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CONTROL JOINT IN CONCRETE MASONRY WALL

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Introduction:

Concrete masonry is a popular construction material because its inherent attributes satisfy the diverse needs of both exterior and interior walls. While these attributes are the primary basis for concrete masonry's popularity, performance should not be taken for granted. Like all construction systems, design decisions significantly influence field performance of the concrete masonry wall system. Proper application of crack control measures, including control joints when required, can help ensure satisfactory performance of the concrete masonry.

Note that crack control considerations for concrete masonry veneers differ from the guidance presented below.

Movement joints such as control joints are one method used to relieve horizontal tensile stresses due to shrinkage of the concrete masonry units, mortar, and when used, grout. They are essentially vertical planes of weakness built into the wall to reduce restraint and permit longitudinal movement due to anticipated shrinkage, and are located where stress concentrations may occur. A bond break is accomplished by replacing all or part of a vertical mortar joint with a minimum of a backer rod and sealant. This keeps the joint weather tight while accommodating small movements. Joint reinforcement and other horizontal reinforcement should be discontinued at control joints unless it is required for structural purposes, as it will act to restrain horizontal movement.

When control joints are required, concrete masonry only requires vertical control joints. When materials with different movement properties, such as concrete masonry and clay masonry, are used in the same wythe the movement difference needs to be accounted for in the design. Normally, joint reinforcement is used in the common joint between the two to distribute the forces and keep any cracks that form tightly closed. Another option is to provide a horizontal slip plane between the two materials to accommodate the differential movement.

Control joints are typically required in exposed above grade concrete masonry walls, where net aesthetic shrinkage cracking may detract from the appearance of the wall, and to limit moisture or air infiltration. Shrinkage cracks in concrete masonry are not a structural concern. In addition, walls with adequate horizontal reinforcement may not require control joints, as the reinforcement effectively reduces the width of shrinkage cracks.

Foundation walls traditionally do not include control joints due to concerns with waterproofing the joint to withstand hydrostatic pressure. Additionally, since foundation walls are subjected to relatively constant temperature and moisture conditions, shrinkage cracking in below grade walls tends to be less significant than in above grade walls.
This research focuses on non-structural cracking resulting from internal volume change of the concrete masonry. Potential cracking resulting from externally applied design loads due to wind, soil pressure, seismic forces, or differential settlement of foundations is controlled by structural design considerations not addressed here. Where external loads are an issue in combination with internal volume change, the design should consider the combined effects of these influences on cracking.

Control joint placement:

When required, control joints should be located where volume changes in the masonry due to drying shrinkage, carbonation, or temperature changes are likely to create tension in the masonry that will exceed its tensile capacity. In practice, this can be difficult to determine since some movements are reversible, quick or gradual, but several methods are presented in the following sections to provide guidance in locating control joints.

In addition, care should be taken to provide joints at locations of stress concentrations such as (see Figure 1a for unreinforced masonry and Figure 1b for reinforced masonry):

1. at changes in wall height,
2. at changes in wall thickness, such as at pipe and duct chases and pilasters,
3. at (above) movement joints in foundations and floors,
4. at (above and below) movement joints in roofs and floors that bear on a wall,
5. near one or both sides of door and window openings, (see following subsection, Control Joints at Openings), and
6. adjacent to corners of walls or intersections within a distance equal to half the control joint spacing.

Consideration must also be given to the effect of control joint placement on load distribution within the wall. For example, locating control joints at the ends of lintels may compromise arching action. Therefore, it may be prudent to design the lintel to carry the full weight of the wall above it in addition to any superimposed loads.

