MERIDIAN™ BRICK

Movement Joint

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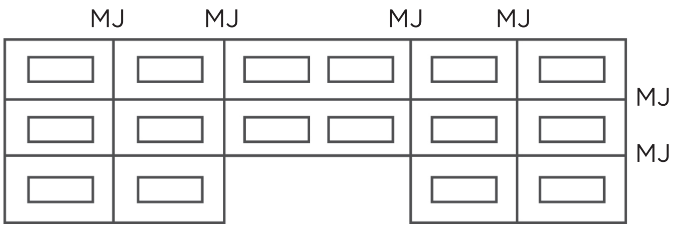
Building materials are dynamic substances which will change size and position due to a change in their environments. This is particularly true of commercial buildings which will be emphasized here. Since commercial buildings typically have more rigid structural frames than residences, the differential movements between the different materials is more critical. Therefore, when brick veneer is placed on commercial buildings special design considerations must be implemented: i.e., movement joints.



These joints are used to prevent cracking in the brick as they and the other materials along the perimeter of the building move at different rates and directions. The determination as to where to place movement joints is based on the material and building movements. It is then possible to evaluate where the movement joints need to be placed.

What is a movement joint? Some people call these joints expansion joints. It does not matter what the joint is called so long as the joint breaks up the brickwork into panels which will not crack or bow due to the various building movements. The movement joint is a continuous space where the brickwork does not touch. The width of the joint, typically 10-12mm, is dependent on the building movements and is kept water tight by a backer rod and a commercial sealant that can withstand the calculated movements.

Building Movements

There are many different types of building movement. Movement caused by temperature, moisture movement, creep in concrete, and horizontal and vertical deflections are the most important to brick veneer. There are a number of other building movements, which are important, such as foundation settlement and seismic displacements, but not to the placement of control joints.

Brick walls move both horizontally and vertically due to changes in temperature and moisture content.
When a brick wall is heated it gets larger and when it cools it gets smaller. When brick gets wet, it expands. Approximately 85% of its maximum expansion occurs in the first 18 months after firing. Sixty percent expansion occurs in the first 3 months. However, when brickwork dries it does not shrink completely to its original dimensions, due to the inherent nature of the brick.

For a straight wall sitting on a foundation, the brickwork expands vertically from zero at the base to a maximum at the top of the wall. It is believed that this vertical movement can be as much as 50% greater than the horizontal movement. As will be discussed later, the design of the adjacent building elements must take into consideration all such movements.

Horizontally, the veneer moves from the center of the wall out to the edges. The horizontal movement at the base of the wall is smaller than the horizontal movement at the top of the wall, since, at the bottom, the dead weight of the brick above reduces the horizontal movement.

The formula for estimating the thermal and moisture movements in brickwork is shown at the end of this technical note with sample calculations figuring the displacements along the outer free edges of the wall.

Free edges are those edges bordering movement joints which are not restrained from movement.
There are a few factors to keep in mind when using the equation:

- The 2.5% design temperature for Toronto is 31°C for July and -20°C for January
- A dark brick get hotter by 10-15°C than the ambient temperature due to solar radiation. Consequently, a dark brown brick may reach 46°C, and a buff brick may reach 41°C.
- Temperature decrease below ambient temperature due to radiation loss could be 5°C. So a brick minimum temperature could be -25°C
- Secondly, insulation between the brick and the backup changes the brick's average temperature. The more thermally isolated the brick, the greater the temperature swing in the brickwork.
- Thirdly, the actual movement joint size may need to be two to four times the calculated movement due to the extensibility of the joint sealant. It is important that the sealant criteria be indicated in the construction specifications. Finally, the sealant type, the temperature at the time the sealant is installed, and the length of the wall will help determine the width of the movement joint.

Another important building movement has to do with concrete structural frames. This movement is called creep. It is the permanent column shortening or beam deflection caused by sustained weight on the frame. With the frame shortening, there may be considerable differential movement between the brickwork and the concrete frame.

For example, a 3 story building with continuous brickwork from the foundation up the full 3 stories will have the most differential movement at the upper floor, particularly in the summer. The brick expands from the base to a maximum at the top of the wall while the concrete frame is shortening with the maximum movement also at the top of the frame. In order to compensate for these movements, window details may need to be reviewed as well as veneer anchors and coping design. If there is a horizontal shelf angle at every floor with a movement joint, the space between the underside of the angle and the top of the brick veneer must be large enough to allow the brick to expand and the frame to shorten. If there is not sufficient space, then the veneer will be confined such that the wall may bow or develop vertical cracks.

