

Where do you need joints?

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Installing joints is the most effective way to control cracks in masonry. This is true whether the cracks come from deflections due to loading or from volume changes due to temperature, moisture, or freezing.

There are three types of movement joints: control joints, expansion joints, and isolation joints. Concrete masonry should be constructed with control joints. Clay masonry should be constructed with expansion joints. And when necessary, isolation joints should be used in both types of masonry.

Install control joints in concrete masonry

Concrete masonry shrinks. Without control joints, the masonry is

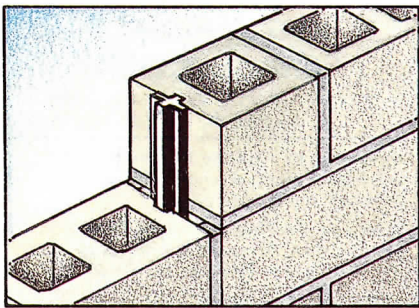


Figure 1. Hard rubber or PVC shear lugs transfer stresses at control joints for concrete block.

more restrained from shrinking. Tensile stresses build up in the masonry units until they exceed the tensile strength of the block or the mortar or the bond strength between the block and the mortar. At that point, a crack occurs—an irregular, unsightly crack.

Reinforcement placed in the bed joints every other course helps keep

shrinkage cracks closed or invisible. Bond beams also help control the size of cracks. But when the shrinkage is great, neither joint reinforcement nor bond beams can hold cracks closed. That is when control joints are required.

A control joint is nothing more than a predetermined, straight crack in concrete masonry. Control joints allow the concrete masonry wall panels between the joints to shrink independently. Over the past 50 years, the strategy of combining joint reinforcement, bond beams, and control joints has been the most effective way to control shrinkage cracking in concrete masonry.

Control joints also must be designed to transfer lateral wind loads from one side of the joint to the other. If they aren't, the wall panels on each side of the joint can become offset. Usually sash blocks and shear lugs are used at control joints for this purpose (Figure 1). The shear lugs are made with hard rubber or polyvinyl chloride (PVC) plastic.

Joint reinforcement and bond beams should not be placed across control joints. So when either of these is used, locate the control joints at points of least bending moment or at supports. This way, the integrity of the wall is maintained. Figure 2 shows three ways of constructing control joints at supports.

Reinforcement in chord beams at the eaves of buildings designed to resist earthquakes usually must continue across control joints. However, the rest of the

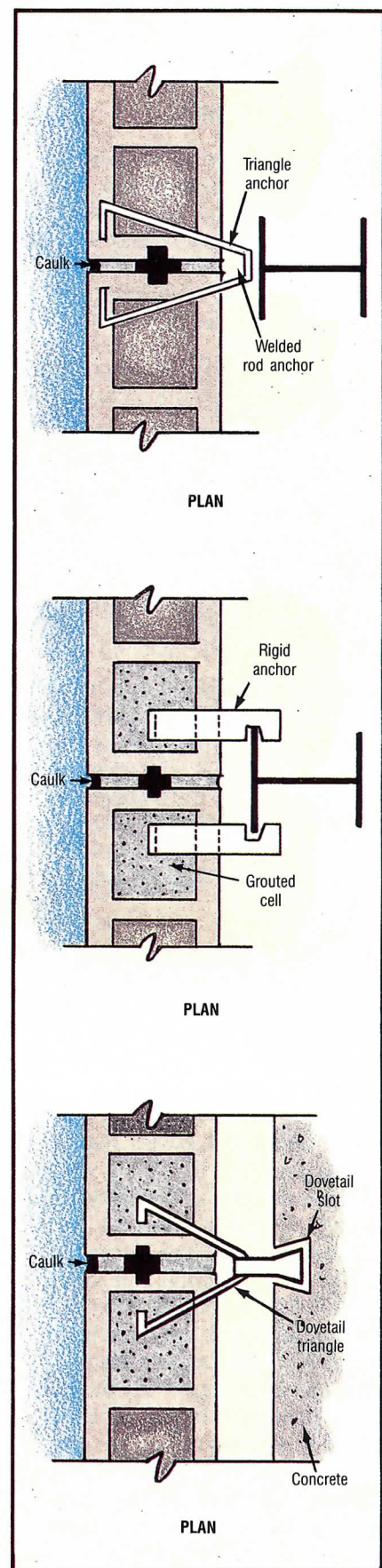


Figure 2. Three ways of constructing control joints at supports. Wire ties can be extended to the outside face shell or embedded in the grout.

horizontal steel in the wall should be interrupted at the control joints.

