OLD MEETS NEW

Westford Symposium on Building Science

July 31, 2017

Presented by: JD Stenner, Superintendent, United Building Envelope Restoration

Pyramids at Giza, completed ca. 2560 BC
photo credit www.nationalgeographic.com

Maison Carrée, Nimes, France completed 2 AD
photo credit www.ot-nimes.fr

Bodiam Castle, East Sussex, England, ca. 1385
photo credit www.britainirelandcastles.com

Old State House, Boston, 1713
photo credit www.amazedesign.com

FBI Building, Washington, DC, 1975
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Historic Masonry Building Technology: **Stone**

- **Quarrying**
  - **Traditional techniques include driving wedges to split stone**
  - **Early 19th century: Gunpowder and dynamite**
  - **Late 19th century: Pneumatic tools introduced**
  - **Modern techniques include diamond drills and saws**

- **Tooling & Finishing**
  - **Stones traditionally shaped/squared with hand tools. Multiple decorative techniques for finishing the face**
    - **Rockface surface**
    - **Bush hammering**
    - **Smooth finish**
    - **Drafted margins**
    - **Honed or polished**

- **Softer stones, such as marble and sandstones, typically used for decorative carving**

Indiana Limestone Quarry
photo credit http://images.indianahistory.org

Stone Mason
photo credit https://commons.wikimedia.org

Historic Masonry Building Technology: **Brick**

- **Most of US building stock constructed before 1875 is from hand-molded brick**
  - **Irregular shape and surface texture from hand pressing into wooden or metal molds**

photo credit www.monarchstoneinternational.com

- **Pressed brick emerged around 1875**
  - **Smooth, regular brick sometimes with "frog" in top often bearing manufacturer's name**

photo credit https://calbricks.netfirms.com

- **Extruded brick become most common method in the early 20th century**
  - **Extruded through die for very regular and standardized brick. Variety of textures possible with this method. Sometimes cored.**

