Durability Principles and Lessons Learned from the Hands-on Study of Historic Building Envelope Details

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Green Design and Historic Preservation:
Exploring the Building Envelope
AIA CES Learning Objectives

Outline of Lecture:

1. Analyze how time-proven traditional construction details succeed technically, and are durable.
2. Understand traditional construction principles for managing water on facades and windows, promoting durability.
3. Evaluate and choose natural materials wisely for their long-term durability, and hence their sustainability.
4. Learn to recognize and minimize the inherent vulnerabilities in construction details.
Durability Principles and Lessons Learned…

Outline of Lecture:

• Introduction
• Concept of Architectural Darwinism
• Exegeses of Some Specific Construction Details
• Some General Principles of Durability Derived
• Closing

Questions and Answers, Discussion
Introduction – Durability and Sustainability

- **Durability is fundamental to sustainability**
- **Sustainability advantages of durable buildings that last centuries**
  - Massive embodied energy savings of one durable building over several replacement buildings
  - Reduce landfill from demolition debris from numerous replacement buildings

Villa Medici, Rome (c. 1544)
Palazzo Braschi, Rome (c. 1790)

The Greenest Building (NTHP)
Intro - Opening food for thought

• Which is the more logical, durable way to build?

• What does your intuition tell you?

• Which answer would a study of historic precedent suggest?
Intro – My Durability Research Project in Rome

• My work in U.S. - bldgs span 200 yrs.
• My project in Rome – bldgs span 2,000 yrs.
  – different climate,
  – different construction

On Borromini’s Oratorio dei Filippini (c. 1640)
Early archival photo of AAR Fellows
Intro - Need for this research in Historic Preservation (Analysis before intervention)

- **Teaching and Research In Preservation**
  - Much at the micro scale
  - Much at the macro scale
  - **Not enough at the intermediate scale**
Intro – Need for this research in both Historic preservation and contemporary architecture

• Most building envelopes and structures actually succeed or fail at the intermediate scale
  – By better understanding how details and designs work technically, we can better understand how to preserve or design these buildings
Overwhelming need for this research in contemporary Architecture

- Current durability crisis in Architecture - pandemic of enclosure failures
  - High-end to low-end
  - Renowned to unknown architects
  - East Coast to West Coast
  - Many failing immediately

Highland District Hospital, Hillsboro OH

EIFS (“synthetic stucco”) houses in the S.E. USA
Intro - Need for this research-in contemporary Architecture

- Current crisis of durability in Architecture - pandemic of enclosure failures
  - High-end to low-end
  - Renowned to unknown architects
  - East Coast to West Coast
  - Many failing immediately
Intro - Need for this research in contemporary Architecture

• Why the crisis in durability?
  – Despite decade-long emphasis on sustainability?

• Among the reasons:
  – Aesthetic innovation forces innovation in detailing
  – Possible, but not easy, to get it right the first time
  – BUT – we are forgetting fundamental, proven principles of designing for durability

Early 20th c. house, Winchester, MA

Gropius House, Lincoln MA, 1937
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Roof Eave Detail
Roof Overhang to Shelter Walls

- Ancient principle, sometimes forgotten
- Protect walls from water run-off, making walls more durable (tufo giallo at left)
- Line of erosion in the sidewalk at right
Roof Eave Details

- Common detail in Rome
- HIGHLY evolved form
  - Functional, structural, architectural are integrated
  - A masterful symphony

Casa di Dante, Rome (Trastevere)
Roof Eave Details

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Casa di Dante, Rome (Trastevere)
Roof Eave Detail
“Decorative” End Cuts in Exposed Wood Framing

• Functional - not decorative
• Reduce exposure of end grain to the weather
• Create multiple drip edges
• Reduce deterioration of exposed wood

Casa de Salone Nero, Ercolano Scavi (1st c. A.D.) – original wood end cut (left), and restored (right)
Roof Eave Details

- Even the dimension of the clay tile overhang is highly evolved!

Palazetto Cenci, Rome (16thc.)

Casa di Dante, Rome (Trastevere)
Roof Eave Detail
Clay Tile Roof Overhang Dimension

- **Acumulated wisdom:**
  - 3 cm (1-1/4”) – too short
  - 12 cm (4-3/4”) – too long
  - 7 cm (2-3/4”) – perfect! (Comon’s experience)

7 cm (2-3/4” inch) clay tile overhang, Palazzetto Cenci

Palazzetto Cenci, Rome (16thc.)