Locating control joints

As shown in Figure 3, control joints in concrete masonry walls should be:

- Spaced closer in walls without joint reinforcement than in walls with joint reinforcement
- Spaced closer when nonmoisture-controlled units are used than when moisture-controlled units are used
- Laid out to create panels of masonry that are as square as possible. The aspect ratio (length divided by height) of a panel should be as close to 1 as practical. If this number exceeds 3, the chance of unwanted cracks between control joints increases greatly.
- Located at changes in the cross-section of a wall

In their literature, the American Concrete Institute (ACI) and the National Concrete Masonry Association (NCMA) have tables that recommend control joint spacings for concrete masonry walls (Ref. 1 and 2). But walls built according to these tables don't always perform as desired. The control joint spacings recommended by NCMA and ACI are much more liberal than spacings recommended for concrete masonry walls by the U.S. Army Corps of Engineers (Ref. 3). They're also more liberal than the spacings recommended for cast-in-place concrete walls by the Portland Cement Association (Ref. 4).

Even though concrete masonry units have partially shrunk before they're laid (unlike cast-in-place concrete), joint spacings still should be close to those required for cast-in-place concrete. Regardless of the aspect ratio of a concrete masonry wall, the control joints should be spaced no more than 20 to 25 feet apart. For the recommendations of the U.S.

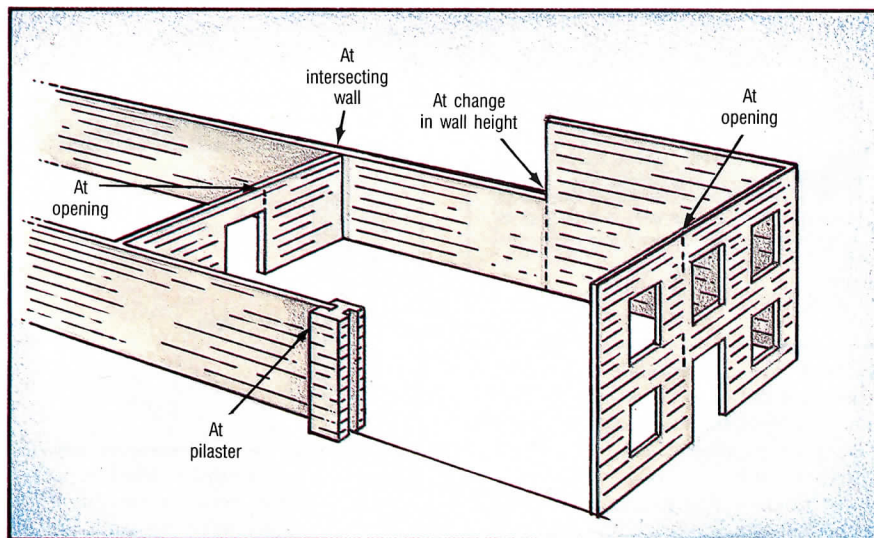


Figure 3. Control joints should be constructed in concrete masonry at openings, pilasters, wall intersections, and changes in wall cross-section. They also should be spaced to form approximately square panels.

Army Corps of Engineers see article on page 301.

Install expansion joints in clay masonry

Clay brick generally expands as it absorbs moisture or freezes. This expansion is partly compensated by mortar shrinkage but the net effect is almost always expansion. To accommodate this expansion, expansion joints must be installed.

An expansion joint provides space for the brick to move when its volume increases. The width of the joint is critical. If the joint is too narrow or if dirt in the joint prevents movement, huge compressive stresses can build up and crush the brick. For example, if a 10-foot-long wall wants to expand $\frac{1}{8}$ inch but can't, the compressive load on the 4-inch brick wythe can exceed 200,000 pounds per square foot.

Determining the width of the expansion joint that is needed is difficult, though. The amount of expansion is affected by the temperature of the brick when it is installed, by creep and shrinkage potential of the backup material, and by the amount of insulation behind the brick. As a result, there are few rules to guide designers. Without such rules, always assume

the largest possible amount of expansion. If it doesn't occur you'll be better off than if you didn't allow for the movement and it did occur. Assuming a 140° F temperature swing, expansion joints

JOINT WIDTH AND SPACING FOR BRICK CAVITY WALLS¹

Anticipated Expansion (ΔL), inch	Joint Width (2 ΔL), inch	Joint Spacing (L), feet
$\frac{1}{16}$	$\frac{1}{8}$	7
$\frac{1}{8}$	$\frac{1}{4}$	14
$\frac{3}{16}$	$\frac{3}{8}$	21
$\frac{1}{4}$	$\frac{1}{2}$	28

¹ Based on the amount of brick expansion caused by a 140° F temperature swing. Brick expansion is calculated by the formula:

$$\Delta L = (0.0002 - 0.000004 \Delta T) L$$

Source: Brick Institute of America, Technical Note 18A, 11490 Commerce Park Drive, Reston, Virginia 22091.

should be sized and spaced as shown in the table.

