

# MASONRY MOVEMENT JOINTS

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## ABSTRACT

The national model masonry code requires building designers to indicate type and location of movement joints on the project drawings. Additionally, the veneer section of this code requires building designers to design and detail the veneer to accommodate differential movement. The speaker will discuss how masonry materials move, define the different types of masonry movement joints, and give recommendations for locating and constructing movement joints. Attendees will be taught about control and expansion joints at corners, shelf angles, and the top of walls; loose vs. fixed lintels; shrinking veneers; open-jointed clip and rail rainscreen walls; load-bearing CMU walls; and adhered veneers.

## SPEAKER

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# MASONRY MOVEMENT JOINTS

## INTRODUCTION

Masonry movement joints are one of the most misunderstood and under-appreciated technical issues in the masonry industry (Figure 1). The lack of properly located, detailed, specified, and installed masonry movement joints can result in damaged masonry and mortar joints, out-of-plane masonry, and unpleasing aesthetic conditions. Negative consequences caused by improper masonry movement control strategy can likewise unnecessarily alarm building owners, damage wall finishes, allow water penetration and staining, dislodge masonry, stress movement joint sealant, and even damage or break metal ties and anchors (Figure 2).

### Why Do We Need Movement Joints?

All construction materials and buildings move, and we need to accommodate or restrain this movement. Movement is caused by internal volume change of construction materials, environmental loads (wind, snow, seismic forces, and soil pressure), settlement, creep, moisture, temperature, concentrated loads, adjacent construction, and impact loads.

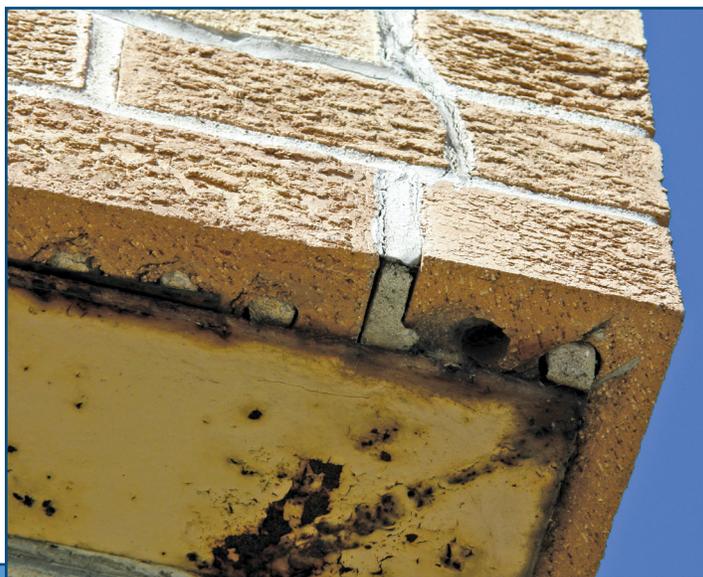
Differential movement occurs in building systems when dissimilar construction

materials are connected within the same wall assembly, such as a structural steel lintel embedded into a masonry wall, an expanding clay brick connected to a shrinking wood structure or deflecting steel stud wall, confined masonry, or diverse masonry materials placed together within the same veneer.

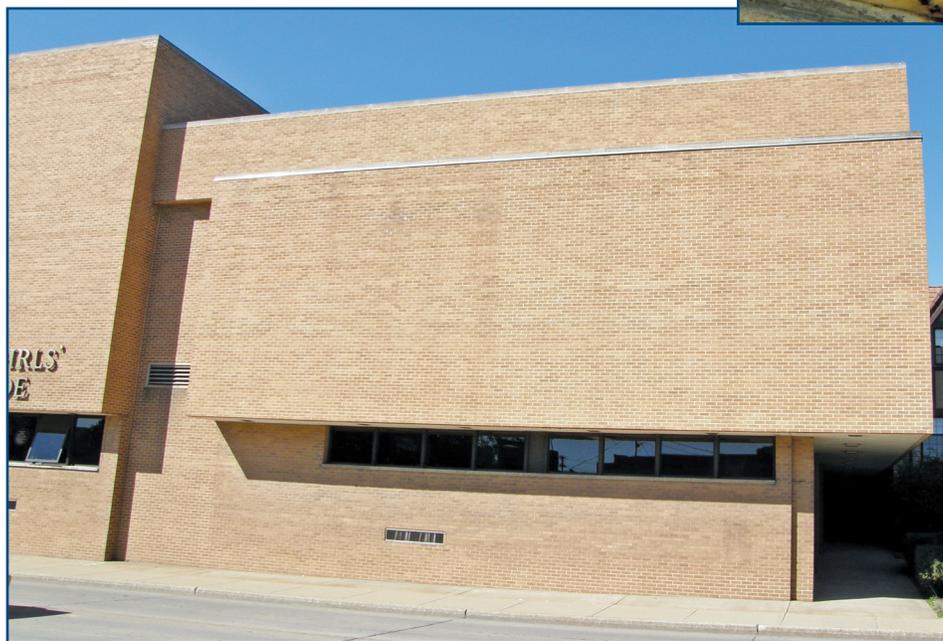
Masonry movement joints are more beneficial in contemporary masonry cavity walls than in older mass masonry buildings. Modern masonry wall assemblies experience unique stresses due to the combination of a variety of natural and manufactured masonry materials within the same veneer, lightweight wall solutions, novel stresses on masonry associated with higher levels of thermal and air control in or on the support wall that leaves exposed masonry with less drying capacity, and exposure to new or increased freeze/

thaw cycles and other temperature-related stress.

The most common, conservative, and cost-effective strategy to deal with movement in masonry wall assemblies is to accommodate it with empirical placement of control joints, expansion joints, or isolation joints. However, with engineered movement control strategies, masonry can be restrained with embedded steel when there is a desire to have masonry control joints spaced further apart or even eliminated in unique situations (Figure 3).



