

Improving Structural Drawings for Masonry Construction

By Richard Filloramo

Communication and coordination between the architect and engineer are essential for improving structural drawings for masonry construction. Errors, omissions and conflicts, which can lead to additional costs, are often caused by a lack of coordination between the architectural plans and specifications and the structural drawings. Structural steel framed buildings with masonry cavity walls seem to generate the most problems.

Structural drawings for masonry construction have improved in recent years, thanks to increased technical literature written and distributed from masonry organizations. This article will review the most important items that have emerged from these communications, as well as those that have come from actual review by International Masonry Institute (IMI) staff.

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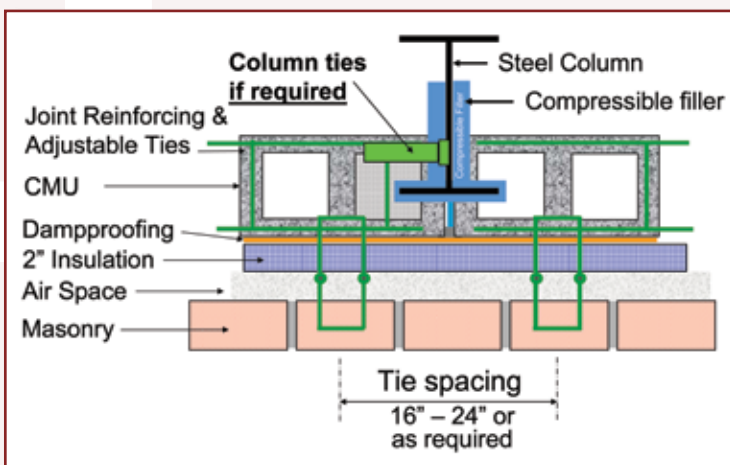


Figure 1: Steel Column within CMU backup

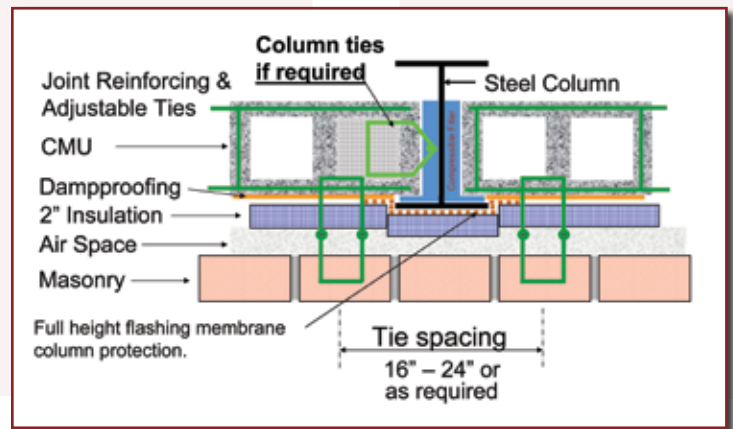


Figure 2: Column penetrates wall cavity

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Structural Steel Frame Columns

Many times, the structural engineer does not consider the exterior masonry wall configuration when designing and locating columns and beams. The location of structural steel columns can interfere with adjacent masonry wall construction. Failure to provide a water-resistant or waterproof barrier at columns that penetrate into the masonry cavity is a common problem. New energy codes that require air and vapor barriers can further complicate these situations. Developing the proper details for these conditions requires a special coordination between the architect and the structural engineer.



Figure 3A: Unprotected column



Figure 3B: Column and spaces are protected by membrane flashing

The detail shown in *Figure 1* illustrates a successfully designed column and masonry interface. The CMU cavity wall backup has a clearance of 3 to 4 inches in front of the column. This allows the backup wall to be continuous and, when dampproofed or waterproofed, forms a moisture-resistant barrier as required by building codes. A control joint is created by the separation of the masonry and steel. Engineers and architects should always indi-

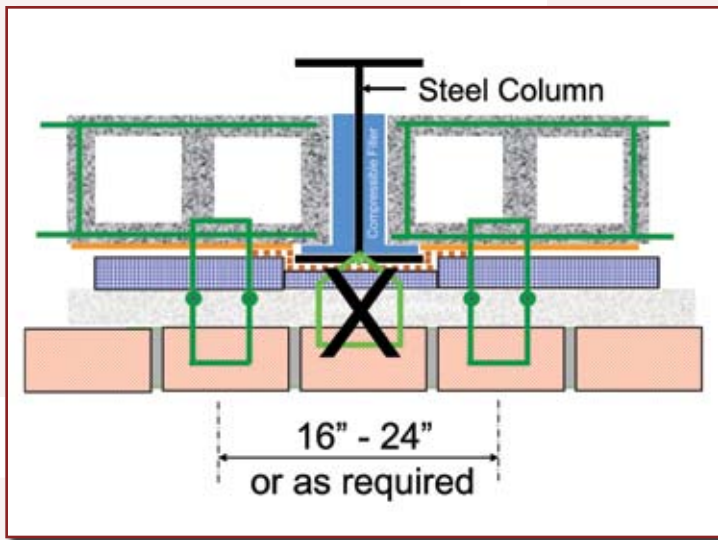


Figure 4: Do NOT penetrate flashing with ties and anchors at steel columns when anchor spacing requirements are maintained

cate when a separation space (usually 1 inch) is required between steel columns and masonry. It is also important to indicate concrete fill around the column base to support the CMU backup wall.