Although expansion joints don't have to be filled with compressible material, doing so prevents debris or mortar droppings from entering the joint and preventing expansion. When a filler is used, it should be as soft as possible. It

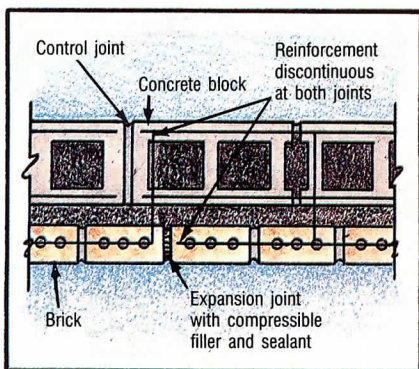


Figure 4. To accommodate differential movement between brick and concrete block in composite walls, expansion joints should be installed in the brick wythe wherever control joints are installed in the block wythe. Insulation in the cavity between the brick and block increases the amount of differential movement.

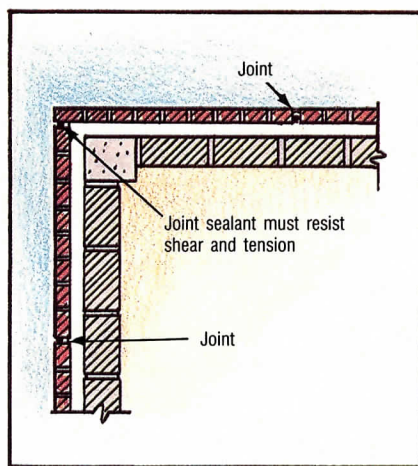


Figure 5. If an expansion joint is not constructed at a corner of two brick walls, the expansion of the walls will push the corner out and crack the wall at or near the corner.

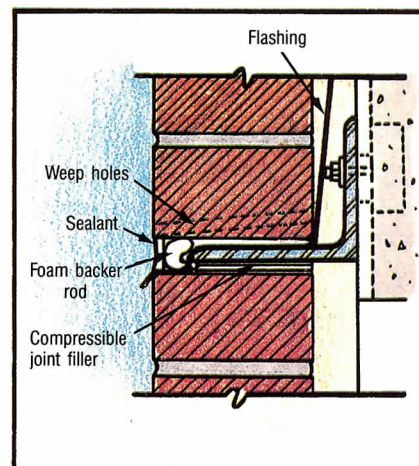


Figure 6. Horizontal expansion joints installed under relieving angles allow brick veneer to expand vertically and the concrete building frame to shrink and shorten.

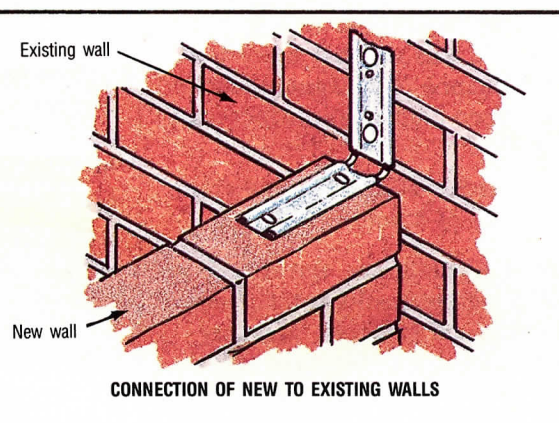
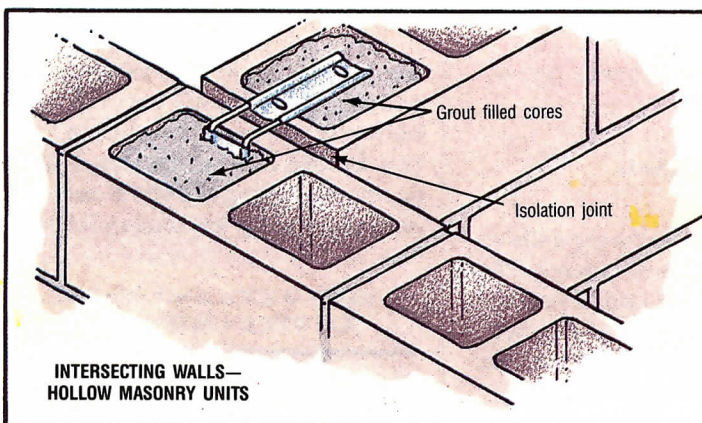