**Figure 2 – This is a close-up of the project in Figure 1. Lack of movement joints in this expanding clay brick veneer resulted in vertical cracks at outside corners as perpendicular planes of brick expanded toward the corner. Remarkably, the CMU support wall on the inside of a stair tower moved with the veneer, resulting in significant cracking and out-of-plane interior CMU.**



**Figure 1 – Mid-20th century architecture seldom included masonry movement joints. The first masonry movement joint code appeared in the mid-1970s. This project had significant cracking and out-of-plane masonry—especially at outside corners.**



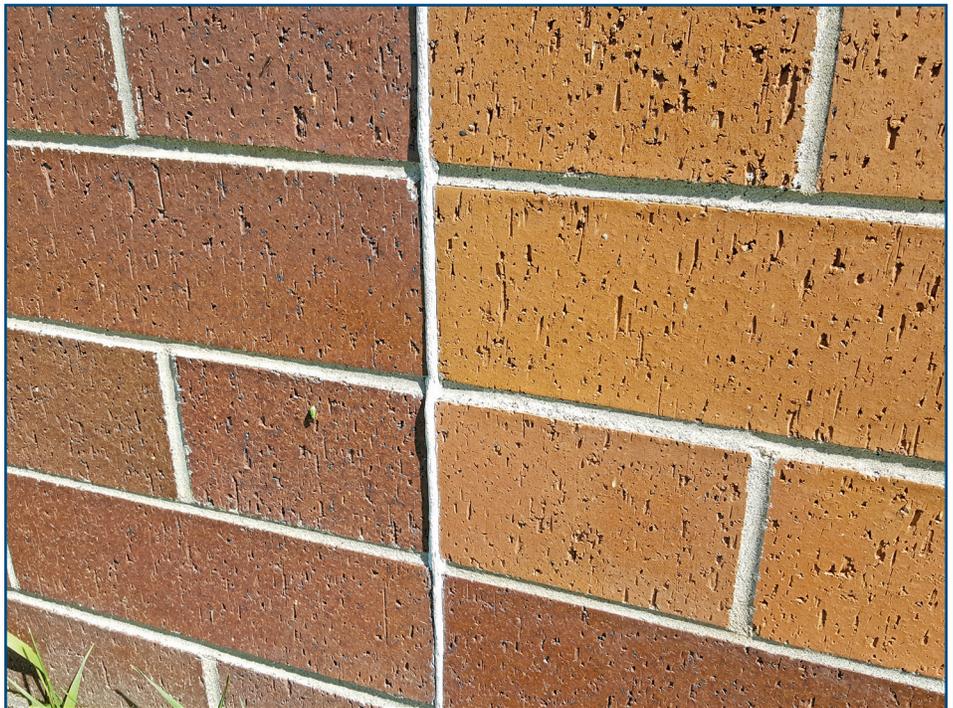
**Figure 3 – This cantilevered CMU firewall (142 ft. long x 58 ft. high x 2 ft. thick) was constructed without any vertical control joints using an engineered solution to restrain movement.**

#### Who Is Responsible?

According to the 2016 edition of the national masonry model code—formerly known as “ACI-530” or the Masonry Standard Joint Committee Code (MSJC)—TMS 402/602, Building Code Requirements and Specification for Masonry Structures, Page C-2, Section 1.2.1 (h), the building designer is required to show on the project drawings: “Provision for dimensional changes resulting from elastic deformation, creep, shrinkage, temperature, and moisture.” On page C-181, Section 12.1.6.3, this code directs building designers to: “Design and detail the veneer to accommodate differential movement.” Additionally, in the specifications portion of this code, Page S-85, Mandatory Requirements Checklist, Part 3, Section 3.3 D.6 requires the architect/engineer to: “Indicate type and location of movement joints on the project drawings.”

The intent of these code citations is for movement joints to be shown on the actual project drawings, such as floor plans or elevations, as opposed to relying on the mason to locate movement joints based on project specification language alone. Building designers understand the intent of masonry walls better than masons for loadbearing conditions, shear walls, horizontally or ver-

tically spanning interior partitions, adjacent construction implications, and other building loads.



**Figure 4 – Example of a 3/8-in.-wide expansion joint installed in a clay brick veneer with large dark-colored units and expansion joints spaced too far apart. The movement joint compresses significantly, and the backer rod and sealant are stressed—often to the point of failure.**

For example, if control joints in concrete masonry unit (CMU) walls are covered only in the project specification by instructing masons to install them 24 ft. on-center, the mason might inadvertently reduce the structural capacity of a key shear wall by segmenting it incorrectly, locate control joints too far from corners, install control joints too close to openings, or install movement joints according to antiquated rules-of-thumb that are not applicable to modern masonry assemblies nor to contemporary material characteristics.

#### CONTROL JOINTS VS. EXPANSION JOINTS

Control joints and expansion joints are not the same.

Expansion joints accommodate the expansion of masonry materials such as clay brick, calcium silicate, terra cotta, and ceramic tile. Because expansion joints get thinner over time due to expanding masonry on both sides of the joint—especially in the case of expanding clay brick with inherent irreversible moisture expansion—it is important for these joints to be clear of mortar droppings and other obstructions to allow for movement and to not impart stress on adjacent expanding masonry materials when the joint width decreases.



**Figure 5 – A 3/8-in.-wide CMU control joint under construction using preformed gasket and sash block. Horizontal joint reinforcement is discontinuous at the control joint, and mortar was cleaned out of the vertical movement joint for installation of backer rod and sealant. An improvement of this detail would be to use ladder-type horizontal reinforcement to allow grout to flow better in vertically grouted and reinforced cells.**

Expansion joints should be designed and installed with a 1/2 in. wide minimum to allow the joint to reduce down to 3/8 in. wide to match mortar joint width. This also prevents excessive stress on the backer rod and sealant which can result in protruding sealant and likely premature sealant failure (Figure 4).