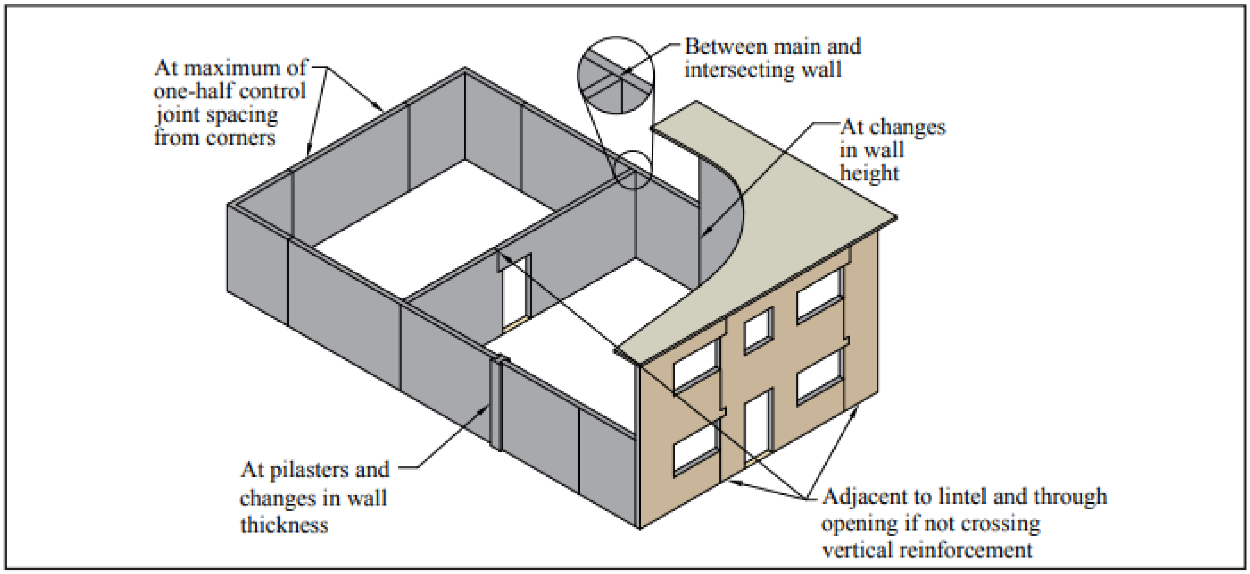

Figure 1a—Typical Control Joint Locations for Unreinforced Masonry

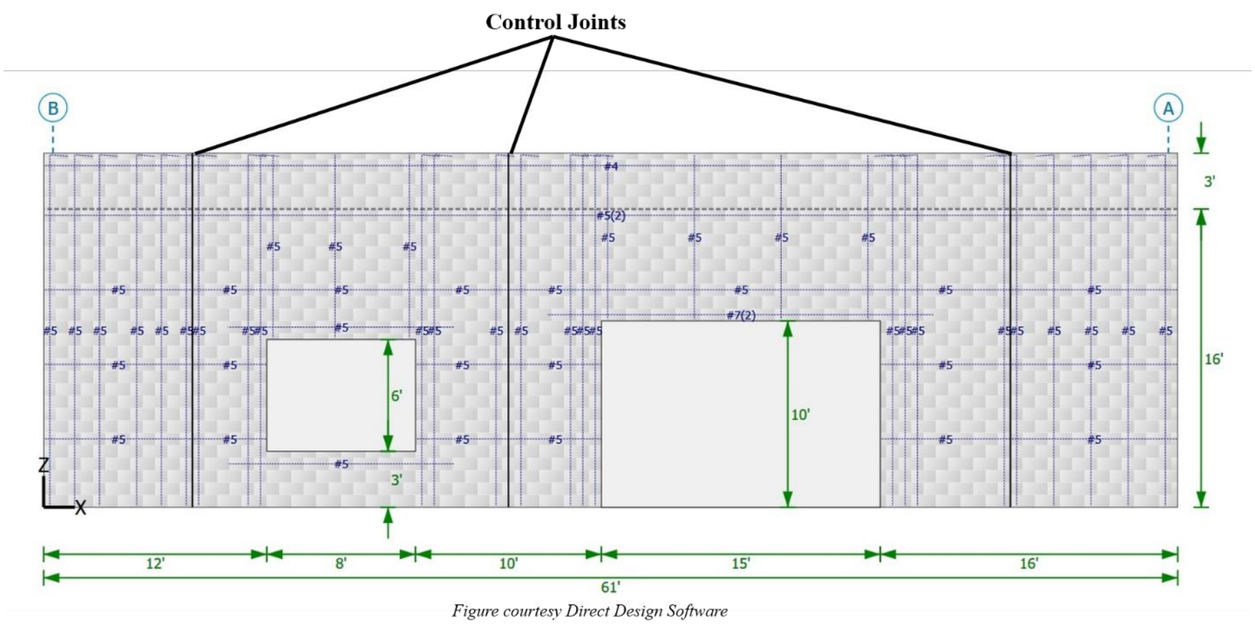

Figure 1b—Typical Control Joint Locations for Reinforced Masonry

Control Joints at Openings:

Because cracking occurs in the planes of greatest weakness, openings are particularly vulnerable. For an opening of up to (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 3i.

In Figure 2a, continuous vertical reinforcement cannot be provided in the cell adjacent to the opening on the left, as crossing the horizontal portion of the control joint (i.e., the slip plane) would effectively pin the two sections together, restraining relative movement. To resist the lateral movement around the slip plane, (610-mm) long horizontal joint reinforcement may be placed at the lintel bearing location and two courses below. If utilizing concrete masonry veneered steel beams over openings in lieu of concrete masonry or precast lintels, it is critical that the steel beam not be welded to the bearing plate where designated control joints are to be constructed, as this will pin the two sections together, restraining movement.

When a slip plane under the bond beam is used for openings larger than (1.83 m), control joints are recommended on both sides of the opening as shown in Figure 2b. Again, the control joint goes under and up the side of the lintel, and allowance for movement between the lintel and the masonry must be provided. Because there is no lateral support at the bottom of the lintel, provision must also be made for load transfer between the panels.

An alternative to avoid having the vertical reinforcement cross the slip plane is to place the reinforcement in the next cell over. Another alternative is to place the control joint away from the opening if adequate tensile reinforcement is placed above, below and beside the opening as discussed below.

