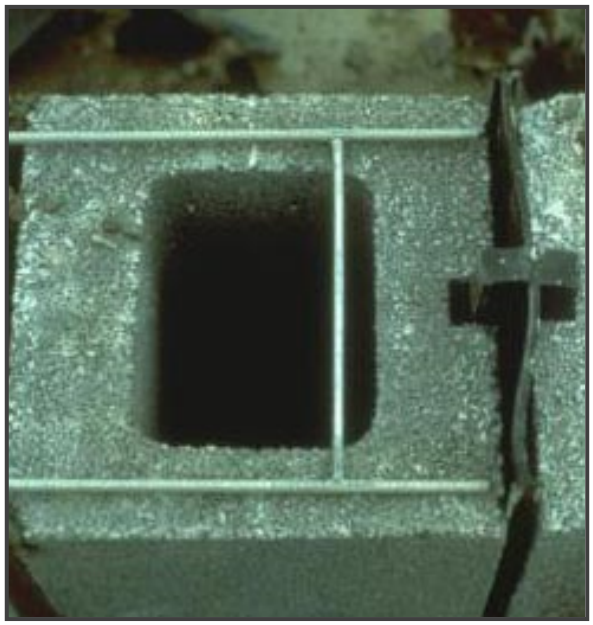


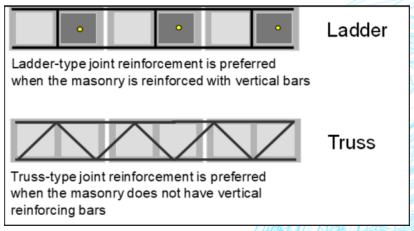
Exactly 16” – there are some manufacturers with cross wires at 15” o.c.

# PART 2: PRODUCTS REINFORCEMENT

**2.7 Reinforcement**

C. Masonry-Joint Reinforcement, General: Ladder type complying with ASTM A951

5. Spacing of Cross Rods: Not more than 16 inches o.c.

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# PART 2: PRODUCTS REINFORCEMENT

- For areas in MI that are in Seismic Design Category B and lower, unreinforced masonry can be used economically for interior walls.

| 8" Ungrouted CMU | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Mortar Type | Density Classification | Maximum Wall Height (ft) | | | | Fire Resistance Rating | | | | STC Rating |
| | | Interior | | Exterior | | | | | | |
| | | Vertical | Horizontal | Vertical | Horizontal | 1 hr | 2 hr | 3 hr | 4 hr | |
| Type N Masonry Cement | Lightweight | 12' - 8" | 16' - 0" | 6' - 8" | 8' - 8" | 2 | 2 | 2*** | 2*** | 46 |
| | Medium Weight | 12' - 8" | 16' - 0" | 6' - 8" | 8' - 8" | 1 | 1 | 1*** | 1*** | 47 |
| | Normal Weight | 12' - 8" | 16' - 0" | 6' - 8" | 8' - 8" | 1 | 1 | 1*** | 1*** | 49 |
| Type S Masonry Cement | Lightweight | 15' - 4" | 20' - 0" | 8' - 8" | 11' - 4" | 2 | 2 | 2*** | 2*** | 46 |
| | Medium Weight | 16' - 0" | 20' - 0" | 8' - 8" | 11' - 4" | 1 | 1 | 1*** | 1*** | 47 |
| | Normal Weight | 16' - 0" | 20' - 0" | 8' - 8" | 11' - 4" | 1 | 1 | 1*** | 1*** | 49 |
| Type N PCL or Mortar Cement | Lightweight | 17' - 4" | 22' - 8" | 9' - 4" | 12' - 8" | 2 | 2 | 2*** | 2*** | 46 |
| | Medium Weight | 17' - 4" | 22' - 8" | 9' - 4" | 12' - 8" | 1 | 1 | 1*** | 1*** | 47 |
| | Normal Weight | 18' - 0" | 22' - 8" | 9' - 4" | 12' - 8" | 1 | 1 | 1*** | 1*** | 49 |
| Type S PCL or Mortar Cement | Lightweight | 20' - 0" | 26' - 0" | 10' - 8" | 14' - 8" | 2 | 2 | 2*** | 2*** | 46 |
| | Medium Weight | 20' - 0" | 26' - 0" | 10' - 8" | 14' - 8" | 1 | 1 | 1*** | 1*** | 47 |
| | Normal Weight | 20' - 0" | 26' - 0" | 10 ' - 8" | 14' - 8" | 1 | 1 | 1*** | 1*** | 49 |

