Technical Services Department

ABC109  Differential Movement and Expansion Joints in Brick Veneer

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Masonry Designer
NCMA TEK Briefs
**Technical Notes on Brick Construction**

**Abstract**

The Technical Notes are devoted to movements that occur in brick constructions. Movements induced by changes in temperature, moisture, and shrinkage of the bricks, as well as thermal expansion, contraction, and other effects, can lead to cracking. This Technical Note describes the various causes of movement in brickwork and outlines a design and detailing of masonry wall panels to minimize movement.

**Keywords**: Cracks, differential movement, expansion}

**Introduction**

The purpose of this note is to describe the various types of movements that occur in brickwork and to provide guidelines for designing and detailing masonry walls to minimize these movements.

**MOvements of Construction Materials**

The stresses and strains in construction materials can vary significantly, depending on the type of material and the environmental conditions. These movements can cause cracking and other damage to the structure. This Technical Note discusses the various types of movements that can occur in brickwork and provides guidelines for minimizing them.

**Table 1**

<table>
<thead>
<tr>
<th>Building Material</th>
<th>Thermal Expansion</th>
<th>Shrinkage</th>
<th>Movement</th>
<th>Crack Susceptibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Masonry</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Concrete</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Steel</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Wood</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**Temperature Movements**

Temperature changes can cause significant movements in brickwork. The coefficient of thermal expansion and contraction of the materials used in the construction are critical factors to consider. Table 1 indicates the coefficients for the expansion and contraction of the materials used.

**Conclusion**

This Technical Note provides guidelines for designing and detailing masonry walls to minimize movement caused by temperature changes and other factors. By following these guidelines, architects and builders can create structures that are more resistant to cracking and other damage.
Clay brick has characteristic expansion and contraction movements that result from changes in temperature and moisture content. This presentation will explain those movements and suggest strategies to limit any cracking that results. We will discuss:

1. How do temperature and moisture changes cause brick and other materials to expand and contract at different rates?
2. Why do we need expansion joints in brick veneer?
3. Where should we place expansion joints for effective crack control, while retaining aesthetic symmetry?
4. Receive practical guidelines for placing expansion joints in brick veneer.
Who wants their building to look like this?
Brick are made from clay...
That is fired at 2000°F
High temperature firing gives genuine clay brick many exceptional properties:

- Durable – lasts for centuries
- Color-fast – colors never fade
- Fire resistant – 1-hr fire rating over wood framing
- Dimensions stable – very low thermal expansion
- One-time moisture expansion
  - Which we will discuss
How does changes in temperature and moisture cause brick and other materials to expand and contract at different rates?
<table>
<thead>
<tr>
<th>Building Material</th>
<th>Thermal Movement</th>
<th>Reversible Moisture</th>
<th>Irreversible Moisture</th>
<th>Elastic Deformation</th>
<th>Creep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Masonry</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Concrete Masonry</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Concrete</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Steel</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Wood</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Moisture Expansion of Fired Clay Brick vs. Time  Fig. 1
<table>
<thead>
<tr>
<th>Material</th>
<th>Expansion in/in dry to max moisture content</th>
<th>Inches in 25 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay brick (one-time expansion)</td>
<td>0.0003 – 0.0004</td>
<td>0.09 – 0.12</td>
</tr>
<tr>
<td>Clay and porcelain tile</td>
<td>0.0002 – 0.0003</td>
<td>0.06 – 0.09</td>
</tr>
<tr>
<td>Concrete Masonry (shrinkage)</td>
<td>0.0002 – 0.00045</td>
<td>0.06 – 0.135</td>
</tr>
<tr>
<td>Wet-cast concrete (shrinkage)</td>
<td>0.0006 – 0.0012</td>
<td>0.18 – 0.36</td>
</tr>
<tr>
<td>Wood parallel to grain</td>
<td>0.0001 or less</td>
<td>0.03 or less</td>
</tr>
<tr>
<td>Wood perpendicular to grain</td>
<td>0.03 – 0.06</td>
<td>9 – 18 inches</td>
</tr>
</tbody>
</table>