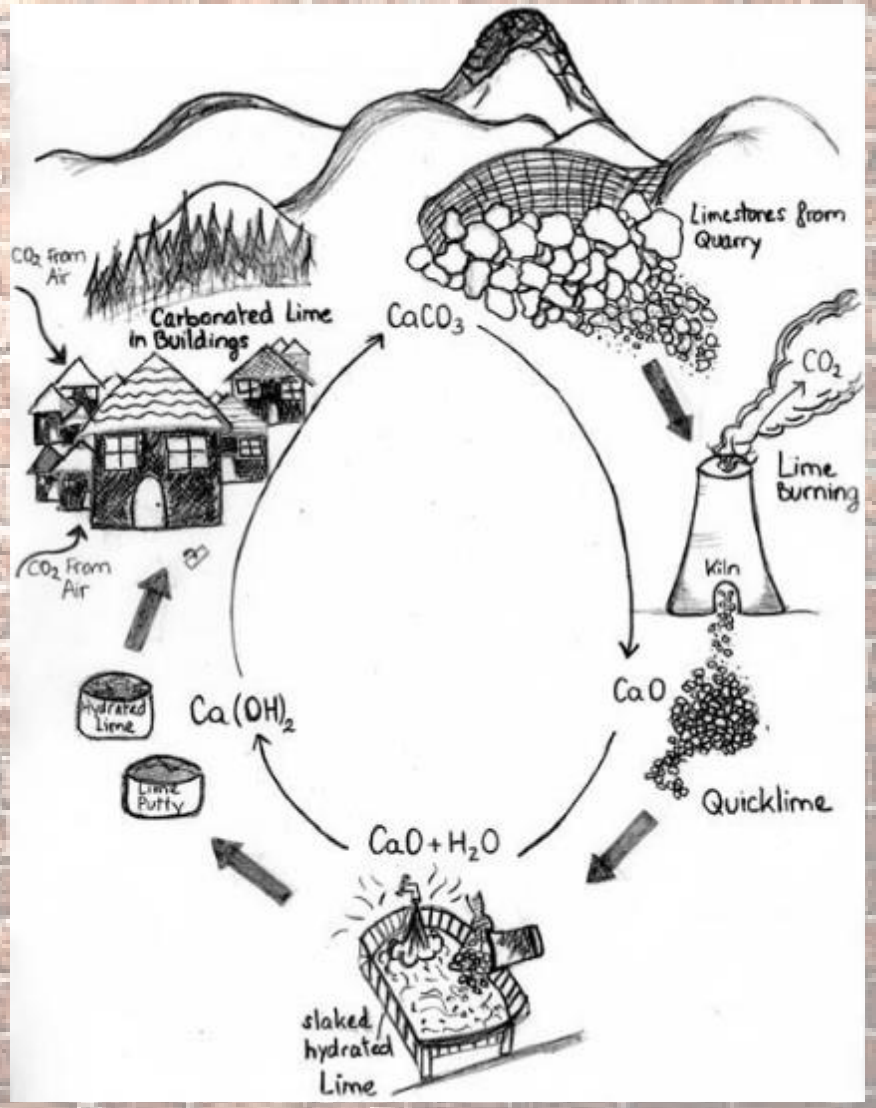
photo credit http://wienerberger.co.uk

Historic Masonry Building Technology: **Brick**

Early 20th century beehive kiln, Occoquan, VA
photo credit http://www.panoramio.com

Historic Masonry Building Technology: **Traditional Mortars**

- **Oldest masonry buildings composed of simple lime and sand mix.**
- **Properties of lime mortars**
  - **Slow to set. Sets through carbonation (CO2 from air)**
  - **Lower compressive strength than brick or stone that it bonds. Acts as the sacrificial component of the wall**
  - **Lime mortar is porous and "breathable." High permeability allows moisture to evaporate easily from mortar rather than getting trapped within masonry.**
  - **Self-healing: where cracks are formed due to movement in the masonry are resealed over time due to chemical reactions of lime**



credit www.biolime.com

Historic Masonry Building Technology: **Traditional Mortars**

- **Portland cement was patented in England in 1824.**
- **In the early 1870s, the first Portland cement was manufactured in the US but was not widespread until the early 20th century.**
- **Rosendale cement overlapped with production of Portland cement**
- **1930s: Masonry cement is invented**
- **Properties of Portland cement**
  - **High strength**
  - **Low Permeability**
  - **Fast setting time**
  - **Ability to set under water**

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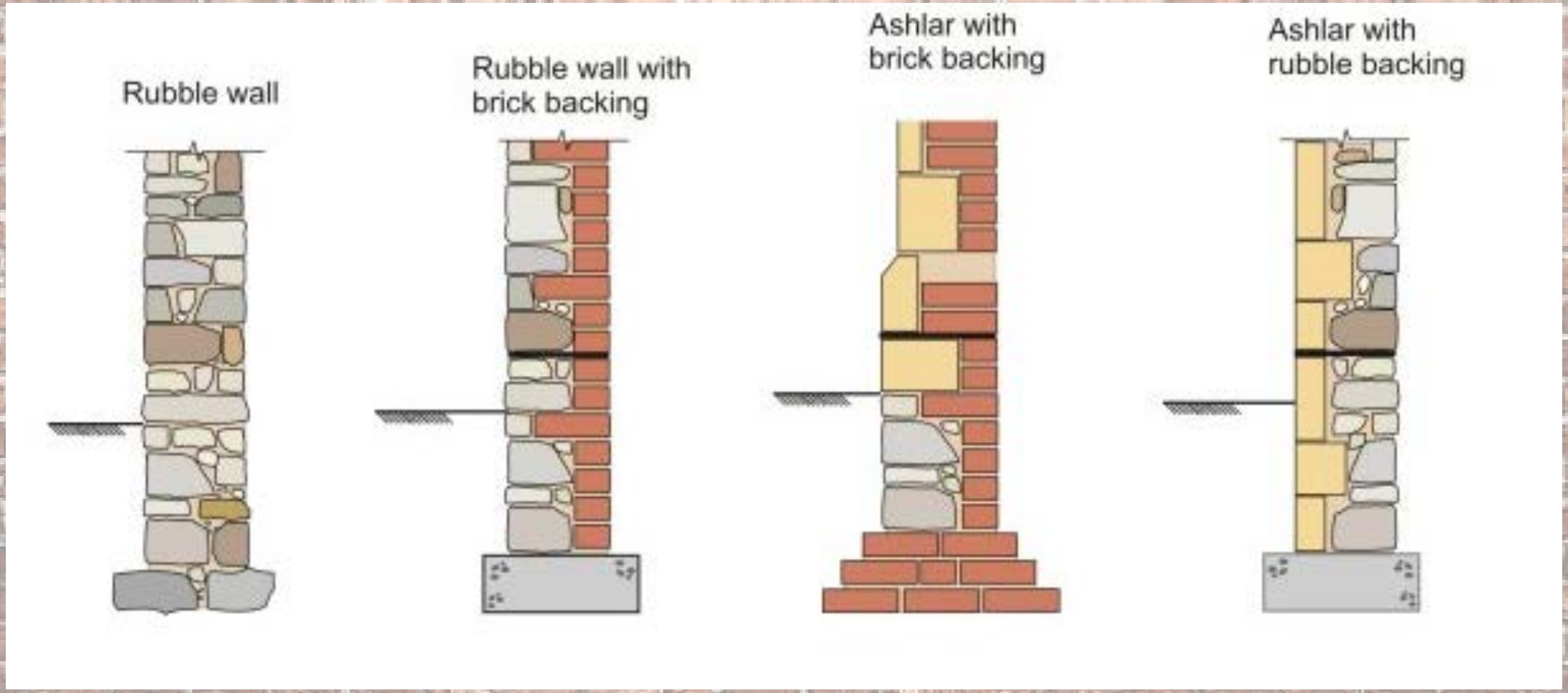
Masonry Wall Types: **Stone**



