Outline

- Introduction
- Wall Construction Typology
- Veneer Anchorage Deterioration and Distress
- Post – Installed Veneer Anchors
- Masonry Anchorage Repair Case Studies
- Conclusion
Masonry Wall Construction Typology

Chronology - Masonry Construction

- Pre 1870: Load Bearing Construction
- 1870-1920: The Age of Experimentation
- 1920-1945: The Age of Transition
- 1945-1970: Modernism
- 1970-2010: Post Modernism
- 2010 and Beyond
If, therefore, we undertake to encase an iron structure with a shell of masonry, that shell must be regarded only as an envelope, having no function other than supporting itself, without lending any support to the iron, or receiving any from it. Whenever an attempt has been made to mingle the two systems, mischief has resulted in the shape of dislocations and unequal settlements.

– Viollet-le-Duc, Eugene-Emmanuel 1877

Age of Experimentation
1920-1940: The Age of Transition

Current: The Second Age of Experimentation

Source: MasonContractors.org
Current: The Second Age of Experimentation
Masonry Veneer Anchors

Building Code Requirements and Specification for Masonry Structures

• Building Code Requirements for Masonry Structures TMS 402-13/ACI 530-13/ASCE5-13
  • Part 4: Prescriptive Design Methods
  • Chapter 12. Veneer

• BIA Tech Note 21B Brick Masonry Cavity Walls – Detailing
  • Table 1

Masonry Veneer Anchors
Veneer Anchorage Deterioration and Distress

Deteriorated Anchorage
Missing / Ineffective Anchorage

Post – Installed Veneer Anchorages
Post – Installed Veneer Anchorage

- Threaded rod
  - Epoxy
  - Grout
  - Through-face
- Expansion anchors
- Helical Anchors
  - Helibars

Post – Installed Lateral Anchorage
Helical Manufacturers/Distributors

Helical Anchors - Bending
## Helical Anchors

![Image of Helical Anchors](image1.jpg)

### Test Data - Helical

<table>
<thead>
<tr>
<th>Material</th>
<th>Effective Minimum Bonded in (in/inches)</th>
<th>Ultimate Tension (ksi/tons)</th>
<th>Ultimate Tension/Compression (ksi/tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortar</td>
<td>1.5</td>
<td>60</td>
<td>750</td>
</tr>
<tr>
<td>Solid Brick (9000 psi)</td>
<td>1.5&quot;</td>
<td>750</td>
<td>750</td>
</tr>
<tr>
<td>Hollow Brick</td>
<td>1.5&quot;</td>
<td>1250</td>
<td>1250</td>
</tr>
<tr>
<td>Normal Weight (6,000 psi)</td>
<td>1&quot;</td>
<td>661</td>
<td>661</td>
</tr>
<tr>
<td>Lightweight (2,000 psi)</td>
<td>2&quot;</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>Ceramic (2000 psi)</td>
<td>1/2&quot;</td>
<td>220</td>
<td>220</td>
</tr>
<tr>
<td>Masonry Brick Steel 2 x 4</td>
<td>1&quot;</td>
<td>500</td>
<td>N/A</td>
</tr>
<tr>
<td>Concrete</td>
<td>1&quot;</td>
<td>500</td>
<td>N/A</td>
</tr>
<tr>
<td>2nd Floor Steel</td>
<td>16 Gauge</td>
<td>310</td>
<td>N/A</td>
</tr>
<tr>
<td>2nd Floor</td>
<td>1/2&quot;</td>
<td>310</td>
<td>N/A</td>
</tr>
<tr>
<td>Masonry</td>
<td>1/2&quot;</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Granite</td>
<td>1/2&quot;</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>Terrazo</td>
<td>1/2&quot;</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Seamless</td>
<td>1/2&quot;</td>
<td>300</td>
<td>300</td>
</tr>
</tbody>
</table>

*Note: Each construction project is unique and the appropriate use of this product is the responsibility of the engineer/architect and others who are familiar with the specific requirements of the project. The data presented above is based on laboratory testing and is intended to support the design of the project. It is not recommended for use as a basis for design, nor is it intended to replace the need for engineering judgment and professional review.*
### Test Data - Helical