The detail shown in Figure 2 and the photos in Figure 3 illustrate conditions where the column penetrates the masonry cavity by 1 inch. Although this can be remedied by installing full-height flashing membrane over the exterior column, it does add cost to the project. Without proper coordination between the architect and structural engineer, this condition often goes unnoticed, leading to water penetration into the building.

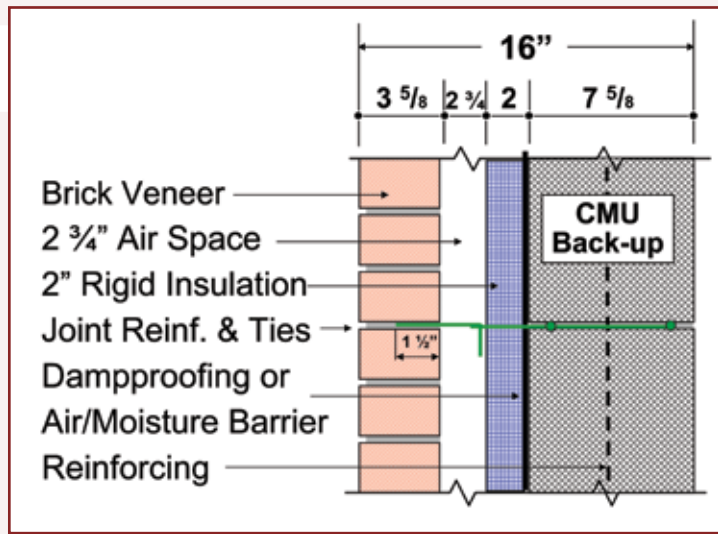


Figure 5: Drainage wall brick veneer/CMU back-up

In Figure 2, the membrane is adhered to the column and onto the adjacent CMU. This application protects the column, and the space between the column and the CMU backup, from air leakage and water penetration. Always specify the manufacturer's recommendations for wall preparation, primers, adhesives, and laps.

Locate adjustable veneer ties within 2 or 4 inches of the columns. Do not specify and indicate ties on structural or architectural drawings that pierce the flashing membrane with anchors from the steel column (Figure 4). This only increases the potential for water penetration and air leakage. Ties are not required at the column if the adjustable ties are maintained at the required horizontal spacing. Although many projects specify ties spaced 16 inches vertically and horizontally, the

MSJC code permits 16- x 24-inch spacing for masonry veneers. It is best to leave the spacing at 16- x 16-inches to allow for tolerances and field conditions, but to accept 24-inch spacing at columns and other locations if necessary. Always check local codes for anchor and tie requirements. If the distance between adjustable ties exceeds 24 inches or the required design distance, additional detailing is required. Contact IMI for information.

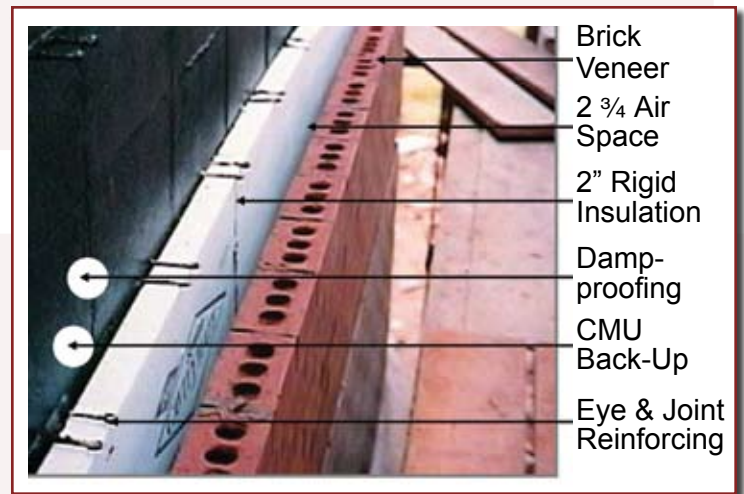


Figure 6: 16-inch drainage wall brick veneer/CMU back-up

Insulation with a thickness of 1 or 1 1/2 inches can be installed over the column membrane to provide a continuous layer of insulation as a thermal break. This is an example of the versatility of the 16 inch drainage wall (Figures 5 and 6) with the 2 3/4-inch air space and 4 3/4-inch cavity. For the condition where the column projects 1 inch into the cavity, the 1 1/2 inch insulation still fits and leaves a 2-inch air space. Compressible fillers or mineral wool can be placed between the column and the CMU to further insulate the area. Engineers must be familiar with these architectural masonry wall configurations. Steel columns projecting greater than 1 inch into the cavity will require the reduction of either the insulation or the air space, and will require special detailing.

It should be noted that cavities can exceed the code maximum of 4 1/2 inches, and typically do, as long as calculations are performed for the anchors. IMI has performed this study and the results are available from IMI.