Control joints, such as those placed in walls made of CMU, concrete brick, or cast stone, create vertical locations of weakness in the wall to regulate where movement cracks can occur (Figure 5). Because the overall characteristic of a control joint is to get wider over time, it is not essential to construct the joint clear of mortar droppings as long as there is adequate space for the proper placement of backer rod and sealant. This is similar to crack control in concrete slabs or sidewalks where the control joint does not need to go completely through the concrete. For control joints in concrete masonry walls to function properly, discontinue the horizontal joint reinforcement at vertical control joints to allow the joint to move.

In modern masonry cavity wall construction, control joints in concrete masonry support walls do not need to align with

veneer movement joints. In the past, when CMU and brick walls were constructed together as composite walls, control joints in the CMU wythe and expansion joints in clay brick veneer needed to be coordinated and aligned. In modern masonry cavity walls, these two different masonry wythes are separated by an air space and connected with flexible metal connectors. This allows the structural engineer to locate control joints as necessary in the support wall and gives the architect flexibility to locate veneer movement joints to address both functional and aesthetic priorities.

#### **Common Masonry Movement Joint Mistakes**

When masonry structural walls, partitions, or veneers crack due to the lack of masonry movement joints, not enough masonry movement joints, or the improper placement of masonry movement joints, this is a design failure—not a masonry failure.

The main mistakes designers make when locating movement joints are:

1. Relying on generic specification language to locate movement joints, instead of showing them on the building plans and elevations as

required by code

2. Locating control joints at the ends of masonry lintels in reinforced masonry walls
3. Not understanding movement control strategies for CMU veneers
4. Not understanding industry recommendations for locating veneer movement joints in relation to outside corners
5. Not locating movement joints at inside corners; some exceptions apply
6. Not understanding the use of isolation joints
7. Not understanding how veneer lintel type influences placement of vertical movement joints at or near window openings
8. Not detailing proper expansion joint width in clay brick veneers
9. Not having horizontal movement joints between dissimilar veneer materials
10. Not having movement joints between masonry and window and door-frames when appropriate

#### **Control Joint Spacing and Locations**

When locating masonry movement joints, it is important to follow code requirements, industry standards, manufacturer or supplier recommendations, regional experience, and professional judgment. Typically, control joints in concrete masonry unit walls are installed at approximately 25 ft. on-center, at inside corners, at changes in wall mass or support wall conditions, at different bearing conditions, at the interface with dissimilar materials, and intentionally placed in relationship to openings and outside corners.

One of the most common mistakes in locating control joints in CMU walls is using older empirical recommendations for unreinforced masonry walls at the end of masonry lintels. In reinforced masonry walls with masonry lintels, it is recommended to locate vertical control joints away from the opening so the control joint is free to operate and is not pinned together by the intersecting horizontal steel reinforcement and grout of the masonry lintel and the vertical reinforcement adjacent to the opening (Figure 6).

In reinforced CMU walls with multiple openings, control joints can be placed between the openings as long as the overall spacing between control joints does not



**Figure 6 – Control joints properly located between openings in this reinforced load-bearing wall. Movement joints are spaced within acceptable limitations for this project at 23'-4" on-center. This is a masonry modular dimension to eliminate cutting.**



**Figure 7 – Control joints in a reinforced loadbearing CMU wall with masonry lintels. Control joints were placed 24 in. away from openings on both sides because placing them in between openings would have exceeded spacing recommendations.**

exceed the typical spacing required for the wall, and there is enough masonry for proper load transfer. When the spacing of control joints between openings exceeds recommended or engineered spacing, control joints can be located on either side of the opening and spaced 2 ft. away from the opening (Figure 7).

Another common mistake with control joint spacing is not adjusting movement control strategies for cement-based masonry veneers (Figure 8). For concrete brick veneers, the National Concrete Masonry

Association (NCMA) Technical Note 10-4 (2001), *Crack Control for Concrete Brick and Other Concrete Masonry Veneers*, is a good resource. It outlines the need for horizontal joint reinforcement in the veneer spaced at least 16 in. on-center with Type N mortar, which is more ductile than Type S mortar. Vertical movement joints in concrete brick veneers are typically spaced 1.5 times the height of the wall, not to exceed 20 ft. For low walls, this wall panel length-to-height ratio is still recommended, but some regional experiences have demonstrated that vertical control joints can be spaced farther apart.



**Figure 8 – A 3/8-in.-wide control joint in concrete brick and block veneer with ladder-type horizontal joint reinforcement, spaced 16 in. on-center, discontinuous at vertical control joints.**

Locating movement joints in walls of dissimilar materials should use more conservative spacing recommendations and a slip plane (Figure 9). For example, when a 4-ft.-high CMU veneer is topped with 20 ft. of clay brick, control joint spacing in the CMU portion of the veneer has been successful at 12 ft. on-center, while the expansion joints in the clay brick can be 24 ft. on-center. A horizontal bond break between the different fields of veneer materials should be used. Regional and professional judgement should be exercised in all design.

### Expansion Joint Spacing and Locations

For placement of expansion joints in clay brick veneers, the Brick Industry Association (BIA) Technical Notes on Brick Construction 18A (2006), *Accommodating Expansion of Brickwork*, is a good resource. Many designers misinterpret this document to suggest all expansion joints to be located approximately 25 ft. on-center. However, this recommendation is only for brick walls without openings. The BIA technical document states, “For brickwork with multiple openings, consider symmetrical placement of expansion joints and reduced spacing of no more than 20'-0" on-center.”

Other scenarios where vertical expansion joints in clay brick veneers may warrant closer spacing include: parapet walls (alternatively, use wider joints), veneers with dark-colored brick, areas of the building that might experience unique environmental stress, veneers connected to less-stiff support walls like wood or light-gauged metal frame walls, stack-bonded veneers, and veneers with large units—especially



Figure 9 – Typical shrinkage crack in low CMU portion of this wall when veneer movement joints were spaced too far apart.

large format cement-based units (Figure 10).

