Shelf Angles

Image by MIT OCW.
Flashing
Single Wythe
Walls

Cavity filter
(TYP B & C)

Weep holes
@2'-8" (813 mm)
O.C. partially open
“L-shaped” head
joints

1" (25 mm)

Image by MIT OCW.
Flashing with Shear Transfer

Mortar net*

#5 (#16) min. @48” (1219 mm) O.C.

4” (102 mm) unit

Drip edge

Image by MIT OCW.
Flashing Reinforced Wall

Architectural unit with inside faceshell and part of webs cut off to fit (TYP A & C)

3” (76 mm) unit for 8” (203 mm) wall, 4” (102 mm) unit for >8” (203 mm) wall

Image by MIT OCW.
End Dams
Flashing Laps

6”
Drainage Materials
Weep Holes
Weep Tubes
Vent Weep Holes
Rope Wicks
Flashing Materials

- Sheet Metal
- Composites
- Plastic and Rubber Compounds
Sheet Metals

<table>
<thead>
<tr>
<th>Material</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>Durable, non staining</td>
<td>Hard to solder and form</td>
</tr>
<tr>
<td>Cold-Rolled Copper</td>
<td>Durable</td>
<td>Damaged by excessive flexing and can stain</td>
</tr>
<tr>
<td>Galvanized Steel</td>
<td>Easy to paint and durable</td>
<td>Difficult to solder, corrodes early in acidic and salty air</td>
</tr>
</tbody>
</table>
## Composites

<table>
<thead>
<tr>
<th>Material</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead-coated copper</td>
<td>Flexible, durable, non-staining</td>
<td>Difficult to solder, damaged by excessive flexing, metal drip edge suggested</td>
</tr>
<tr>
<td>Copper laminates</td>
<td>Easy to form</td>
<td>Degraded in UV light, more easily torn than metal</td>
</tr>
</tbody>
</table>
# Plastics and Rubber Compounds

<table>
<thead>
<tr>
<th>Material</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPDM</td>
<td>Flexible, easy to form, non-staining</td>
<td>Aesthetics if not used with a metal drip edge, full support required</td>
</tr>
<tr>
<td>Rubberized asphalt</td>
<td>Fully adhered, separate lap adhesive not needed, self healing, flexible, easy to form and join</td>
<td>Full support required, degrades in UV light, metal drip edge required</td>
</tr>
<tr>
<td>PVC</td>
<td>Easy to form and join, non-staining, low cost</td>
<td>Easily damaged, full support required, metal drip edge required, questionable durability</td>
</tr>
</tbody>
</table>
Bldg felt and poly sheeting
Bldg felt and poly sheeting
Colorless Coatings

- Used for a variety of reasons
- Recommended for Concrete Masonry
- Questionable for Clay Masonry
Possible Dangers

• Water can still penetrate
• Could cause spalling
• If efflorescence occurs under coating, it may be impossible to remove
• Recoating will be necessary
Coating Types

- Colorless Coatings
- Paints
Colorless Coatings

- Penetrating
  - Silanes
  - Siloxanes
- Film-forming
  - Acrylics
  - Stearates
Coating Types

• Paints
  – Cement based
  – Latex
  – Alkyd
  – Oil-based Paints
Differential Movement

• Movements
  – Temperature Movement
  – Moisture Movement
  – Elastic Deformation

• Movement Joints
  – Design
  – Placement
Causes of Cracking

- Differential Movement
- Restraint
- Settlement
- Elastic Deformations
- Creep
Types of Movement

<table>
<thead>
<tr>
<th>Building Material</th>
<th>Thermal</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>
Temperature Movement

- Coefficient of Thermal Expansion
  - Brick = $3.6 \times 10^{-6}$
  - Concrete Masonry = $4.3 \times 10^{-6}$
  - Aluminum = $12.8 \times 10^{-6}$
  - Steel = $6.5 \times 10^{-6}$
Moisture Movement