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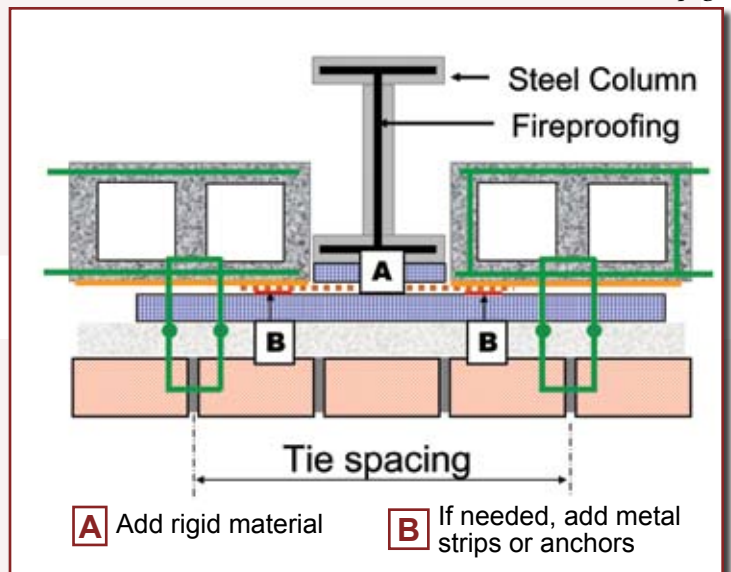


Figure 7: Columns with fireproofing or voids

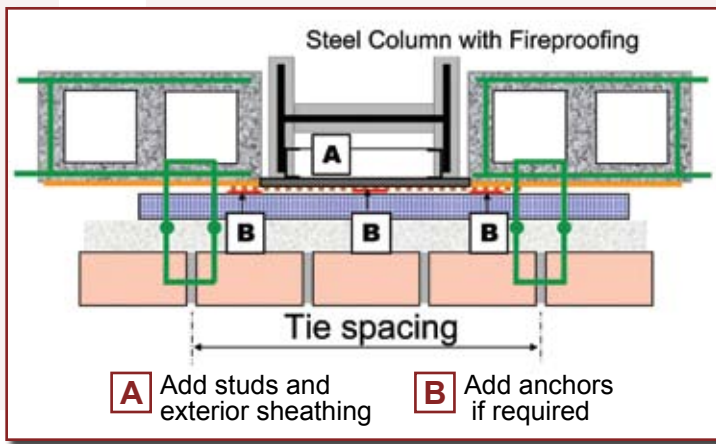


Figure 8: Columns with fireproofing or voids

If the open web of a steel column faces the cavity, or if a large space remains, it must be in-filled with masonry, insulation or some other rigid material to provide support for the vertical membrane waterproofing. This also applies to columns with fireproofing (Figures 7, 8 and 9). Once again, do not indicate ties on the steel column that penetrate the flashing.

Column ties to CMU backup (shown in Figure 1) are only required if the wall spans horizontally. Most exterior walls span vertically and are attached to the structure above (Figure 10). These ties, if not required, only interfere with column wraps, fireproofing, insulation and other construction, making the detail difficult to build. Engineers and architects should work together to eliminate these ties when not required since substantial cost savings can be realized.



Figure 9: Columns with fireproofing or voids

Structural Steel Beams

Structural engineers must consider the position, size, and location of structural steel beams since they will affect the moisture-control systems with adjacent masonry construction. Figures 11 and 12 illustrate how the lack of water-resistant protection can lead to air leakage and water penetration within the building. It is best to maintain a continuous wall plane of CMU backup at beams as shown in Figure 10. There must be at least 4 inches of clear space from the exterior face of the CMU backup units to the beam web to install the CMU filler. Full 3-inch (actual size) solid units are available for tight conditions since 2-inch soap units may not provide adequate support for the veneer when required. If there is not sufficient beam space to provide support for CMU backup, an alternate detail should be used as shown in Figure 13.

To improve structural drawings, engineers need to consider masonry coursing heights when indicating the location of bond beams. Bond beams should not be located directly below a steel beam unless the beam is offset to provide at least 4 inches of clear space on one side for pouring the grout into the bond beam. Notice in Figures 14 and 15 that the bond beam is located one course below the beam, but there is space to pour the grout. In most cases, the bond beam will be located two courses below the beam, as shown in Figure 10 and Figure 16. Since beam heights and depths will vary (Figure 17), it may be easier for the structural drawings to include a notation for locating bond beams a minimum of 4 inches below and a maximum of 12 inches below beams, unless there is access for grouting.

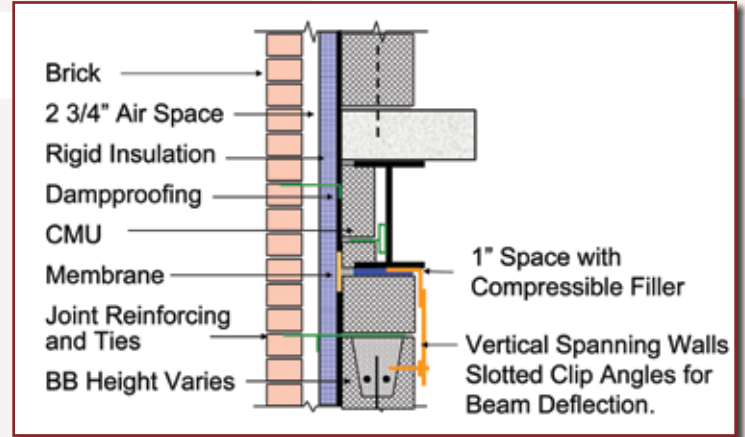


Figure 10: Good Detail

In most CMU details, a clear space, usually about 1 inch, is left open between the bottom of the steel beam and the top course of CMU to provide for deflection (Figure 18). If required, engineers should indicate this on the drawings. The resulting space in all details must be covered with a flexible water-resistant barrier. A compressible filler with a facing can be used if it is compatible with the CMU dampproofing. Mortar is sometimes used if the CMU extends beyond the beam and does not contact the beam, and if movement can be compensated within the beam.

