Durability, Resilience and Energy Efficiency:
Working Together to Make Sustainable Buildings

EEBA Excellence in Building Conference
28 September 2016

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Learning Objectives

- Understand basic building science principles of air, water and thermal management as they pertain to wall systems
- Understand the key material properties which must be assessed when designing wall systems with increased thermal performance
- Review the progress in the development of industry standards and guidelines for detailing highly insulated wall assemblies.

Resilience

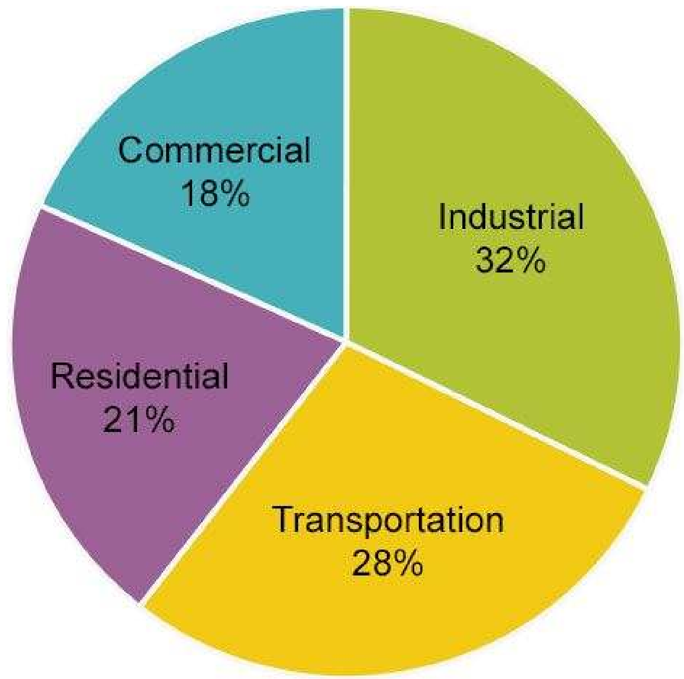
Sustainable

Energy Efficient

Durability

Energy Efficient

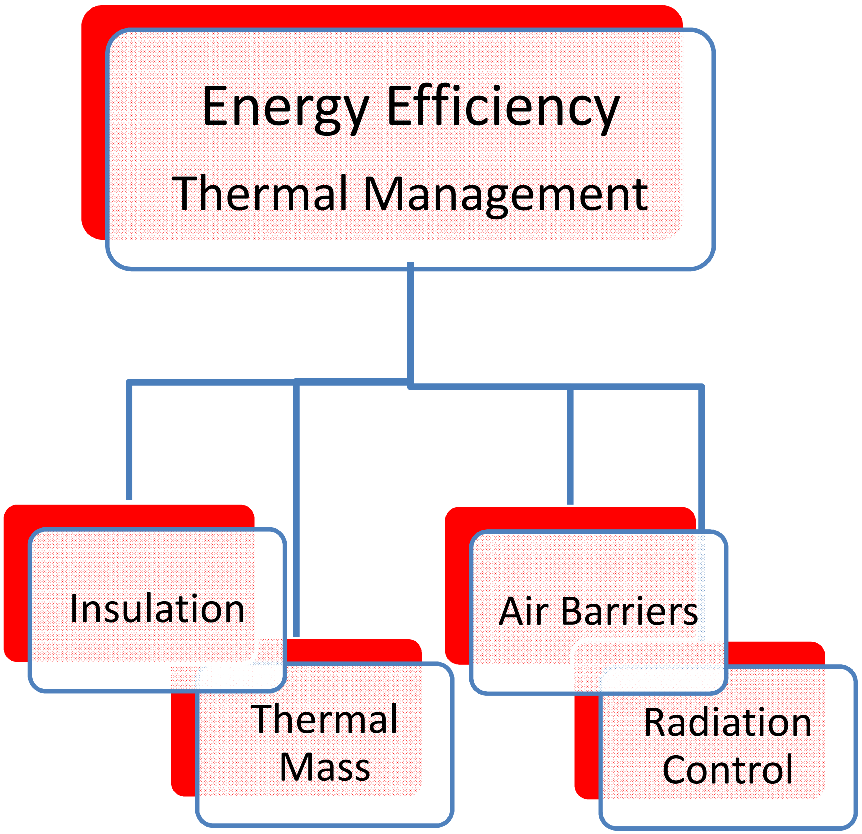
Share of total energy consumed by major sectors of the economy, 2012[1]



[1]Includes electricity consumption.
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 2.1 (April 2013),preliminary 2012 data.

US DOE Building Energy Codes Program Goals

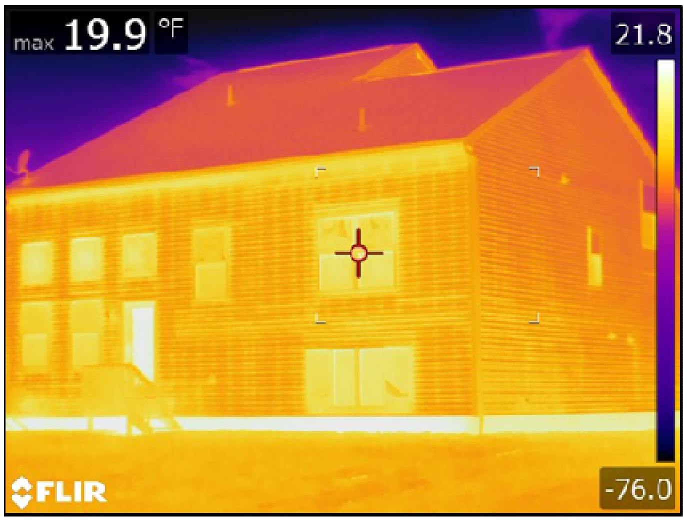
Goals by FY	Baseline	2010	2011	2012	2013	2014	2015	2016	2017
IECC Code Improvement	IECC 2006	IECC 2009 (17%)		IECC 2012 (30%)			IECC 2015 (50%)		
ASHRAE 90.1 Code Improvement	90.1-2004		90.1-2010 (30%)			90.1-2013 (50%)			
Adoption Rate for IECC 2009 (or equivalent)									80%
Compliance Rate with IECC 2009	Unknown								90%



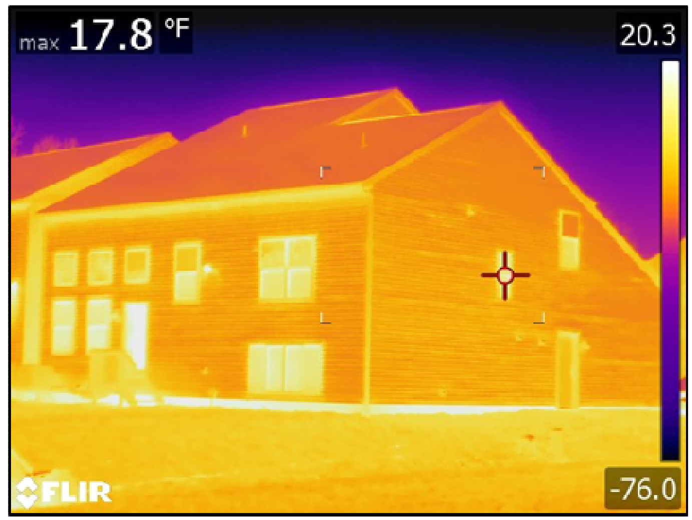
- Increase cavity insulation
- Increase exterior continuous insulation
- Reduce thermal bridges
  - Advanced framing
- Reduce air leakage
  - Air barriers
  - Air impermeable insulation
  - Insulation installation

Thermal Bridges

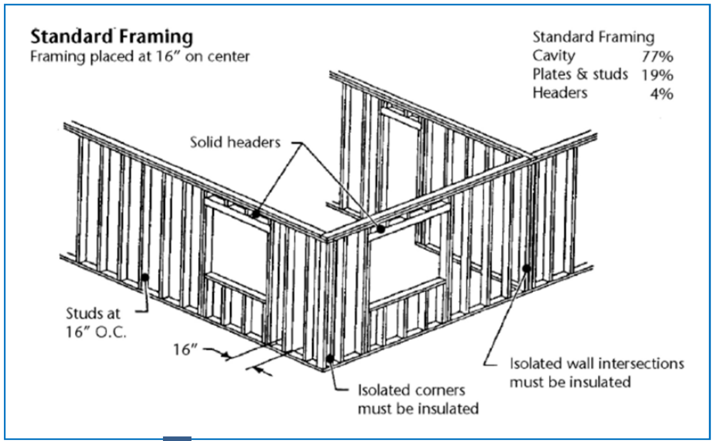
No Exterior Insulation

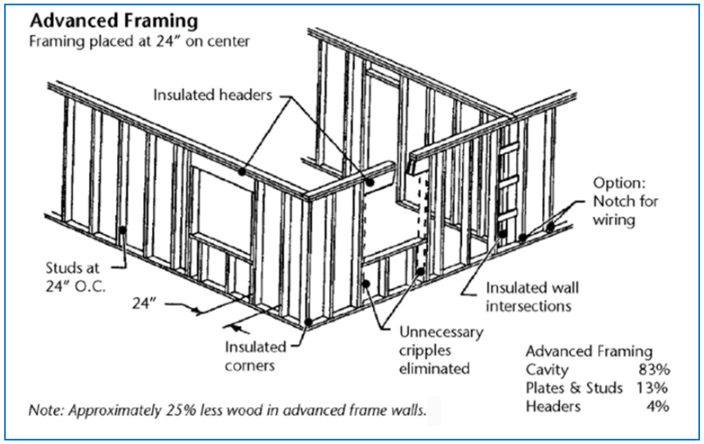


With Exterior Insulation



Reducing Thermal Bridges





Exterior Insulation

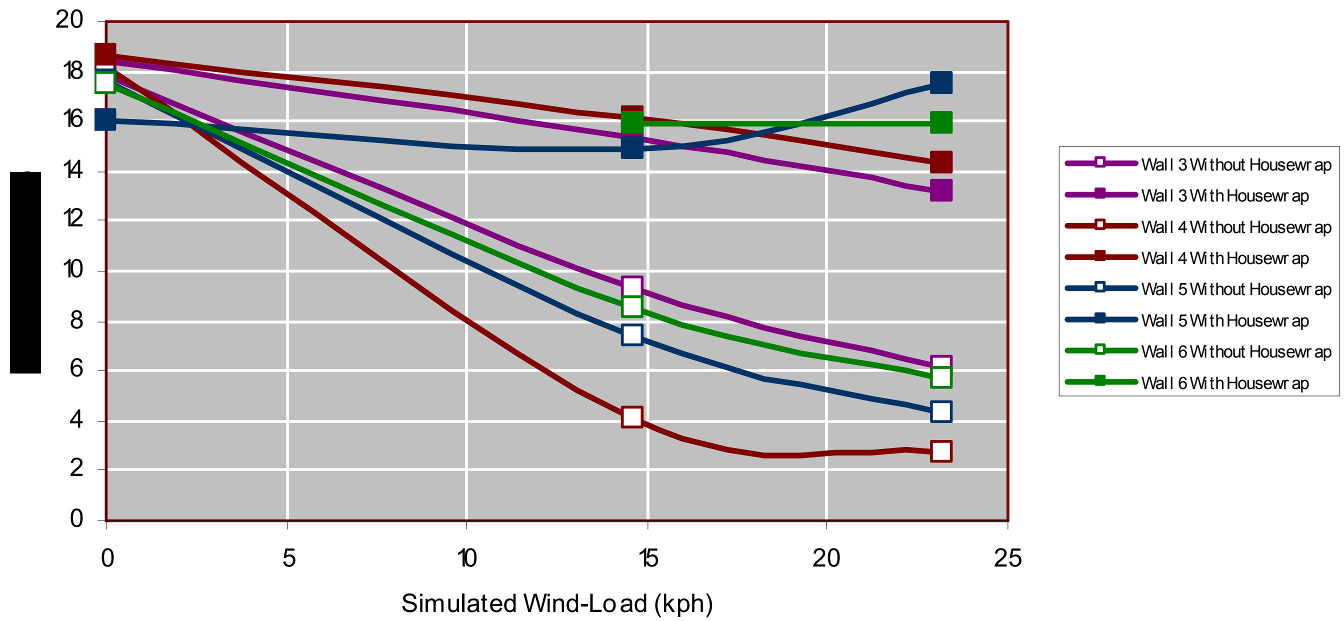
Figures from *WSEC Builder's Field Guide, 8th Edition*, Washington State University Extension Energy Program. Photo courtesy of Construction Instruction.