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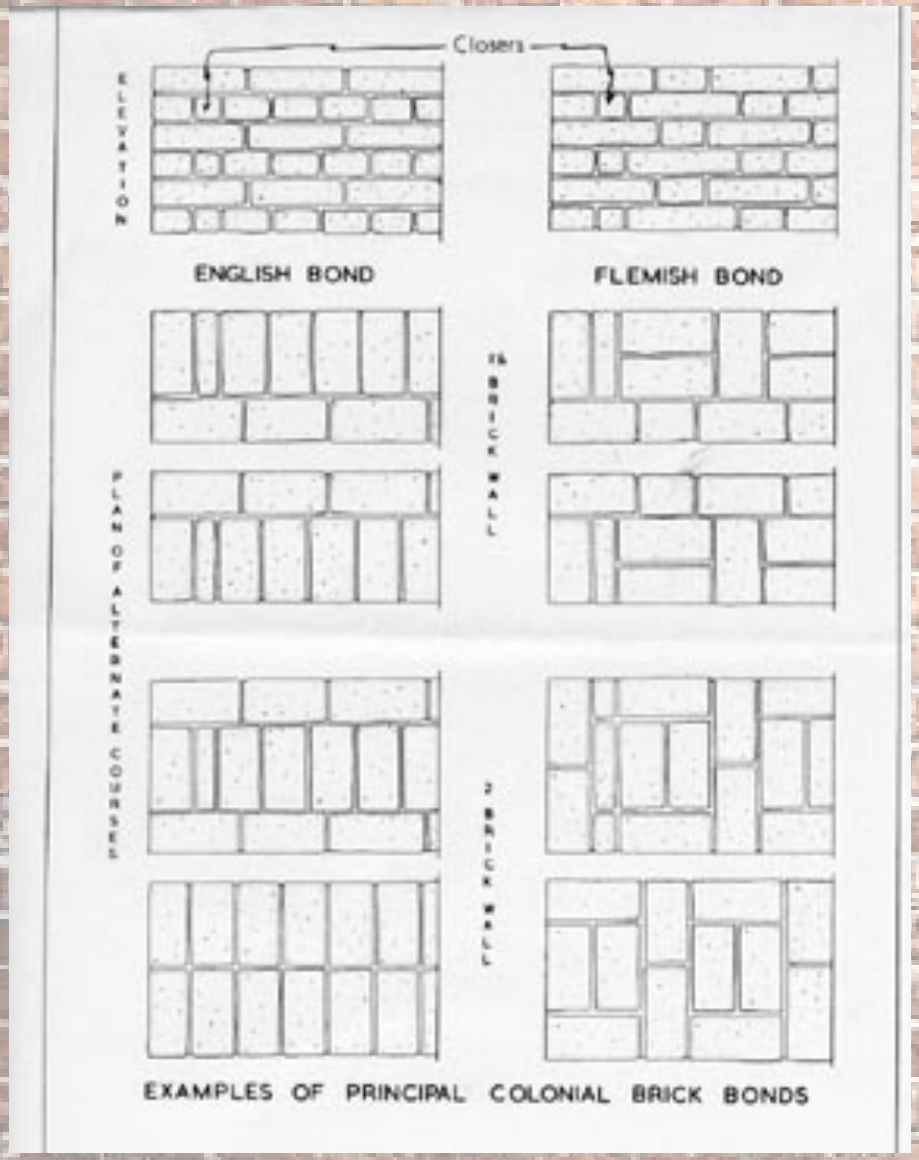
Masonry Wall Types: **Brick**