The distance between masonry movement joints should be a masonry modular dimension, as determined by the masonry units in the wall. For example, 24', 24'-8", or 25'-4" are appropriate masonry modular dimensions because they are all divisible by 8". Masonry modular dimensions work well with masonry layouts to reduce waste, speed up construction, keep cost low, produce masonry details that fit well together without small or awkwardly shaped pieces of masonry, and minimize airborne dust from cutting.

When locating expansion joints at or near veneer openings, consideration should

be given to how the brick is supported over the opening. For example, when a veneer lintel is connected to the support wall, it is a good idea to locate vertical movement joints at the ends of the lintel to isolate differential movement between the veneer portion that bears on the lintel versus the part of the veneer that bears on the foundation wall (Figure 11).

When loose lintels are used in the veneer (where the steel lintel bears on the masonry on either side of the opening and is not connected to the backing wall), expansion joints can be aligned with opening jambs, at the end of the lintel, or even between openings since the loose lintel is

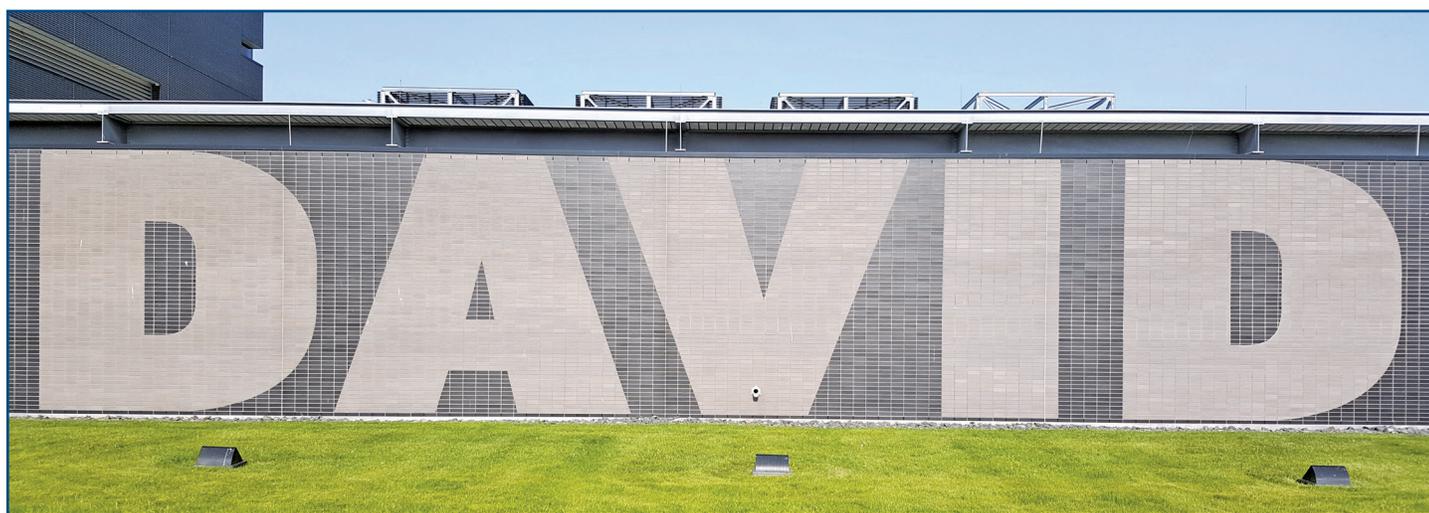
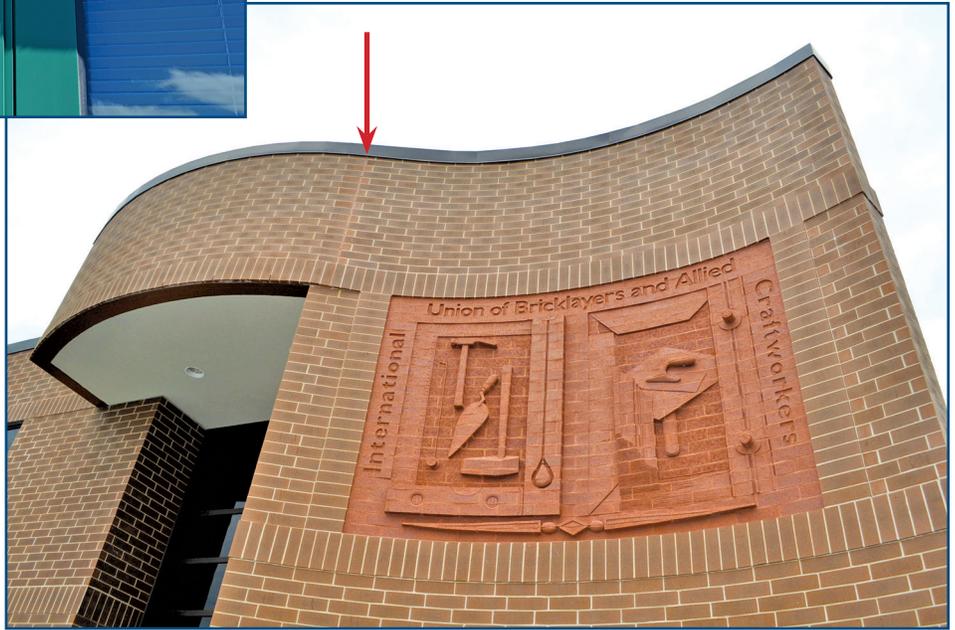


Figure 10 – Expansion joint spacing for this black-stack bond clay brick veneer was properly reduced from the recommended 25 ft. on-center to 20 ft. to allow for expected growth from solar gain on this west elevation.



**Figure 12 – Damaged horizontal mortar joint at lintel bearing. Improvements to this detail would include a metal drip edge to the end of the lintel and sealant under the drip edge at lintel bearing.**



**Figure 11 – Vertical isolation joint (expansion joint) to accommodate differential movement between portions of veneer with different bearing conditions. Also notice the sealant color selection to blend movement joint into masonry.**

free to move with the veneer. If a vertical expansion joint is aligned with an opening jamb, it is recommended to install a metal or plastic slip plane under the lintel bearing points, and install a void between the end of the lintel and adjacent masonry.