*Interior wall assumes uniform 5psf load with a 1.6 load factor
**Exterior wall assumes ASCE7 component and cladding level load with V = 115mph
*** Cell fill required to meet fire resistance rating

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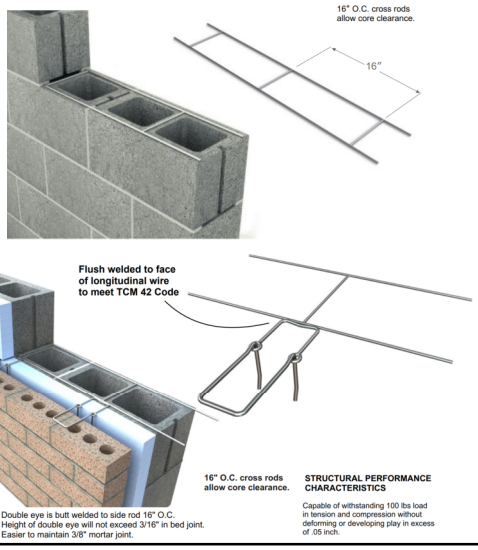
# PART 2: PRODUCTS REINFORCEMENT




MIM's reference specification includes the following joint reinforcement:

1. Type for Single-Wythe Masonry: Ladder type with a single pair of longitudinal wires spaced for placement over each face shell.
2. Type for Multi-Wythe Masonry: Ladder type with single pair of longitudinal wires spaced for placement over each face shell, with "eyes" to receive pintle anchors butt welded next to one of the longitudinal wires. Engage double pintle anchors in "eyes" of joint reinforcement with sufficient length to extend minimum 1-1/2 inches into veneer with minimum 5/8-inch cover to exterior face.

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# PART 2: PRODUCTS TIES AND ANCHORS

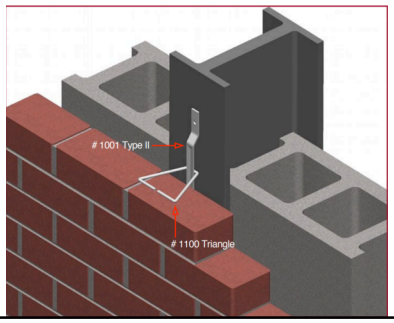
For solid units, anchors are required to be embedded in mortar a minimum of 1-1/2-inch with at least 5/8-inch mortar cover to the outside face.

For hollow units, anchors are required to be embedded in mortar or grout a minimum of 1-1/2-inch with at least 5/8-inch mortar or grout cover to the outside face. Proper anchorage of veneer anchors into hollow units can be achieved by:

1. Mortaring anchors in bed joints or on the cross-webs of the units
2. Grouting the cells or cores adjacent to the anchor
3. Following the anchor manufacturer's requirements.

**2.8 Ties and Anchors**

A. General: Ties and anchors shall extend at least 1-1/2 inches into masonry but with at least a 5/8-inch cover on the outside face.

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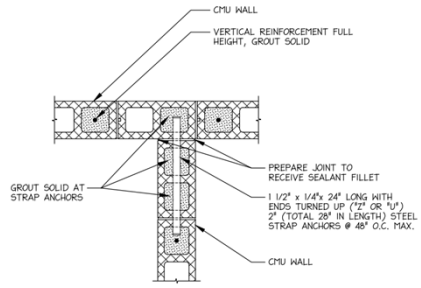
# PART 2: PRODUCTS TIES AND ANCHORS

2.07 Masonry Accessories

MIM's reference specification (Section 2.07) includes the following:

Connections at wall intersections required to transfer in-plane and out-of-plane forces: Provide rigid Z-strap anchors only when intersection does not have 50 percent of the masonry units overlapped and does not have reinforced bond beams. Fabricate anchors from ASTM A36 steel, 1-1/2 inches wide by 1/4 inch thick by 24 inches long with ends turned up 2 inches (total 28 inches in length).