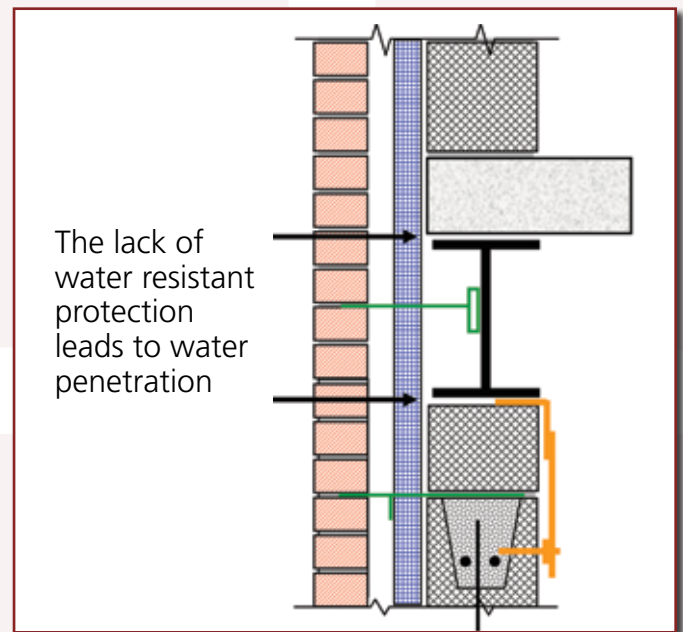


Figure 11: Poor Detail

Masonry Notes

Structural drawings usually have a page dedicated to masonry details and notes. It is essential to coordinate these notes with the architect's specifications. A common error, which causes great confusion, is inconsistency in CMU strength requirements. The architectural specification will call for CMU to conform to ASTM C-90 with a net compressive strength of 1900 psi. This will yield an f'_m of 1500 psi based on MSJC 2002, Section 1.4.B, 2b, Table 2. If the project requires higher strength CMU for shear walls, firewalls or loadbearing walls, the architect and engineer should be clear and consistent in indicating where these units are required. The engineer is required by code to indicate the CMU strength, as well as the intended f'_m . The contractor may achieve the required design strength using lower strength block by prism testing.

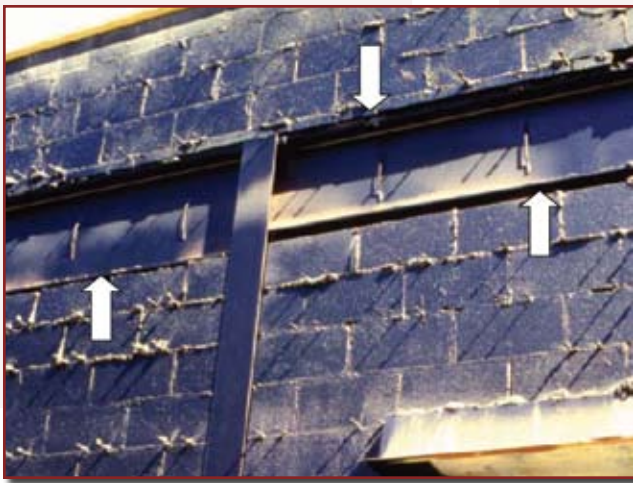


Figure 12: Moisture protection at steel beams. Poor Detail - the lack of water resistant protection leads to water penetration

Other Items of Importance

Engineers should highlight plans by cross hatching the exact location and length of shear walls. The elevation and section for these walls should be clearly indicated on the plan and be differentiated from non-structural masonry walls. A good example is shown in Figure 19. In this actual project, Glastonbury Elementary School, Macchi Engineers clearly indicates reinforcing requirements and has coordinated with Moser Pilon Nelson Architects on the architectural drawings.

A common mistake, usually found on the masonry structural drawing, is an elevation titled "Typical Masonry Wall Reinforcing". In most cases, this causes confusion for the bidders. The drawings should clearly indicate reinforcing for structural walls, exterior walls and interior walls. Interior walls in moderate and low seismic risk categories generally do not require vertical reinforcing. Figures 20 and 21 from Macchi Engineers drawings are excellent, efficient and cost effective examples that indicate masonry partition wall requirements.

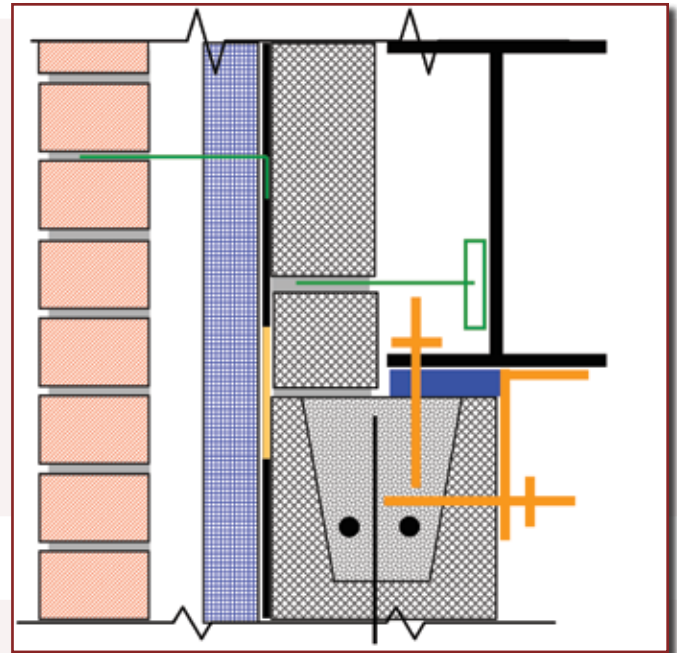


Figure 14: Locate bond beam directly under steel beam only if there is room to grout from the exterior side. Maintain 1-inch space and use slotted angles or bolts