No matter where the vertical movement joint is located, there should be horizontal sealant—not mortar—at the toe of the horizontal leg of the lintel that bears on the veneer. This is a common oversight and often produces cracked mortar and water penetration issues at that location (Figure 12).

With all steel lintel types in the veneer, differential movement should be accommodated between the steel and masonry veneer because the steel moves at a higher rate of thermal expansion and contraction than that of the masonry. For fixed veneer lintels that extend past the opening jamb, there should be a void between the lintel and the veneer below the lintel.

When a shelf angle is used to support the brickwork above openings, there are more options for vertical expansion joint placement.

### **Movement Joints Near Corners**

Masonry movement joints near corners should be carefully considered—for both control joints in single-wythe masonry and veneer expansion joints. The general rule-of-thumb for movement joints near outside corners—as described in BIA Technical Note 18A—is to keep the cumulative distance between the movement joints on either side of the corner spaced no further than the typical spacing used for the project.

For example, if it is determined that a 20-ft. spacing is appropriate for a certain

clay brick veneer with multiple openings, then a vertical expansion joint could be placed 10 ft. from one side of an outside corner, and the closest vertical expansion joint on the other side should also be within 10 ft. of that corner. When locating a movement joint near a window that is near a corner, it is recommended to place the movement joint on the corner side of the window (Figure 13).

If these corner placement guidelines are followed, it is not necessary to locate control joints any closer to the corner. However, some

designers have established “office standards” to locate vertical movement joints at certain predetermined distances from outside corners.

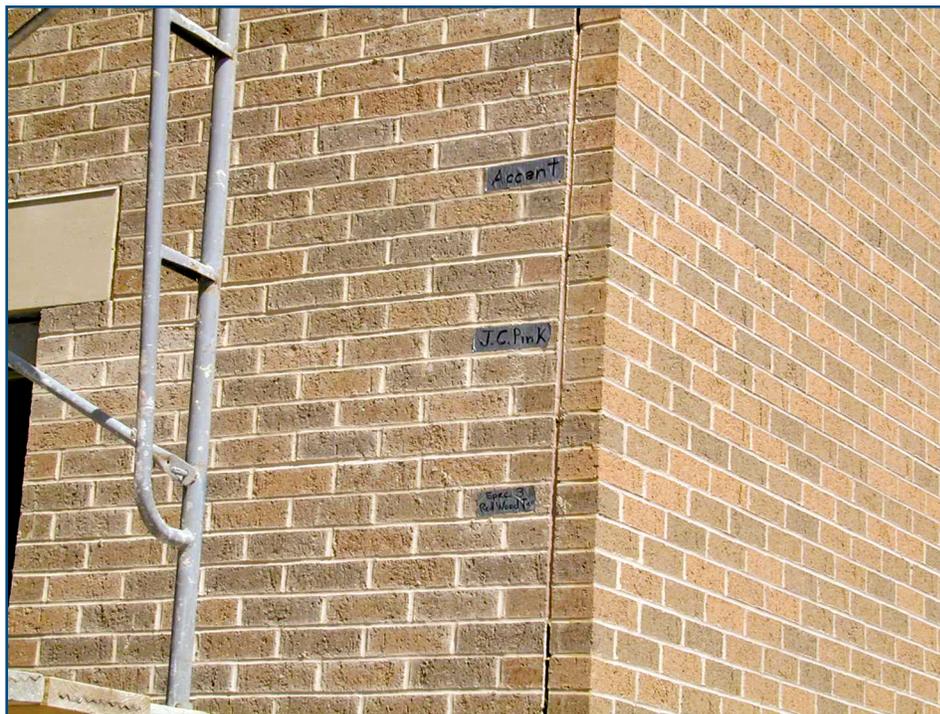
For instance, one large firm specializing



**Figure 13 – Vertical expansion joints used as design elements located on both sides of the corner.**

in educational projects has a long-standing office tenet of locating vertical veneer expansion joints 2'-8" on both sides of every outside corner of their school buildings. Masons typically like this strategy because it creates natural end points for a corner "masonry lead" to be built by experienced bricklayers.

There is nothing functionally wrong with locating a movement joint one-unit thickness away from an outside corner. However, this solution creates a panelized masonry aesthetic, the joint is sometimes difficult to keep straight, depending on normal unit variation and tolerance, additional veneer connectors are required to be located within 1 ft. of the corner, and it is more difficult for masons to build the corner. For these reasons, vertical masonry movement joints are more cost-effective, functional, and perhaps aesthetically pleasing when not located one-unit thickness away from outside corners (Figure 14).



**Figure 14 – Vertical expansion joints located one brick unit width away from the corner makes masonry on this project look panelized. Also, notice the design team used this corner of the building to explore different sealant colors in order to make a final sealant color selection after the sealant is exposed to the elements during construction.**

### Horizontal Movement Joints

Horizontal movement joints are beneficial below mid-wall shelf angles, between dissimilar materials, at the top of interior partitions and masonry infill panels, to panelize multi-story adhered veneers over frame walls, and between the top-of-veneer and top-of-wall coping stones with wood frame support walls (Figure 15).

The 2016 edition of the national masonry code, *Building Code Requirements and Specification for Masonry Structures*, Page C-186 and C-187, Sections 12.2.2.6.1 and 12.2.7.1, respectively, requires that anchored veneer with a backing of wood and cold-formed steel framing not exceed 30 ft. or 38 ft. at a gable in height above the location of where the veneer is supported, and every story above 30 ft.