2 S-2 FLANGED SHEAR WALL CONNECTION DETAIL

(APPLIES ONLY WHERE SPECIFICALLY CALLED FOR ON THE PLANS)

NOTE TO DESIGN PROFESSIONAL: THIS DETAIL DEVELOPS FLANGE ACTION (SHEAR TRANSFER). FOR ECONOMY, DETAIL 1 IS RECOMMENDED WHEN FLANGE ACTION HAS NOT BEEN USED IN THE WALL DESIGN.

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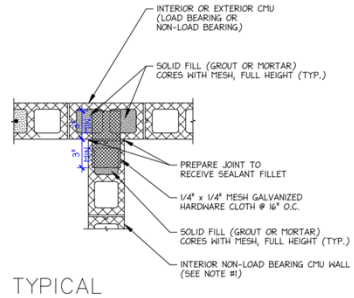
# PART 2: PRODUCTS TIES AND ANCHORS

2.07 Masonry Accessories

MIM's reference specification (Section 2.07) includes the following:

Connectors at wall intersections required to transfer out-of-plane forces from one wall to another only: Provide welded wire mesh anchors fabricated from 1/2-inch by 1/2-inch mesh of wire size W0.3 or 1/4-inch by 1/4-inch mesh of wire size W0.06 in width 2 inches less than nominal thickness of masonry wythe and length not less than twice the thickness; ASTM A185 wire with hot-dip galvanizing per ASTM A153 Class B-2.

Note: This is not included in the 2013 or 2016 TMS 402. It will be included in the 2022 version of the standard.




1 S-2 TYPICAL INTERSECTING WALL DETAIL

NOTES:
1) INTERIOR LOAD BEARING WALLS USUALLY ACHIEVE LATERAL SUPPORT FROM SUPPORTING FRAMING MEMBERS, AND ARE NOT DEPENDENT ON INTERSECTING WALLS FOR LATERAL SUPPORT. SUCH WALLS NEED NOT BE CONNECTED TO OTHER CMU WALLS.

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# PART 2: PRODUCTS
# TIES AND ANCHORS

5.1.1 Intersections walls

5.1.1.1 Wall intersections shall meet one of the following requirements:

(a) Design shall conform to the provisions of Section 5.1.1.2

(b) Transfer of shear between the walls shall be prevented

5.1.1.2 Design of wall intersection

5.1.1.2.1 Masonry shall be in running bond

5.1.1.2.2 Flanges shall be considered effective in resisting applied loads.

5.1.1.2.3 The width of the flange to be considered effective on each side of the web shall be the smaller of the actual flange on each side of the web and the value shown in Table 5.1.1.2.3 based on the state of stress in the flange and whether or not the masonry is reinforced. The effective flange width shall not extend past a movement joint.

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# TMS 402 PROVISIONS

5.1.1.2.5 The connection of intersecting walls shall conform to one of the following requirements:

(a) At least fifty percent of the masonry units at the face shall interlock.

(b) Walls shall be anchored by steel connectors grouted into the wall and meeting the following requirements…

(c) Intersecting bond beams shall be provided at a maximum spacing of 48 in. on center.

| Stress State in Flange | Unreinforced (U) or Reinforced( R) Masonry | Effective Flange Width |
|---|---|---|
| Compression | U, R | 6 x nominal flange thickness |
| Tension | U | 6 x nominal flange thickness |
| | R | 0.75 x floor-to-floor wall height |

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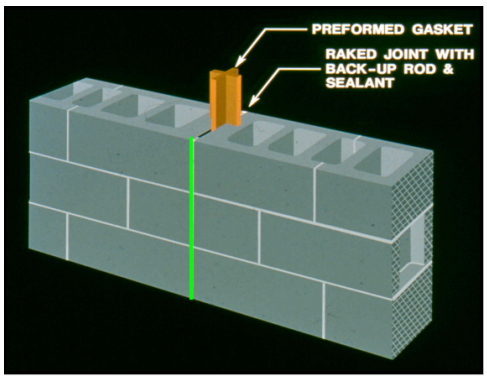
# PART 2: PRODUCTS CONTROL JOINTS




**2.10 Miscellaneous Masonry Accessories**

A. Preformed Control-Joint Gaskets: Made from [**styrene-butadiene-rubber compound**] [**or**] [**PVC**] and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.

B. Compressible Filler: Premolded filler strips complying with ASTM D1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from [**neoprene**] [**urethane**] [**or**] [**PVC**].

Does CMU expand?