In walls containing vertical reinforcement, the cell adjacent to the opening is usually grouted and reinforced to provide solid support and additional strength for jambs. Using the same type of detail as for the unreinforced wall would require the control joint to cross the vertical reinforcement, thereby preventing movement and defeating the purpose of the control joint. However, if the opening is completely surrounded by reinforcement as shown in Figure 2c and 2d, the area around the opening is strengthened and control joints can be placed away from the opening.

As an alternative to extending the lintel reinforcement a minimum of (305 mm) past the vertical reinforcement adjacent to the opening (Figure 2c), joint reinforcement may be placed in the first two mortar joints above the opening and extended to the control joint on each side, or a horizontal bond beam could be used, as shown in Figure 2d.

For best performance, the vertical reinforcement should be placed in the cell immediately adjacent to the opening. However, due to congestion in the cell at this location, vertical reinforcement is sometimes placed in the second cell from the opening. In this case, the cell next to the opening should be grouted, as should the cell containing the reinforcement, to provide additional resistance for attaching the door or window frames. These details may also be used in unreinforced walls and walls utilizing steel lintels, since the area surrounding the opening is strengthened by the additional reinforcement.

Shear transfer devices such as preformed gaskets or shear keys (such as those shown in Figures 3a, 3d, 3e, 3f, 3h and 3i) may not be necessary when using openings wrapped with reinforcement in wall segments designed to resist the lateral loads applied directly to them plus those transferred from the opening enclosure. However, some designers incorporate shear transfer devices to limit the relative movement between the two panels on either side of a control joint, thereby reducing the stress on the joint sealant and providing longer life.