This prescriptive requirement often results in mid-wall shelf angles for veneers over steel stud walls. It should be noted that mid-wall shelf angles are not required, by code, for masonry veneers over masonry support walls. For this reason, masonry veneers installed over non-

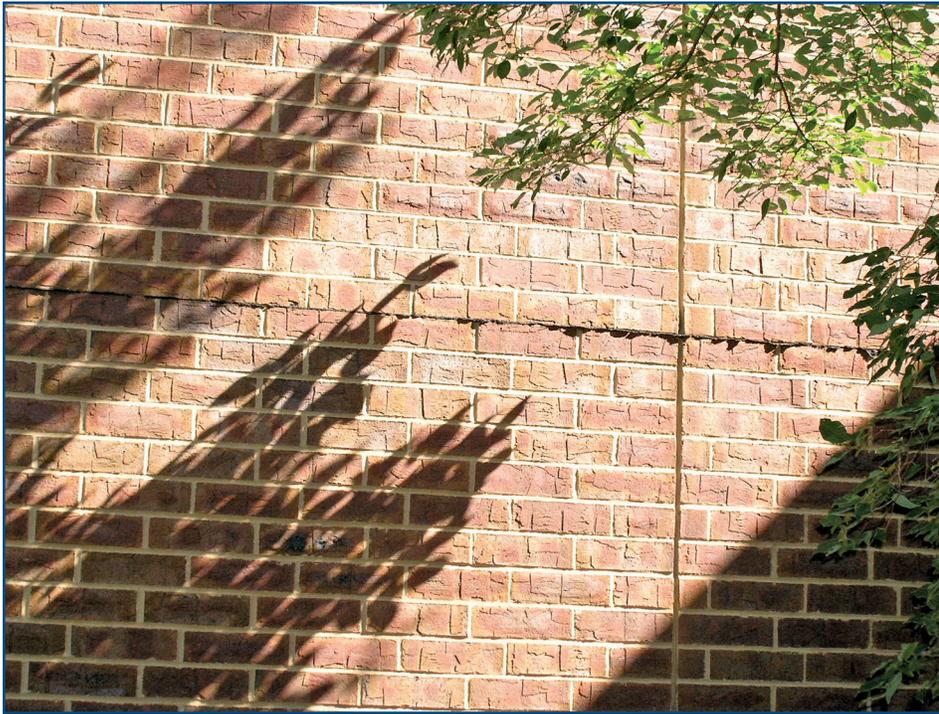
wood or steel support walls can eliminate or minimize costly and thermally inefficient mid-wall shelf angles.

When shelf angles are used, it is important to locate a horizontal movement joint (backer rod and sealant) under the shelf angle to allow differential movement

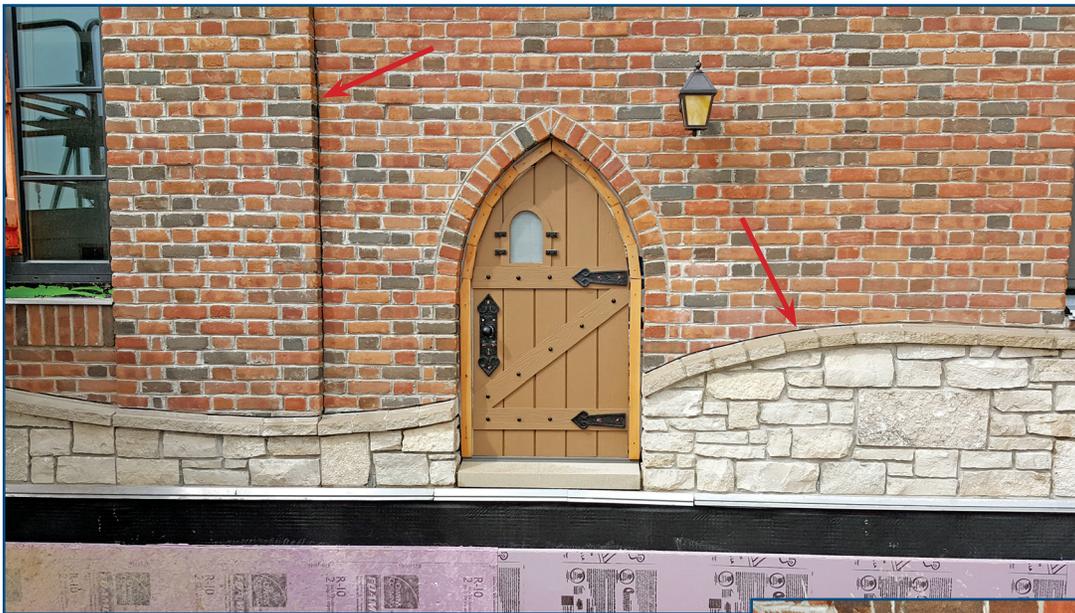
between shelf angle and the veneer below it. This gap is typically 3/8-in. wide but can be calculated to be smaller or wider (Figure 16). When the joint gets too large from an aesthetic perspective, a lipped brick can be used to minimize the visual impact of the joint.



**Figure 15 – Horizontal movement joints are installed at the top of these 8-in. CMU infill walls on this nine-story office building, to accommodate differential movement of the structural steel frame and the masonry infill. Vertical control joints were also used to segment infill masonry (red lines).**



**Figure 16 – Horizontal movement joint at this mid-wall shelf angle was designed too small.**



**Figure 17 – Raked mortar joint with bond break between different veneer materials. Also notice vertical movement joint hidden at inside corner.**

**Figure 18 – Bond break and ¼-in.-deep raked horizontal joint between dissimilar veneer materials for installation of backer rod and sealant.**

