Example RCJ-05 — Differential Movement in Brick/Block Exterior Wall

The unreinforced exterior wall on Grid Line B between Grids 1 and 2 is composed of a noncomposite exterior brick wythe and an interior block wythe (cavity wall). The block wythe is loadbearing. The exterior brick wythe is subject to thermal, moisture, and freezing expansions. The interior block wythe is subject to elastic deformation, shrinkage, and creep. To accommodate these differential movements an expansion joint should be provided at the top of the exterior brick wythe. This example estimates the magnitude of those differential movements and designs the necessary expansion joint.

Calculations and Discussion

Clay Brick Masonry Exterior Wythe

Thermal expansion: Assume wall built at 40°F and maximum service mean temperature of 140°F.

The temperature rise is 100°F.

The coefficient of thermal expansion, \( k_t \), is \( 4 \times 10^{-6} \) in./in. °F.

Therefore, thermal expansion strain is:

\[
4 \times 10^{-6} \times 100 = 0.0004 \text{ in./in.}
\]

Moisture expansion (\( k_m \)) = 0.0003 in./in.

Subtotal clay masonry expansion = 0.0007 in./in.

Total clay masonry height = 484 in.

Total clay masonry expansion = 0.339 in.

Note that the elastic deformation of the clay masonry is neglected since the brick wythe is nonloadbearing. Creep is normally not a problem in clay masonry and that fact, coupled with the low axial load in the clay masonry wythe, justifies neglecting creep deformation.

Concrete Masonry Interior Wythe

CMU elastic deformation:

From MDG Example RCJ-1 the compressive strength of the CMU is 1,500 psi, and the CMU wythe is 8 in. nominal, ungrouted.

Mortar is ASTM C 270 Type N.

Elastic modulus of the concrete masonry: \( E_m = 900 \times f_m' = 1.35 \times 10^6 \) psi

From MDG Appendix A: Area = 30 in.²/ft.

<table>
<thead>
<tr>
<th>Story</th>
<th>Dead Load (lb)</th>
<th>Wall Wt. (lb)</th>
<th>P/A Stress (psi)</th>
<th>Unit ED, ( P/AE ) ( \times 10^6 ) in./in.</th>
<th>Story Height (in.)</th>
<th>ED/story (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>8,380</td>
<td>250</td>
<td>288</td>
<td>213</td>
<td>130</td>
<td>0.028</td>
</tr>
<tr>
<td>2nd</td>
<td>6,060</td>
<td>220</td>
<td>209</td>
<td>155</td>
<td>116</td>
<td>0.018</td>
</tr>
<tr>
<td>3rd</td>
<td>3,740</td>
<td>220</td>
<td>132</td>
<td>98</td>
<td>116</td>
<td>0.011</td>
</tr>
<tr>
<td>4th</td>
<td>1,425</td>
<td>280</td>
<td>57</td>
<td>42</td>
<td>116</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Total wall elastic deformation = 0.062
CMU Shrinkage

The maximum linear drying shrinkage permitted by ATSM C90 for CMU is equal to 0.00065 in./in. It is reasonable to use one-half this value in computing the shrinkage strain.

Shrinkage strain: $0.5 \times 0.00065 = 0.000325$ in./in.

Wall height (concrete block) = 478 in.

Total shrinkage = 0.155 in.

CMU Creep

Creep strain in concrete masonry is $2.5 \times 10^{-7}$ in./in. - psi

Creep deformation (CD):

<table>
<thead>
<tr>
<th>Story</th>
<th>Stress (psi)</th>
<th>Unit CD, $(10^{-6}, \text{in./in.})$</th>
<th>Story Height (in.)</th>
<th>CD/story (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>288</td>
<td>71.9</td>
<td>130</td>
<td>0.0094</td>
</tr>
<tr>
<td>2nd</td>
<td>209</td>
<td>52.3</td>
<td>116</td>
<td>0.0061</td>
</tr>
<tr>
<td>3rd</td>
<td>132</td>
<td>33.0</td>
<td>116</td>
<td>0.0038</td>
</tr>
<tr>
<td>4th</td>
<td>57</td>
<td>14.2</td>
<td>116</td>
<td>0.0016</td>
</tr>
</tbody>
</table>

Subtotal creep 0.0209

Subtotal concrete masonry contraction: $0.062 + 0.155 + 0.0209 = 0.238$ in.

Total differential movement = $0.339$ (clay brick $\uparrow$) + $0.238$ (CMU $\downarrow$) = 0.577 in.

Expansion joint sealant elasticity = 50%

Total expansion joint thickness = $0.577/0.5 = 1.15$ in.

The detail shown below includes a 1-1/4” expansion joint that accommodates the calculated differential movement.