Differential Movement – Beware the Backup Structure

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What we used to build…

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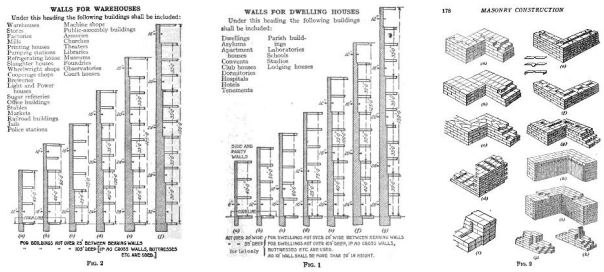
The way we used to build…



International Correspondence School Building Trades Handbook, 1914

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Why we build the way we do now…

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What we build today…

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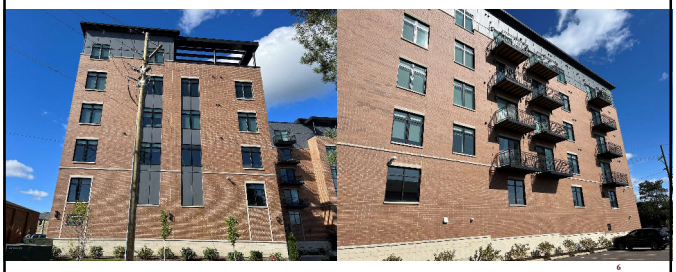
What we build today…



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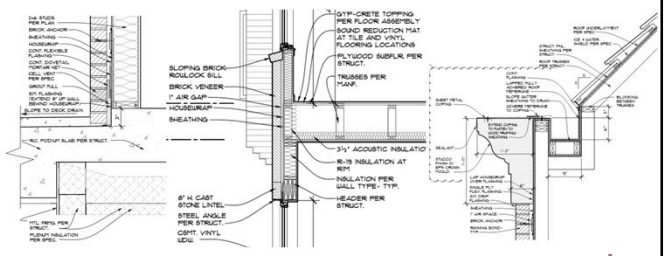
The way we build today…



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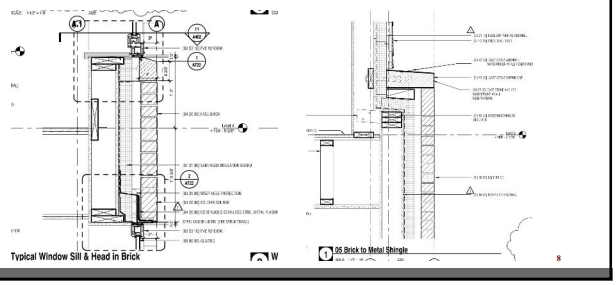
The way we build today…



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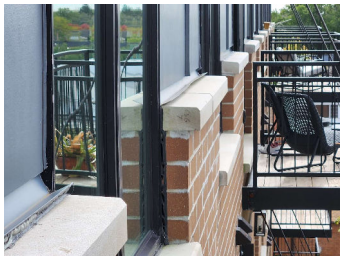
What happens when we build this way…



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What happens when we build this way…

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Material Movement

All building materials experience volume changes due to variations in temperature and moisture.

- Restraint of these movements causes stresses within building elements

Building Material	Thermal	Reversible Moisture	Irreversible Moisture	Elastic Deformation	Creep
Brick Masonry	✓	—	✓	✓	✓
Concrete Masonry	✓	✓	—	✓	✓
Concrete	✓	✓	—	✓	✓
Steel	✓	—	—	✓	—
Wood	✓	✓	—	✓	✓

Table 1. Types of Movement of Building Materials; BIA Tech Note 18 Volume Changes – Analysis and Effects of Movement

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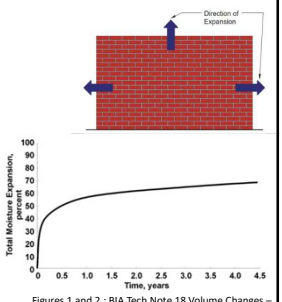
Material Movement

- Brick **increases** in size over its service life.
  - Influence primarily by irreversible moisture expansion
  - Elements or sections of brickwork will expand vertically from their supports and horizontally from their centers
- Wood **decreases** in size over its service life
  - Moisture content in wood recedes from the fiber saturation point until reaching equilibrium
  - Wood shrinkage: **28-30%**