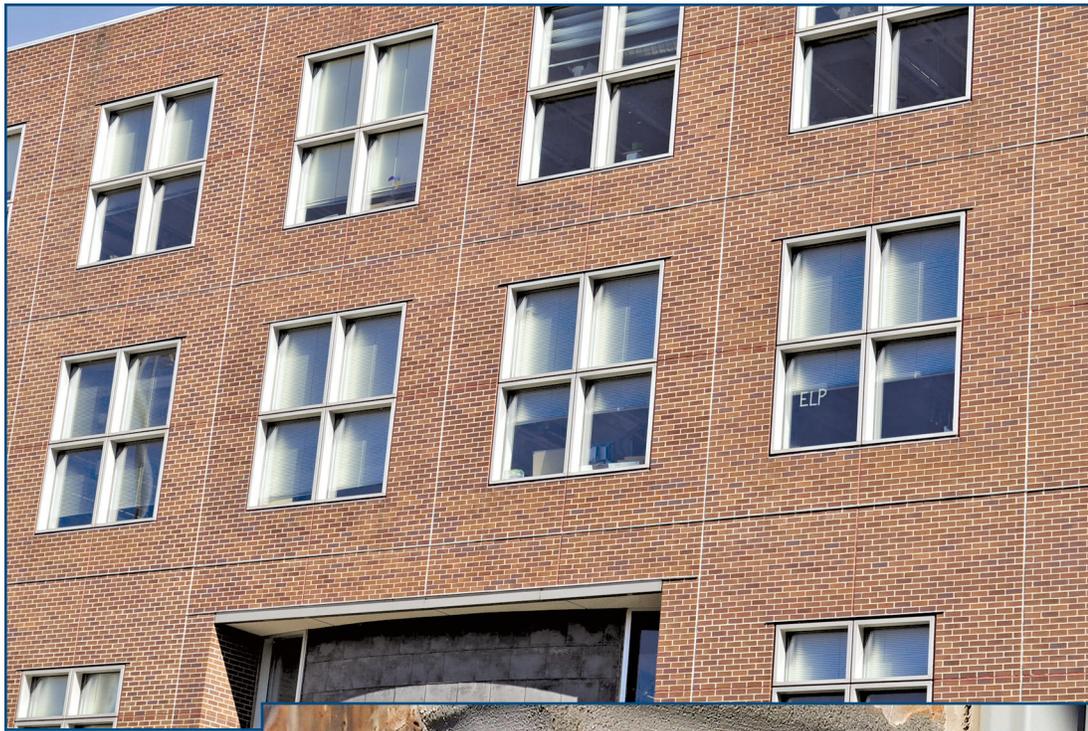


When bands or accents of dissimilar materials are used in the same veneer, provisions should be made to accommodate the differential movement with a bond break, raked mortar joints  $\frac{3}{4}$  in. minimum, and backer rod and sealant (Figures 17 and 18). With a single-course band of dissimilar masonry, care should be taken to attach masonry bands to the support wall by either connecting the band to the support wall with anchors in the vertical joints between masonry units (head joints) of the band, or by only breaking the bond at the top joint of the band. Factor in professional judgement and regional experience.

An alternative strategy to achieve masonry banding aesthetics without the special detailing and concerns of differentially moving masonry materials within the same veneer, is to use bands of similarly moving masonry materials with different unit size, unit orientation, color, or texture. For example, one could use different-colored clay bricks to articulate a masonry veneer, or calcium silicate unit bands within a clay brick veneer (Figure 19).

### **Movement Joints at Opening Frames**

For anchored or adhered masonry veneers, designers should illustrate, specify, and dimension  $\frac{1}{4}$  to  $\frac{3}{8}$  in. clear gaps on all sides of windows and doors frames for installation of backer rod and sealant. This provides a moisture-resistance interface between masonry and the opening frame and allows for differential movement (Figure 20). Mortar does not bond well to metal or wood door



**Figure 19 – Articulation of the veneer is achieved by using similar material types but with different colors. Also, horizontal and vertical sealant colors were intentionally selected for aesthetic reasons.**

and window frames. In multi-story wood frame construction, the space under windows and other architectural elements fixed to the backing wall that extend into the masonry veneer may need to increase per floor to accommodate differential movement.

### Sealant Color Selection

Many designers think vertical and horizontal masonry movement joints detract from the appearance of their masonry project (Figure 21). This author believes cracks, out-of-plane masonry, and stains detract more. Therefore, some designers—either intentionally or unintentionally—refrain from showing movement joints on their building elevations or space them far apart to minimize the visual impact of movement joints. However, with the proper sealant color selection, masonry movement joints can blend into the appearance of the masonry.

Consequently, a more conservative



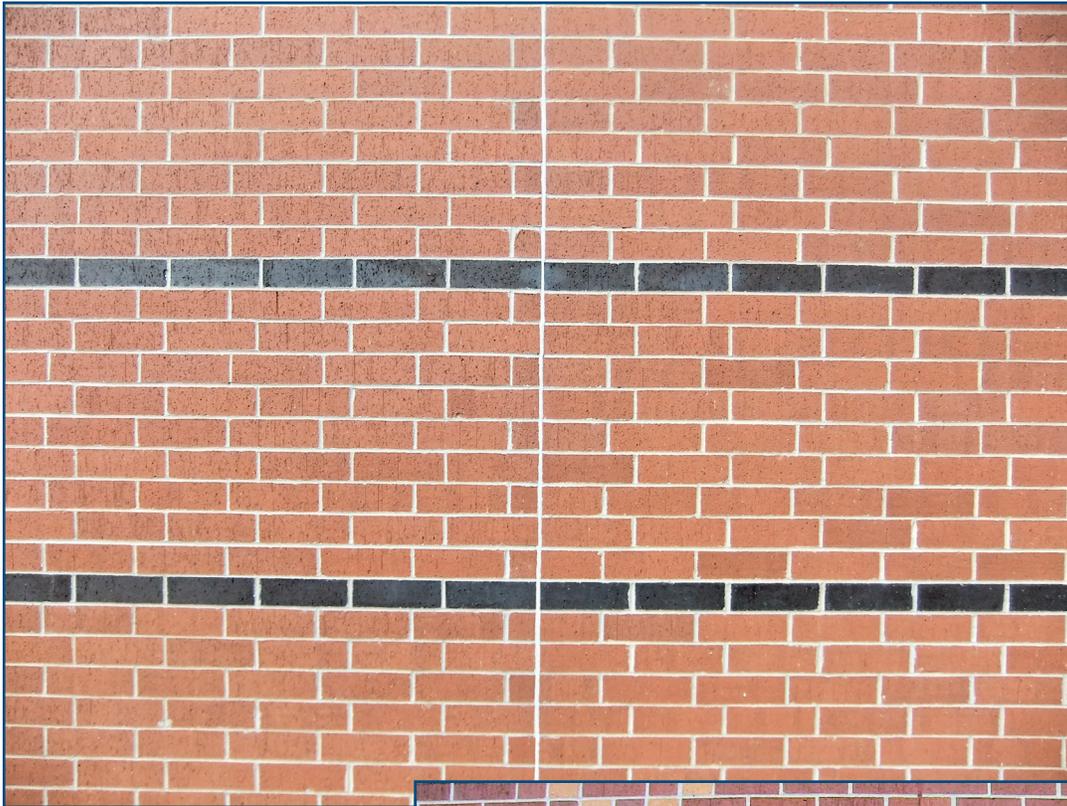
**Figure 20 – Masonry built tight against window frames does not leave room for backer rod and a properly proportioned sealant at the interface of the masonry and the window.**