R-values of Components & Assemblies

Wall Assembly Component	2x4		2x6		2x4 + c.i.	
	Studs	Cavity	Studs	Cavity	Studs	Cavity
Outside Air Film	.17	.17	.17	.17	.17	.17
Exterior Insulation	n/a	n/a	n/a	n/a	5	5
½" OSB	.62	.62	.62	.62	.62	.62
Stud Wood	3.71	n/a	5.83	n/a	3.71	n/a
Cavity Insulation	n/a	13	n/a	20	n/a	13
½" Gypsum Wallboard	.45	.45	.45	.45	.45	.45
Interior Air Film	.68	.68	.68	.68	.68	.68
Total	**5.6**	**14.9**	**7.75**	**21.9**	**10.6**	**19.9**
Total Wall (Standard Framing - 23%)	**10.8**		**15.4**		**16.6**	
Total Wall (Advanced Framing – 17%)			**16.7**			

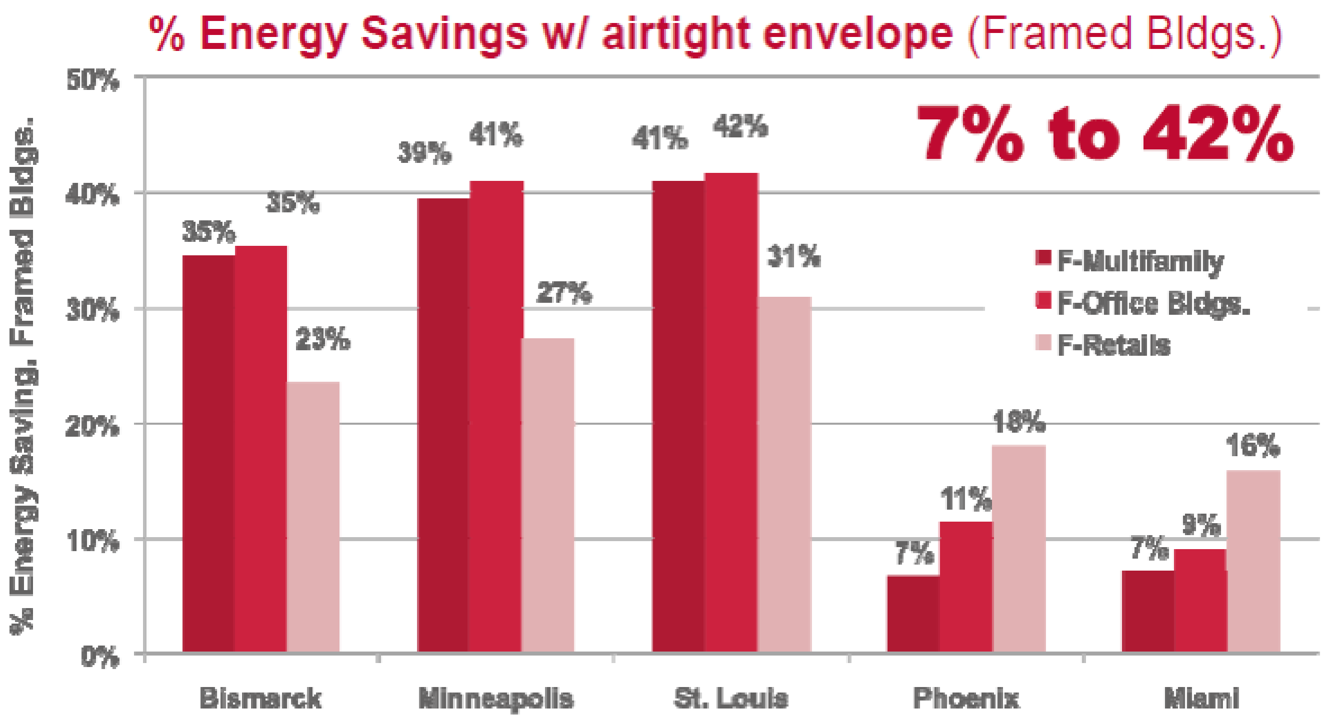
Air Leakage Impact on Energy Use:
Degradation of Thermal Insulation Performance

Measured Effective R-value under Simulated Wind-Load (R-19 Walls).
Data from Jones, 1995

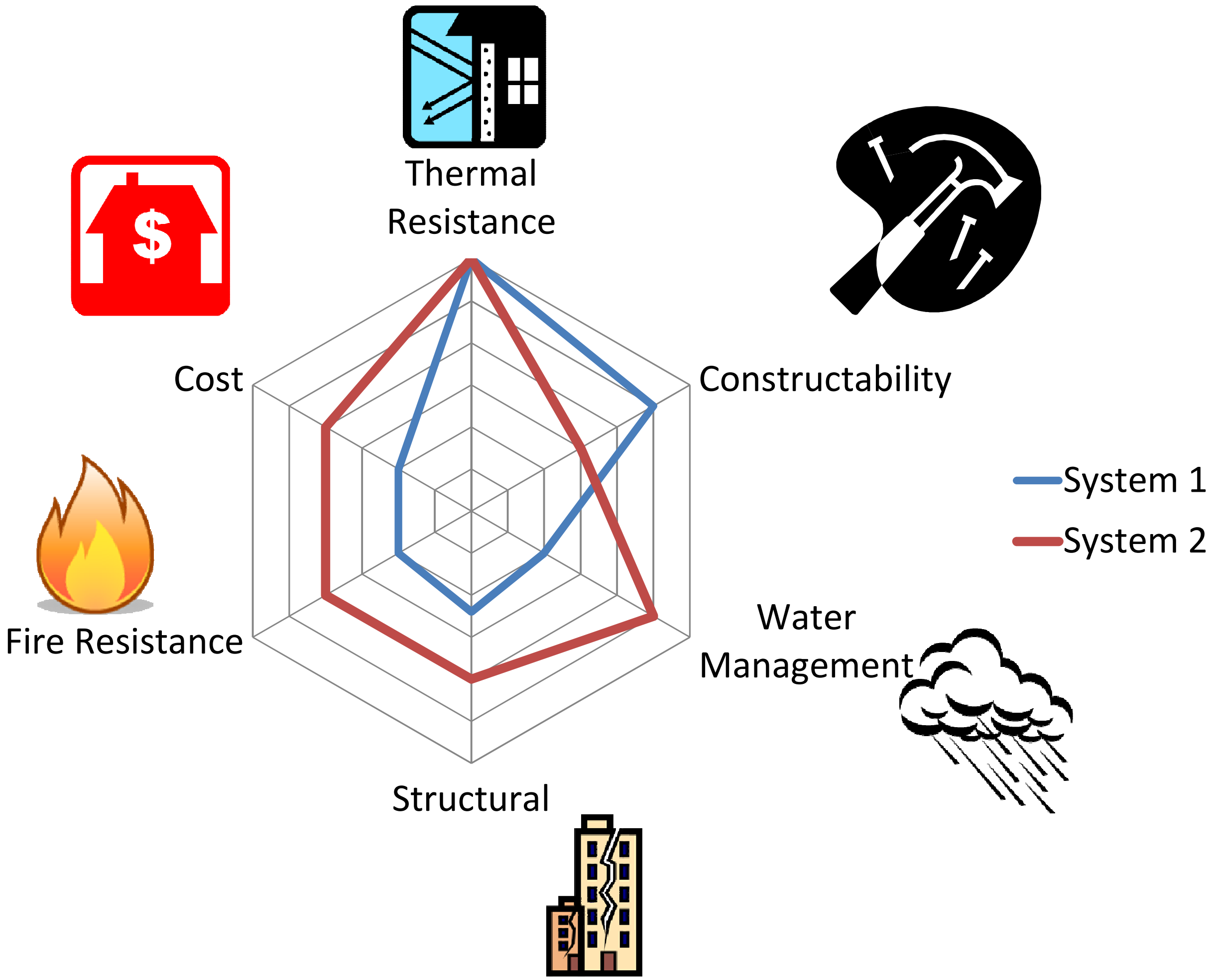


Source: Impact of Airflow on the Thermal Performance of Various Residential Wall Systems utilizing a calibrated hot box, Thermal Envelopes VI/ Heat Transfer in Walls -- Principles

Effect of Air Leakage on Heating and Cooling Energy



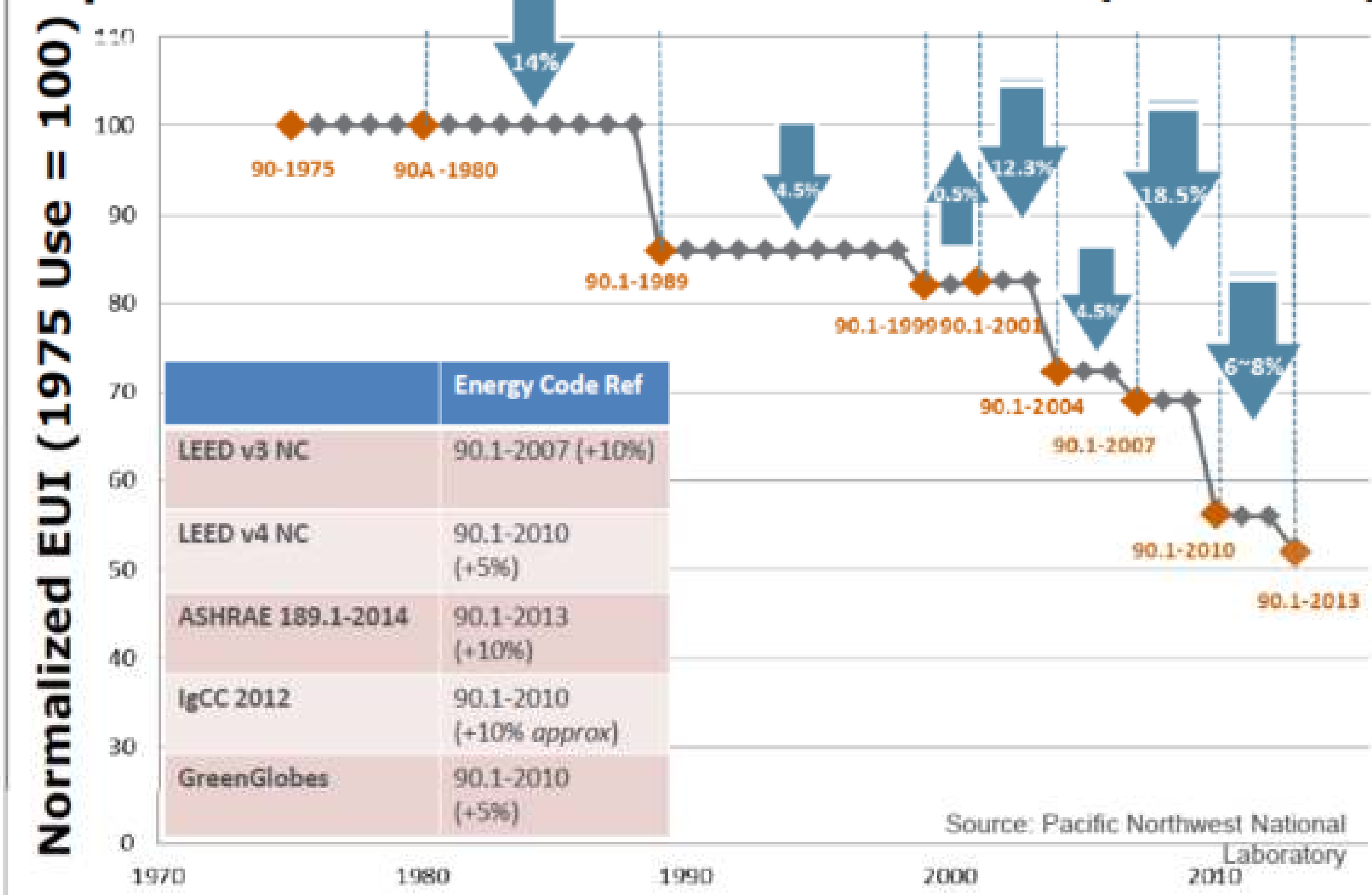
Source: "Investigation of the impact of Commercial Building Envelope Airtightness on HVAC Energy Use", *S. J. Emmerich, Tim McDowell, W. Anis*


Thermal
Resistance
Constructability
Water
Management
Structural
Fire Resistance
Cost
System 1
System 2

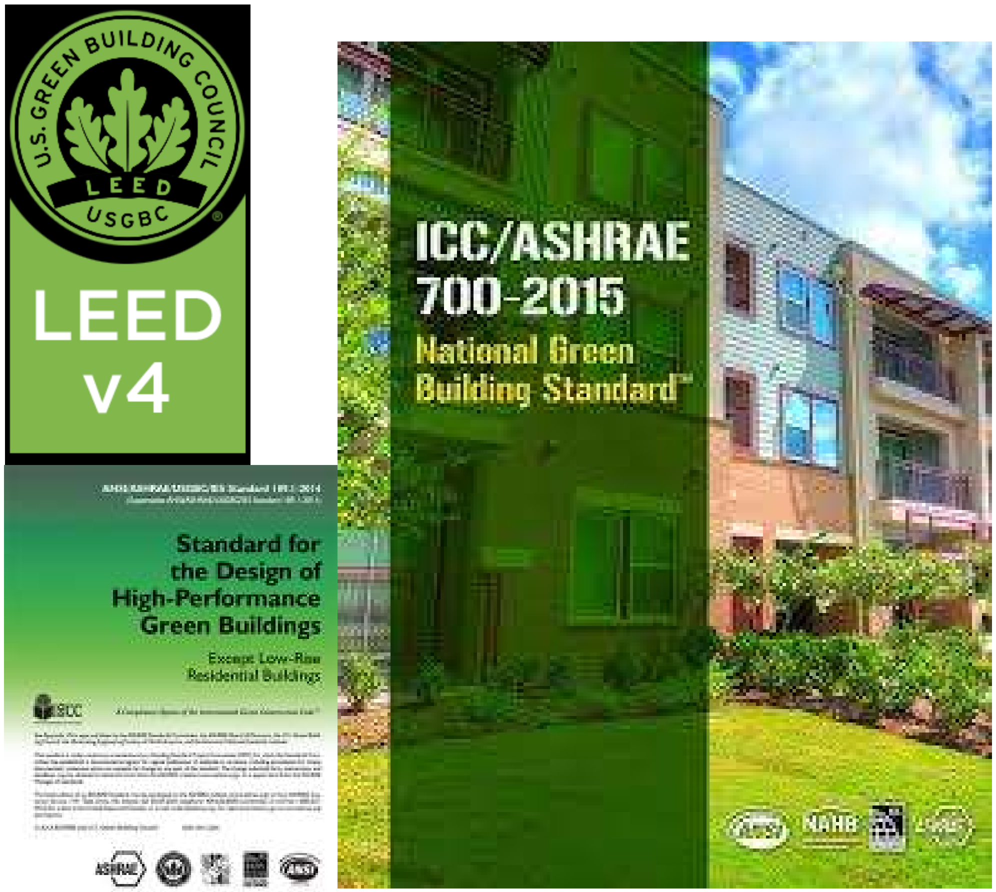
Sustainable

1. the ability to be sustained, supported, upheld, or confirmed.
2. Environmental Science. the quality of not being harmful to the environment or depleting natural resources, and thereby supporting long-term ecological balance:

Improvement in ASHRAE Standard 90.1 (1975-2013)

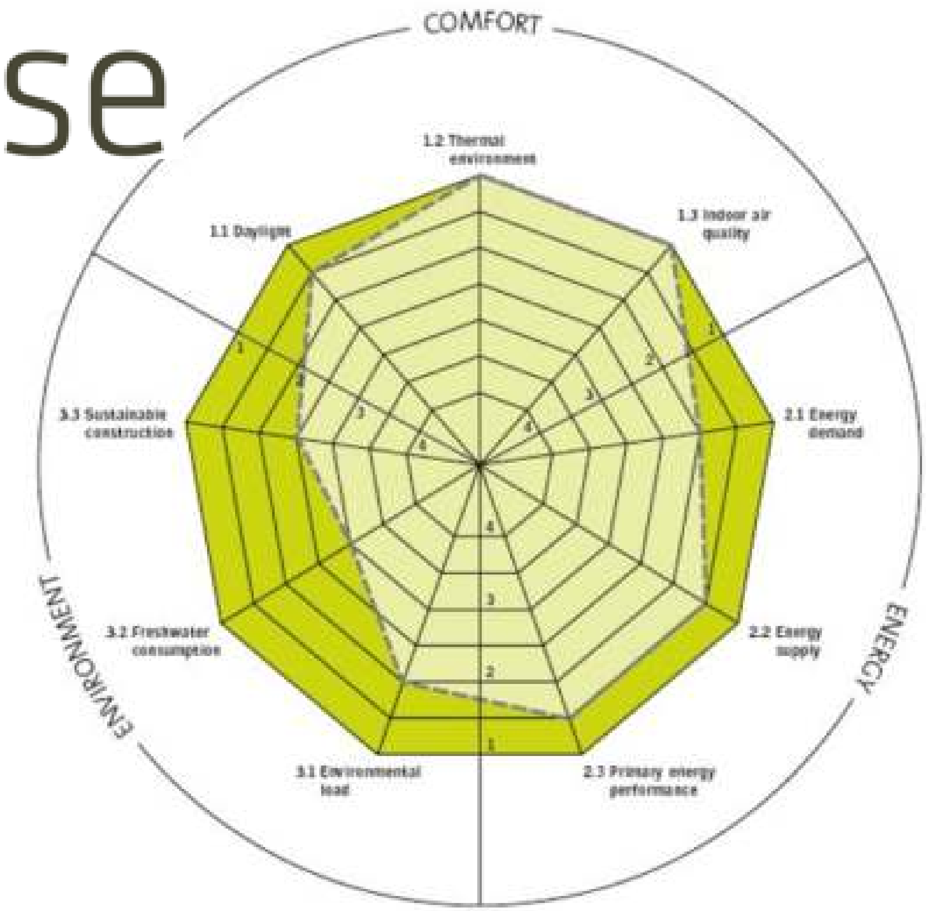


	Energy Code Ref
LEED v3 NC	90.1-2007 (+10%)
LEED v4 NC	90.1-2010 (+5%)
ASHRAE 189.1-2014	90.1-2013 (+10%)
IgCC 2012	90.1-2010 (+10% *approx*)
GreenGlobes	90.1-2010 (+5%)



1) Scope and Administration
2) Definitions
3) Compliance Method
4) Site Design and Development
5) Lot Design, Preparation and Development
6) Resource Efficiency
7) Energy Efficiency
8) Water Efficiency
9) Indoor Environmental Quality
10) Operation, Maintenance and Building Owner Education
11) Remodeling
12) Remodeling of Functional Areas
13) Referenced Documents

activehouse



Green-product attributes

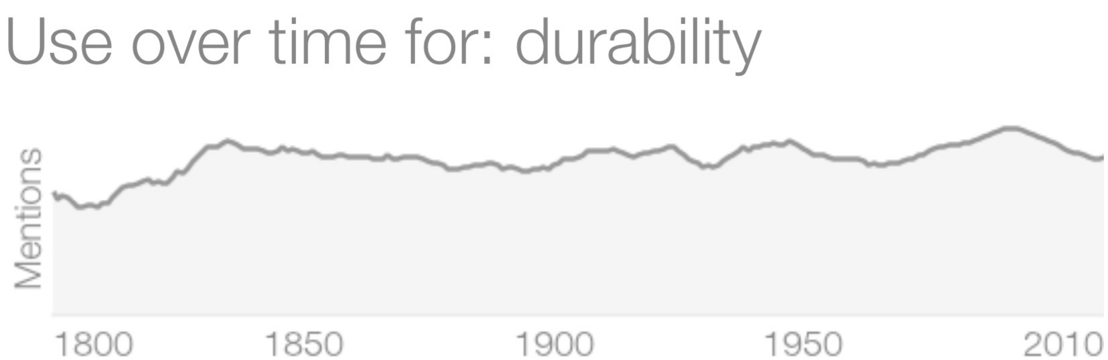
(rated by importance to user)

Ability to last the life of the building	4.38
Cost vs. equivalent conventional product	4.27
Availability of product to job site	4.16
Use of renewable resources	4.01

From Building Design & Construction White Paper on Sustainability, November 2003

Durability

1. the ability to withstand wear, pressure, or damage.

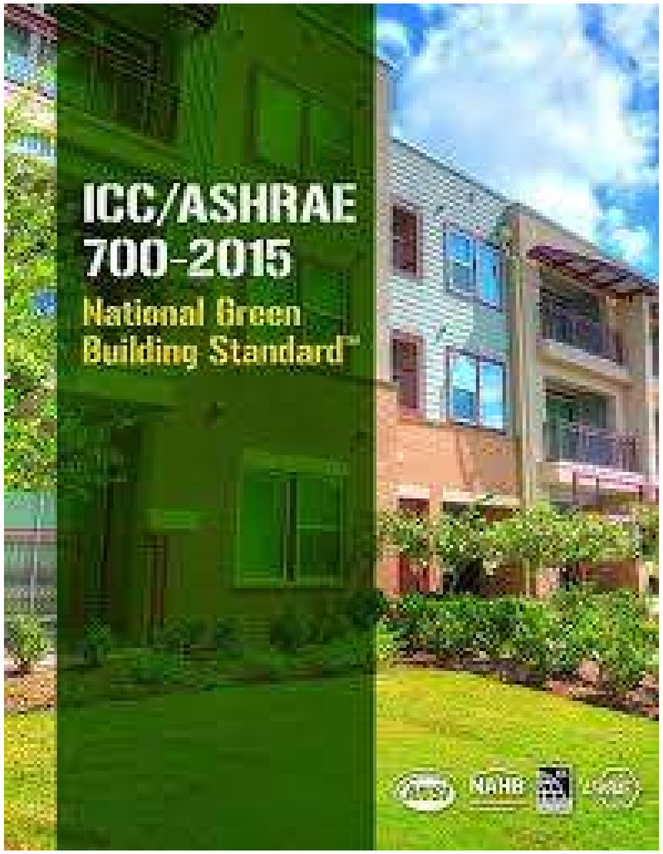


S478-95
Guideline on Durability in Buildings
Structures (Design)

- Durability: *"the ability of a building or any of its components to perform its required functions in its service environment over a period of time without unforeseen cost for maintenance or repair."*

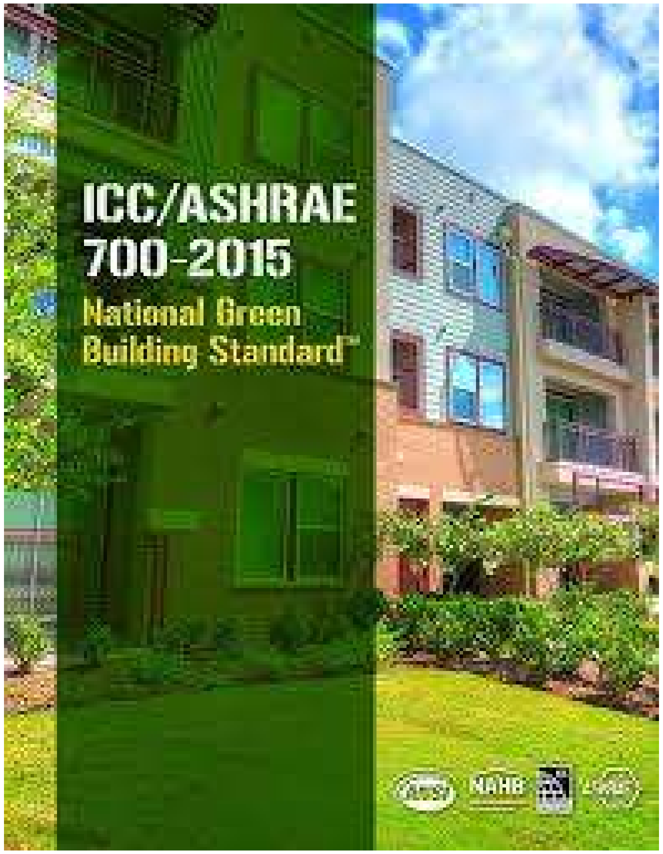
- *"Moisture, with or without contaminants, is the most important environmental agent causing premature deterioration. The application of principles of building science permits the generation of models for predicting the mechanisms, paths, volumes, and forms of moisture which building assemblies will need to accommodate and resist."*

ICC/ASHRAE 700-2015 Chapter 6: Resource Efficiency



- Quality of Construction Materials and Waste
- **Enhanced Durability and Reduced Maintenance**
- Reused or Salvaged Materials
- Recycled-Content Building Materials
- Recycled Construction Waste
- Renewable Materials
- Recycling and Waste Reduction
- Resource-Efficient Materials
- Regional Materials
- Life Cycle Assessment
- Innovative Practices

ICC/ASHRAE 700-2015 Chapter 6: Resource Efficiency

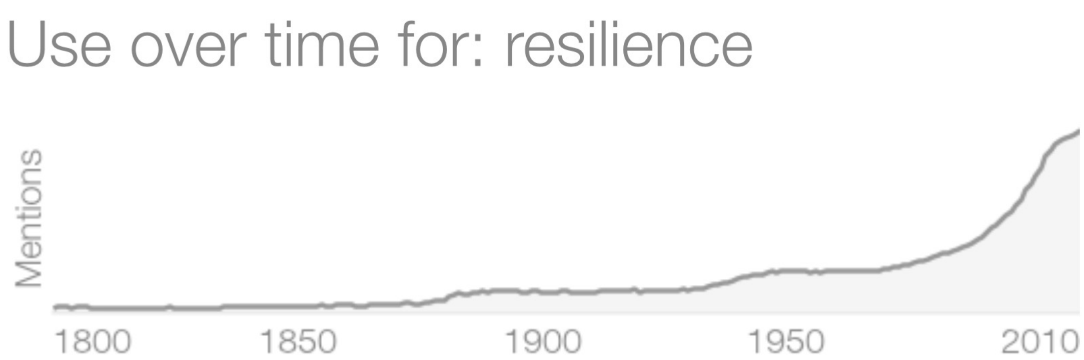


1. Quality of Construction Materials and Waste
2. **Enhanced Durability and Reduced Maintenance**
    1. **Intent**
    2. **Moisture management – building envelope**
    3. **Roof surfaces**
    4. **Roof water discharge**
    5. **Finished Grade**
3. Reused or Salvaged Materials
4. Recycled-Content Building Materials
5. Recycled Construction Waste
6. Renewable Materials
7. Recycling and Waste Reduction
8. Resource-Efficient Materials
9. Regional Materials
10. Life Cycle Assessment
11. Innovative Practices

Resilience

1. the ability of a substance or object to spring back into shape; elasticity.

3. the capacity to recover quickly from difficulties; toughness.