Significance: Unaccommodated differential movement can result in significant displacement of exterior elements, resulting in drainage issues and materials degradation



Figures 1 and 2.; BIA Tech Note 18 Volume Changes – Analysis and Effects of Movement

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Rough Openings

- Window and door openings
  - More movement occurs above/below openings than between openings
- Differential movements between restrained materials creates stress concentrations
  - Cracked brick and sealant joints

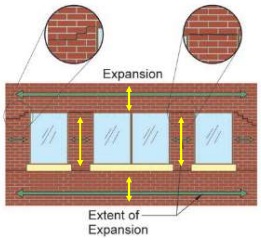

Figure 4.; BIA Tech Note 18A Accommodating Expansion of Brickwork

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Rough Openings

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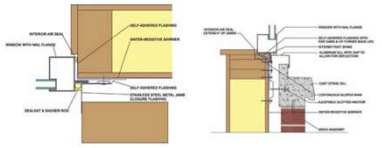
Rough Openings

- Need to design details to accommodate movement
  - Allow for brick growth AND wood shrinkage
  - Fasten windows only to the backup structure
  - Control joints



Silvester, et. al. "Brick Cladding Over Wood-Framed Structures – Determining Differential Movement and Overcoming Resulting Detailing Challenges"

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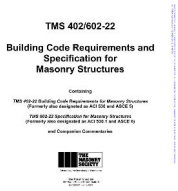
Building Code Requirements

- Brick veneer with wood stud backing mainly used in residential construction
  - Subject to provisions of either the IRC (or IBC in commercial applications)
- IBC references provisions of the Building Code Requirements for Masonry Structures – TMS 402/602 gives provisions for managing movement.


TMS 402/602-22

Building Code Requirements and Specification for Masonry Structures

Containing

TMS 402-22 Building Code Requirements for Masonry Structures (Formerly also designated as ACI 530 and ASCE 5)

TMS 602-22 Specification for Masonry Structures (Formerly also designated as ACI 530.1 and ASCE 6)

and Companion Commentaries


PART 4 PRESCRIPTIVE DESIGN METHODS

CHAPTER 13 VENEER

TMS 402 CODE

COMMENTARY

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Building Code Requirements

- Height Limits
  - Differential movement to be accommodated when veneer exceeds 30 ft., or 38 ft. at gables (TMS 402/602-22 Section 13.1.2.2.2)

13.1.2.2.2 *Wood Light Frame Backing* — Exterior veneer connected to wood light frame construction exceeding 30 ft (9.1 m), or 38 ft (11.58 m) at a gable, in height above the vertical support shall be designed and detailed to accommodate differential movement.

13.1.2.2.2 *Wood Light Frame Backing* — Exterior veneer connected to wood light frame construction — When veneer with a backing of wood exceeds 30 ft (9.1 m), or 38 ft (11.58 m) at a gable, in height, design and detailing for differential movement between the wood light frame backing and masonry veneer is critical to the performance of the masonry veneer. Alternative framing, such as balloon framing instead of platform framing, is one option to limit the shrinkage of the wood frame. Detailing around openings and penetrations through the veneer needs to be carefully considered. Information on conducting an analysis for heights exceeding 30 ft (9.1 m) and proper detailing are given in Silvester et al. (2014) and Clark et al. (2015).

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Building Code Requirements

- Balloon Framing vs. Platform Framing
  - Fire performance concerns with balloon framing

Story	Balloon Framing			Platform Framing		
	Shrinkage [in.]	Creep [in.]	Cumulative [in.]	Shrinkage [in.]	Creep [in.]	Cumulative [in.]
5th	-0.13	-0.012	-0.83	-0.27	-0.06	-1.78
4th	-0.13	-0.024	-0.69	-0.27	-0.12	-1.45
3th	-0.13	-0.036	-0.53	-0.27	-0.06	-1.06
2th	-0.13	-0.048	-0.37	-0.27	-0.08	-0.73
1th	-0.13	-0.06	-0.19	-0.27	-0.11	-0.38

Silvester, et. al. "Brick Cladding Over Wood-Framed Structures – Determining Differential Movement and Overcoming Resulting Detailing Challenges"