- Brick - irreversible expansion

- Concrete masonry – drying shrinkage and carbonation
Types of Movement Joints

- Expansion Joint - Brick Masonry
- Control Joint - Concrete Masonry
- Building Joint - Structures
Expansion Joint

- Used in Clay Masonry
- Used to separate brick into sections so cracking will not occur
- Horizontal / Vertical
- Entire joint is unobstructed and formed from a highly elastic, continuous material
Types of Expansion Joints (Details)

(A) Sealant and Backer Rod

(B) Premolded Foam Pad

(C) Copper Waterstop

(D) Neoprene Pad

Image by MIT OCW.
Expansion Joint
Typical Spacing and Locations of Expansion Joints

- Long Walls
- Corners
- Setbacks & Offsets
- Parapet walls
- Beneath shelf angles
Expansion Joints at Corners

\[ L_1 + L_2 < \text{Typical Spacing Between Expansion Joints} \]
\[ L_1 \text{ or } L_2 = 10 \text{ Ft Maximum} \]

Image by MIT OCW.
Horizontal Expansion Joint

Image by MIT OCW.
False Horizontal EJ
Hiding Expansion Joints
Control Joint

- Used in Concrete Masonry
  - Relieve horizontal tensile stresses
  - Reduce restraint and permit longitudinal movement
  - Separate dissimilar materials
Types of Control Joints

• Pre-formed gasket

• Formed paper

• Special shape units
Pre-formed Gasket
Formed Paper (also known as Michigan Joint)
Special Shape Unit
Joint Reinforcement at CJ
Bond Beams

- Do not cut bond beam reinforcement unless specifically indicated on the plans
Control Joint Locations

- At intersecting walls
- Over openings
- Over opening
- Change in wall height
- At pilaster
Control Joint Spacing

• Two methods:
  – Empirical
    • based on historical performance
  – Engineered
    • based on a crack control coefficient
Empirical Control Joint Criteria

- Spacing for above grade exposed concrete masonry walls
  - Distance between joints is the lesser of:
  - Length to height ratio or
  \[
  1 \frac{1}{2} \quad 25 \text{ feet}
  \]
  - Notes:
    - Based on horizontal reinforcement of 0.025 in.²/ft
    - Applies to both Type I and Type II units
    - Can be modified based on local experience
## Engineered Crack Control Criteria

<table>
<thead>
<tr>
<th>Crack Control Coefficient</th>
<th>in./in. (mm/mm)</th>
<th>0.0010</th>
<th>0.0015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum wall length, ft (m)</td>
<td>25 (7.62)</td>
<td>20 (6.10)</td>
<td></td>
</tr>
<tr>
<td>Panel dimensions length/height ratio</td>
<td>2 ½</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Min. horizontal reinf. ratio $A_s/A_n$</td>
<td>0.0007</td>
<td>0.0007</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

$A_s = \text{cross-sectional area of steel, in}^2/\text{ft (mm}^2/\text{m})$

$A_n = \text{net cross-sectional area of masonry, in}^2/\text{ft (mm}^2/\text{m})$
Engineered Crack Control Criteria (cont.)

Notes:

- Need not apply if $A_s/A_n \geq 0.002$ - see Table 4.
- See Table 3 for $A_s/A_n = 0.0007$ minimum requirement.
- Minimum reinforcement ratio need not apply if length is $\leq \frac{1}{2}$ maximum length shown in table.
- CCC’s less than 0.0010 may be available in some areas and spacing should be adjusted accordingly.
- Control joint spacing may be adjusted up or down based on local experience.
<table>
<thead>
<tr>
<th>Wall thick in.</th>
<th>#5</th>
<th>#4</th>
<th>#3</th>
<th>4x3/16</th>
<th>4 x 8 gage</th>
<th>4 x 9 gage</th>
<th>2x3/16</th>
<th>2 x 8 gage</th>
<th>2 x 9 gage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ungrouted or partially grouted walls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

1. $A_n$ includes cross-sectional area of grout in bond beams.
Brick and Block Together

- Align Expansion Joints and Control Joints
Bond Breaks

- Use to separate bands of different masonry types