Figure 7. Isolation joints are installed wherever masonry abuts other building materials or wherever new masonry abuts existing masonry. The device shown here transfers transverse loads, but still lets the abutting wall elements move independently.

should compress to 30% to 50% of its original thickness. If it compresses to half its original thickness, the joint should be made double the width needed for the anticipated movement.

The joint filler should be a closed cell material that is impervious to water. When absorbent materials freeze, the water in them expands and stresses adjacent brick.


Expansion joints should be installed in the following locations:

- At concrete masonry control joints in composite walls (Figure 4)

- At offsets, junctions, and corners (Figure 5)
- At parapets using about one-half the spacing used in the wall below
- Underneath shelf angles (Figure 6)

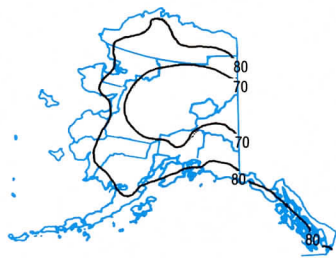
Isolation joints

Isolation joints are installed wherever masonry abuts other building materials or wherever new masonry abuts existing masonry. They're used, for example, when a masonry wall abuts a concrete wall or concrete column. An isolation joint breaks the bond between the masonry and the other material and allows the two to contract and expand independently.

One device used to create an isolation joint is shown in Figure 7. This anchor transfers transverse loads, but still lets the abutting wall elements move independently. 

References

1. "Commentary to Building Code Requirements for Concrete Masonry Structures," ACI 531-79, American Concrete Institute, P.O. Box 19150, Detroit, Michigan 48219.
2. "Control of Wall Movement with Concrete Masonry," NCMA TEK 3, 1972, National Concrete Masonry Association, 2302 Horsepen Road, Herndon, Virginia 22070.
3. *Masonry Structural Design for Buildings*, Army TM 5-809-3, August 1982, U.S. Army Corps of Engineers, National Technical Information Services, 5285 Port Royal Road, Springfield, Virginia 22161.
4. "Building Movements and Joints," 1982, Portland Cement Association, 5420 Old Orchard Road, Skokie, Illinois 60077.



Spacing control joints in concrete masonry

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The maximum horizontal spacing between vertical control joints in concrete masonry walls is determined by:

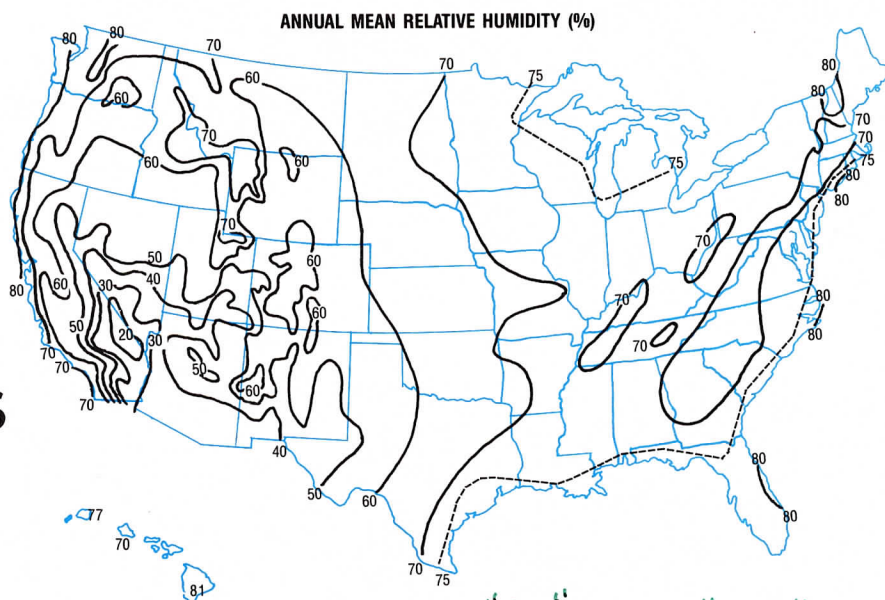
- The local average annual relative humidity
- Whether the concrete masonry units are moisture controlled or nonmoisture controlled, as defined by ASTM C 90 (Ref. 1)
- The vertical spacing of bed joint reinforcement
- Exposure to weather

The table shown here recommends spacings for control joints based on these four criteria as presented in *Masonry Structural Design for Buildings* (Ref. 2).