#### Helical Test Data Comparison

<table>
<thead>
<tr>
<th>Material</th>
<th>Embedment (in.)</th>
<th>HELIFIX</th>
<th>BLOK-LOK</th>
<th>CTP</th>
<th>Powers</th>
<th>Simpson</th>
</tr>
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<tbody>
<tr>
<td>Mortar Joint</td>
<td>3</td>
<td>380</td>
<td>360</td>
<td>360</td>
<td>360</td>
<td>360</td>
</tr>
<tr>
<td>Solid Brick</td>
<td>3.625</td>
<td>750</td>
<td>700</td>
<td>700</td>
<td>865</td>
<td>865</td>
</tr>
<tr>
<td>Cavity Brick</td>
<td>3.625</td>
<td>1350</td>
<td>1300</td>
<td>1400</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>Normal Weight CMU</td>
<td>4</td>
<td>507</td>
<td>507</td>
<td>500</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>Light Weight CMU</td>
<td>2</td>
<td>550</td>
<td>550</td>
<td>550</td>
<td>545</td>
<td>545</td>
</tr>
<tr>
<td>Concrete</td>
<td>1.25</td>
<td>1300</td>
<td>1300</td>
<td>1300</td>
<td>1200</td>
<td>880</td>
</tr>
<tr>
<td>Wood Studs 2x4</td>
<td>3</td>
<td>517</td>
<td>517</td>
<td>510</td>
<td>510</td>
<td>590</td>
</tr>
<tr>
<td>Wood Studs 2x6</td>
<td>3</td>
<td>510</td>
<td>510</td>
<td>510</td>
<td>510</td>
<td>n/a</td>
</tr>
<tr>
<td>Metal Stud</td>
<td>16 ga</td>
<td>310</td>
<td>310</td>
<td>300</td>
<td>300</td>
<td>200</td>
</tr>
<tr>
<td>Granite</td>
<td>2.125</td>
<td>620</td>
<td>620</td>
<td>590</td>
<td>590</td>
<td>590</td>
</tr>
<tr>
<td>Travertine</td>
<td>0.875</td>
<td>550</td>
<td>550</td>
<td>500</td>
<td>500</td>
<td>n/a</td>
</tr>
<tr>
<td>Limestone</td>
<td>3</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>n/a</td>
</tr>
<tr>
<td>3/16&quot; steel</td>
<td>0.1875</td>
<td>520</td>
<td>520</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
**Test Data - Expansion**

**Anchor Selection**

Masonry - Masonry

<table>
<thead>
<tr>
<th>Maximum Cavity Standard Masonry</th>
<th>Nominal Anchor Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 5/8&quot;</td>
<td>4 1/2&quot;</td>
</tr>
<tr>
<td>2 1/4&quot;</td>
<td>5 1/2&quot;</td>
</tr>
<tr>
<td>3 1/2&quot;</td>
<td>6 1/2&quot;</td>
</tr>
<tr>
<td>4 1/2&quot;</td>
<td>7 1/2&quot;</td>
</tr>
<tr>
<td>5 5/8&quot;</td>
<td>8 1/2&quot;</td>
</tr>
<tr>
<td>6 1/2&quot;</td>
<td>9 1/2&quot;</td>
</tr>
<tr>
<td>7 1/2&quot;</td>
<td>10 1/2&quot;</td>
</tr>
<tr>
<td>8&quot;</td>
<td>11&quot;</td>
</tr>
</tbody>
</table>

Note: Minimum cavity is dependent on the width of the facade and the maximum depth that can be drilled into the backup material.

**Typical Performance**

Average of 20 tests

<table>
<thead>
<tr>
<th>Substrate Material</th>
<th>Compressive Strength (psi)</th>
<th>Pull Out Load (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering Brick</td>
<td>7250</td>
<td>1325+</td>
</tr>
<tr>
<td>Brick</td>
<td>3990</td>
<td>1127</td>
</tr>
<tr>
<td>Soft Brick</td>
<td>2465</td>
<td>818</td>
</tr>
<tr>
<td>Reinforced Conc.</td>
<td>7250</td>
<td>1105</td>
</tr>
<tr>
<td>Precast Conc.</td>
<td>3900</td>
<td>1150</td>
</tr>
<tr>
<td>CMU 13 Mpa</td>
<td>2175</td>
<td>600</td>
</tr>
<tr>
<td>CMU - LW</td>
<td>1015</td>
<td>398</td>
</tr>
<tr>
<td>Pavers</td>
<td>--</td>
<td>990</td>
</tr>
<tr>
<td>1&quot; Travertine</td>
<td>--</td>
<td>400</td>
</tr>
</tbody>
</table>