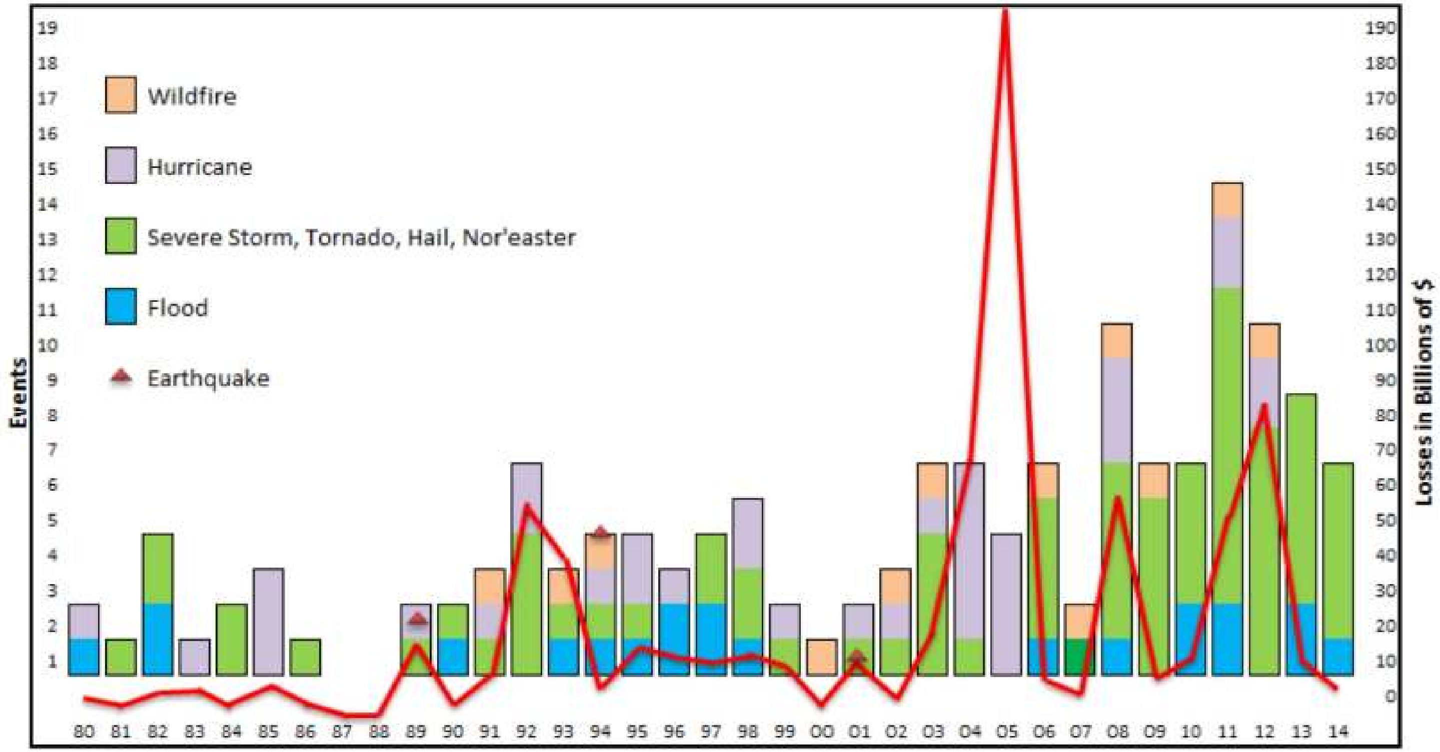


Figure 1: Billion Dollar+ Extreme Weather Events in Frequency and Losses from 1980-2014 (Earthquake Losses Included)[4]

From "Developing Pre-Disaster Resilience Based on Public and Private Incentivization," National Institute of Building Sciences, October 29, 2015

ASTM Resilience Related Standards

Resiliency (or resilience), n. — The ability of an object or material to endure daily wear in the intended and expected service circumstances and/or be easily repaired after a more catastrophic occurrence without the need for complete replacement.

- WK35237 New Test Method for Standard Test Method for Water Immersion and Drying for Evaluation of Flood Damage Resistance

- E2026-16a Standard Guide for Seismic Risk Assessment of Buildings
- E2557-16a Standard Practice for Probable Maximum Loss (PML) Evaluations for Earthquake Due-Diligence Assessments
- WK55885 Seismic Risk Assessment of Real Estate Portfolios

Fortified Home Standards

ASCE/SEI 7 Minimum Design Loads For Buildings and Other Structures

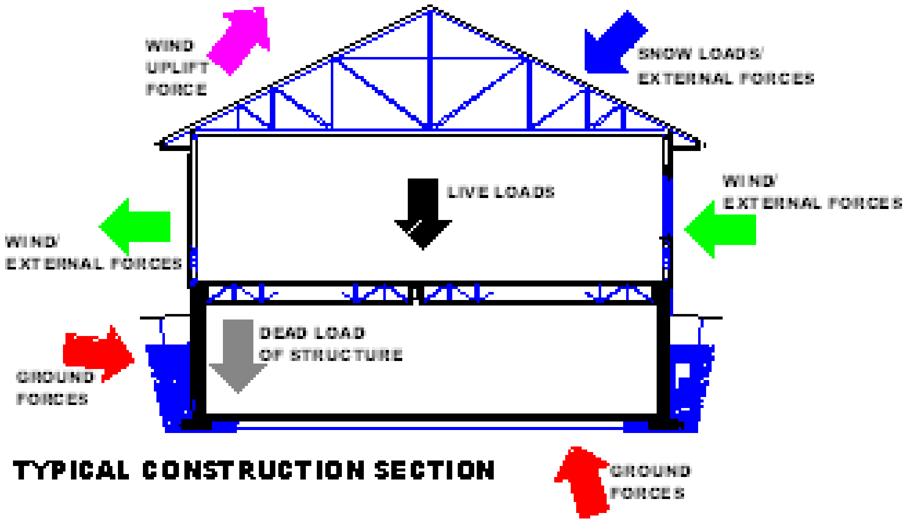


Figure from http://www.kdietrich.com/

ASCE 7-16 TECHNICAL CHANGES

“The 2016 edition of **ASCE 7 Minimum Design Loads and Associated Criteria for Buildings and Other Structures** provides the most up-to-date and coordinated loading standard for structural design. Along with improved coordination and routine updates, ASCE 7-16 includes many significant changes as follows:

- New seismic maps that reflect the updated National Seismic Hazard Maps, including increased requirements for the region surrounding Las Vegas, Nevada, to address local concerns. The basis for the increase was developed and supported by the State of Nevada Geologist’s office.
- New wind speed maps that result in reduced wind speeds for much of the country and clarify the special wind study zones, including new maps for Hawaii. Also new maps for Risk Category IV separate from Category III.
- New regional snow data generated by state Structural Engineers Associations in Colorado, Oregon, New Hampshire, Washington and other mountainous states, that is now directly referenced and eliminates many, older site-specific Case Study zones.
- Updated rain duration provisions align design requirements with International Plumbing Code provisions for drainage.
- New provisions for performance fire design in Appendix E.
- Entirely new chapter with tsunami design provisions, which is important to west coast states, Alaska, and Hawaii. "

From ASCE website

Structural performance can be affected by moisture durability

"EMERALD ISLE, N.C. – Nails deteriorated by years of exposure to the sand, salt and moisture from the ocean gave way, causing a deck collapse that hurt 24 people as they posed for a picture at a North Carolina beachfront home, authorities said." (Foxnews, July 6, 2015)

"A memorandum from inspectors at the Berkeley Building and Safety Division says that the deck's severed joist ends -- horizontal, parallel beams that support a ceiling or floor -- looked "extensively rotted" where the structure had ripped from the wall. " (CNN, June 23, 2015)

Photo from L A Times

Nationally, construction defect losses run into the billions.

- 69% of all construction defect claims are related to moisture penetration through the building envelope (2007 Study by University of Florida)
- The availability of general liability insurance for homebuilders and subcontractors has become increasingly limited and more expensive
  - *"The companies are finding it more difficult than five years ago to tap insurance to cover payments to homeowners because insurers have added so many exceptions, said Dave Stern, vice president at West Coast Casualty Service Inc., an insurance adjuster in Westlake Village, California. In California, "basically, the thing leaks, it's the builder that's liable," Stern said."*
- Some moisture problems are blamed on increasing energy efficiency
  - *"Building codes adopted in the 1970s and strengthened through the '80s and early '90s, required greater energy efficiency. Paradoxically, the demise of the drafty house had an unintended consequence: When moisture penetrates today's walls, they tend to stay wet."*

Sources: "Building Defects Spoil Homeowners' Dreams, The Oregonian, June 19, 2005; "Homebuilder Shares Undermined by Creeping Costs of Construction Boom Flaws", Bloomberg, February 10, 2011; Grosskopf and Lucas, "Identifying the Causes of Moisture-Related Defect Litigation in U.S.Building Construction", COBRA 2008 The construction and building research conference of the Royal Institution of Chartered Surveyors, Dublin Institute of Technology, 4-5 September 2008.

S478-95
Guideline on Durability in Buildings
Structures (Design)

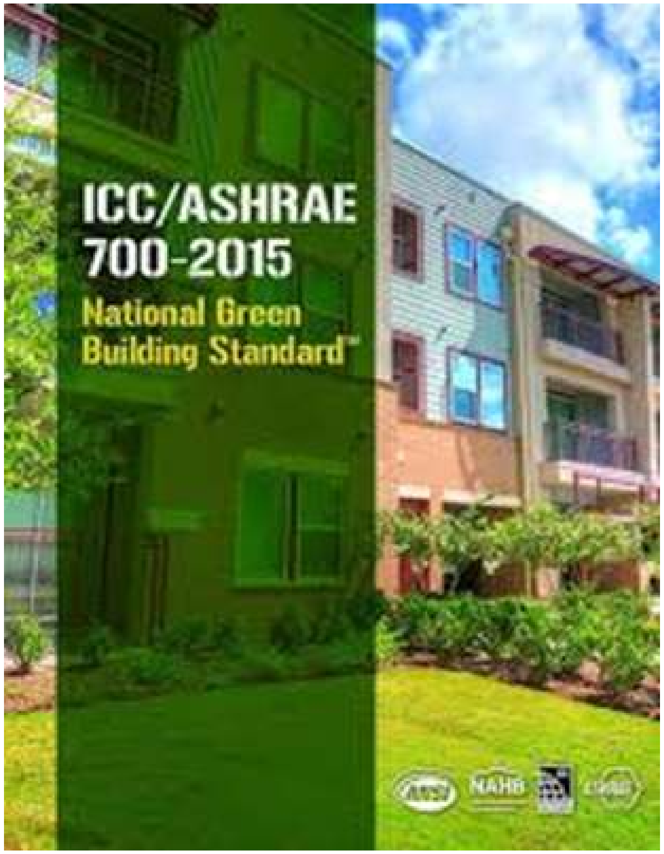
7.2 Methods to Predict Service Life

7.2.1 The predicted service life of components or assemblies may be assessed by one or more of the following three methods:

(a) demonstrated effectiveness, in accordance with Clause 7.3

(b) modelling of the deterioration process, in accordance with Clause 7.4; and

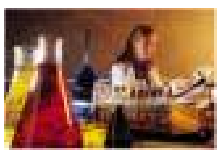
(c) testing, in accordance with Clause 7.5



602.1.7.3 Building envelope assemblies are designed for moisture control based on documented hygrothermal simulation or field study analysis. Hygrothermal analysis is required to incorporate representative climatic conditions, interior conditions and include heating and cooling seasonal variation.

(4 points)

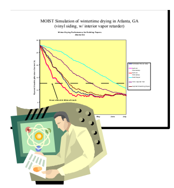
Laboratory Assembly Testing

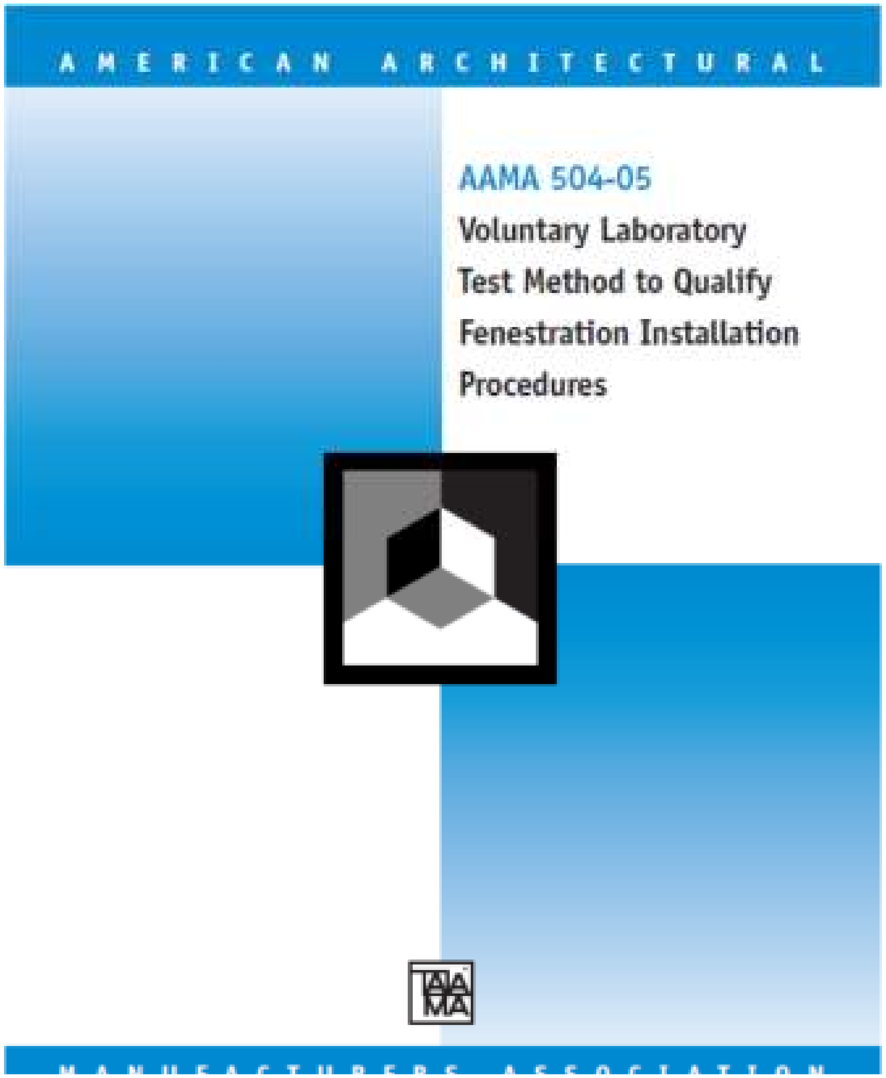


Laboratory Materials Testing

Field Testing

Hygrothermal Modeling





Test Assembly: fenestration product, fasteners, sealant, flashing components and weather resistant barrier shall be included. Exterior cladding, interior perimeter cavity insulation and expanding foam shall not be applied to the test mockup for this evaluation.