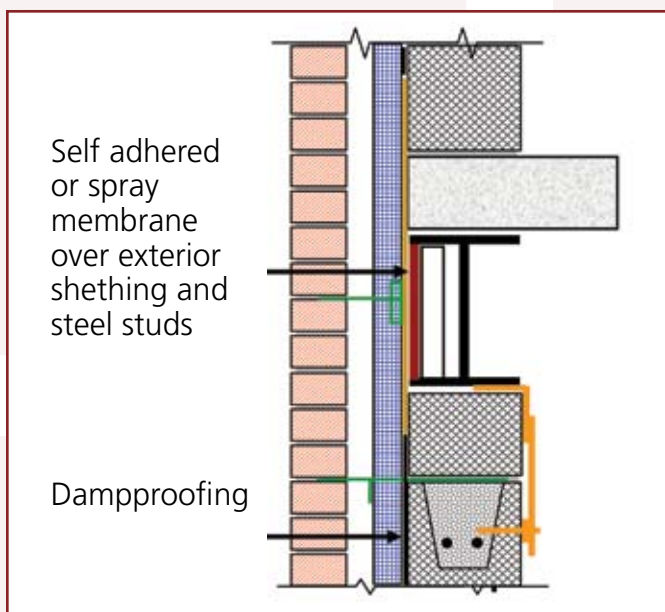


Figure 13: Good Detail

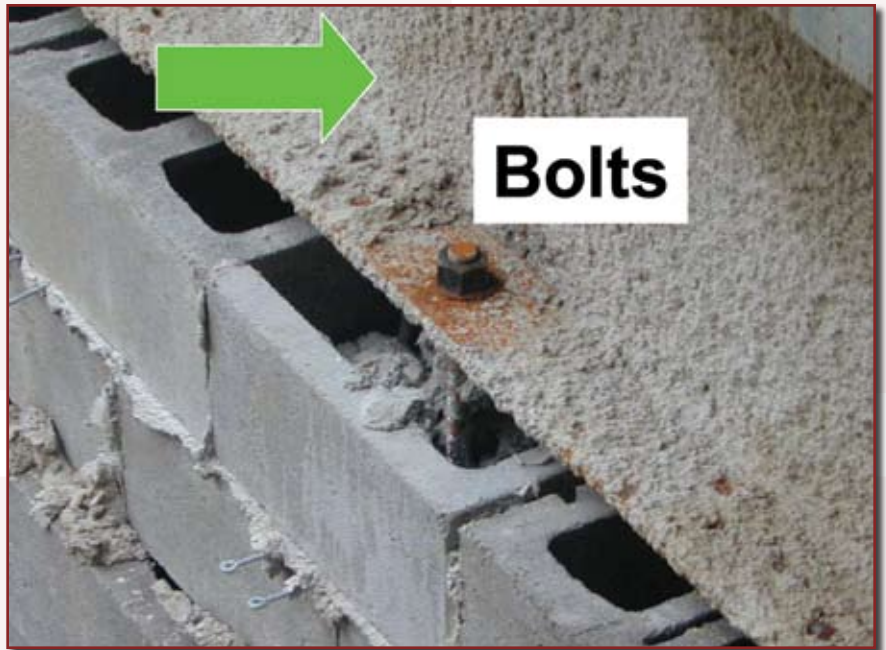
The architect and engineer also need to communicate on the specified density of the CMU. The weight of the masonry wall will affect the structural design. In some areas, lightweight CMU (<105 pcf) are common while in other areas medium weight (105 to 125 pcf) or normal weight (>125 pcf) CMU are used. Lightweight CMU have many advantageous characteristics and should be investigated for use on projects. Contact IMI for more information.

The project requirements for masonry inspection and testing are the responsibility of the engineer. The engineer must clearly identify the type and frequency of testing, as is required by the code and the design. It is essential that architectural specifications and engineering requirements are closely coordinated.

continued on next page



Figure 15: Locate bond beam directly under steel beam only if there is room to grout from the exterior side



Making It Work

Construction managers, architects, engineers, masonry industry representatives and mason contractors should be involved with plan reviews prior to project bidding. For example: Industrial Construction, a construction manager from Newington, CT, typically has an IMI member mason contractor review the architectural and structural drawings prior to final plan release. They also involve many of the sub-trades. The notes are then sent to the architect and engineer for comment. A conference, or conference call, is then initiated to discuss the items of concern. Changes are made on both architectural and structural drawings prior to bid date. The end results yield coordinated masonry details and thousands of dollars in cost savings.

Structural Drawings for masonry construction have evolved to meet new and more complex code requirements, as well as new architectural design concepts. To ensure masonry structural drawings are clear, concise and coordinated:

1. Increase communications and coordination with the architect.
2. Check all column locations within the masonry wall system.
3. Check masonry coursing to the bottom of beams for bond beam locations.
4. Involve construction managers, architects, engineers, masonry industry representatives and mason contractors in plan reviews.
5. Provide more "enlarged" masonry details and sections on the drawings.
6. Review specifications and coordinate with notes on structural drawings.
7. Designers, specifiers and structural engineers should incorporate 3-D CAD images into drawings of complex building elements and details.
8. Verify that the mason contractor and craftworkers are skilled and experienced with the type of construction on the project, and that they meet the project qualification requirements. ■



Figure 16: Grouting bond beams too close to the bottom of steel beams can be difficult





