MCC August Symposium

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minnesota concrete council
Dedicated to Cast-in-Place Concrete

Avoiding Common Oversights in the Design and Construction of Mid-Rise Wood-Framed Buildings

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Learning Objectives

1. Develop an awareness of common detailing and construction problems
2. Understand considerations necessary to minimize risk of water infiltration
3. Recognize potentially problematic details
4. Understand potential repair approaches

Presentation Overview

- Mid-Rise Wood Frame Construction
- Brick Veneer Expansion
- Wood Frame Shrinkage/Settlement
- Water infiltration through brick veneer
- Cladding interfaces
  - Horizontal, Vertical, and Penetrations

Mid-Rise Wood-Frame Buildings

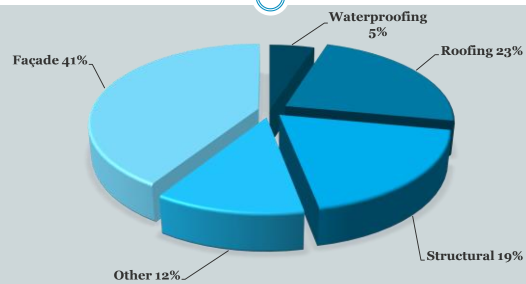
- 4 to 6 stories in height
- Multiple stories of wood framing often on elevation concrete “podium.”
- A fully sprinklered building (NFPA 13 or 13R) allows higher heights/ additional stories
- Construction type falls below threshold of high-rise construction

Mid-Rise Wood-Frame Buildings

Mid-Rise Wood-Frame Buildings

- Why Mid-Rise Wood-Frame Discussion?
  1. Increasing number and significance of problems
  2. Critical design details often left up to contractor
  3. Lack of understanding and/or regard for potential differential movement

Sources of Construction Claims



Brick Veneer - Overview

- Height limitations
- Moisture/temperature expansion
- Wood frame shrinkage/settlement
- Differential movement
- Water infiltration

Height Limitations

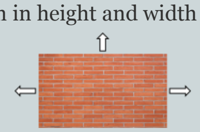
Height Limitations

- IBC* Height Limitations
  - 30 ft. height limit
  - Greater than 30 ft. using alternate design approach

* IBC Chapter 14, Sections 6.1 and 6.2 of TMS 402/ACI 530/ASCE 5

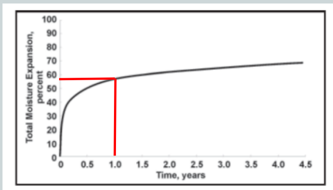
Moisture Expansion

- Brick expand when exposed to moisture
- Irreversible
- Growth in height and width



Moisture Expansion

Moisture expansion vs. time



Moisture Coefficient

ACI 530-05/ASCE 6-05/TMS 602-05 Bldg. Code Requirements for Masonry Structures	$K_e = 3 \times 10^{-4}$ in/in
BIA Technical Note 18, 2006	$K_e = 5 \times 10^{-4}$ in/in
Masonry Designers Guide, TMS 2003	$K_e = 4$ to 9×10^{-4} in/in

K_e	Expansion in 10 feet
3×10^{-4} in/in	≈ 1/32 inch
4×10^{-4} in/in	≈ 3/64 inch
5×10^{-4} in/in	≈ 1/16 inch
9×10^{-4} in/in	≈ 1/8 inch

Temperature Expansion

ACI 530-05/ASCE 6-05/TMS 602-05 Bldg. Code Requirements for Masonry Structures	$K_t = 4 \times 10^{-6}$ in/in/°F

Temperature Change	Expansion in 10 feet
50°F	≈ 1/32 inch
100°F	≈ 3/64 inch

Moisture/temperature Expansion

Type of Movement	Movement, in. per floor
Irreversible expansion due to moisture*	≈ 1/32
Thermal expansion*	≈ 1/32
Total	≈ 1/16

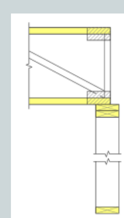
*Using code coefficients and ΔT = 70F

Wood Frame Movement

- Vertical movement
  - Wood frame shrinkage
  - Wood frame settlement

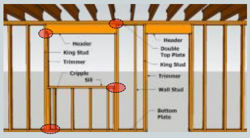
Shrinkage

- Primarily wood plates (3)
- Truss chords (2)
- Moisture content change



Settlement

- Settlement from closing of gaps at stacked wall components
- Occurs when loads increase



Settlement

Wood Frame Shrinkage and Settlement

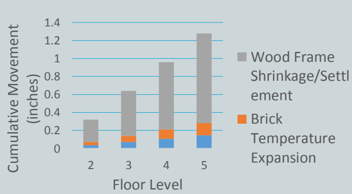
Framing system	Description	Movement in. per floor
1	I-Joists and wall framing at or below 19 percent	0.25
2	I-Joists and wall framing greater than 19 percent	0.375 to 0.5
3	Solid-sawn joists	0.5 to 1.0

Reference: Martin, Z., Anderson, E., Multi-Story Wood-Frame Shrinkage Effects on Exterior Deck Drainage: A Case Study, Wood Design Focus, v. 20, n. 3, Fall 2010, p. 6-11.