- Never embed wood in masonry work. Wood will expand from moisture and crack masonry work.
- Special precautions to allow for wood shrinkage for brick veneer on multi-story wood framing.
  - Wood can shrink 3/8” per floor
  - 1.5” in four-story building
<table>
<thead>
<tr>
<th>Material</th>
<th>Thermal Expansion $^{*10^{-6}}$ Inch/inch $^0F$</th>
<th>Thermal Expansion Inch / 100 ft Per 100 $^0F$</th>
<th>Material</th>
<th>Thermal Expansion $^{*10^{-6}}$ Inch/inch $^0F$</th>
<th>Thermal Expansion Inch / 100 ft Per 100 $^0F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay or shale brick</td>
<td>3.6</td>
<td>0.43 (7/16)</td>
<td>Metals</td>
<td>Aluminum</td>
<td>12.8</td>
</tr>
<tr>
<td>Fired clay brick</td>
<td>2.5</td>
<td>0.30 (5/16)</td>
<td>Bronze</td>
<td>10.1</td>
<td></td>
</tr>
<tr>
<td>Clay or shale tile</td>
<td>3.3</td>
<td>0.40 (3/8)</td>
<td>Stainless steel</td>
<td>9.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Structural steel</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>Concrete Masonry</td>
<td></td>
<td></td>
<td>Wood Parallel to Grain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dense aggregate</td>
<td>5.2</td>
<td>0.62 (5/8)</td>
<td>Fir</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>Cinder Aggregate</td>
<td>3.1</td>
<td>0.37 (3/8)</td>
<td>Maple</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Expanded shale aggregate</td>
<td>4.3</td>
<td>0.52 (1/2)</td>
<td>Oak</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Expanded slag aggregate</td>
<td>4.6</td>
<td>0.55 (9/16)</td>
<td>Pine</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Pumice or cinder aggregate</td>
<td>4.1</td>
<td>0.49 (1/2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stone</td>
<td></td>
<td></td>
<td>Wood Perp. to Grain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granite</td>
<td>4.7</td>
<td>0.56 (9/16)</td>
<td>Fir</td>
<td>32.0</td>
<td></td>
</tr>
<tr>
<td>Limestone</td>
<td>4.4</td>
<td>0.53 (1/2)</td>
<td>Maple</td>
<td>27.0</td>
<td></td>
</tr>
<tr>
<td>Marble</td>
<td>7.3</td>
<td>0.88 (7/8)</td>
<td>Oak</td>
<td>30.0</td>
<td></td>
</tr>
<tr>
<td>Plaster</td>
<td></td>
<td></td>
<td>Pine</td>
<td>19.0</td>
<td></td>
</tr>
<tr>
<td>Concrete</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravel Aggregate</td>
<td>6.0</td>
<td>0.72 (3/4)</td>
<td>Gypsum aggregate</td>
<td>7.6</td>
<td></td>
</tr>
<tr>
<td>Lightweight Structural</td>
<td>4.5</td>
<td>0.54 (9/16)</td>
<td>Perlite aggregate</td>
<td>5.3</td>
<td></td>
</tr>
</tbody>
</table>

Note: All values are in $10^{-6}$ Inch/inch $^0F$ and Inch / 100 ft Per 100 $^0F$.
<table>
<thead>
<tr>
<th>Material</th>
<th>Expansion</th>
<th>Difference From Brick</th>
<th>Material</th>
<th>Expansion</th>
<th>Difference From Brick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay brick</td>
<td>0.108</td>
<td>0</td>
<td>Fir Lumber With Grain</td>
<td>0.063&quot;</td>
<td>-.045</td>
</tr>
<tr>
<td>Clay tile</td>
<td>0.075</td>
<td>-.033</td>
<td>Maple With Grain</td>
<td>0.108&quot;</td>
<td>0</td>
</tr>
<tr>
<td>NW Concrete Masonry</td>
<td>0.156</td>
<td>0.048</td>
<td>Oak With Grain</td>
<td>0.081&quot;</td>
<td>-.027</td>
</tr>
<tr>
<td>LW Concrete Masonry</td>
<td>0.129</td>
<td>0.021</td>
<td>Pine With Grain</td>
<td>0.108&quot;</td>
<td></td>
</tr>
<tr>
<td>Granite</td>
<td>0.141&quot;</td>
<td>0.033</td>
<td>Fir Lumber Across Grain</td>
<td>0.960&quot;</td>
<td>0.852 *</td>
</tr>
<tr>
<td>Limestone</td>
<td>0.132&quot;</td>
<td>0.024</td>
<td>Maple Across Grain</td>
<td>0.810&quot;</td>
<td>0.702 *</td>
</tr>
<tr>
<td>Marble</td>
<td>0.219&quot;</td>
<td>0.111</td>
<td>Oak Across Grain</td>
<td>0.900&quot;</td>
<td>0.792 *</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pine Across Grain</td>
<td>0.570&quot;</td>
<td>0.462 *</td>
</tr>
<tr>
<td>Normal Weight Concrete</td>
<td>0.180&quot;</td>
<td></td>
<td>Aluminum</td>
<td>0.384&quot;</td>
<td>0.276 **</td>
</tr>
<tr>
<td>Light Weight Concrete</td>
<td>0.135&quot;</td>
<td></td>
<td>Brass</td>
<td>0.312&quot;</td>
<td>0.204 **</td>
</tr>
<tr>
<td>Gypsum Plaster</td>
<td>0.228&quot;</td>
<td></td>
<td>Stainless steel</td>
<td>0.288&quot;</td>
<td>0.180 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Structural steel</td>
<td>0.201&quot;</td>
<td>0.093 **</td>
</tr>
</tbody>
</table>

*Never embed wood in masonry work. Wood will expand from moisture and crack masonry work.