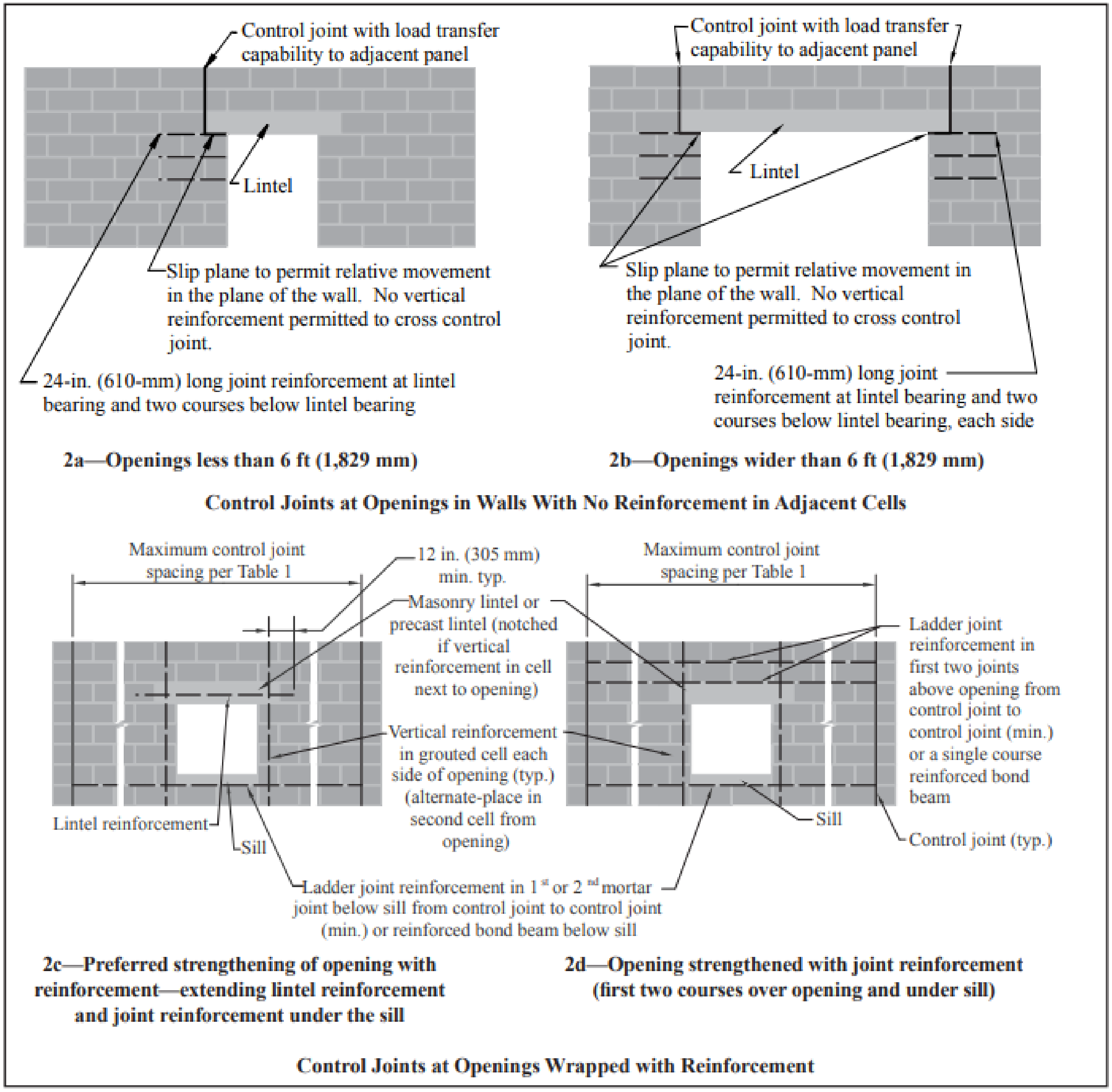

Figure 2—Control Joints at Openings

Empirical crack control criteria:

At other points of wall stress concentration, control joints are used to effectively divide a wall into a series of isolated panels. Table 1 lists recommended maximum spacing of these control joints based on empirical criteria. This criterion has been developed based on successful historical performance over many years in various geographical conditions. The empirical method is the most commonly used method of locating control joints and is applicable to most building types.