Control joints also should be placed at:

- Changes in wall height or thickness
- At pilasters, recesses, and chases
- At one side of all wall openings
- At wall intersections

Bed joint reinforcement referred to in the table is two #9, cold drawn, steel wires, one in each face shell bed. Bed joint reinforcement may be replaced by bond



beams reinforced with two ~~#9~~ continuous reinforcing rods. The vertical spacing of the bond beams can be four times the vertical spacing required for joint reinforcement. If used, bond beams should be placed at the top and base of the wall, and below windows.

The map provides approximate average annual relative humidities in the United States, but lo-

cal weather records will provide better data. **A**

References

1. Specification for Hollow Load-bearing Concrete Masonry Units, ASTM C 90, ASTM, 1916 Race Street, Philadelphia, Pennsylvania 19103.
2. *Masonry Structural Design for Buildings*, Army TM 5-809-3, Department of the Army, Navy, and Air Force, August 1982, pages 3-1 ff. National Technical Information Services, 5285 Port Royal Road, Springfield, Virginia 22161.

MAXIMUM HORIZONTAL SPACING OF VERTICAL CONTROL JOINTS IN CONCRETE MASONRY WALLS (feet)

Average Annual Relative Humidity	Wall Location	Vertical Spacing of Bed Joint Reinforcement, (inches)	Type of Concrete Masonry ¹	
			I Moisture Controlled	II Nonmoisture Controlled
LESS THAN 50% Greater than 75%	exterior	none	12	6
		16	18	10
		8	24	14
	interior	none	16.5	9
		16	24	14
		8	31.6	19
Between 50% and 75%	exterior	none	18	12
		16	24	16
		8	30	20
	interior	none	22.5	15
		16	30	20
		8	37.6	25
GREATER THAN 75% Less than 50%	exterior	none	24	18
		16	30	22
		8	36	26
	interior	none	28.5	21
		16	36	26
		8	43.6	31

¹ As defined in ASTM C 90 (Ref. 1).

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Vertical Movement Joint Placement Matrix - Empirical Design

	The Masonry Society (TMS)	National Concrete Masonry Institute (NCMA)	Brick Industries Association (BIA)	Division of Facility Development (f) (DFD)	Division of Facility Development (g) (DFD)
CONCRETE MASONRY					
Exterior		< 25 (d)		8 to 12	
< 50% (a)	10 (c)				
50 - 75% (a) (b)	16 (c)				
>75% (a)	22 (c)				
Load-Bearing					40 or 60 (h)
Non Load-Bearing					30 or 50 (h)
Interior		< 25 (d)		20 to 25 (e)	
< 50% (a)	14 (c)				
50 - 75% (a)	20 (c)				
>75% (a)	26 (c)				
Corners		within half of typical spacing			
Load-Bearing					20 or 30 (h)
Non Load-Bearing					20 or 25 (h)
Openings		< 6' one side, > 6' both sides			
CLAY MASONRY					
Exterior	approx. 25		< 30	20 to 25	
Load-Bearing					100 or 140 (h)
Non Load-Bearing					60 or 100 (h)
Parapet	approx. 12			reduce spacing 50 %, or increase joint width 50%	
Corners	within half of typical spacing		one within 10', sum of distances from corner less than or equal to typical spacing	one within 4' on side of expected greatest movement, 8' to 12' other side	
Load-Bearing					50 or 70 (h)
Non Load-Bearing					40 or 50 (h)
Openings				> 8' both sides	

- (a) Average annual relative humidity.
 (b) Average annual relative humidity for Wisconsin.
 (c) Assumes horizontal joint reinforcement sixteen inches vertically, ASTM C90 Type II Units.
 (d) Empirical rule-of-thumb length/height ratio equal to 1.5, or < 25 feet.
 (e) Joints in the concrete masonry wythe should be located approximately halfway between typical vertical movement joints in the clay face brick wythe.
 (f) Per Minimum Requirements and Guidelines for The Exterior Building Envelope, Mar 1994.
 (g) Per Wisconsin Administrative Code, Dept of Commerce Chapter 53.222 (7).
 Note: jointing required is for public safety and is not intended to prevent minor cracking.
 (h) Select spacing based on percentage openings of total wall area, see Wisconsin Administrative Code, Table 53-XII.