Detailing to accommodate vertical expansion

Design cavity wall caps, ties, and openings that allow for differential movement

By Walter Laska

In low-rise construction, vertical expansion of masonry walls is minimal and not of major concern. In much high-rise construction, masonry walls are segmented into horizontal bands by shelf angles, concrete slabs, and openings. Such buildings have horizontal expansion joints beneath the shelf angles to accommodate vertical expansion and differential frame movements.

But some masonry walls that are tall enough to experience significant vertical expansion are constructed without shelf angles. Loadbearing cavity walls ranging from 50 to 90 feet high fall into this category. So do structural frame systems of similar height that use concrete masonry as infill panels. Designers need to consider special provisions to compensate for vertical expansion in these types of construction.

Differential movement

A typical cavity wall system is subject to two types of movement. The outer wythe of brick expands due to thermal and moisture gains. The inner wythe of concrete masonry compresses due to unit shrinkage, compression under load, and frame shortening. As a result, the two wythes of masonry are moving in opposite directions.

Differential movement is greatest at the top of the wall where the masonry is unrestrained. The difference in movement between the two wythes can be nearly 2 inches.

Consider a 60-foot-high cavity wall connected to a structural concrete frame. The brick is bearing on the foundation and it spans, uninterrupted, to the top of the wall. The concrete masonry is assembled within the concrete frame.

The total unrestrained vertical
expansion of the outer wythe of brick can be estimated from the following formula (see Reference):

\[ M = (0.0005 + 0.000004 (\Delta T)) L \]

Where:
- \( M \) = Total expansion of the exterior wythe of brick
- \( L \) = Length of the wall in inches
- \( \Delta T \) = Minimum mean wall temperature subtracted from the maximum mean wall temperature in degrees Fahrenheit

0.0005 = Design value of the coefficient of moisture expansion, inches/inch
0.000004 = The coefficient of thermal expansion, inches/inch

Assume a southern exposure, somewhere in the Midwestern United States, and a temperature range of 135 degrees.

\[ M = (0.0005 + 0.000004 (135)) \]
\[ = (0.0005 + 0.00054) \]
\[ = (0.00104) (720) \]
\[ = 0.7488 \text{ or } \frac{3}{4} \text{ inch} \]

A structural concrete frame can compress or shrink (as a result of creep) at a rate of about \( \frac{3}{8} \) inch per 10 vertical feet. Thus, a 60-foot-high concrete frame can compress \( \frac{3}{4} \) inch. The accumulated difference in frame height is greatest at the top of the wall and at the inner wythe of the concrete masonry. The total differential movement between the two wythes can be estimated at 1 1/2 inches (Figure 1).

**Compensating for vertical movement**

Designers should concentrate on accommodating vertical movement in three areas of the wall—at the top, at ties between wythes, and at openings.

**Cap details.** The top of the wall is the most obvious area because this is where most of the movement will occur. It’s common masonry practice to provide a coping or cap of a similar material, such as limestone or precast concrete, at the top of the wall. But where differential vertical movement is likely, specifying a metal cap is beneficial. You want a detail that allows the two wythes of masonry to move independently, and a metal cap provides this flexibility.

Figure 2 shows a masonry cap detail that accommodates the differential movement of the two wythes. The cap is connected to the brick through vertically slotted cleats at connection points that allow the exterior wythe of brick to expand upward without displacing or crimping the metal cap. At the same time, the soft joint beneath the plywood accommodates the downward movement of the interior wythe of concrete masonry.

**Ties.** Another consideration is the type of tie used to connect the two wythes of masonry together. Differential movements between the two wythes will be transferred into the ties that connect them. Because differential movements as great as 1 1/2 inches are possible at the roof level, it’s important to specify ties that can accommodate this movement.

The cross wires of standard joint reinforcement will deform and bend when subjected to differential movement. This deformation can break the galvanized coating on the cross wire, subject-
ing the joint reinforcement to oxidation. Furthermore, bending or crimping the cross wire can reduce its ductility, affecting its structural capacity (Figure 3).

For such applications, specify adjustable ties that will accommodate the differential movement of wythes without compromising structural capacity. Only double-wire ties are allowed by code. Two common types of adjustable ties are shown in Figure 4.

**Openings.** The third consideration is how to accommodate movement at wall openings. Window frames should be attached to the concrete masonry backup, not to both wythes. Otherwise, differential movements can cause the frame to distort.

Brick that is directly adjacent to window jambs should be allowed to expand without obstruction. However, this expansion can create a bonding problem for sealant in the building joint between the window jamb and the brick. Although most sealants perform well when subjected to tensile or compressive forces, vertical movement of the brick will stress the sealant in shear. Most sealants can resist only \( \frac{1}{4} \) inch movement before the bond with the brick is broken. Because movement at window openings on upper floors can easily exceed \( \frac{1}{4} \) inch, resealing these joints annually might be required. Providing special slippage joints between the window jambs and brick is another alternative (see Figure 5).

Window alignment and configuration also affect the amount of movement to be expected. Walls

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**Figure 3.** Wall ties between wythes need to accommodate movement without distortion or weakening.

**Figure 4.** Use individual adjustable unit ties or adjustable truss- or ladder-type joint reinforcement to accommodate vertical movement.

**Figure 5.** Two-piece jamb receptors, available through window manufacturers, allow slippage between veneer brick and a window frame connected to a concrete masonry backup wythe.
with few windows will experience more vertical movement at the top. Walls with strips of windows aligned vertically should be designed to accommodate movement of the masonry between the strips. On the other hand, walls with numerous openings or those with horizontal window bands generally experience little vertical movement.

The differential movement of dissimilar materials needn't cause performance problems in masonry buildings, as long as designers anticipate its occurrence and provide details to accommodate it.

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Reference
“Design and Detailing of Movement Joints, Part II,” Technical Notes on Brick Construction, Number 18A, Brick Institute of America, 11490 Commerce Park Dr., Reston, VA 22091.