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Characteristics of Traditional Masonry Construction

- **Thick, load-bearing walls constructed of porous materials that absorb moisture from the outer surface and release it gradually through evaporation before it enters the buildings interior**

- **Detailing including drip edges, sloped surfaces, water tables, copings, etc. served to shed water and direct it away from vulnerable areas.**

- **Soft, lime-based mortars that are permeable to allow moisture to escape through the joints and are self-healing**

- **Non-rigid building materials allow movement and thermal expansion/contraction without cracking**

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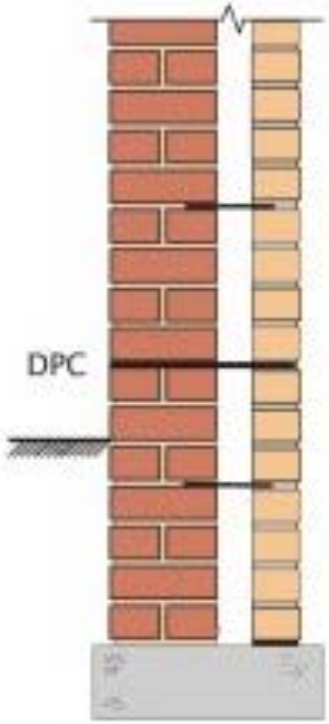
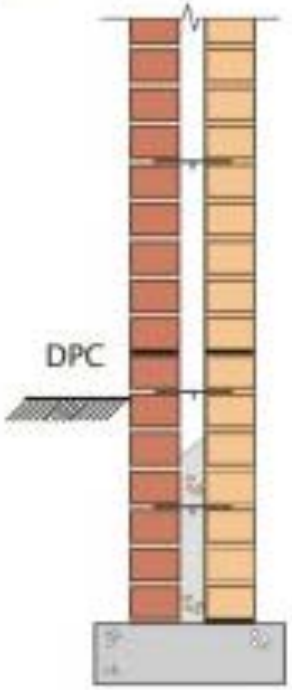
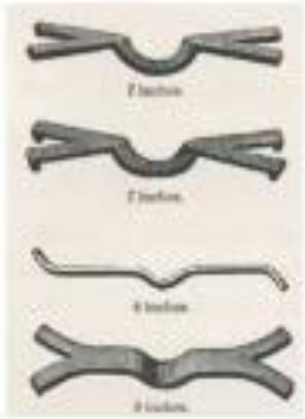
Masonry Wall Types: **Cavity Wall**