**Anchor Testing**

- Evaluates masonry capacity
- Directly evaluates retrofit options
- Must evaluate multiple substrates
In-Situ Testing – Pre-Construction

Testing of Veneer
Testing of Back-up

Testing of Installed Assembly
Testing of Various Anchors
Case Studies
Case Study – Historic Hybrid Wall

St. Louis, Missouri

Historic Hybrid Wall

- Transitional high-rise building
- Built in 1920s
- 15 stories tall
- Concrete framed structure
- In filled with clay tile and brick
- Brick cladding
- Terra cotta accents
Historic Hybrid Wall

Historic Hybrid Wall
Historic Hybrid Wall

Historic Hybrid Wall
Historic Hybrid Wall

Gravity Support
Cracked Corner Repair

Crack Stitching

Cracked masonry is best stabilized by bonding Helidor stainless steel rods into appropriate bed joints or cut slots. Tensile loads are redistributed along the masonry to minimize further developments of the crack which may occur with simple injection methods.

Benefits
- Quick, simple, effective and permanent
- Helidor and Heliflord joint to produce an excellent bond within the substrate
- Masonry remains flexible enough to accommodate natural building movement
- Non-disruptive structural stabilization with no additional stress

Points to Note

When cracks are less than 6mm in width, pastes are a better choice for repair. When cracks are greater than 6mm, a structural injection is required. Application of the correct range of injection products is necessary to ensure long-term durability.

Detail Elevation on East Elevation

Scale: 1/8" = 1'-0"
**Typical Helibeam Detail**

1. **STEP 1**
   - Grind or chisel to remove full mortar joint height to a depth of 1/2".
   - Brick surfaces must be totally free of mortar or other residue before installing grout. Remove all dust from slot and flush with water.

2. **STEP 2**
   - Provide damp or primed surface prior to installing grout.
   - Install first bead of Helibond cementitious grout, 3/8" thick.
   - Push first 4.5 mm helibar into grout to obtain good coverage. Provide min laps between helibars segments of 20".

3. **STEP 3**
   - Install second bead of Helibond cementitious grout, 3/8" thick.
   - Push second 4.5 mm helibar into grout to obtain good coverage. Stagger laps between 2 continuous bars.

4. **STEP 4**
   - Install final bead of Helibond cementitious grout and trowel smooth.
   - Leave ½" clear for pointing. Saturate joint and allow to surface dry before to pointing. Apply prehydrated mortar in ½" deep layers, tooling each layer after it is "thumbprint" hard.

*Scale: 3" = 1'-0"*
Supplemental Lateral Anchorage
Case Study – Thin Stone Veneer

Chicago, Illinois

Thin Stone Veneer

- Built mid-1970s
- 75 stories tall
- Reinforced concrete structure
- 3 cm Georgia Marble veneer
Thin Stone Veneer

- Bowing and strength loss of marble panels
- Supplemental lateral ties
- 16000 psi concrete backup

Thin Stone Veneer

Asymmetrical Ties?
Design Considerations

- Use data from in-situ testing to design stabilization/anchorage
- General spacing per BIA Tech Note 44B, but will need modification for wind loads and pullout values.
  - 16” x 24” or 16” x 16”??
- Safety Factor 4 or 5?
- Should we test assemblies?

Quality Control - Testing

- How many specify field testing of supplemental lateral anchors in the field during construction?
- Is there an amount that is acceptable?
  - A percentage?
  - One per elevation?
Case Study – Contemporary Brick Veneer

Chicago, Illinois

Contemporary Brick Veneer

- Built in 2002
- 3 stories tall
- Reinforced concrete structure
- CMU Backup
- Brick Veneer
- Cast Stone Accents
Contemporary Brick Veneer

- Missing ¾ of specified lateral ties
- Those installed not engaged

Contemporary Brick Veneer

- Lateral ties – WRB?
Case Study – Contemporary Stone Veneer

Blacksburg, Virginia

- 6" rough-cut stone
- 10" CMU
- 1-3/8" air cavity
- 2" rigid insulation
- Dampproofing
Specified metal tie system

Drypack setting material

Drypack in collar joint

2" insulation

CMU w/ dampproofing

Improperly installed metal ties

Before After
- Lateral anchorage
  - Capacity of retrofit anchors in bed joint (480#, 16" o.c. Ea. Way)
**Conclusion**

- When is post-installed veneer anchorage necessary?
- How can we determine the “best” anchor for the conditions?
- How do we obtain values for assemblies that are not published?