When brickwork is supported by structural beams, excessive deflection of these members may develop vertical flexural cracks in the wall. To minimize this problem, CSA S304 recommends that the deflection of the brick supporting angles not exceed Span/480 or 20 mm. If a wall is continuous past a column, the deflection in the beams between the columns may cause vertical cracks to occur at the column. The amount of vertical deflection of the beams or angles supporting the brick and the expansion in the walls should not exceed the space between the angles and the brickwork below the angles.

When the brickwork and the structural backup deflect due to wind pressure, horizontal cracks may develop in the veneer. This can be of particular concern if the backup is metal studs, since the design of the metal studs may not be sufficient to provide support against cracking. Judicious placement of control joints will not improve the inherent design problems.

If the backup for the brickwork is concrete block with continuous one piece ladder horizontal reinforcement, a strong wall will be created with minimum amount of deflection. The use of horizontal truss type reinforcement in a long wall with insulation in the cavity may cause bowing and possibly cracking and is not recommended.

There are a number of special building conditions that require additional movement joint considerations. For example, parapet walls have both sides exposed to the sun, which means that one side of the wall may be expanding while the other side is shrinking. This causes increased differential movement between the back and the front walls.

A second special detail is when different materials, such as stone or block, are built into the brickwork. The differential movement due to the difference in temperature and moisture expansions for the different materials can cause horizontal mortar cracks. If stone or concrete copings are built on a brick wall which move more than the brick, these materials may bow up or horizontal mortar cracks may develop.

A third special condition occurs when a short brick wall is built continuously with a tall brick wall. Where the two walls meet, a vertical crack may develop since the short wall moves vertically at a faster rate than the tall wall which moves slower because of all the weight of the brickwork above.

A fourth special condition is when two walls meeting at a corner are designed so that one wall is load bearing and the adjacent wall is not. The non - load bearing wall will move more than the load bearing and may crack.

A final condition may develop where the building moves laterally due to the wind and potentially can develop high shear forces in the brickwork. This normally is not a problem since flexible anchors and control joints will allow sufficient movement between the brick and the frame to minimize stresses.

Movement Joint Locations

The determination as to where to place movement joints must take into account the various movements that have been discussed. An additional distinction that needs to be made has to do with the difference between a lintel and a shelf angle. A lintel is a loose angle that supports the brick over an opening and bears directly on the brickwork on each side of the opening. It moves with the brick. A shelf angle is a horizontal angle that is fastened to the structural frame. It moves with the frame. It is essential to keep this point in mind when locating movement joints. The vertical movement joints should not go through the lintel. Vertical movement joints may go through the shelf angle. The brick that does sit on the shelf angle should be separated with a movement from brick that sits on the foundation.

Vertical Movement Joint Spacing

The location of the movement joints is based on where and why brickwork cracks. The joints create brick panels which are independent of each other. For vertical movement joints, there are a number of conditions that need to be considered. First, vertical cracks may occur at the corners. When there are no vertical movement joints near a corner, the brickwork on both walls meeting at the corner will want to expand or contract due to a change in the brick temperature and moisture. Since the brickwork is bonded together at the corner there is no place for the internal wall stresses to be relieved, therefore cracks develop. The way to prevent the cracks is to make the length of the walls meeting at the corner short by placing movement joints near the corner. The normal "rule of thumb" is to place either one joint at the corner or to place two joints spaced no more than 6 to 8 m apart around the corner. For example, the distance on one corner wall from the movement joint to the corner may be 2.5m, which would mean that the second adjacent wall would be 3.5 – 5m long. Shorter walls are permissible.

A second area where vertical cracks may occur happens on short offset walls that adjoin two long perpendicular walls. When the ends of these long walls that adjoin the short wall expand, the ends move in opposite directions. These opposing movements generate high shear stresses in the short wall, causing the wall to crack. These cracks can be avoided by placing a movement joint at the interior corner and a second movement joint 6m away going around the exterior corner. Another approach would be to place movement joints 6 to 8 m apart on the two long walls with the short wall between them.

For straight solid walls, the spacing between movement joints is determined by the width of the movement joints and the type of sealant; however the walls should not exceed 12 m. If a 10 to12 mm wide joint is desired, then the spacing between joints is approximately 8 m which also corresponds to the column spacing. This is based on a sealant which has an extensibility of +/- 50%. If the walls are 12m long, the movement joint width may need to be 22 mm.

If the solid wall has continuous strip windows above, the movement joint spacing is the same as just mentioned. However, if the windows are discontinuous then there are several alternative methods for placing movement joints. When the walls have punched out windows which are windows built with loose lintels, then the vertical movement joints should be placed between the windows and not at the window jambs. For doors with lintels, the movement joint should not be placed at the door jamb. The pier widths adjacent to the movement joints should be at least 600 mm. If narrow piers are important, an alternative is to replace the lintels with a shelf angle over the tops of the windows. The vertical movement joints can then be placed next to the window jamb. The use of shelf angles will allow vertical movement joints to be placed anywhere in the panel no matter if there are continuous strip windows or piers between the windows.