Figure 17

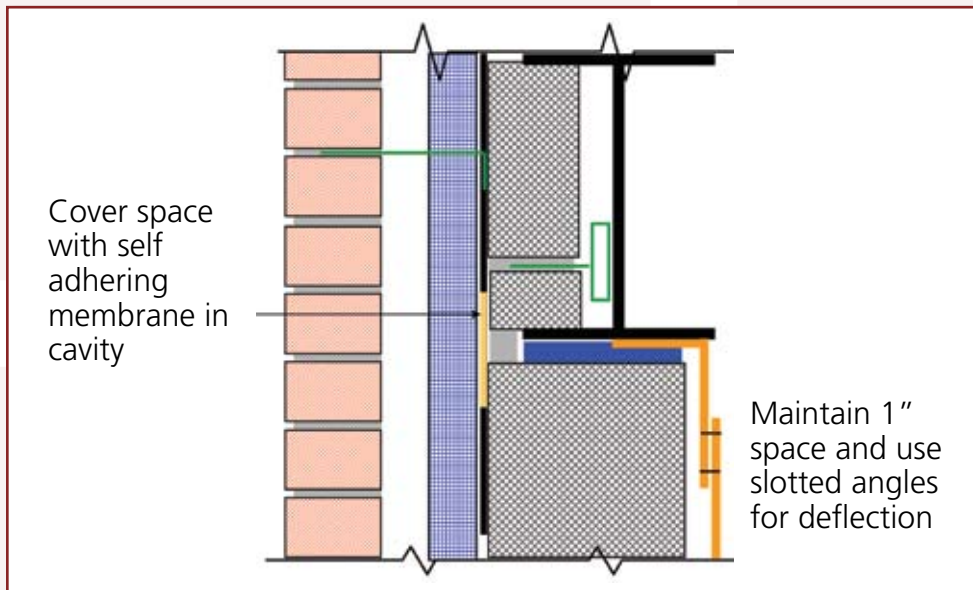


Figure 18: Steel beam

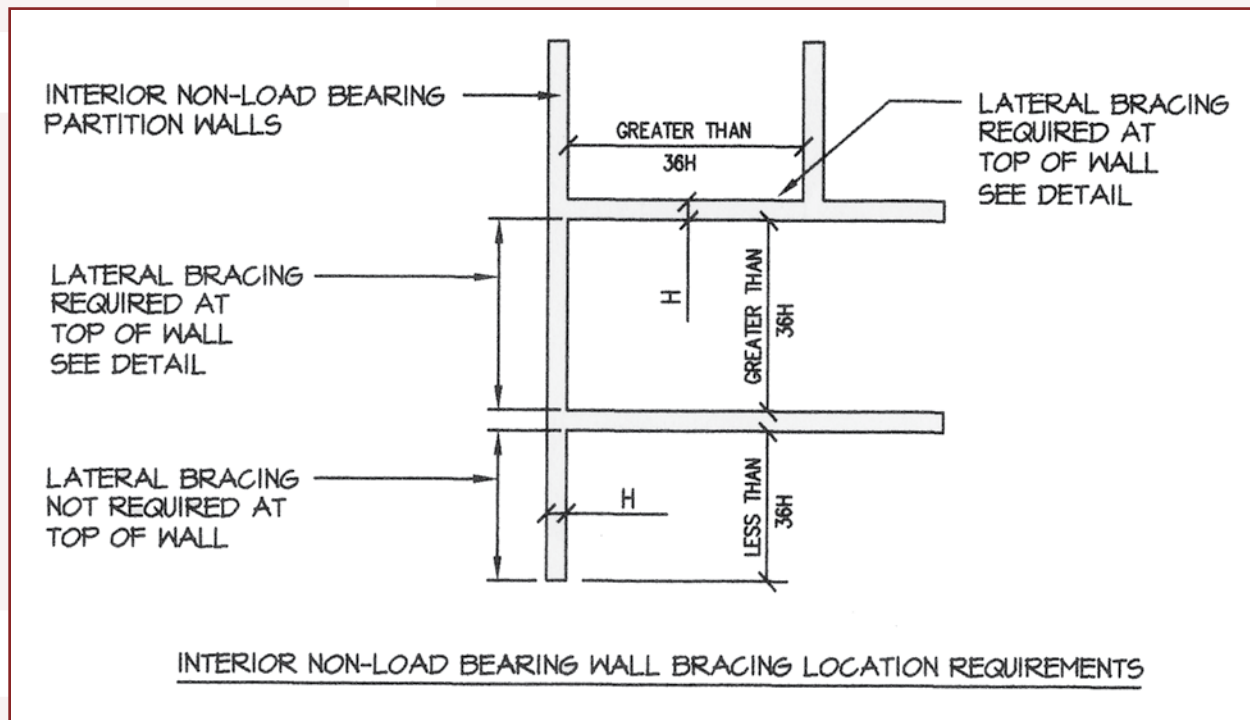
References

1. Masonry Standards Joint Committee (MSJC) Building Code Requirements for Masonry Structures (ACI 530-02/ASCE 5-02/TMS 402-02), Specifications for Masonry Structures (ACI 530.1-02/ASCE 6-02/TMS 602-02) and Commentaries.
2. International Masonry Institute – Detailing Masonry Construction Educational Series
3. International Masonry Institute – IMI Technical Briefs on Masonry Construction
4. ASTM C 90-05 Standard Specifications for Loadbearing Concrete Masonry Units

