OLD MEETS NEW

Westford Symposium on Building Science

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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
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

- Pressed brick emerged around 1875
  - Smooth, regular brick sometimes with “frog” in top often bearing manufacturer’s name

- 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.
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
Masonry Wall Types: **Stone**

credit https://tet.uwe.ac.uk
Masonry Wall Types: **Brick**

credit http://nautarch.tamu.edu
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 building's 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.
Masonry Wall Types: **Cavity Wall**

Two examples of early cavity walls

Two examples of early cavity walls

DPC

DPC

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

Galvanized steel ties from the mid-1920s.

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

photo credit www.dezeen.com

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Failures in Modern Masonry Construction
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
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.
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.

Photo credit https://www.nps.gov/tps/
THANK YOU

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