Differential Movement

- Results from:
  - Moisture/temperature expansion of brick (+)
  - Wood frame shrinkage and settlement (-)
- Is cumulative
  - Greatest movement occurs at highest floor level

Differential Movement



Differential Movement

- Analysis of wood shrinkage > 2 floors and roof
  - IBC section 2304.3.3
- Also*:
  - Design and detail the veneer to accommodate differential movement
  - Max. 1-in. air space for corrugated veneer ties
  - Min. 1-in. air space for other anchors

*IBC 1405.6 – 6.1 and 6.2 of TMS 402/ACI 530/ASCE 5

Differential Movement

- Potential problems*
  - Sealant failures (window head, jambs)
  - Cracking, displacement of brick at horizontal interfaces
  - Back-pitched flashing
  - Water infiltration
  - Deformed, disengaged brick tie anchors
  - Crushing at window sills

*Generally avoided with C.I.P. concrete construction

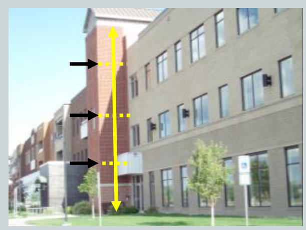
Differential Movement

- Reducing problems
  - Anticipate/accommodate a reasonable amount of differential movement
  - Provide slip joints in horizontal flashings*
  - Provide clearance at all items attached to frame*
  - Use brick tie anchors with movement capacity*
  - Accommodate movement at window sills*
  - Expect sealant failures*

Differential Movement

- Reducing problems
  - Protect lumber and structure from moisture
  - Erect as much of building as possible before constructing veneer
  - Utilize panelized wood-framed walls
  - Incorporate engineered wood products

Water Infiltration



Water Infiltration

- Primary goals
  - Minimize water penetration
  - Manage water penetration

Water Penetration

- Consequences - excessive penetration
  - Greater volume of water to manage
  - Greater risk of moisture-related problems
    - Corrosion of anchor ties
    - Water and vapor penetration through WRB
    - Efflorescence

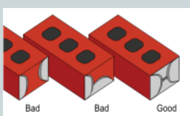
Problems

Water Penetration

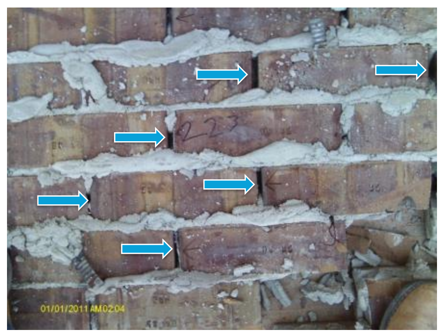
- Entry points
  - Separations between brick and mortar
  - Cracks
  - Failed sealant joints
  - Interfaces

Water Penetration

- Incompletely filled head joints
  - Cause majority of water infiltration
  - Water penetration rates can be high



Source: BIA Tech Note 7B – December 2005



Water Penetration

- Minimize by:
  - Design*
    - Good detailing
    - Material selection (i.e., brick/mortar compatibility)
    - Use concave tooled joints (avoid raked joints)
  - Workmanship*
    - Providing full, well-compacted and tooled head joints

Managing Water Penetration

- Drainage cavity
  - Max. 1-in. (corrugated ties) or 1-in. min. (other ties) required by code
  - 2-in. min. recommended by BIA
    - Allows fully filled head joints
    - Requires proper anchor ties
  - Avoid recessed brick courses
  - Specify units without cores for projecting courses
  - Minimize mortar bridges

Managing Water Penetration

- Mortar bridges
  - Impede downward flow of water (Plinkos)
  - Permit water to bridge cavity
  - Impede air circulation and drying
  - Clog weeps

Managing Water Penetration

- Wider drainage cavities
  - Improve flow of moisture
  - Allow for construction tolerances
  - Accommodate some mortar bridging