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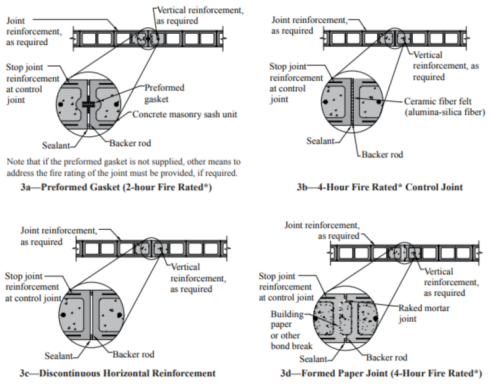
# PART 2: PRODUCTS CONTROL JOINTS

- The type of control joints used will affect structural performance under lateral loads, differential movement, and fire resistance rating.

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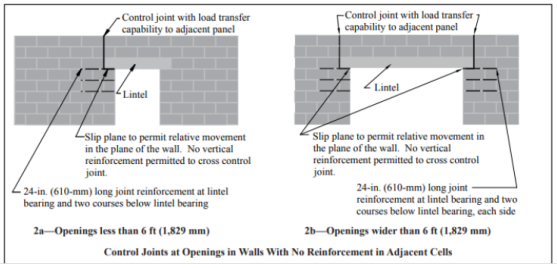
# PART 2: PRODUCTS CONTROL JOINTS

- Especially if control joints are placed at the edge of openings (which we do <u>not</u> recommend), NCMA notes that load path continuity is critical.




**Control Joints at Openings in Walls With No Reinforcement in Adjacent Cells**

Because cracking occurs in the planes of greatest weakness, openings are particularly vulnerable. For an opening of up to 6 ft (1.83 m) in width that are not wrapped with reinforcement, a control joint should be placed at one side of the opening as shown in Figure 2a. Notice that the joint goes around the lintel and allowance for movement (a slip plane in the form of flashing or other bond breaker) between the lintel and the masonry must be provided. Because the lintel is not laterally supported at the bottom due to the slip plane, control joints capable of providing load transfer between panels are required, such as the joints shown in Figures 3a, 3d, 3e, 3f, 3h and 3l.

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# PART 2: PRODUCTS CONTROL JOINTS

- To avoid this, we typically locate control joints away from openings and reinforce the jambs of the opening.

Plus, you get the added benefit of arching action!

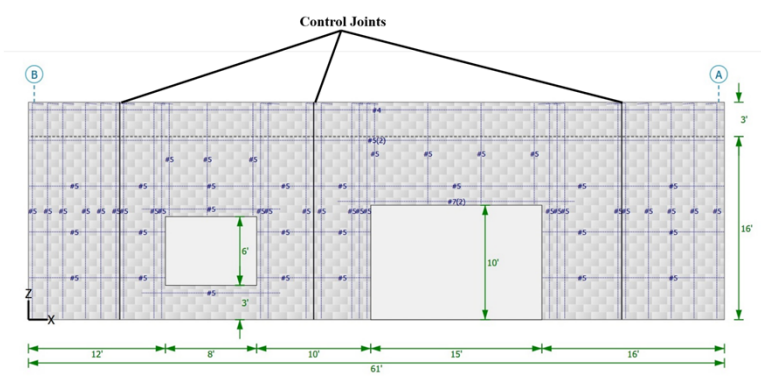


*Figure courtesy Direct Design Software*

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# TMS 402 PROVISIONS

- Poll Question 3: What is the maximum span of a one-course 8-inch lintel?

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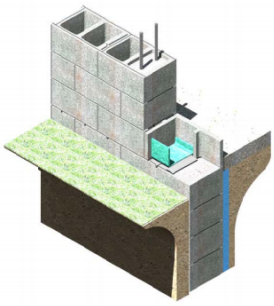
# PART 2: PRODUCTS MASONRY ACCESSORIES

**2.9 Embedded Flashing Materials**

MIM's reference specification (Section 2.05) includes the following:

E. Single Wythe Pan Flashing System for Single Wythe CMU
   1. Material: High-density polyethylene incorporating chemical stabilizers.
   2. Configuration: Pans with weep spouts extending from center of pan to outside face of masonry and connector bridges.
   3. Seven inch by 14-inch drainage mats made of 90 percent open weave polyester mesh for insertion into masonry cores above pan.