The vertical movement joints in parapet walls should not exceed 6 to 8 m. This can create a problem if the movement joints are spaced 12m apart in the lower portion of the building. One approach is to make all the movement joints 6 to 8 m apart all the way to the top of the parapet. Otherwise a shelf angle provided at the roof line will enable vertical movement joints to be placed at any spacing in the parapet, perhaps half the distance of the spacing in the lower portion of the building. Vertical movement joint spacing requirements at the corners and short offsets also apply to parapets.

Horizontal Movement Joint Spacing

The location of horizontal movement joints is not as involved as the vertical joints. The building code limits brick veneer/stud construction to a height of 11 m above the foundation. Above this height, brick veneer should be supported on shelf angle at each floor. As the wall gets taller without movement joints, special considerations need to be taken such as the coping detail, the space between the windows, and the brickwork at the upper floors and the type of adjustable anchors for the brick.

The movement joint is created by providing a horizontal shelf angle with sufficient space between the underside of the angle and the top of the brickwork below the angle to accommodate all the building and brick movements. The joint is made watertight with a backer rod and a commercial sealant.

Normally, horizontal movement joints are placed every floor over the windows. A 10 to 12 mm wide joint is satisfactory for movement joints every 3 m for a steel frame. A concrete frame may require a wider joint. If the horizontal joint stops at a wall, the shelf angle must also stop at the wall without continuing through the vertical movement joint. Similarly no horizontal reinforcing should go through the vertical movement joint. When the movement joint is continuous around the building perimeter, the angle does not interfere with the vertical movement joints.

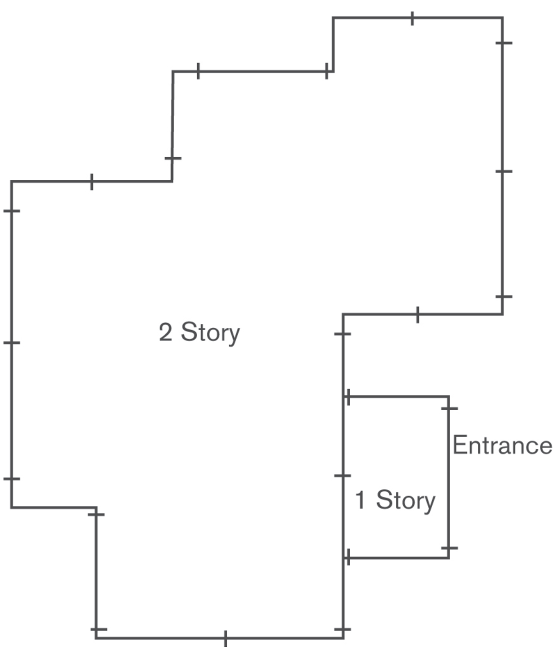
A special condition occurs when there is brickwork surrounding a large opening in the building facade. There must be a shelf angle over the opening to support the brick. One approach for placing movement joints is to provide a shelf angle only long enough for the opening and then install vertical movement joints that line up with the ends of the opening in the panel above the opening. Another approach is to extend the shelf angle over the opening either to the next vertical movement joint or all around the building perimeter. Then vertical movement joints can be placed anywhere in the panel above the opening.

Another special condition develops with the coping design on top of the parapet wall. If there were no horizontal movement joints, the vertical movement at the top of the brickwork may be sufficient to push the coping. Therefore, either there must be a space between the top of the brick and the underside of the coping blocking, or a horizontal movement joint is placed near the roof line to minimize the vertical movement in the brickwork.

In summary, the approach for locating vertical movement joints can be delineated as follows. Normally, wall elevations are sufficient to determine joint placement. However, sometimes floor plans are also necessary for complicated buildings.

1. Start with an exterior corner, place control joints so that the distance between joints around the corner is less than 8 m.
2. Proceed along one of the two walls, placing movement joints on the straight portion 8 to 9 m apart or at the column lines or in the middle of window piers or along the edge of the window jamb if there is a horizontal movement joint over the window.
3. When you get to an offset in the wall, place a movement joint either at an interior corner or two movement joints 6 to 8 m apart.
4. Continue all around the building until vertical movement joints have been placed on every wall, bearing in mind special circumstances such as different height walls, parapets, wide facade openings, set back walls, different exterior materials and column locations.