Two examples of early cavity walls





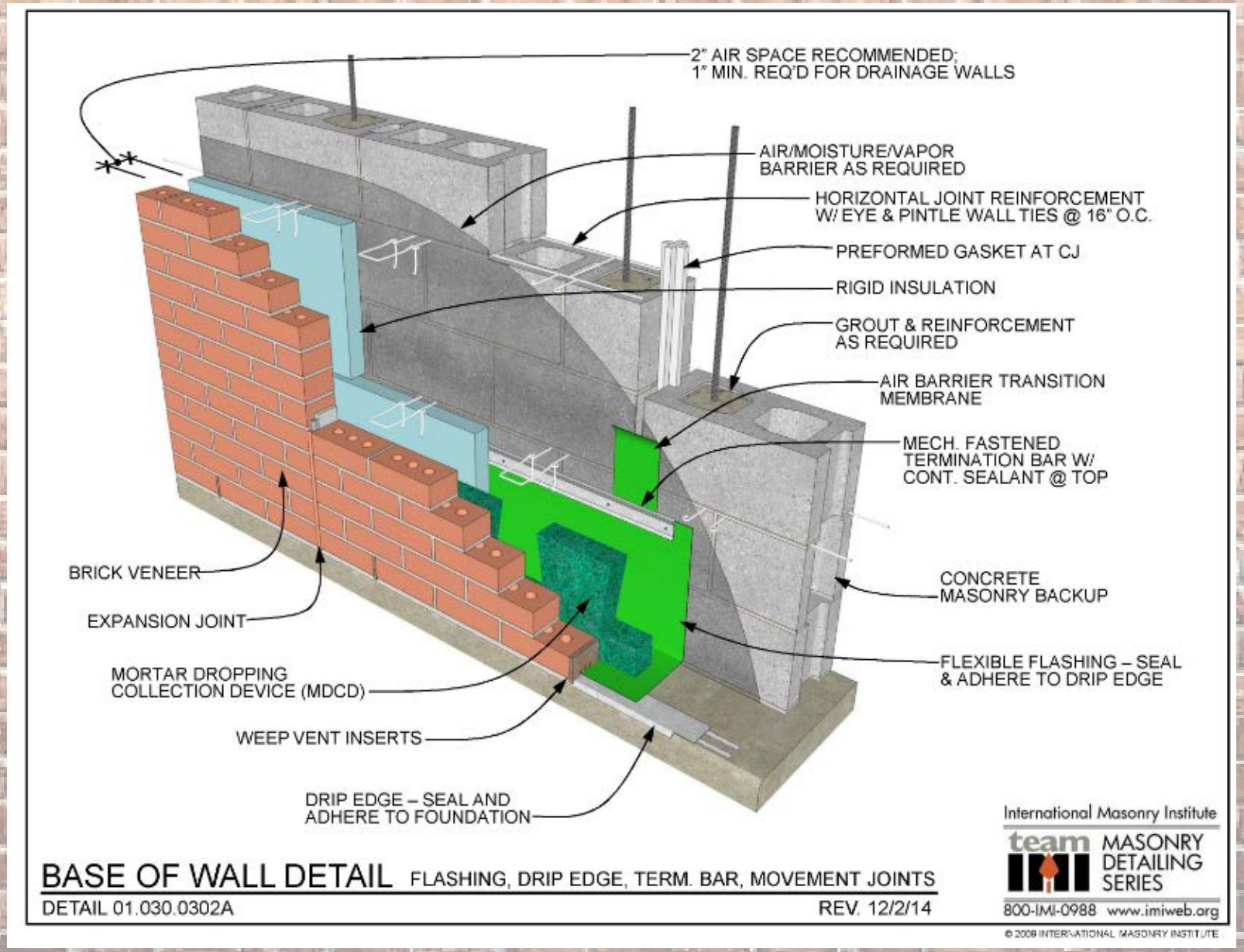


Ties from the late 1890s.
The top two are cast iron,
the bottom two wrought iron

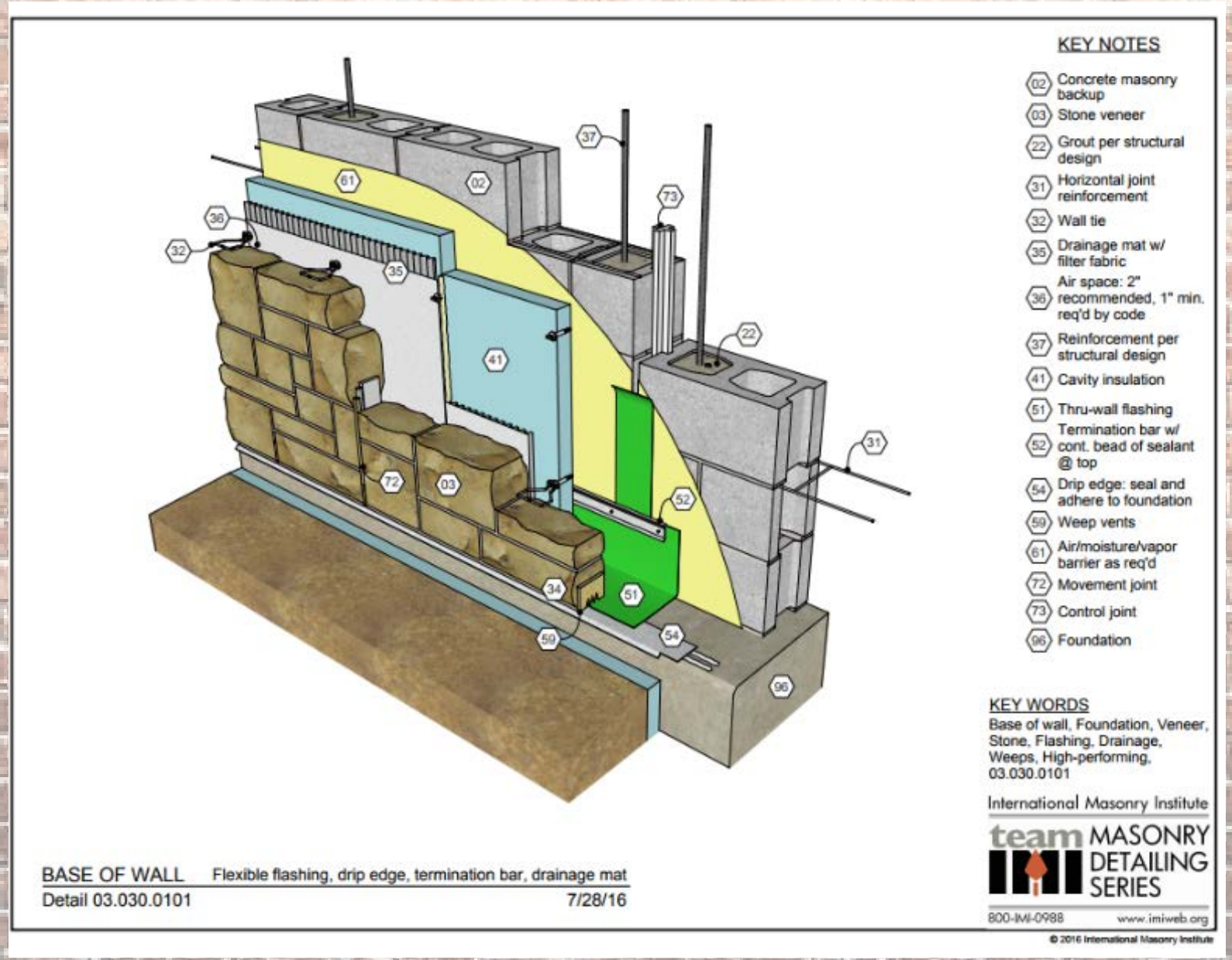
Galvanised steel ties
from the mid1920s.

credit https://fet.uwe.ac.uk

Modern Masonry Construction



Modern Masonry Construction



Characteristics of Modern Masonry Construction

- **Thin walls made of multiple, prefabricated components**
- **Modern bricks are harder than historic bricks and tend to crack easier.**
- **Impermeable materials. Focus on keeping water out of wall through moisture and air barriers, cavity walls, flashing, impermeable sealants, etc.**
- **Focus on insulation for thermal efficiency, whereas thickness of load-bearing masonry wall provided thermal efficiency**
- **Rigid, hard materials that do not absorb movement/expansion & contraction. Results in need for expansion joints to prevent cracking.**
- **Polymer sealants often replacing mortar for sealing joints**
- **Hard, impermeable Portland cement mortars with additives**
- **Flat roofs become more common**
- **Modern systems to simulate tradition materials, such as EIFS and fiberglass panel to replace stucco and cast stone and other man-made materials to replace natural stone**