The completed mockup shall be preloaded prior to testing using 10 positive cycles of 480 Pa (10 psf) followed by 10 negative cycles of 480 Pa (10 psf).

Test for air leakage in accordance with ASTM E 283 at a pressure differential of 75 Pa (1.57 psf).

Test for water penetration resistance in accordance with ASTM E 331 at a minimum test pressure of 150 Pa (3.0 psf) for 60 minutes.

The entire mockup shall be subjected to 14 twelve hour durability cycles in accordance with ASTM E 2264 Method A, Level 1:

- *Exterior Temperature Exposure*
  - **Level 1 49°C (120 °F)**
  - Level 2 3°C (150 °F)
  - Level 3 82°C (180 6°F)

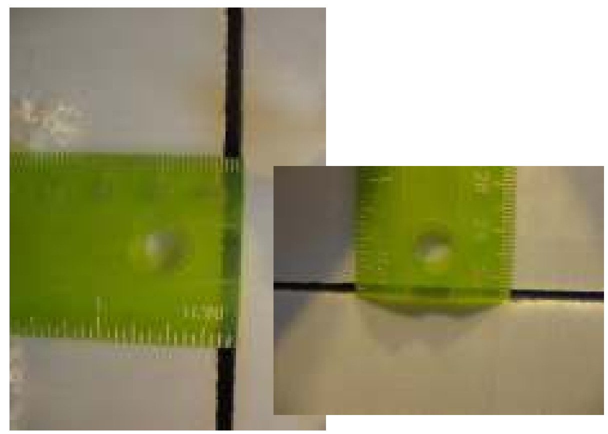
Exterior Low Ambient Air Temperature: –30°C (–22°F)

Following cycling, the mockup shall again be tested for air leakage and water penetration resistance

The entire mockup shall be tested for structural loads in accordance with ASTM E 330 at a minimum test pressure of 1440 Pa (30 psf) positive and negative.

Material deformation and loss of adhesion

Joints open



Hygrothermal Building Envelope Simulation Standards

ASTM E3054/E3054M-16 Standard Guide for Characterization and Use of Hygrothermal Models for Moisture Control Design in Building Envelopes

ANSI/ASHRAE Standard 160-2009

Criteria for Moisture-Control Design Analysis in Buildings

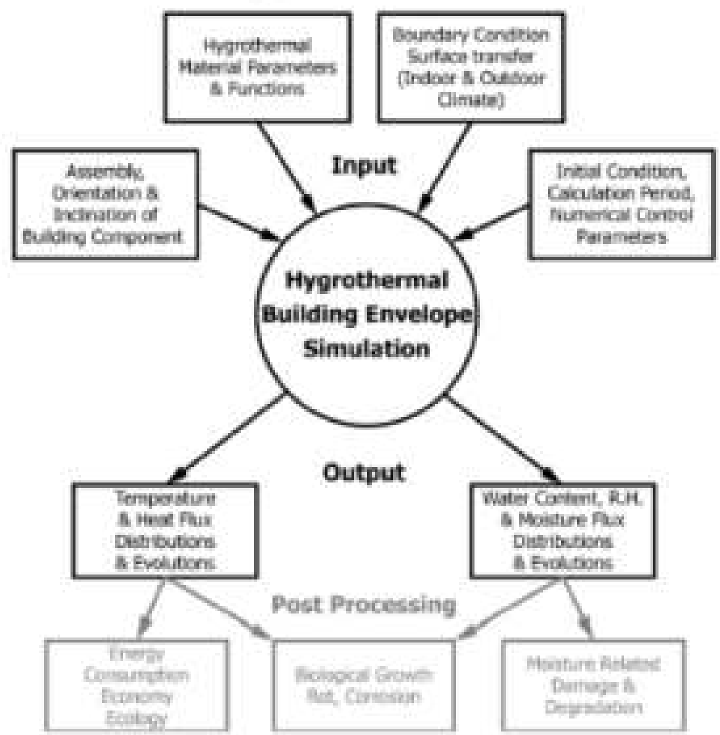
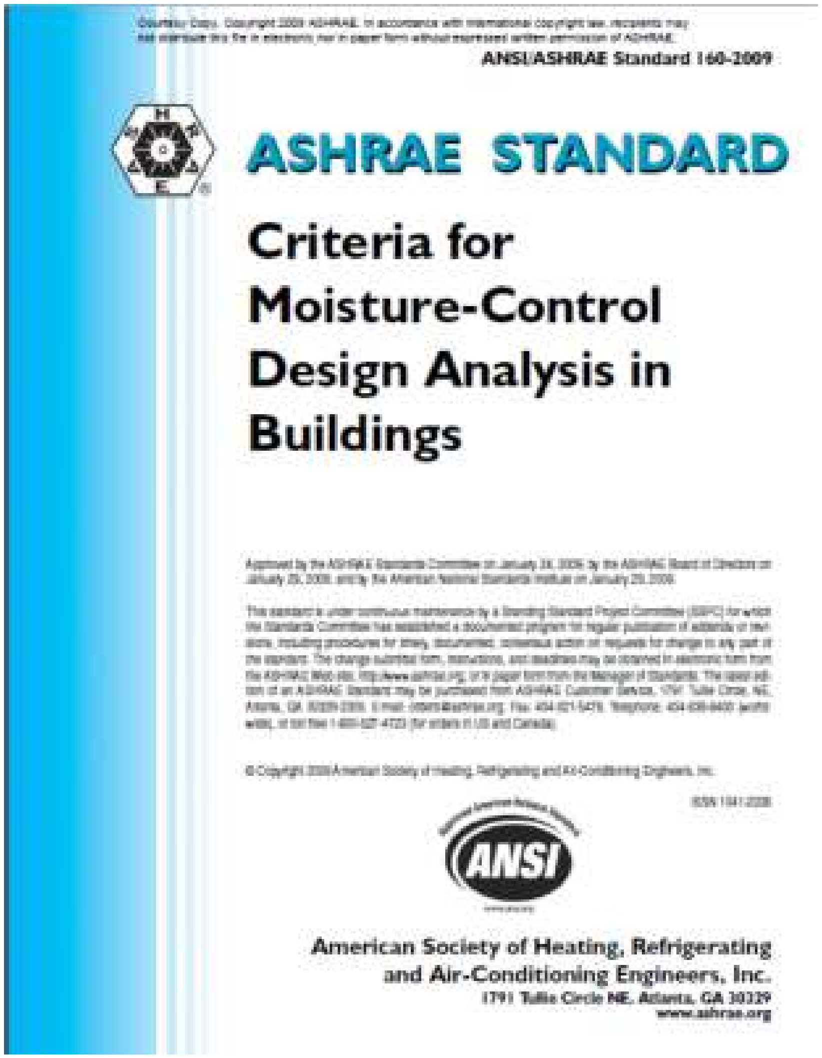


FIG. 1 Input and Output Chart for Hygrothermal Simulations



ANSI/ASHRAE Standard 160-2009

ASHRAE STANDARD

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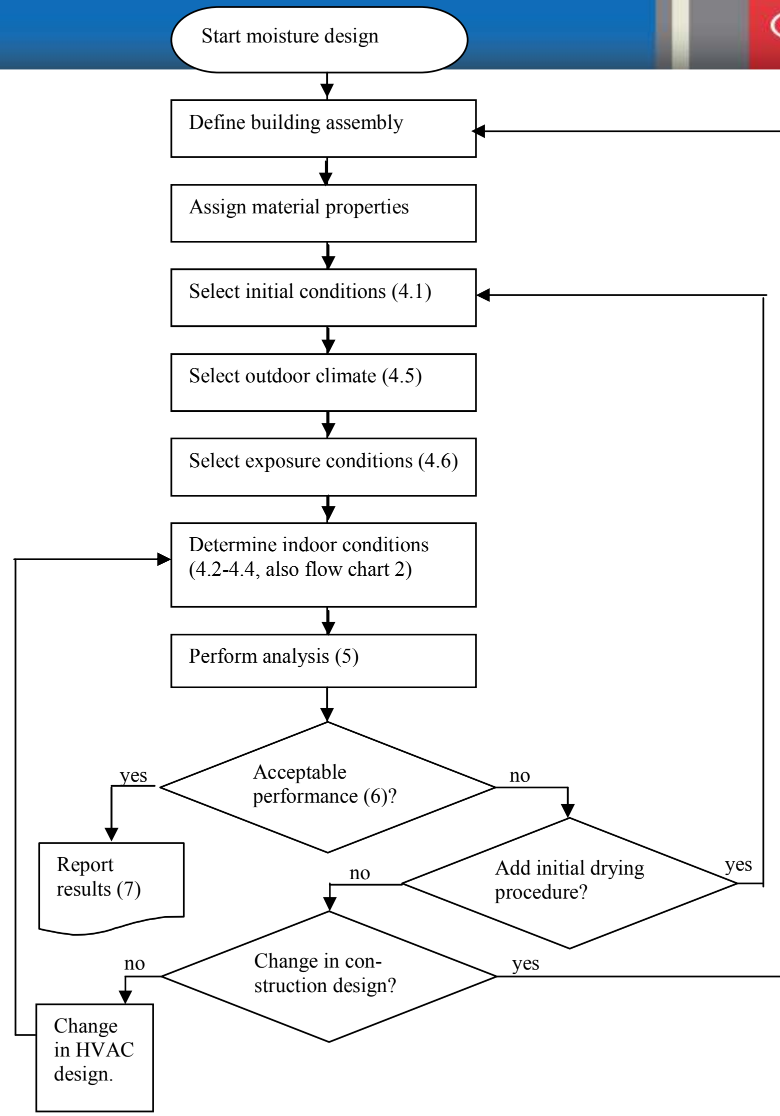
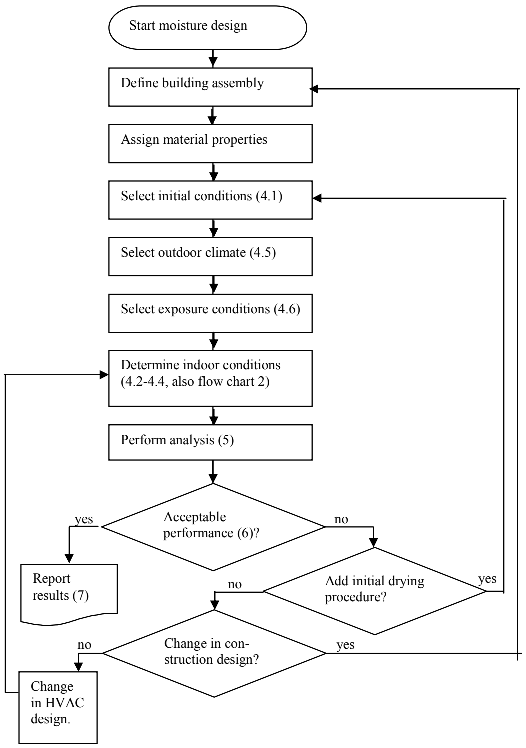
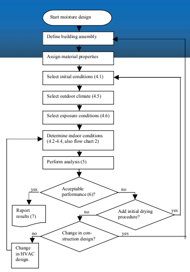
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org