Foreman Comon
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General Principles of Designing for Durability

Principles:
• Water Management is paramount – «Shed and Shelter»
• Put each material in a position to succeed
  – Extrapolation: The primary building/structure form should be heavily influenced by the two principles above
• Durability of an individual building component should be proportional to the consequences of failure
• Recognize inherent vulnerabilities in a design, and then design to minimize exposure & susceptibility to them
  – Corollary: Accept that weathering and material degradation are inevitable, and design in a «Plan B» to avoid catastrophic failure
Principles of Durability-Enclosure Form-finding

- Which is the more logical, durable way to build?

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Inverted Stepped pyramid

Stepped pyramid
Principles of Durability-Enclosure Form-finding

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• Which is the more logical, durable way to build?
Principles of Durability-Enclosure Form-finding

- Inverted stepped pyramid
- Not a new modern idea

Inverted Stepped pyramid

Paul Revere House (1680-83) Boston
Principles of Durability-Enclosure Form-finding

- Inverted stepped pyramid
- Not a new modern idea

19th and early 20th c. houses in suburban Boston
Principles of Durability-Enclosure Form-finding

• Inverted stepped pyramid
• Not a new modern idea
  – How and why it works

Early 20th c. house in suburban Boston
Principles of Durability-Enclosure Form-finding

• Inverted stepped pyramid
• **Not** a new modern idea
  – How and why it works
  – Shed and Shelter

15th c. cottage, Sussex England (John Fidler photo)

Wattle and daub panel on 16th c. Shakespear’s House, England (John Fidler photo)

Early 20th c. house in suburban Boston
Principles of Durability-Enclosure Form-finding

- Inverted stepped pyramid
- **Not** a new modern idea
  - Also precedents in masonry (though less common)

Venice streetscapes

Renaissance-era building, Venice
Principles of Durability-Enclosure Form-finding

• Other ways to shed and shelter
  – Variations on a theme

The Pantheon, Rome (124-126 A.D.)

Cornice projection strategy
Principles of Durability-Enclosure Form-finding

• Other ways to shed and shelter
  – Variations on a theme

Shedding strategy

Basilica Palladiana, Vicenza, 16-17th c. (Palladio, et al)
Principles of Durability-Enclosure Form-finding

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Principles of Durability-
Water, Water, Water – Manage Water

• Critical - even in climate with no freeze/thaw
• Shed and Shelter
  – Overall facade forms
  – Roofs
  – Roof overhangs on walls
  – Window hoods
  – Window sills
  – Ledges, bandcourses
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Principles of Durability: Put Each Material in a Position to Succeed

- It’s NOT about using all the best materials, everywhere
- It is about making smart choices, to allocate limited resources wisely:
  - Limited materials
  - Limited budgets

Succeed: The stones of Ercolano ("Herculaneum"), basalt, tufo rosidis, tufo giallo, pre-79 A.D.
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Fail: The peperino of Palazzo Chiovendo, Rome (16th c)
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Succeed and Fail: Ext. and Int. Walls of Palazzo Braschi, Rome (c. 1790)
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Succeed: Bernini’s colonnade (1556-67) at St. Peter’s, the Vatican, Rome
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Principles of Durability: Durability of a Material or Component

Durability should be proportional to:
- Difficulty to inspect it
- Difficulty to replace it if it fails, and
- Consequences of Failure
  • Note: These often conflict with typical approach to «value engineering»

Corroded door hinge, Legnaia, Villa Doria Pamphilj, Rome (c. 1690)
Door Hinge, Natatorium, Foro Italico, Natatorium (1937) Rome
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Marble column and architrave, and bronze dowel and strap, Ercolano (pre 79 AD)
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Principles of Durability: Recognize and Minimize Inherent Vulnerabilities

- Even good designs will have some inherent vulnerability
- Keys are to:
  - Learn to recognize them, then
  - Design to minimize your susceptibility to them

Succeed: Luigi Moretti’s ex-GIL (1933), Rome (Trastevere section)
Principles of Durability: Recognize and Minimize Inherent Vulnerabilities

Two buildings, same period, same concept of glass block and concrete skylight

- Moretti’s ex-GIL building (1933) minimized the vulnerability
- Del Debbio’s ex-Foresteria Sud (c. 1933) did not...