ISOMETRIC VIEW

REINFORCED CELL PICTURE

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# PART 2: PRODUCTS
# MASONRY ACCESSORIES

**Post Installed Thru-Wall Flashing Guide[1,7,8,9,10]**

| Flashing Materials | Thickness or Weight | Exposure | | | | | Installation[5] | | | | Performance | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | minimum | UV resistance | require drip[2] | water proof | corrosion resistance | staining masonry | ease of sealing laps | ease of field forming | self adhering[3] | air gap support required | expected building life | relative material and labor cost |
| **Plastics and Rubbers** | | | | | | | | | | | | |
| Self-Adhered Rubberized Asphalt | 40 mil | | Y | H | H | Y[6] | H | H | Y | Y | H | L |
| Ethylene Propylene Diene Monomer (EPDM) | 40 mil | | Y | H | H | N | M | M | N | Y | H | L |
| **Composites** | | | | | | | | | | | | |
| Copper Laminates | 3, 5, & 7 oz | | Y | H | H | Y | M | H | N | Y | H | M/H |
| Self Adhered Stainless Steel Laminate | 2 mil | | Y | H | H | N | H | M | Y | Y | H | M/H |
| Stainless Steel Laminate | 2 mil | | Y | H | H | N | M | M | N | Y | H | M/H |
| **Sheet Metals[4]** | | | | | | | | | | | | |
| Stainless Steel Flashing | 28 gauge | VH | Y | H | H | N | M | L | N | N | H | VH |
| Stainless Steel Drip | 28 gauge | VH | Y | H | H | N | M | H | N | | H | L |

**Not Recommended**

Polyvinyl Chloride (PVC), Copper
Galvanized Steel, Aluminum
Lead

**SOURCES:**

Brick Industry Association, BIA Technical Notes 7A, 2017
National Concrete Masonry Association, NCMA TEK 19-4A, 2008

**NOTES**

1 Selection of a proper flashing material is of utmost importance because it is a critical element for the drainage system.
2 When drip edge is not used, hold fully adhered flashing back or cut flush with the face of wall. Flush cutting not recommended for aspalt flashing
3 Substrates should be dry and clean for proper adhesion. Primers may be required. Confirm compatibility between flashing and sealants in the wall.
4 For linear sections of sheet metal flashing consider the expansion and contraction at the laps
5 For surfaced mounted applications consider a termination bar for positive attachment.
6 If drooling occurs from asphalt flashing it may be desirable to remove and clean
7 Use caution exposing sharp metal drip edges at all locations within pedestrian reach, including base of wall, first floor window sills, garden walls and site walls.
8 All flashings based on per manufacturers installtions guideleines, MIM details and MIM Exposed Metal Flashing Bulletin 2015
9 A drainage space, flashing system and weep holes are required to remove moisture from behind the veneer
10 The wall system must be designed and constructed to prevent water from entering the building.

**LEGEND:** L-low, M-moderate, M/H-moderate/high, H-high, VH -very high, Y-yes, N-no

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# PART 2: PRODUCTS
# MORTAR AND GROUT MIXES

- **2.12 Mortar and Grout Mixes**
  - A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.
    1. Use [**Portland cement-lime**] [**masonry cement**] [**or**] [**mortar cement**] mortar unless otherwise indicated.
    2. For exterior masonry, use [**Portland cement-lime**] [**masonry cement**] [**or**] [**mortar cement**] mortar.
    3. For reinforced masonry, use [**Portland cement-lime**] [**masonry cement**] [**or**] [**mortar cement**] mortar.
    4. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.

See MIM Reference Specification – Recommendation not to specify mortar type unless required for seismic reasons

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# PART 2: PRODUCTS
# MORTAR AND GROUT MIXES

- Poll Question 4: What mortar type is recommended for masonry veneers?

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# PART 2: PRODUCTS
# MORTAR AND GROUT MIXES

- **2.12 Mortar and Grout Mixes**
  - C. Mortar for Unit Masonry: Comply with ASTM C270, [**Proportion**] [**Property**] Specification. Provide the following types or mortar for applications stated unless another type is indicated [**or needed to provide required compressive strength of masonry**].
    1. For masonry below grade or in contact with earth, use [**Type M**] [**Type S**].
    2. For reinforced masonry, use [**Type S**] [**Type N**].
    3. For mortar parge coats, use [**Type S**] [**Type N**].
    4. For exterior, above-grade, load-bearing and non-load-bearing walls and parapet walls; for interior load-bearing walls; for interior non-load-bearing partitions; and for other applications where another type is not indicated, use Type N.
    5. For interior non-load-bearing partitions, Type O may be used instead of Type N.