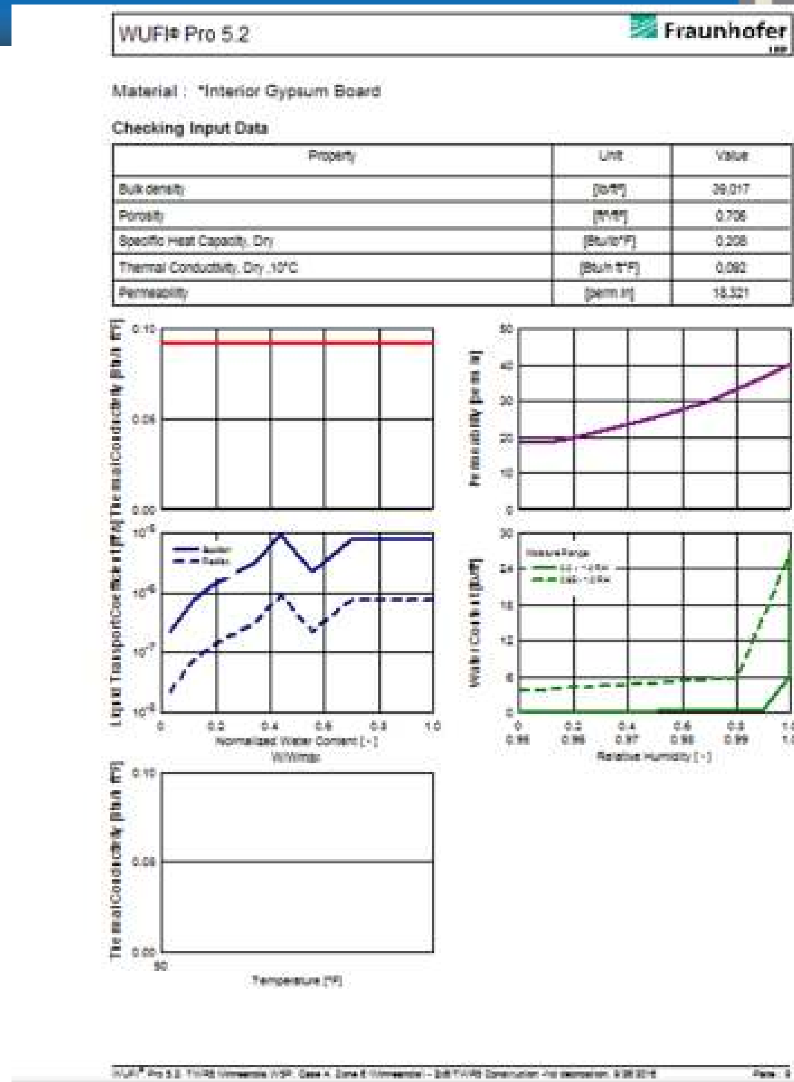
Define Building Assembly

- “Provide a description of the building envelope assembly.
  - Assembly
  - Type (wall, roof, etc.)
  - Orientation
  - Surface coefficients
  - Air space locations and air space ventilation rates with outdoor air
  - List of materials (include reference source of data)”



Assign Material Properties

- “Provide data on each of the materials in the building envelope assembly.
  - Material description
  - Thickness
  - Density
  - Thermal conductivity, and its dependency on temperature and moisture content, if applicable Specific heat (heat capacity)
  - **Vapor permeance or permeability**
  - Sorption isotherm
  - Liquid diffusivity or liquid conductivity
  - Suction isotherm
  - Initial moisture content
  - Other material properties required for the analytic model, possibly including:
    - Porosity
    - Capillary saturation
    - Maximum saturation
    - Airflow permeability”

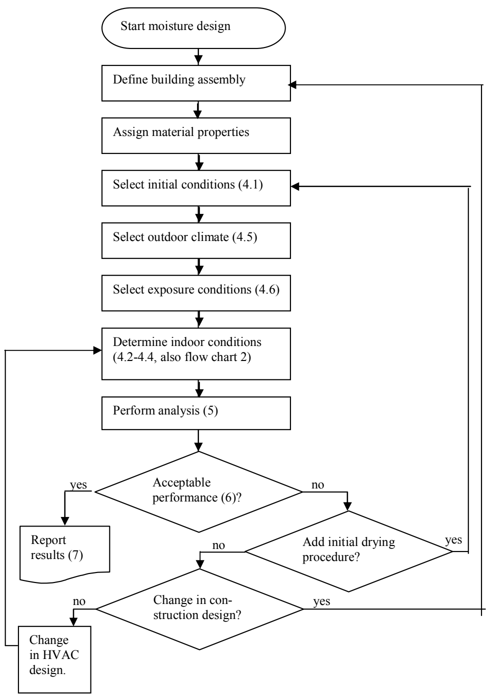


WUFI® Pro 5.2 Fraunhofer

Material : *Interior Gypsum Board

Checking Input Data

Property	Unit	Value
Bulk density	[lb/ft³]	39.017
Porosity	[ft³/ft³]	0.706
Specific Heat Capacity, Dry	[Btu/lb°F]	0.208
Thermal Conductivity, Dry ,10°C	[Btu/h ft°F]	0.092
Permeability	[perm in]	18.321



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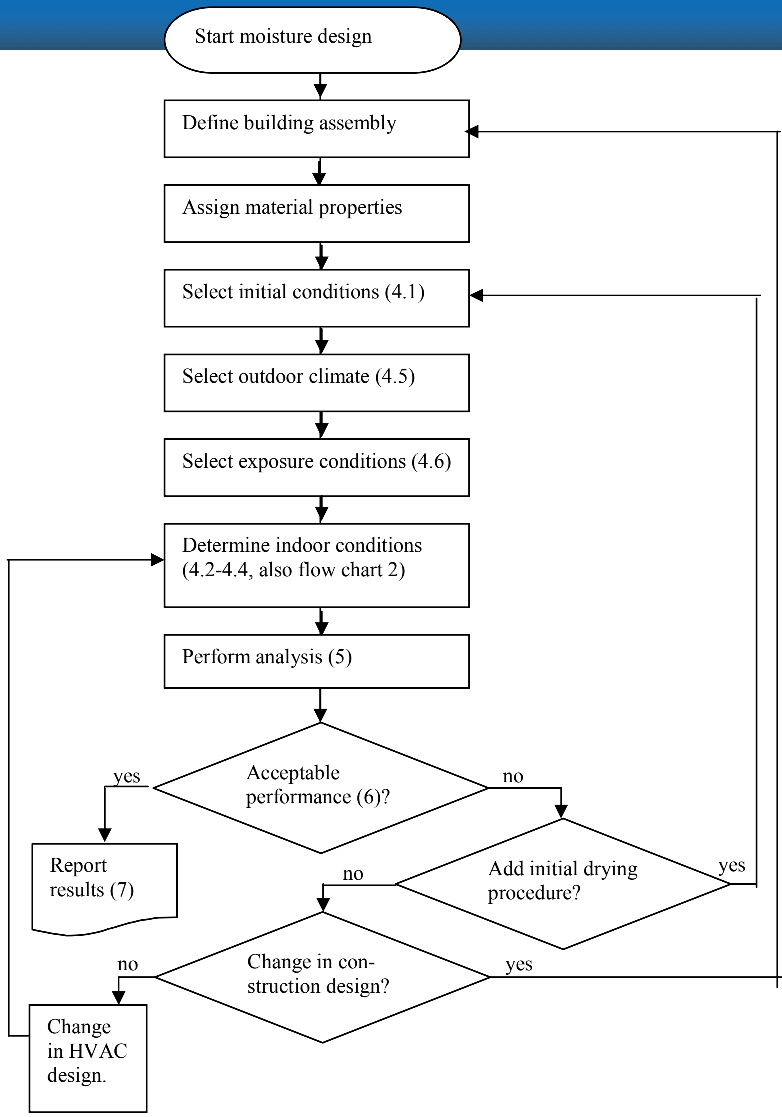
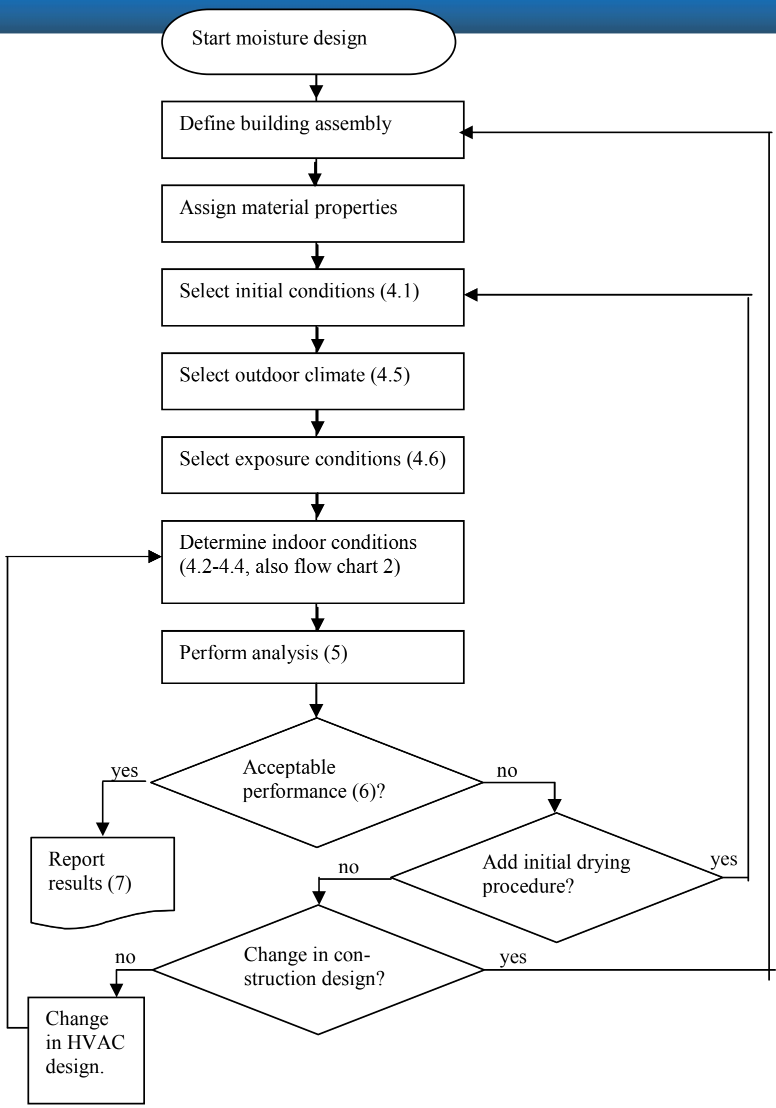
Vapor Retarder Requirements – Interior side of frame walls

Climate Zone	IBC - Requirement	Exceptions
1 & 2	Class I or II vapor retarders shall not be provided	
3	Class I vapor retarders shall not be provided	
4 x-marine	Class I vapor retarders shall not be provided	
4 marine	Class II vapor retarders shall be provided	Class III vapor retarders can be used with vented cladding or specific R-values of exterior insulation. Only Class III vapor retarders shall be used with exterior foam plastic insulating sheathing with perm rating of less than 1 perm
5 to 8	Class I or II vapor retarders shall be provided	Class III vapor retarders can be used with vented cladding or specific R-values of exterior insulation Only Class III vapor retarders shall be used with exterior foam plastic insulating sheathing with perm rating of less than 1 perm


Start moisture design
Define building assembly
Assign material properties
Select initial conditions (4.1)
Select outdoor climate (4.5)
Select exposure conditions (4.6)
Determine indoor conditions (4.2-4.4, also flow chart 2)
Perform analysis (5)
Acceptable performance (6)?
yes
no
Report results (7)
Add initial drying procedure?
no
yes
Change in construction design?
no
yes
Change in HVAC design.



✓Perform Analysis

✓Moisture Performance Evaluation Criteria

- ❑Mold
- ❑Corrosion


ANSI/ASHRAE Standard 160-2009

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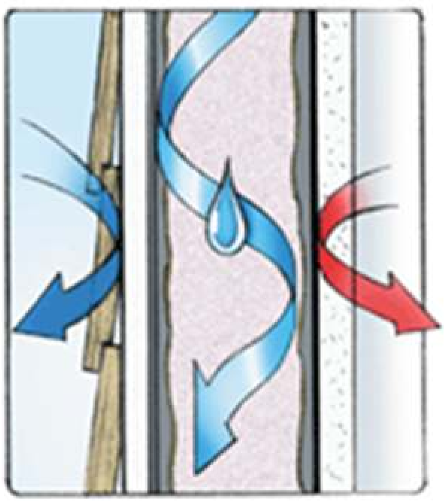
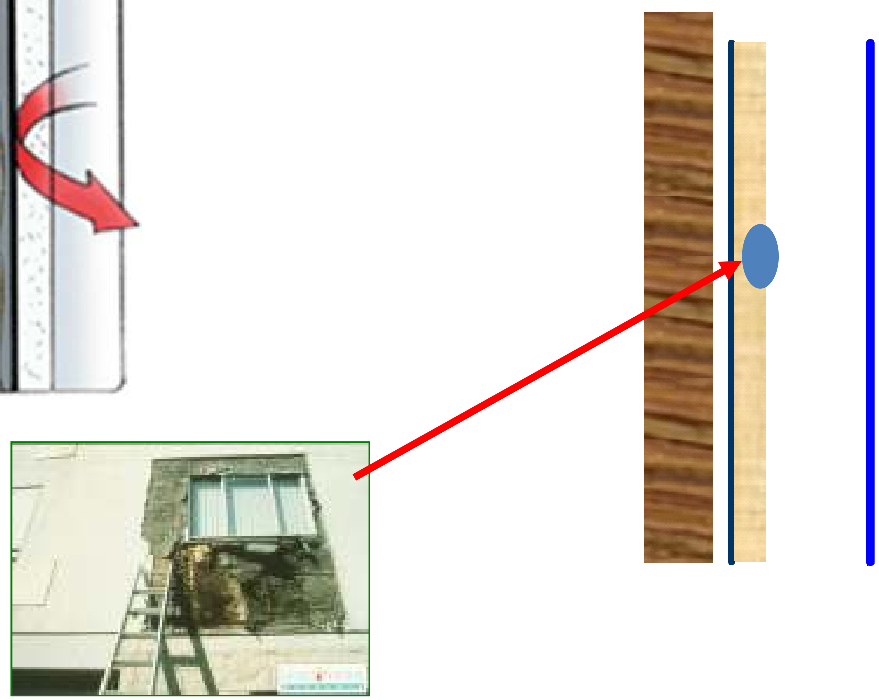
2.5 This standard does not address the design of building components or envelopes to resist liquid water leakage from sources such as rainwater, ground water, flooding, or ice dams.[B-1]

INFORMATIVE ANNEX B
COMMENTARY ON STANDARD 160

[B-1] Although this standard applies to all parts of all buildings, additional information may be needed for the proper design of foundations and ventilated cavities, such as crawl spaces and attics. This standard assumes that appropriate measures have been taken to limit bulk water entry into the building and building envelope. For information and guidance on selection and installation of materials and systems to avoid water damage, the following documents may be helpful. See Annex C, "Bibliography," for complete references.