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Building Code Requirements

Table 13.2.2.3: General Prescriptive Anchored Veneer Requirements

Backing	Veneer Tie Type	Maximum Specified Cavity Width	Other requirements
Wood Light Framing	Corrugated Sheet-metal	1 in. (25.4 mm)	Fastener: Minimum 2.5 in. (63.5 mm) x 0.131 in. (3.33 mm) ring-shank nail(s) with minimum 1 ½ in. (34.9 mm) penetration into backing or No. 10 screw(s) with ⅝ in. (15.9 mm) penetration into backing. Where sheathing is present, the minimum penetration shall be into the structural member behind the sheathing. Locate fastener within ½ in. (12.7 mm) of the 90-degree bend in the veneer tie. The limiting p_{veneer} values for prescriptive design method shall be 75 percent of those listed in Table 13.2.1.1. Corrugated ties shall not be used on veneers greater than 30 ft (9.14 mm), or 38 ft (11.58 m) at a gable, in height.
	Sheet Metal	4 in. (101.6 mm)	Fastener: Minimum No. 10 screw(s) with 1 ½ in. (34.9 mm) penetration into backing, or, where sheathing is present, into the structural member behind the sheathing. Exterior veneer exceeding 30 ft (9.1 m), or 38 ft (11.58 m) at a gable, in height above the vertical support shall be designed and detailed to provide for differential movement.
	Adjustable	6 in. (152 mm)	Fastener: Minimum No. 10 screw(s) with 1 ½ in. (34.9 mm) penetration into backing, or, where sheathing is present, into the structural member behind the sheathing. Exterior veneer exceeding 30 ft (9.1 m), or 38 ft (11.58 m) at a gable, in height above the vertical support shall be designed and detailed to provide for differential movement.

- Differential movement requirement only for veneers exceeding 30 ft (38 ft at gable).

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Veneer Anchors

- Corrugated and sheet metal anchors
  - Single point of attachment
  - Will flex and stretch
- Wire and screw anchor
  - Single point of attachment
- Adjustable anchors
  - Location relative to the mortar joint

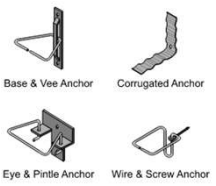

Figure 4
Unit Anchors for Wood Backing
BIA Tech Note 28 Brick Veneer/Wood Stud Walls

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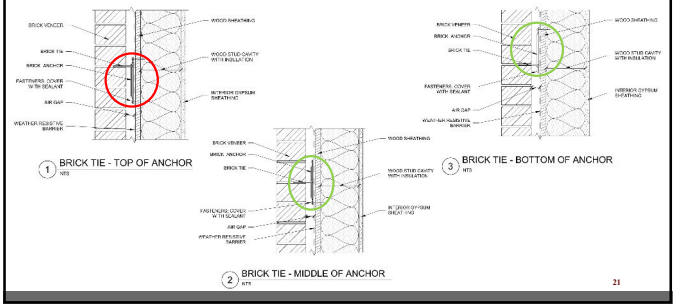
Veneer Anchors



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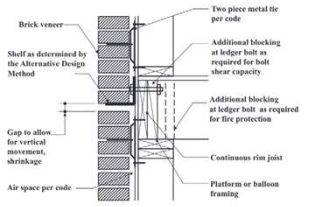
Other Considerations

- Masonry Support
  - 30 ft limit – how do you support the masonry above that height?
  - How many architects willing to see this joint?
  - Sprinkler requirements



"Options for Brick Veneers on Mid-Rise Wood-Frame Buildings," WoodWorks Wood Products Council

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Recommendations

- Understand the potential for movement incompatibility
- Identify facade areas where differential movement could be detrimental to the overall performance (rough openings, etc.)
- Locate control joints to minimize effects of differential movement (panelize the facade)
- Verify anchor location requirements to allow for differential movement

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Resources

- BIA Tech Notes
  - 18, 18A, 28
- TMS 402/602-22
- Clark, et. al. "Designing Anchored Brick Veneer Above 30 Feet with a Backing of Wood Framing" (TMS 12th NAMC)
- Silvester, et. al. "Brick Cladding Over Wood-Framed Structures – Determining Differential Movement and Overcoming Resulting Detailing Challenges" (Structural Engineer)
- Malone, R.T. "Options for Brick Veneer on Mid-Rise Wood-Frame Buildings" (WoodWorks)

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Acknowlegements

- Luke J. Lundberg, SGH
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