approach to crack control is to have more movement joints, not fewer, and pick the right color sealant to avoid them being noticeable. On some projects, masonry movement joints—vertical and/or horizontal—have been used successfully to enhance building aesthetics.

When it is desired to blend vertical masonry movement joints into non-stack bond masonry, sealant color should match the color of the masonry units or be slightly darker. To explain, with a modular brick

veneer, approximately 80 percent of the perceived veneer color comes from the color of the brick, while the remaining veneer color comes from the mortar.

By matching the sealant to the larger percentage of the apparent veneer color, a vertical movement joint will not be as noticeable (Figure 22). With multi-colored brick veneers, the trick is to match the darker-color brick of the blend, or the most prominent color. With stack bond masonry veneers and horizontal movement joints,



**Figure 21** – When matching the mortar color in non-stack bond veneer bonding patterns, vertical movement joints are more noticeable.

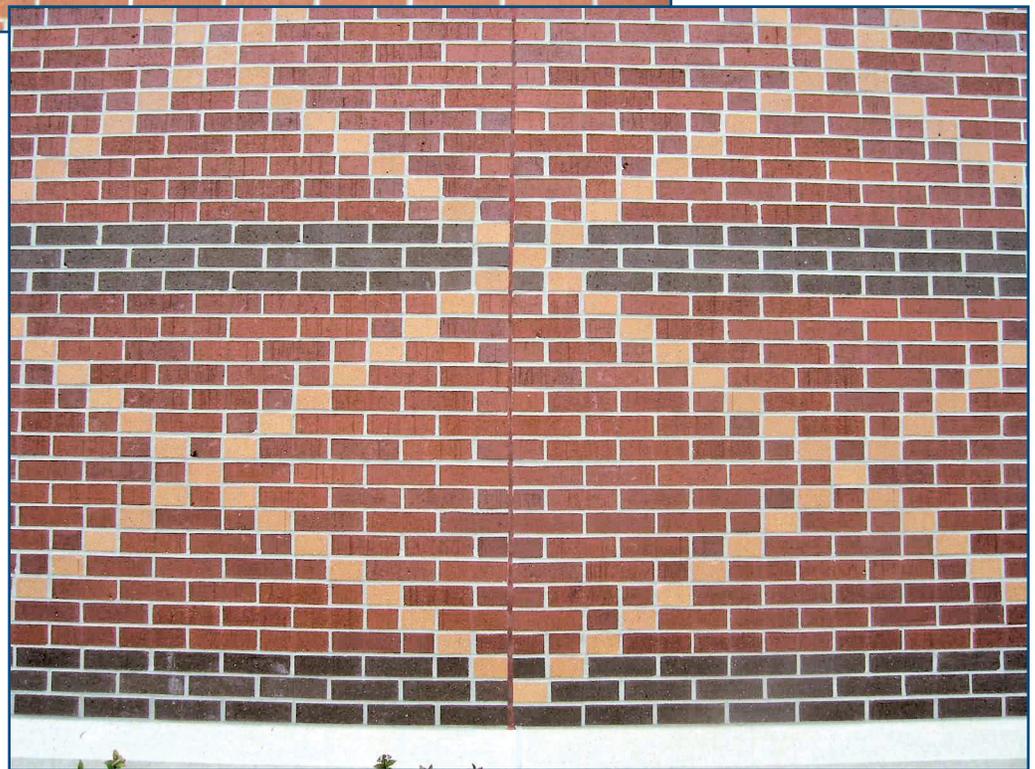
**Figure 22** – When matching sealant color to the masonry—not the mortar—in vertical movement joints running through non-stack bond veneers, movement joints tend to blend into the masonry, especially from a distance.

matching the mortar color will help the movement joint blend into the masonry.

## SUMMARY

Modern masonry assemblies generally require more movement joints or other engineered solutions to accommodate or restrain movement than earlier masonry wall assemblies. When following simple guidelines for placement of control joints, expansion joints, and isolation joints, designers can easily locate vertical and horizontal movement joints—even on complicated building enclosure configurations.

To start the process of locating masonry movement joints, first understand the overall inherent movement characteristic of all masonry materials used on the project. Then locate movement joints at all inside corners—unless there are profound reasons otherwise. Then segment remaining portions of the wall appropriately, respect outside corner rules, consider lintel types, and be aware of different bearing conditions of the masonry, differ-



ent support wall conditions, and possible bond breaks. Lastly, determine if it is the designer's desire to hide or accentuate the movement joints, and pick the sealant color accordingly.

When considering whether to exceed

industry recommendations, a good mantra to follow is: "When in doubt, add one more." And finally, designers, not contractors, should make the decisions regarding placement of movement joints. 