The elevation sketch on the first page illustrates one possible choice for movement joint locations on one wall. There are many different options. The plan view below illustrates one possible set of movement joint locations all around the building. (- line indicates movement joint)



Determining Movement Joint Widths

The determination of movement joint widths is based on many factors, such as the color of the brick, the temperature variation in the brick over a year's time, the length of the wall, the temperature of the brick when the sealant is installed and the sealant extensibility.

Since it is not possible to determine the temperature when the sealant is installed, the yearly temperature variation is assumed to be the worst case. If the sealant extensibility is +/- 50%, then the required as-built movement joint width needs to be 2 times the calculated movement at the joint. If the sealant extensibility is +/- 25%, the required as-built control joint width needs to be 4 times the calculated movement at the joint.

The following equation is the recommendation for calculating the horizontal movement along a free edge.

$$w = (.0007 + .000006\,(rT))L$$

w = movement along a free edge

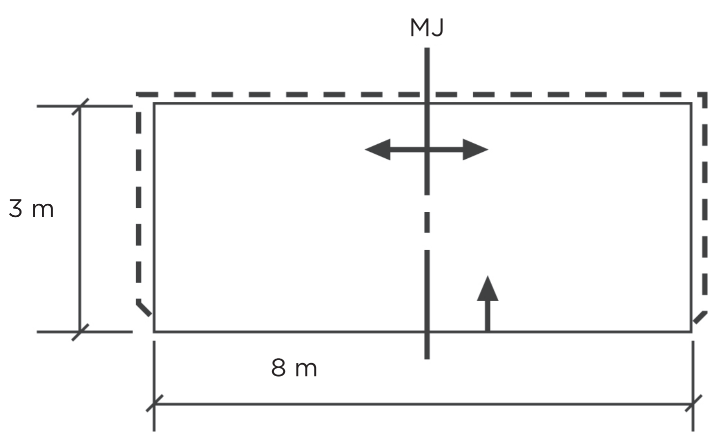
.0007 = coefficient of moisture expansion

.000006 = coefficient of thermal expansion

(rT) = maximum yearly temperature change

L = distance from point where there is no wall movement to the point on the wall where the maximum movement occurs. Horizontally, L is half the length of the wall. However normally there are two walls meeting at one joint, consequently the calculated movement occurring at the joint must be twice the calculated number for one panel. Vertically, L is the height of the panel.

Sample Calculations



A. Assume:

maximum brick temperature = 46˚C

minimum brick temperature = -21˚C

sealant extensibility = +/-50

Vertical movement along the top edge of the panel

w = (.0007 + .000006 (67)) 3 000 mm = 3.3 mm
sealant factor = 2
MJ width = 2 x (3.3) = 6.6 mm < 10 mm

Horizontal movement along the top edge of the panel

w = (.0007 + .000006 (67)) 4 000 mm = 4.4 mm

Since 2 panels meet at same MJ

Actual w = 2 x 4.4 = 9 mm

Sealant factor = 2

MJ Width = 2 x 9 mm = 18 mm

If extensibility of the sealant is 25%, then the sealant factor is 4. The MJ width along the top of the panel is 4.4 mm x 4 = 17.6 mm and the MJ width along the vertical movement joint is 9 mm x 4 = 36 mm.

B. If the brick has been out of the kiln for 3 months, the coefficient of moisture expansion would be approximately .0002 instead of .0007. This changes the size of the required MJ widths.

Movement along the top edge of the panel

w = (.0002 + .000006 (67)) 3 000 = 1.8 mm

MJ Width = 2 x 1.8 = 3.6 mm

Movement along the vertical edge of the panel

w = (.0002 + .000006 (67)) 4 000 mm = 2.4 mm

MJ Width = 2x 2x 2.4 = 9.6 mm

Waiting for the brick to expand due to moisture, will reduce the size of the MJ.

For calculating movement of clay brick masonry on buildings, the following coefficients should be used, taken from Table 1, Masonry Dimensional Properties, of CSA S304 Design of masonry structures

Thermal movement
horizontal (mm/m/100˚C) 0.5 – 0.6

Thermal movement
vertical (mm/m/100˚C) 0.7 – 0.9

Moisture movement
reversible (mm/m) 0.2

Moisture movement
permanent shrinkage (mm/m) 0.2 – 0.7

Load movement
Initial elastic modulus (GPa) 4 - 26

Load movement
Long term strain/initial strain 2 - 4

Additional Reading Material:

1. BIA, Technical Notes 18 and 18A

2. Grimm, C.T., Masonry Cracks: A Review of the Literature, Masonry: Materials, Design, Construction and Maintenance, ASTM STP 992, 1988, pp. 257-280