See MIM Reference Specification – Use Type S for Unreinforced and Type N for veneers.

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# PART 2: PRODUCTS
# MORTAR AND GROUT MIXES

- **2.8 Mortar and Grout Mixes**

  MIM's reference specification includes the following:

  A. Mortar Mix: ASTM C270, Proportion Specification.
     1. Type M or S for masonry below grade or in contact with earth.
     2. Type S for unreinforced masonry above grade.
     3. Type [**N**] [**S**] for reinforced masonry above grade.
     4. Type N for veneer masonry.
     5. Admixtures: Permitted admixtures are specified in Article 2.03 A.4. If admixture is used, add at consistent rate for exposed mortar to ensure consistent mortar color, regardless of weather. Test for compatibility with other products and assemblies.
     6. Mix mortar in accordance with TMS 602 Article 2.6 A.

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# PART 2: PRODUCTS
# MORTAR AND GROUT MIXES




**Portland Cement-Hydrated Lime**
- A combination of cement and lime.

**Masonry Cement**
- Proprietary product.
- Contains Portland cement and fines, such as ground limestone
- Additives such as air entraining and water repellency agents.
- Simple batching and "fluffiness" due to entrained air leads to good productivity.

**Mortar Cement**
- Proprietary product similar to masonry cement.
- More stringent limitations on the amount of air.
- Specified bond strength to a standard unit.
- Recognized by codes to be equivalent to PCL mortar.

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# PART 2: PRODUCTS
# MORTAR AND GROUT MIXES

Mortar can be specified by either the *Proportion Method* or the *Property Method*.

- Note: The *Proportion Method* governs if neither is given.

| Mortar | Type | Proportion by Volume (Cementious Materials) | | | | | Aggregate Ratio (measured in damp, loose conditions) |
|---|---|---|---|---|---|---|---|
| | | Portland Cement | Masonry or Mortar Cement | | | Hydrated Lime or Lime Putty | |
| | | | M | S | N | | |
| Portland-Cement Lime | M | 1 | | | | $^1/_4$ | 2 $^1/_4$ to 3 times the sum of the separate volumes of cementious materials |
| | S | 1 | | | | $^1/_4$ - $^1/_2$ | |
| | N | 1 | | | | $^1/_2$ - $1^1/_4$ | |
| | O | 1 | | | | $1^1/_4$ - $2^1/_2$ | |
| Masonry or Mortar Cement | M | 1 | | | 1 | | |
| | M | | 1 | | | | |
| | S | 1/2 | | | 1 | | |
| | S | | | 1 | | | |
| | N | | | | 1 | | |
| | O | | | | 1 | | |

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# PART 2: PRODUCTS
# MORTAR AND GROUT MIXES

- **2.12 Mortar and Grout Mixes**
  - F. Grout for Unit Masonry: Comply with ASTM C476.
    1. Use grout of type indicate or, if not otherwise indicated, of type (fine or coarse) that will comply with TMS 602/ACI 530.1/ASCE 6 for dimensions of grout spaces and pour height.
    2. Proportion grout in accordance with ASTM C476, [**Table 1**] [**or**] [**paragraph 4.2.2 for specified 28-day compressive strength indicated, but not less than 2000 psi**].
    3. Provide grout with a slump of [**8 to 11 inches**] [**10 to 11 inches**] as measured according to ASTM C143.

TMS 402 requires the compressive strength of the grout to equal or exceed $f'_m$. The *Strength Design* methodology limits it to a maximum of 5000 psi.

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# PART 2: PRODUCTS
# MORTAR AND GROUT MIXES

- **2.8 Mortar and Grout Mixes**

  MIM's reference specification includes the following:

  A. Grout Mix: ASTM C476
     1. Minimum compressive strength at 28 days: [**2000**] [**2650**] [**3400**] [**4350**] [ ] psi when tested in accordance with ASTM C1019.
     2. Provide fine or coarse grout per TMS 602 Table 7, Grout Space Requirements, based upon masonry pour height (height of constructed masonry) and size of grout space.