Drying Ability: Adding Rain Intrusion

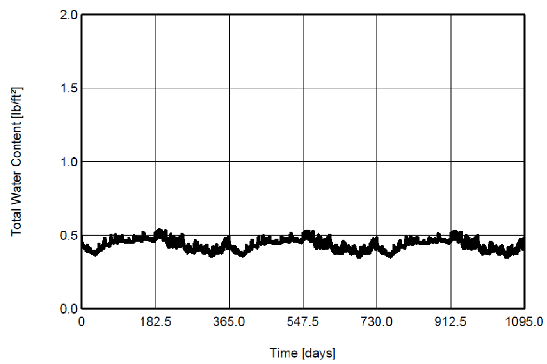


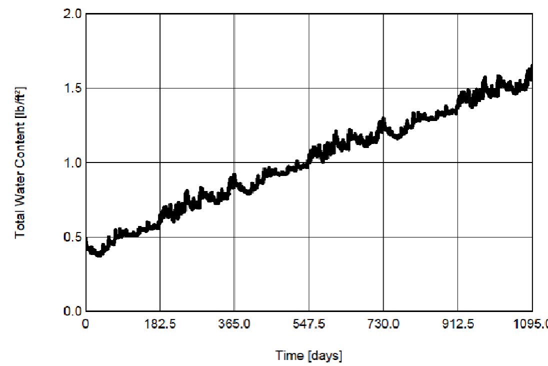


Simulation: Minneapolis

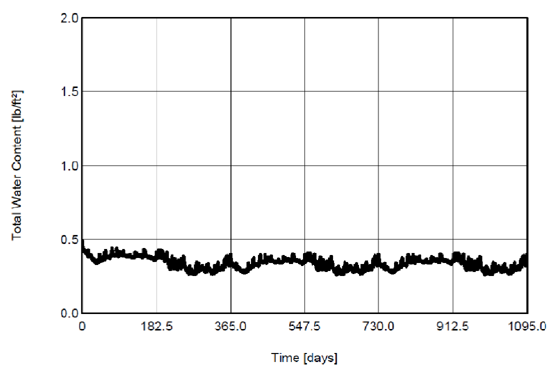
No Bulk Water Intrusion | **1% Bulk Water Defect**

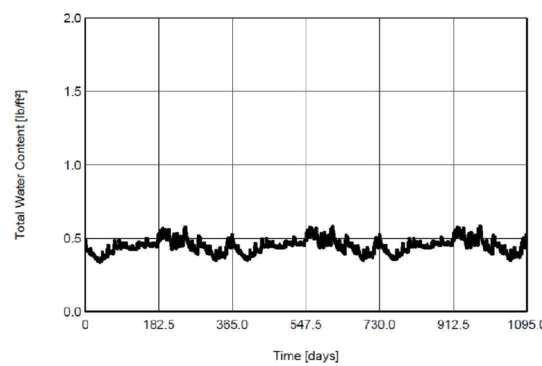
Exterior Foam Sheathing

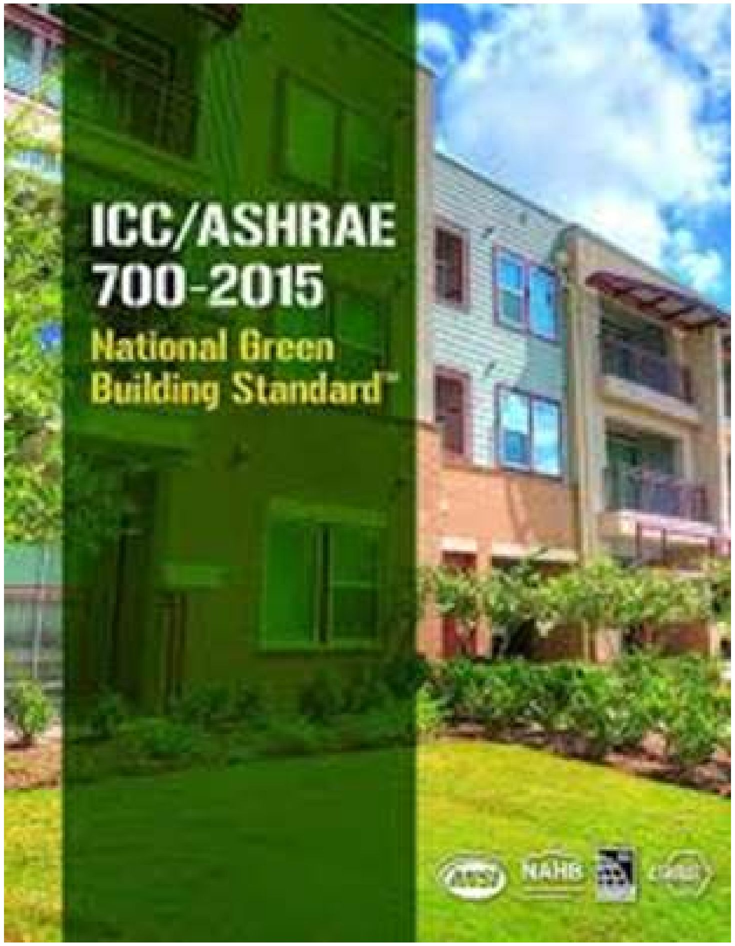




Vapor Permeable Exterior insulation







- **602.1.8 Water-resistive barrier**. Where required by the ICC, IRC, or IBC, a water-resistive barrier and/or drainage plane system is installed behind exterior veneer and/or siding
- **602.1.9 Flashing.** Flashing is provided as follows to minimize water entry into wall and roof assemblies and to direct water to exterior surfaces or exterior water-resistive barriers for drainage. Flashing details are provided in the construction documents and are in accordance with the fenestration manufacturer's instructions, the flashing manufacturer's instructions, or as detailed by a registered design professional.

Moisture Sources in Buildings

Bulk Water

- Rain & Snow:
- Construction Moisture

1 → >>1,000X

Water Vapor

Transported by air currents — 98% — 2 → 100X

Diffusion — 2% — 3 → 1X

International Residential Code (2012): Wall Weather Resistance Requirements

R703.1 General. Exterior walls shall provide the building with a weather-resistant exterior wall envelope. The exterior wall envelope shall include flashing as described in Section R703.8.

R703.1.1 Water resistance. The exterior wall envelope shall be designed and constructed in a manner that prevents the accumulation of water within the wall assembly by providing a water-resistant barrier behind the exterior veneer as required by Section R703.2 and a means of draining to the exterior water that enters the assembly. Protection against condensation in the exterior wall assembly shall be provided in accordance with Section R702.7 of this code.

- **Flashing**
- **Water-resistive barrier**
- **Means of draining water**
- **Protection against condensation**

Material/Component Standards for Management of Bulk Water Entry at Walls

Water-Resistive Barriers Materials & Assemblies

- ASTM D226/D226M-09 Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
- Active Standard(Latest Version)ASTM E2556/E2556M-10 Standard Specification for Vapor Permeable Flexible Sheet Water-Resistive Barriers Intended for Mechanical Attachment
- ASTM E1677-11 Standard Specification for Air Barrier (AB) Material or System for Low-Rise Framed Building Walls
- ASTM WK16958 New Specification for Fluid-Applied Air Barrier Materials
- ASTM WK50742 New Practice for Standard Practice for Assessing the Durability of Membrane Forming Fluid-Applied Air and Water-Resistive Barriers

Flashing Materials

- AAMA 711-13, Voluntary Specification for Self Adhering Flashing Used for Installation of Exterior Wall Fenestration Products
- AAMA 712-11, Voluntary Specification for Mechanically Attached Flexible Flashing
- AAMA 714-15 Voluntary Specification for Liquid Applied Flashing Used to Create a Water-Resistive Seal around Exterior Wall Openings in Buildings

Drainage Media

- ASTM E2925-14 Standard Specification for Manufactured Polymeric Drainage and Ventilation Materials Used to Provide a Rainscreen Function

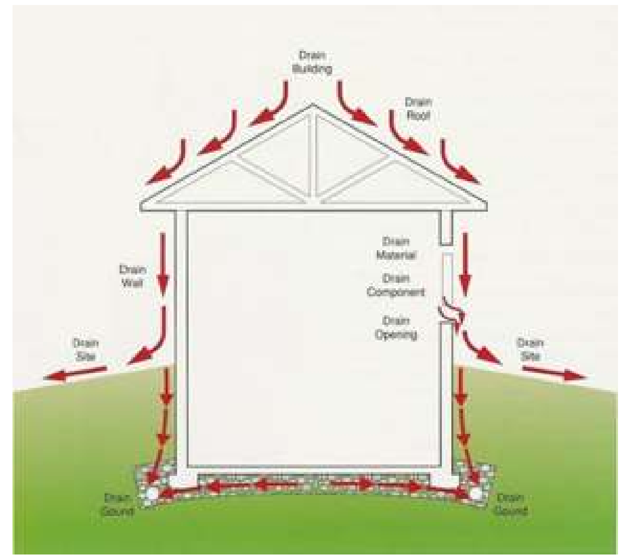


Illustration from the EEBA Water Management Guide, 2002

ASTM E2556-09 Standard Specification for Vapor Permeable Flexible Sheet Water-Resistive Barriers Intended for Mechanical Attachment

Consensus standard which can be referenced in specifications, etc.

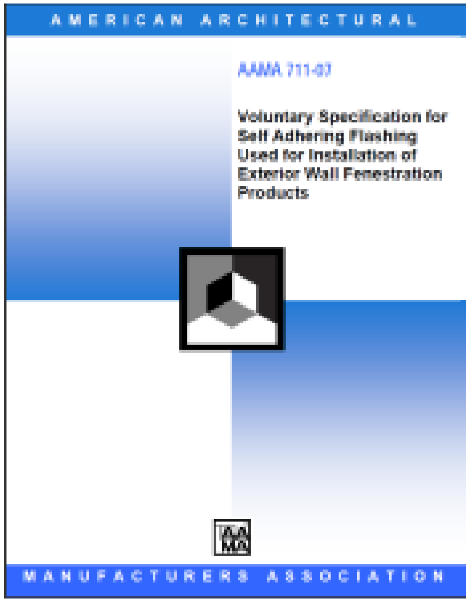
- Referenced in 2015 IBC, Section 2510.6
- Based on ICC-ES AC-38
- Includes building felt, building paper and building wraps
- Two types of WRB based on water resistance (perforated vs. non-perforated)

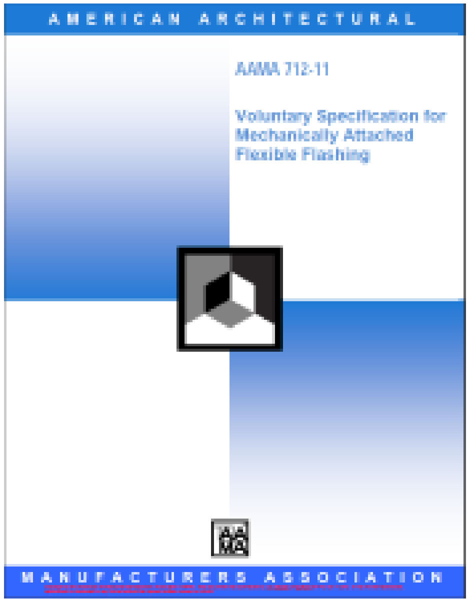
E2556/E2556M – 09

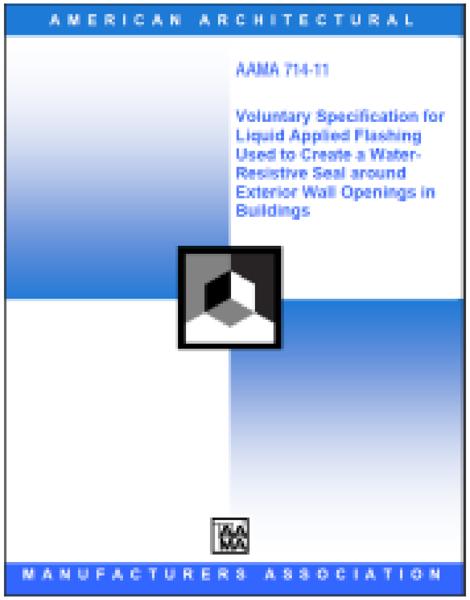
TABLE 1 Requirements for Water Resistive Barriers