Fail: Enrico Del Debbio’s ex-Foresteria Sud (c. 1931-33), Foro Italico, Rome

Succeed: Moretti’s ex-GIL (1933), Rome
General Principles of Designing for Durability

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Principles of Durability: Deterioration Happens - Design-in a “Plan B”

• Expect Inevitable Weathering and Degradation

• Design in a “Plan B” (fail-safe) to Avoid Major Failure
  – Here, alternate load path if (when) mortar erodes

Nickerson House, Dedham Ma (built by Norcross Bros. to HH Richardson inspired design by Shepley Rutan and Coolidge, 1870's)

Vernacular construction, Tuscan village – stones in wall are “chinked” (shimmed)
Principles of Durability: Deterioration Happens - Design-in a “Plan B”

- Expect Inevitable Weathering and Degradation
- Design in a “Plan B” (fail-safe) to Avoid Major Failure
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Vernacular construction, Tuscany

Hampden County Courthouse, Springfield MA (1872) – each stone in wall shimmed with slate. (HH Richardson design, Norcross Bros construction)
Principles of Durability: Deterioration Happens - Design-in a “Plan B”

• Expect Inevitable Weathering and Degradation, and
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Miamus River Bridge, I-95, Greenwich CT

Fail  (1983 catastrophic failure, 3 fatalities)

Fail
Succeed
Pinned suspended span  Cantilevered span
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• Closing
Closing Thoughts from Vitruvius

- Told us what qualities a building MUST have to be considered architecture
  - He set the bar high

Later (1684) depiction of Vitruvius presenting De Architettura to the Roman Emperor Augustus

*De Architectura*
(The Ten Books”)

“Vitruvian Man” illustr. by Leonardo da Vinci

Later (1684) depiction of Vitruvius presenting De Architettura to the Roman Emperor Augustus
Durability of Architecture: Closing

Vitruvius told us:

• **ALL buildings, whether:**
  - Public or private
  - Residential, civic, or utilitarian

• **MUST** have all three qualities to be architecture
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American Academy in Rome:
Questions and Answers, Discussion

• This concludes the AIA CEUS program

• Please take a handout (it includes):
  – Principles of Designing for Durability
  – Further reading,
    • A few favorite references on historic details
    • Some papers on durability
  – Address of my Rome blog http://vitruviusfootsteps.wordpress.com/
  – My contact info (feel free to call or e-mail me):
    mbbronski@sgh.com  tel: 781-907-9000

• Your Questions?
Exegeses of Three Common Construction Details

• Very common, traditional forms in Rome
  – Break them down, really understand how they work
Window Surrounds

Typical Renaissance style window:
- surrounds well-designed for water management
- Integrated design (waterproofing, durability, structural, aesthetics)

Palazzo Braschi, Museo di Roma (1790, neo-Renaissance style)
Window Surrounds

Structural

- Scroll brackets are structural
- Note wall thickness below sill

Palazzo Braschi, Museo di Roma (1790, neo-Renaissance style)
Window Surrounds

Water management

- Shed and shelter
- Note scroll bracket locations

Palazzo Braschi, Museo di Roma (1790, neo-Renaissance style)
Window Surrounds - Hoods

- Window hoods need to shed water, like a roof, to avoid leakage and deterioration.
- Flat-topped window hoods like the one at right were repaired to shed water, and on later buildings, often evolved to (below left).

Evolved, concave sloped window hood form

Palazzo Carpegna – deteriorating flat peperino stone window hood capped with sheet metal flashing at right (front façade), and flat topped travertine window hood was sloped with mortar topping at left (courtyard).
Window Surrounds - Sills

Water management
- Compare water flow at A vs. B
- Compare wall thickness at A vs. B
- Why stone below sill?
- What design magic happens at sill?

Palazzo Braschi, Museo di Roma (1790)

Leakage, deterioration at sills, Castello Theodoli (10-12th c.)
Window Surrounds - Sills

Water management – design challenge at sills

– How the design magic happens at the sill
– Sill below has extraordinarily well-designed internal and external troughs (original)

Palazzo Braschi, Museo di Roma (1790, neo-Renaissance style) – double drainage troughs at sill
Window Surrounds

Reminder of a big point throughout:
- Do NOT need to imitate, but
- DO need to learn the lessons and principles

Palazzo Braschi, Rome (1790)
Principles of Durability: Recognize and Minimize Inherent Vulnerabilities

Terraces over occupied space

• Minimize vulnerabilities
  – Get the water off quickly
  – Minimize ingress
  – Moisture-tolerant interior conditions
    • Interior finishes
    • Less sensitive occupancies

Fail: Thousand Oaks Civic Arts Plaza (Antoine Predock, 1991), Los Angeles area
Principles of Durability: Recognize and Minimize Inherent Vulnerabilities

Terraces over occupied space

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  – Get the water off quickly
  – Minimize ingress
  – Moisture-tolerant interior conditions
    • Interior finishes

Succeed: Triangolo Barberini, Subiaco area, (1640’s, Contini)