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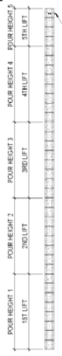
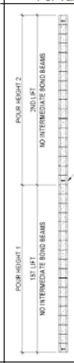
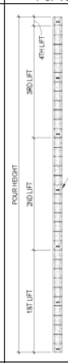
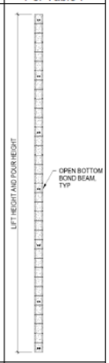
| Type of Grouting* | Grouting with no cure time limit | Conventional grout with no intermediate bond beams | Conventional grout with intermediate bond beams | Self-consolidating grout with or without intermediate bond beams |
|---|---|---|---|---|
| TMS 602 Article | 3.5 D.1.c<br>3.5 D.2.b | 3.5 D.1.a | 3.5 D.1.b | 3.5 D.2.a |
| Lift Limit | 5 ft-4 in. | 12 ft-8 in. | See Limitation | Pour Height |
| Pour Height | Per Table 7 | Per Table 7 | Per Table 7 | Per Table 7 |
| Configuration |  |  |  |  |
| Limitations | • Grout slump between 8 and 11 inches<br>• Conventional grout or self-consolidating grout<br>• Lift height is 1-1/2 inches less than pour height for shear key, except at top of wall. | • Masonry cured for at least 4 hours<br>• Grout slump between 10 and 11 inches | • Masonry cured for at least 4 hours<br>• Grout slump between 10 and 11 inches<br>• Lift cannot exceed maximum 12 ft-8 in.<br>• Limit grout lift to the bottom of lowest bond beam that is more than 5 ft-4 in. above bottom of grout lift<br>• Lift height is 1-1/2 inches below the top of block for shear key, except at top of wall | • Masonry cured for at least 4 hours |
| Cleanouts Required | No | Yes | Yes | Yes |

*Grout must conform to ASTM C476

# PART 2: PRODUCTS
# MORTAR AND GROUT MIXES

The TMS 602 Specification, Article 3.5 D addresses grout lift heights. There are four types of grouting. This grout figure is being developed for the 2022 TMS402/602 document.

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# PART 3: EXECUTION TOLERANCES

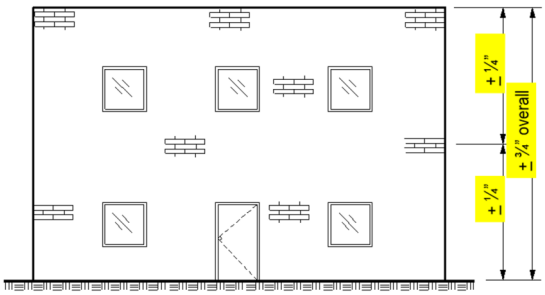


**Figure 4.17** Permissible variation of element indicated in elevation.

**3.3 Tolerances**

A. Dimensions and Locations of Elements

1. For location of elements in elevation, do not vary from that indicated by more than plus or minus 1/4-inch in a story height or 1/2-inch total.

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# PART 3: EXECUTION TOLERANCES

- **3.3 Tolerances**

B. Dimensions and Locations of Elements

2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8-inch in 10 feet, 1/4-inch in 20 feet, or 1/2-inch maximum.
4. For conspicuous vertical lines, such as external corners, door jambs reveals, and expansion and control joints, do not vary from plumb by more than 1/8-inch in 10 feet, 1/4-inch in 20 feet, or 1/2-inch maximum.
6. For vertical alignment of exposed head joints, do not vary from plumb by more 1/4-inch in 10 feet, or 1/2-inch maximum.
7. For faces of adjacent exposed masonry units, do not vary from flush alignment by more than 1/16-inch.

Not in the TMS

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# PART 3: EXECUTION TOLERANCES

- **3.3 Tolerances**

C. Dimensions and Locations of Elements

Not in the TMS

2. For exposed bed joints, do not vary from bed joint thickness of adjacent courses by more than 1/8-inch.
4. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8-inch.

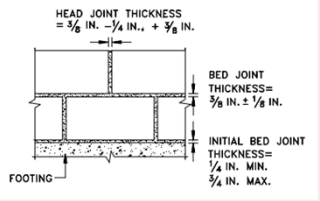


Figure 1—Mortar Joint Tolerances

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# PART 3: EXECUTION REINFORCEMENT

10. *Joint reinforcement* — There must be a minimum protective cover for the joint reinforcement as shown in Figure SC-12. Deeply tooled mortar joints, which provide inadequate protective cover for joint reinforcement, should be avoided.