Richard Filloramo is Area Director of Market Development and Technical Services for the International Masonry Institute New England Region – Connecticut Office. He has more than 28 years of experience in the masonry industry. Mr. Filloramo is a member of the Masonry Standards Joint Committee, the code writing body responsible for the Masonry 530 Code. Mr. Filloramo has been involved with the design, construction and inspection of more than 5,000 building projects.

see next page for figures 19, 20 and 21

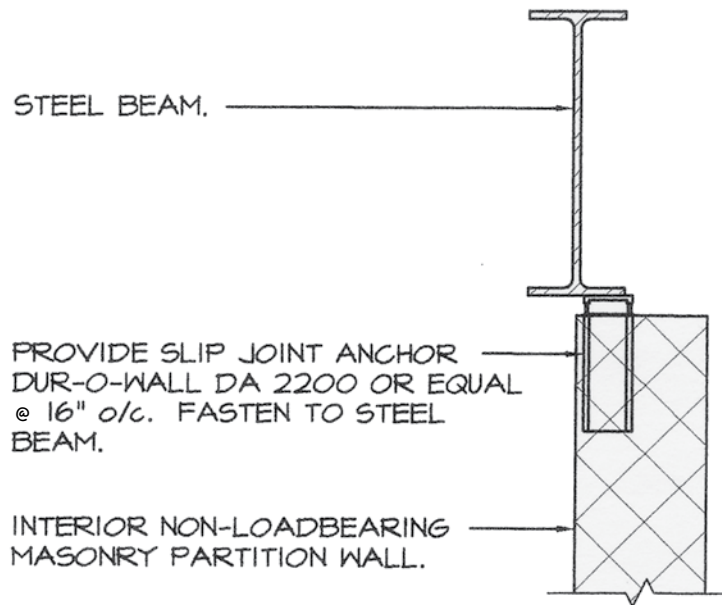
WALL HEIGHT & TYPE (SEE NOTE 7)		VERTICAL REINFORCING	REMARKS
EXTERIOR WALLS	ALL WALLS	SEE SECTIONS	GROUT VOIDS SOLID @ REINFORCING SEE NOTE 5
INTERIOR WALLS	ALL WALLS	NO VERTICAL REINFORCING REQUIRED	SEE NOTES 2, 3, 4



1. NON LOAD BEARING PARTITION WALLS SHALL BE ISOLATED FROM INTERIOR STEEL COLUMNS.
2. ALL INTERIOR PARTITION WALLS SHALL BE HORIZONTALLY REINFORCED WITH W1.7 (#9) HORIZONTAL REINFORCING WIRE @ 16" o/c.
3. INTERIOR NON-LOAD BEARING MASONRY PARTITIONS SHALL BE SUPPORTED AT INTERVALS NOT EXCEEDING 36 TIMES THEIR THICKNESS. THIS SHALL BE ACCOMPLISHED BY EITHER OF THE TWO METHODS NOTED BELOW AT THE OPTION OF THE CONTRACTOR:
 - A) ANCHOR INTERIOR PARTITIONS TO SLAB, ROOF DECKING, OR BEAMS IN ACCORDANCE WITH DETAILS INDICATED ON THIS DRAWING OR SECTIONS.
 - B) ANCHOR INTERIOR PARTITION WALLS BY ANCHORING THEM TO INTERSECTING PARTITIONS WALLS UTILIZING EITHER JOINT REINFORCING SPACED VERTICALLY AT 16" O.C., 1/4" GALVANIZED MESH AT 16" O.C., OR EQUIVALENT STEEL STRAP ANCHORS IN ACCORDANCE WITH BOCA SECTION 2110.2.5.
4. FOR INTERIOR NON-LOAD BEARING PARTITIONS THAT DO NOT EXTEND FOR FULL HEIGHT, AND DO NOT HAVE SUFFICIENT LATERAL BRACING FROM INTERSECTING MASONRY, LATERALLY BRACE WALLS WITH METAL STUDS IN ACCORDANCE WITH "INTERIOR NON-LOAD BEARING DETAIL FOR NON-FULL HEIGHT WALLS".
5. PROVIDE BOND BEAMS @ 10' o/c MAX. AT ALL EXTERIOR WALLS.
6. ALL REINFORCING TO BE LAPPED 40 BAR DIAMETERS U.N.O. ON EITHER THE PLANS OR SECTIONS.
7. HEIGHT OF WALL IS DISTANCE FROM FLOOR TO POINT OF SUPPORT ABOVE FLOOR.
8. EXTERIOR WALLS ARE ANY WALL WITH WIND EXPOSURE AT ANY POINT ALONG THE HEIGHT OR LENGTH OF THE WALL. SEE SECTIONS FOR REINFORCING