** Use great care where Aluminum, Brass, Stainless Steel, and Structural steel join brickwork. These common materials expand much faster than brick or other masonry products.
The total extent of movement can be estimated by this formula from BIA.

\[ TE = L \times 0.0009 \]

Where:

- \( TE \) = total expansion of a fixed brick wall
- \( L \) = is the total length of the wall, in
- 0.0009 is the expansion coefficient
How far between expansion joints?

\[ S = \frac{(W \times E)}{0.09} \]

where:

- \( S \) = spacing between expansion joints, in.
- \( W \) = width of expansion joint, typically the mortar joint width, in.
- \( E \) = percent extensibility of expansion joint material

The expansion joint is typically sized to resemble a mortar joint, usually 3/8 in. to 1/2 in.

The width of an expansion joint may be limited by the sealant capabilities.

Extensibility of sealants in the 25 percent to 50 percent range is typical for brickwork.

Compressibility of filler materials may be up to 75 percent.
Example.

Consider a typical brick veneer with a desired expansion joint size of 1/2 in. (13 mm) and a sealant with 50 percent extensibility.

Eq. 1 gives the following theoretical expansion joint spacing:

\[ S = \frac{0.5 \text{ in.} \times 50}{0.09} = 278 \text{ in. or 23 ft - 2 in.} \]

To make it easy expansion joints should be between 20 and 25 feet.
Special Precautions for Pre-stressed and Post-tensioned Concrete

Pre-stressed and post-tensioned concrete will shrink from creep in the direction of tensioning.
• This is in addition to drying shrinkage
• Occurs over several months to 1 year
• Have structural engineer and concrete producer estimate both drying and tensioning shrinkage for all slab floors.
• Allow for movements in framing design
• Allow for effects of movements on veneer design
Why do we need expansion joints in brick?

1. Because brick and all building materials expand and contract with changes in temperature, humidity and other environmental conditions.
2. Because those materials move at different rates.
3. Because nature will put them in if you forget.
Where should we put expansion joints in brick?

1. Periodically in long walls.
2. At offsets in walls.
3. Where short runs of masonry meet long runs.
4. At outside corners.
5. Where different materials meet.
6. At parapets and parapet wall caps.
7. Bond break at foundations, shelf angles, and lintels.
8. At junctions with different functions or different heights.
Periodically in long walls.
At offsets in walls.
(a) Movement at Offset Without Expansion Joints

(b) Proper Expansion Joint Locations at Offset
Where short runs of masonry join long runs.
At outside corners.
L1 + L2 = TYPICAL SPACE BETWEEN EXP JOINTS
L1 OR L2 = 2'-0 MINIMUM
L1 OR L2 = 10'-0 MAXIMUM

AS BRICK EXPANDS HORIZONTALLY, WALL BENDS AND CRACKS.

CORNERS WITHOUT EXPANSION JOINTS

EXPANSION JOINTS AT CORNERS
Where different materials meet.
At parapets and parapet wall caps.
Row lock caps need additional exp joints 12-16 feet. This also goes for brick pavers.
Expansion Joint and Bond Breaks
Foundations, Shelf Angles and Lintels
Foundations
Shelf Angles

Figure 8
Expansion Joint at Shelf Angle
Hold back 1/2" from jamb

Shelf Angle

Expansion Joint

Elevation

Expansion Joint at Shelf Angle
EXPANSION JOINTS AT JUNCTIONS WITH DIFFERENT FUNCTIONS OR DIFFERENT HEIGHTS
Let’s Look a little close at the expansion joint.
BRICK EXPANSION JOINTS

- Clean Out ALL Mortar

- Backer Rod

- W/2 Sealant Thickness = 1/2 Joint Width, W

BRICK EXPANSION JOINTS
Concrete Masonry Control Joint
(May have mortar in joint)
Hiding Expansion Joints
Match sealant color to brick.
Dust wet sealant with sand.
Hide joints with brick details.
Use joint line as a feature.
Hide joints with brick details.
Use joint line as a feature.
Hide joints with brick details.
Put joints on inside corners.
Whatever you do, keep it simple!
Beautiful Brick Work
Art Complex 789, Beijing China