Managing Water Penetration

Managing Water Penetration

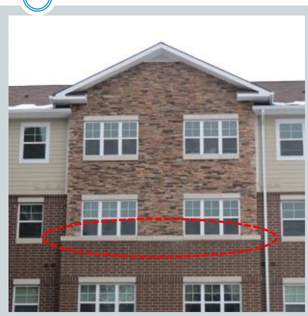
- Flashing defects to avoid
  - Unsealed lap joints*
  - Unsupported at drainage cavity*
  - Flashing held back from exterior*
  - Improperly constructed/missing end dams*

Managing Water Penetration

- Potential Considerations
  - Exercise good design and construction
  - Use a wider drainage cavity and/or drainage material
  - Proper detailing of through-wall flashing
  - Proper detailing of WRB
  - Promote air movement and transfer of moisture at weeps

Cladding Interfaces - Overview

- Horizontal Interfaces



Cladding Interfaces - Overview

- Vertical Interfaces

Cladding Interfaces - Overview

- Balconies and Decks

Cladding Interfaces – Overview

- Interfaces pose higher potential for problems
- Different cladding materials and properties
- Transition between subcontractor trades
- Three dimensional interfaces

Horizontal Cladding Interfaces

- Flashing can become back pitched due to differential building movement

Horizontal Cladding Interfaces

- Flashing often intersects wall openings

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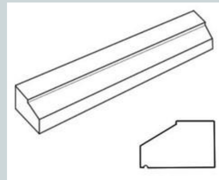
Horizontal Cladding Interfaces

- Potential Considerations:
  - Avoid horizontal cladding terminations at windows and other wall openings
  - Properly construct end dams
  - Accommodate building movement
  - Plan to correct sealant failures due to differential movement

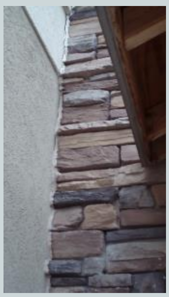
Horizontal Cladding Interfaces

- Potential Considerations:
  - Consider masonry sills with horizontal bottom with integrated drip and sloped top surface



Vertical Cladding Interfaces

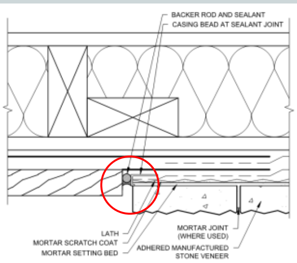
- Difficult to seal to irregular surfaces such as brick and adhered masonry veneer
- Sealant failures are to be expected at vertical interfaces with brick



Vertical Cladding Interfaces

- Potential Considerations:
  - Extend WRB well beyond vertical interface
  - Ensure mortar is not in direct contact with the WRB at inside corner
  - Sealant joints should be properly designed, dimensioned, visible and maintainable

Vertical Cladding Interfaces



Installation Guide for Adhered Manufactured Stone Veneer, 4th Edition 1st Printing

Decks and Balconies

- Potential problems at ledger flashing:
  - Openings in lapped surfaces
  - Lack of sufficient slope away from building
  - Accumulation of debris can exacerbate drainage issues

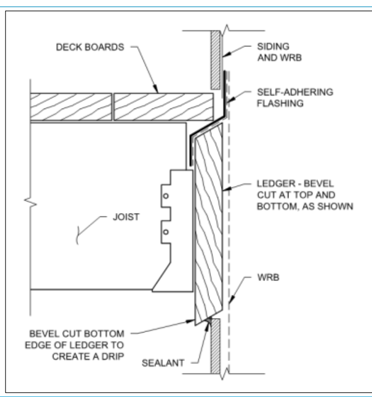
Decks and Balconies

Decks and Balconies

- Potential Considerations:
  - Incorporation of roof overhang at balcony stack
  - Incorporate slope into horizontal flashing leg to facilitate drainage
  - Utilize a self-adhering membrane flashing in a “belt-and-suspenders” approach

Decks and Balconies

Decks and Balconies

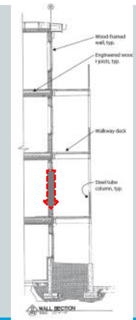


Deck Ledger Flashing

Balcony Beam Penetrations

Balcony Beam Penetrations

- Potential Considerations:
  - Avoid beam penetrations where possible
  - If using columns for support, consider frame shrinkage.



Balcony Beam Penetrations

- Proper detailing of flashing

Balcony Beam Penetrations

Other penetrations

- Dryer vent pipes/fireplace vent pipes

Points to Remember

- Combination of wood frame and brick veneer can result in significant differential movement
- Minimize and manage water infiltration
- Avoid problems through proper detailing and construction
- Utilize peer review, pre-installation meetings and mock-ups


Thank You