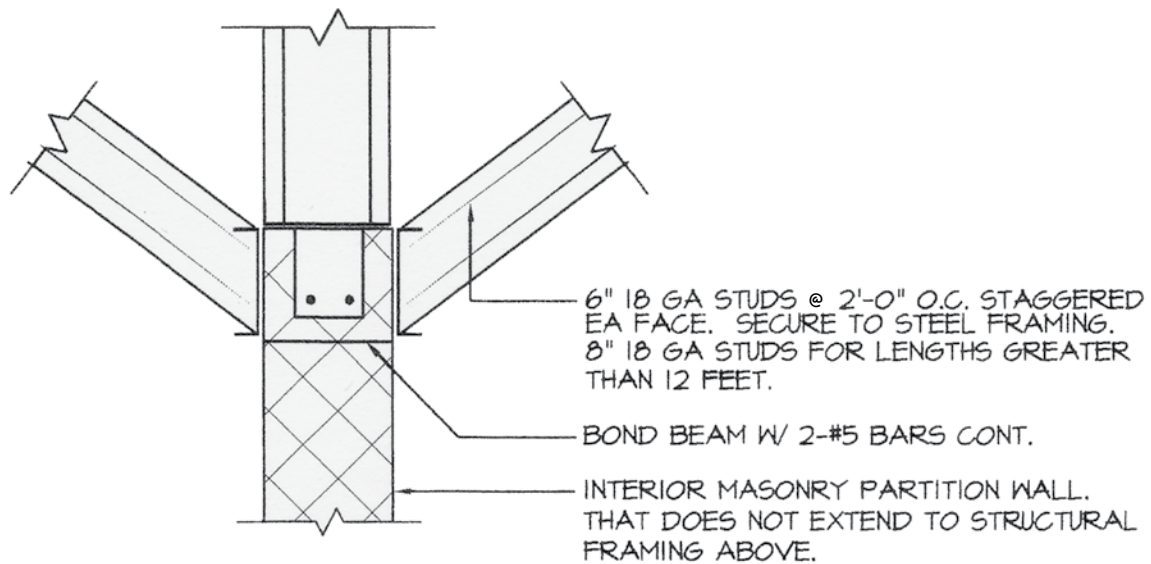
Figure 20: A good example to indicate masonry partition wall requirements. Drawings courtesy of Macchi Engineers, Moser Pilon Architects for Glastonbury Elementary School, Connecticut

see next page for Figure 21a and 21b



TYPICAL INTERIOR LATERAL MASONRY PARTITION CONNECTION PARALLEL TO STEEL FRAMING:

NOT TO SCALE



INTERIOR NON-LOAD BEARING DETAIL FOR NON-FULL HEIGHT WALLS

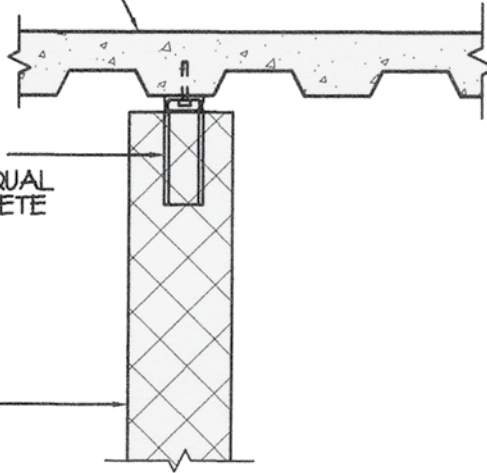
NOT TO SCALE

Figure 21a: Interior partition connection details. Drawings courtesy of Macchi Engineers, Moser Pilon Architects for Glastonbury Elementary School, Connecticut

SEE PLAN FOR FLOOR DECK INFORMATION AND DETAILS.

PROVIDE SLIP JOINT ANCHOR DUR-O-WALL DA 2200 OR EQUAL @ 16" o/c. FASTEN TO CONCRETE WITH POWER ACTUATED PINS, OR SELF TAPPING SCREWS

INTERIOR MASONRY PARTITION WALL.



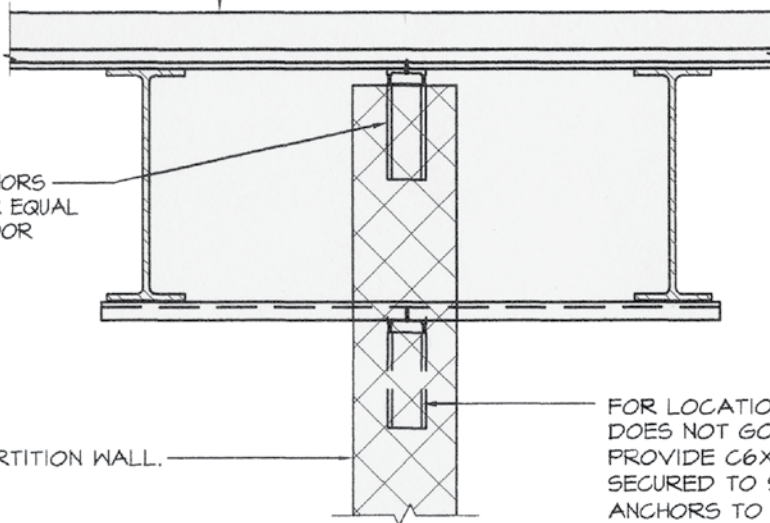
TYPICAL INTERIOR MASONRY PARTITION WALL CONNECTION • FLOOR DECK:

NOT TO SCALE

SEE PLAN FOR FLOOR DECK TYPE DIRECTION OF SPAN.

PROVIDE SLIP JOINT ANCHORS DUR-O-WALL DA 2200 OR EQUAL @ 16" o/c. FASTEN TO FLOOR DECK WITH SELF TAPPING SCREWS.

INTERIOR MASONRY PARTITION WALL.



FOR LOCATIONS WHERE BLOCK DOES NOT GO TO DECKING PROVIDE C6X8.2 CHANNELS @ 16" o/c. SECURED TO STEEL. FASTEN DUR-O-WALL ANCHORS TO CHANNEL.

TYPICAL INTERIOR MASONRY PARTITION WALL LATERAL CONNECTION • METAL FLOOR DECK:

NOT TO SCALE

Figure 21b: Interior partition connection details. Drawings courtesy of Macchi Engineers, Moser Pilon Architects for Glastonbury Elementary School, Connecticut