An engineered method Control Joints for Concrete Masonry Walls—Alternative Engineered Method, which is based on limiting crack width to (0.51 mm), since water repellent coatings can effectively resist water penetration for cracks of this size. The engineered method is generally used only when unusual conditions are encountered such as dark-colored units in climates with large temperature changes.

The provisions in this research assume that units used in the construction comply with the minimum requirements of ASTM C90, Standard Specification for Loadbearing Concrete Masonry Units (ref. 4) and that a minimum amount of horizontal reinforcement is provided between control joints as indicated in Footnotes 2 and 3 of Table 1. For units with a nominal height of 8 inches (203 mm), the minimum area of reinforcement given, 0.025 in.^{2}/ft (52.9 mm^2/m) of height, translates to horizontal reinforcement spaced as indicated in Table 2A. It is intended to provide the most straightforward guidelines for those cases where detailed volume change properties of the concrete masonry are not known at the time of design. As indicated in Table 1 Footnote 1, local experience may justify an adjustment to the control joint spacings presented in the table.

Similar to concrete masonry veneers, half high concrete masonry unit assemblies are installed with a larger percentage of mortar, which in turn has a larger potential for system shrinkage and therefore cracking potential. As such, the prescriptive crack control recommendations detailed in Table 1 increase the area of horizontal reinforcement and decrease the maximum control joint spacing of half high unit assemblies compared to full height unit assemblies. See Table 2B for horizontal reinforcement spacing translating to 0.034 in.^{2}/ft (72.0 mm^2/m) of height.

To illustrate these criteria, consider a 20 ft (6.10 m) tall warehouse with walls 100 ft (30.48 m) long using 8 inch (203 mm) nominal height CMU. Table 1 indicates a maximum control joint spacing of the lesser of:

- a length to height ratio of 1½: 1, which corresponds to 1½ x (20 ft) = 30 ft (9.14 m), or
- control joints spaced every 25 ft (7.62 m).

In this example, the maximum spacing of 25 ft (7.62 m) governs over the length to height ratio.

For walls containing masonry parapets, consider the parapet as part of the masonry wall below when determining the length to height ratio if it is structurally connected by masonry materials.

	Maximum Length-to-Height Ratio of Concrete Masonry Panel	Maximum spacing, in. (mm)
Above Grade Concrete Masonry Walls		
Nominal Unit Height: 8 in. (203 mm)[2]	1.5 to 1	25 ft. (7.62 m)
Nominal Unit Height: 4 in. (102 mm)[3]	1.5 to 1	20 ft. (6.10 m)

[1]Adjust spacing as needed where local experience or project conditions warrant.
[2]Include horizontal reinforcement having an equilavent area of not less than 0.025 in.^{2}/ft. (52.9 mm^2/m) of height. See Table 2A.
[3]Include horizontal reinforcement having an equivalent area of not less than 0.034 in. ^{2}/ft. (72.0 mm^2/m) of height. See Table 2B.

Table 1 - Empirical Control Joint Spacing for Concrete Masonry Walls

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.

Table 2A—Maximum Spacing of Horizontal Reinforcement to Provide 0.025 Square Inches per Foot of Masonry Height (52.9 Square Millimeters per Meter)

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.

Table 2B—Maximum Spacing of Horizontal Reinforcement to Provide 0.034 Square Inches per Foot of Masonry Height (72.0 Square Millimeters per Meter)

References:

1- Standard Specifications for Loadbearing Concrete Masonry Units, ASTM C90-16a. ASTM International.
2- Some researchers from Internet.