Common Failures in Modern Masonry Construction

- **Corrosion of veneer ties and other steel elements leads to rust jacking, cracking, water infiltration, and even structural failure of outer wythe of cavity wall**
- **Complex systems with multiple materials with different rates of expansion and contraction**
- **Stone veneers installed as thinly as possible, often leading to warping and failure of the material**
- **Water intrusion at overlapping flashing/sealant interfaces**
- **Polymers and synthetics that do not hold up to UV radiation**
- **Failures of reinforced concrete including corrosion of reinforcement and deterioration due to alkali-aggregate reaction**
- **Failures of modern materials that do not have the durability of traditional masonry materials**

Case Studies in DC: Smithsonian Air & Space Museum

photo credit www.ncpc.gov

Case Studies in DC: National Gallery of Art

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Failures in Modern Masonry Construction

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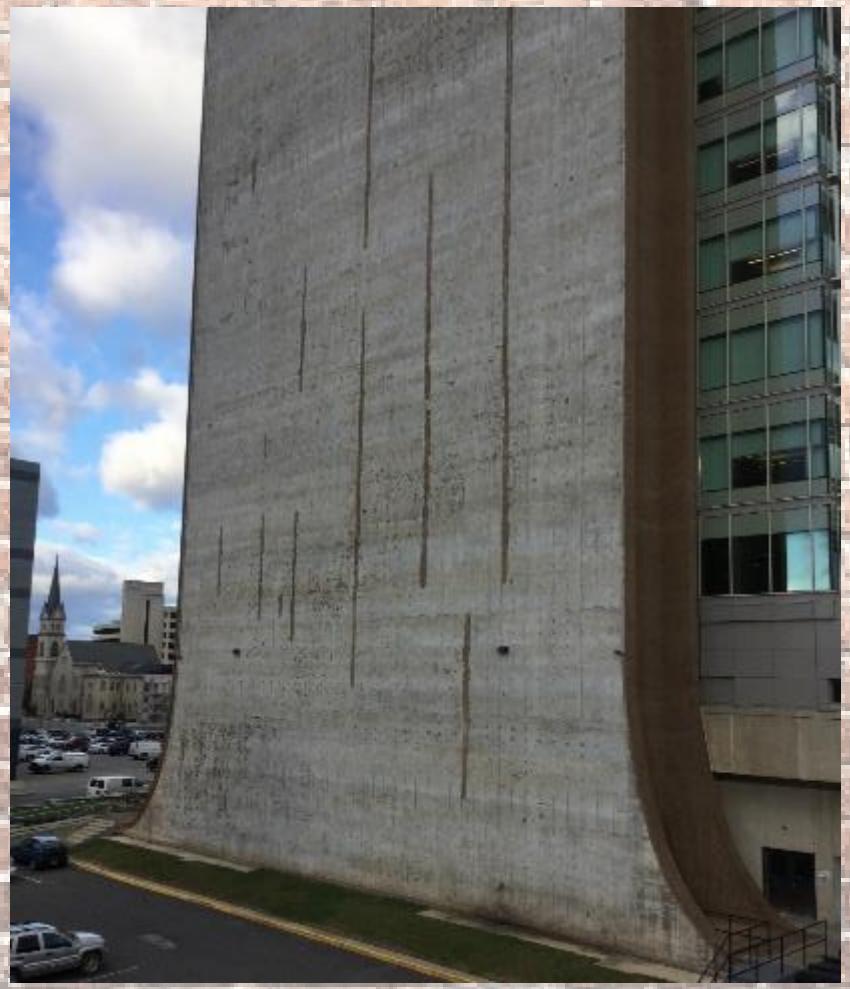

Improper Repointing

- **Improper repointing of historic masonry can cause both visual and physical damage to a building**
  - **Freeze thaw damage**
  - **Efflorescence**
  - **Spalling of masonry units**
  - **Inconsistent appearance**
- **Avoid Portland cement-based mortars**

photo credit www.nps.gov

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Appropriate Repointing

- **Match existing mortar in terms of physical characteristics and appearance**
- **Perform mortar analysis create samples/mockups**
- **Tool joints to match historic profile**
- **Follow proper curing techniques required for lime mortars**