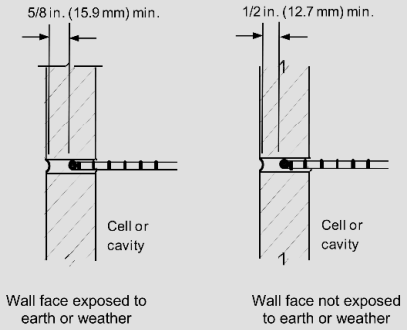


*Figure SC-12 Joint Reinforcement Cover Requirements*

NCMA recommends joint reinforcement at 12 inches o.c. for half high CMU construction.

**3.7 Masonry-Joint Reinforcement**

A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8-inch on exterior side of walls, 1/2-inch. Lap reinforcement a minimum of 6 inches.

1. Space reinforcement not more than 16 inches o.c.
2. Space reinforcement not more than 8 inches o.c. in foundation walls and parapet walls.
3. Provide reinforcement not more than 8 inches above and below wall openings and extending 12 inches beyond openings.
4. **Place wire around corners.**

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# PART 3: EXECUTION REINFORCEMENT

If control joints are designed using the *Empirical Method*, NCMA provides the following maximum spacing of horizontal joint reinforcement:

- For 8-inch nominal unit heights, provide 0.025 $in^2/ft$ of height.
  - W1.7 (9 gage) at 16-inches on center.
- For 4-inch nominal unit heights, provide 0.034 $in^2/ft$ of height.
  - W1.7 (9 gage) at 12-inches on center.

| Reinforcement size | Maximum spacing, in. (mm) |
|---|---|
| W1.7 (9 gage) (MW11)[1] | 16 (406) |
| W2.1 (8 gage) (MW13)[1] | 16 (406) |
| W2.8 (3/16 in.) (MW18)[1] | 24 (610) |
| No. 3 (M#10) | 48 (129) |
| No. 4 (M#13) | 96 (2,348) |
| No. 5 (M#16) or larger | 144 (3,658) |
| [1] Minimum two wires per course. | |

Maximum spacing of horizontal reinforcement to provide 0.025 square inches per foot of masonry height

| Reinforcement size | Maximum spacing, in. (mm) |
|---|---|
| W1.7 (9 gage) (MW11)[1] | 12 (305) |
| W2.1 (8 gage) (MW13)[1] | 12 (305) |
| W2.8 (3/16 in.) (MW18)[1] | 16 (406) |
| No. 3 (M#10) | 40 (1,016) |
| No. 4 (M#13) | 68 (1,727) |
| No. 5 (M#16) | 108 (2,743) |
| No. 6 (M#19) or larger | 144 (3,658) |
| [1] Minimum two wires per course. | |

Maximum spacing of horizontal reinforcement to provide 0.034 square inches per foot of masonry height

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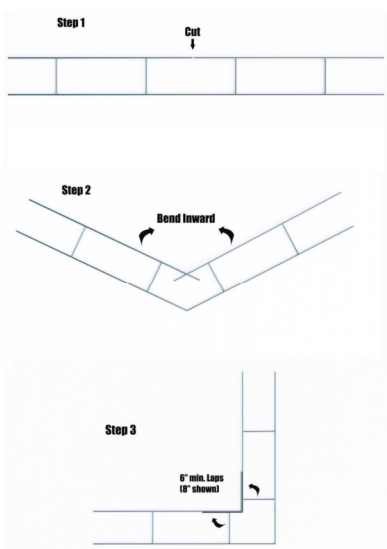
# PART 3: EXECUTION REINFORCEMENT




**3.7 Masonry-Joint Reinforcement**

E. Cut and bend reinforcing units as directed by the manufacturer for continuity at [**corners,**] returns, offsets, column fireproofing, pipe enclosures, and other special conditions.

Field fabricated joint reinforcement has several advantages:
- No extra lead time needed
- No additional cost to purchase
- More likely to be installed since material is on site

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# QUESTIONS?

phil@masonryinfo.org
www.masonryinfo.org

MASONRY
Institute of Michigan

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