Stone Repair: Dutchman

Stone Repair: Dutchman

Stone Repair: Patching

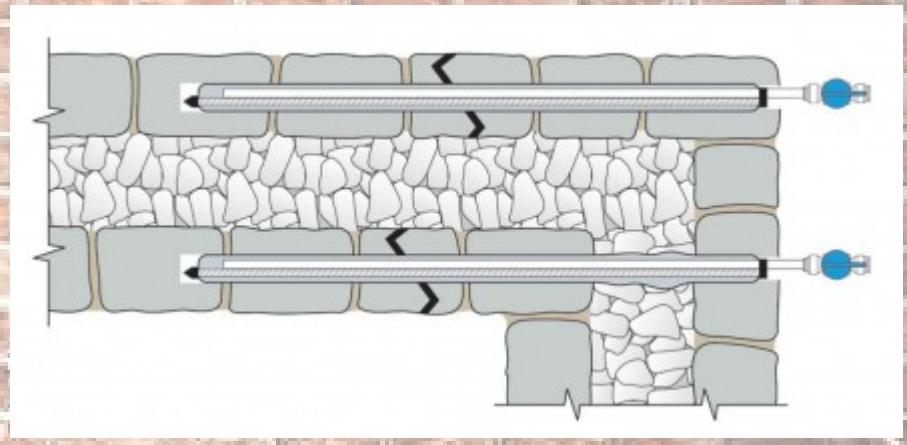
Structural repairs: Grouting, Pinning, and Underpinning

- **Structural wall repairs include pinning and structural grouting to fill voids in masonry and reinforce unstable masonry due to seismic damage, deterioration, etc.**

- **There are a number of stainless steel ties on the market to stitch cracks, tie bulging walls, tie wythes together, tie veneer wall to backup wall, etc.**

- **Grouting to fill voids in walls (multiwythe masonry or rubble) should be performed with a grout that is compatible with the historic material and not too rigid. Sock anchors can be useful for additional pinning and to contain grout.**

- **Historic masonry walls experiencing distress due to settlement can be underpinned to provide additional support to foundation**



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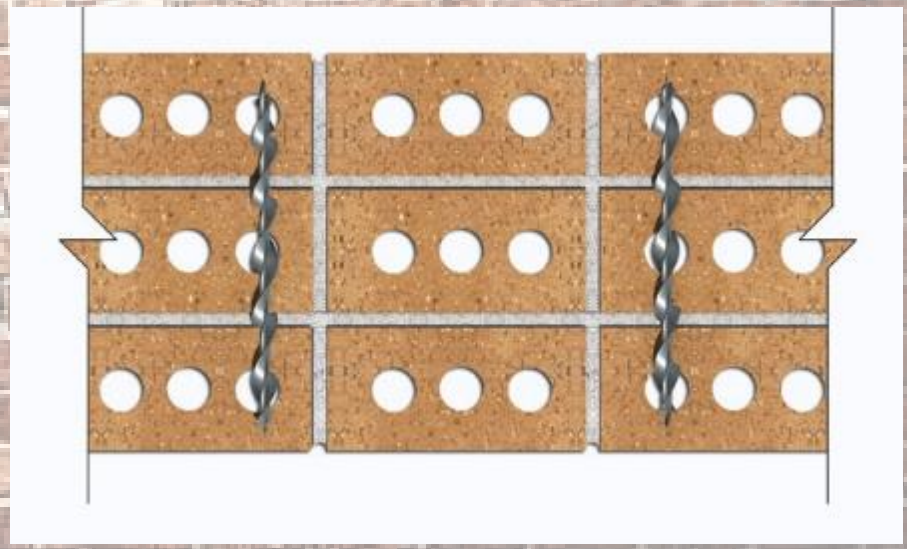

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Modern Materials and Historic Preservation

- **Retrofitting the interior with modern insulation and vapor barriers in historic masonry buildings can cause moisture damage.**
- **Paints and waterproof coatings, even those that are marketed as "breathable" should be avoided where possible.**
- **Modern masonry cleaners should always be tested prior to application.**
- **Modern mortars can be very harmful to historic masonry.**

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THANK YOU

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