Test Requirement	Specimen Type	Test Method	Minimum Performance Requirements	
			Type I	Type II
Dry tensile strength or dry breaking force (choose 1)	(1) as manufactured and (2) aged in accordance with A1.2	Test Method D828 for paper and felt materials, or	3500 N/m (20 lb/in.) minimum (machine and cross direction)	
		Test Methods D882 for polymeric materials, or	3500 N/m (20 lb/in.) minimum (machine and cross direction)	
		Test Method D5034 (Grab Method)	178 N (40 lbf) minimum (machine direction) 156 N (35 lbf) minimum (cross direction)	
Water resistance test (choose 1)	(1) as manufactured and (2) aged in accordance with A1.2	Test Method D779, or	10 min minimum	60 min minimum
		Water Resistance Ponding Test (A1.1), or	No water shall transmit through the membrane in 120 min	not applicable
		AATCC Test Method 127 except that the specimens shall be held at a hydrostatic head of 55 cm (21.6 in.)	not applicable	No leakage is permitted to the underside of any specimen in 300 min
Water vapor transmission test	as received	Test Method E96/E96M (Desiccant Method)	290 ng/(Pa · s · m²) (5 perms) minimum	
Pliability test	as received	see A1.3	The material shall not crack when bent over a 1.6 mm ($\frac{1}{16}$-in.) diameter mandrel at a temperature of 0°C (32°F)	

Flashing Materials



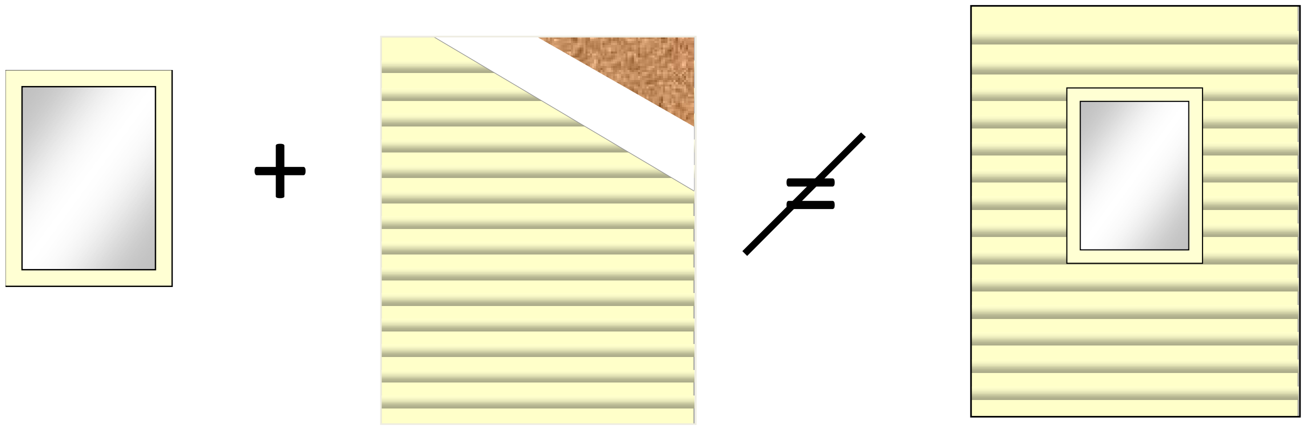




AAMA 711-13 Voluntary Specification for Self Adhering Flashing Used for Installation of Exterior Wall Fenestration Products

Property	Test Method	Minimum Requirement
SECTION 5.1		
- Tensile Strength – Rubber and Thermoplastics - Tensile Strength – Polymer Modified Bitumens - Tensile Strength – Woven/Nonwoven Textile Fabrics	ASTM D412, Method A, Die C ASTM D1970, Section 7.3 ASTM D5034	985 kPa (143 psi) minimum 985 kPa (143 psi) minimum 0.5 N/mm (2.9 lbs/in) minimum
SECTION 5.2		
- Water Penetration Around Nails: • After 24 hours @ 23°C ± 2°C (73°F ± 4°F) & 50% ± 10 RH • After thermal cycling (10 cycles)	ASTM D1970, Section 7.9, modified per 5.2.1.	Must Pass 31 mm (1.2 in) of water Must Pass
- Water Penetration Around Nails (alt.): • After 24 hours @ 23°C ± 2°C (73°F ± 4°F) & 50% ± 10 RH • After thermal cycling (10 cycles)	ASTM E331/E547, or modified test per Annex 1	Must Pass Must Pass
SECTION 5.3		
- 90° Peel Adhesion (initial) - After 24 hours @ 23°C ± 2°C (73°F ± 4°F) & 50% ± 10 RH - All Suitable Substrates	ASTM D3330, Method F	0.26 N/mm (1.5 lbs/in) minimum
SECTION 5.4		
- Accelerated UV Aging - 90° Peel Adhesion - Appearance	ASTM G154 or ASTM G155 (per Cycle 7a) ASTM D3330, Method F Visual	0.26 N/mm (1.5 lbs/in) minimum Note change from original appearance
SECTION 5.5		
- Elevated Temperature Exposure • Level 1 - 50°C (122°F) 7 days • Level 2 - 65°C (149°F) 7 days • Level 3 - 80°C (176°F) 7 days - Appearance	ASTM D 3330, Method F Visual	0.26 N/mm (1.5 lbs/in) minimum Note change from original appearance
SECTION 5.6		
- Thermal Cycling (10 cycles) - 90° Peel Adhesion (See Section 5.6 for temperatures) - Appearance	ASTM D 3330, Method F, Section 16 Visual	0.26 N/mm (1.5 lbs/in) minimum Note change from original appearance
SECTION 5.7		
- Cold Temperature Pliability	ASTM C 765	Must Pass -18°C (0°F)
SECTION 5.8		
- Adhesion after water immersion	AAMA 800, Sections 2.4.1.3.1/2.4.1.4.3 Test B	0.26N/mm (1.5 lbs/in) minimum
SECTION 5.9		
- Resistance to Peel	Annex 2	Report Only

TABLE 1: Summary of the Test Methods



Building Envelope Discontinuity – The Fenestration

Water damage can occur at the Fenestration due to infiltration from many sources, the most common being:

1. Through the window joinery – window leaks
2. At the window-wall interface – improper integration with flashing/sealant
3. From above the Fenestration – in the wall cavity / behind the sheathing or WRB

5
4

Window Installation Standards

Designation: E2112 – 07

Standard Practice for Installation of Exterior Windows, Doors and Skylights[1]

This standard is issued under the fixed designation E2112; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

This document is intended to provide technical guidance to organizations that are developing training programs for installers of fenestration units in low-rise residential and light commercial structures. The majority of fenestration units selected for installation in these types of structures are certified as meeting specified performance characteristics in standardized laboratory testing. Experience indicates, however, that the performance of fenestration installations is frequently significantly inferior to the performance of the manufactured units in laboratory testing. Installation of fenestration units can significantly influence in-service performance.

The requirements promulgated in this practice have, by consensus, (of individuals with specialized knowledge concerning installation of fenestration units) been identified as necessary to ensure that as-installed performance is roughly equivalent to performance in laboratory testing. The task group responsible for development of this practice recognizes that building owners sometimes, accept as adequate, in-service performance of fenestration installations that are significantly inferior those of the units in laboratory testing. This practice is not intended for use in such circumstances, where owner expectations are modest. The intent of this practice is to provide guidance to those concerned with ensuring that as-installed performance is comparable to the capabilities of the units installed for a solid majority of installations.

A particularly noticeable behavior that indicates deficiencies in installation is rainwater leakage. Rainwater leakage has been the leading reason for dissatisfaction of building owners with performance of fenestration installations. For this reason, this practice places greater emphasis on preventing or limiting rainwater leakage than on any other single performance characteristic.

This practice emphasizes that the water-shedding surfaces of fenestration units must be adequately integrated with adjacent water-shedding surfaces of the building envelope. It does not, however, attempt to promulgate requirements for water-shedding surfaces of building envelopes other than

FMA/AAMA/WDMA Installation Committee

- Formed by FMA in 2005 (after extreme 2004 Hurricane season) to address fenestration water intrusion concerns with residential construction in the southeast region. AAMA and WDMA joined shortly after
- Developing robust, easy to follow (something that could be given to an installer), illustrated installation standards for specific window/door/wall system combinations
- Standard practices developed by industry experts from Window Manufacturers, Flashing / Sealant Manufactures, Installers, Building Officials, and Building Science Consultants
- Initial series focused on Southeastern US Wall System & Extreme Exposure conditions

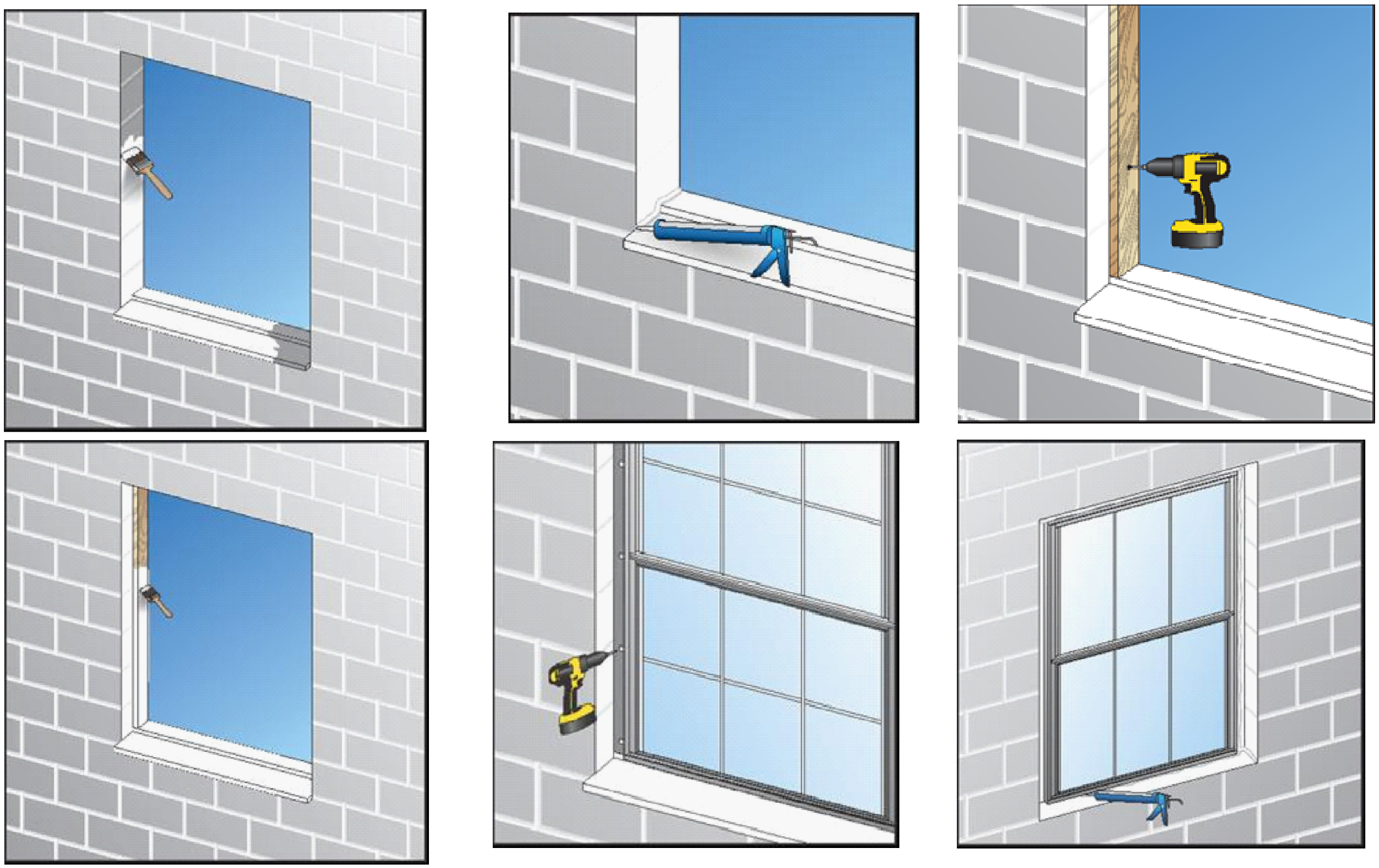
FMA/AAMA/WDMA Installation Committee

- Representative installation methods from all documents are installed and tested by members of the committee – resulting in key learning's that impact the content of the standard practice
- For all extreme exposure guidelines, representative installations are wall tested per ASTM E331 or E547
- Criteria for Success:
  - Installation Feasibility – practical application
  - Water Intrusion Management in areas related to installation method

FMA/AAMA/WDMA Installation Standards

Document	Fenestration	Wall System
FMA/AAMA 100-12	Windows: Flanged or Mounting Fins (Wood, Al, or Vinyl)	Wood Frame
FMA/AAMA 200- 12	Windows: Frontal Flanged (Aluminum and Vinyl)	Surface Barrier Masonry Construction for Extreme Wind/Water Conditions.
FMA / WDMA 250-10	Windows: Non-frontal flanged (Wood)	Surface Barrier Masonry Construction for Extreme Wind / Water Conditions
FMA / AAMA / WDMA 300-12	Exterior Doors with mounting fins, brick mold, and box frame	Wood Frame Construction for Extreme Wind/Water Exposure
FMA / AAMA / WDMA 400-13	Exterior Doors with mounting fins, brick mold, and box frame	Surface Barrier Masonry Construction for Extreme Wind/Water Exposure
FMA / AAMA / WDMA 500-16	Windows: Flanged or Mounting Fins	Wood frame Foam Plastic Insulating Sheathing (FPIS) with a Separate Water-Resistive Barrier (WTB)

FMA / AAMA 200-12 – Isolate the Rough Opening Method



FMA/AAMA/WDMA 500-16 Standard Practice for the Installation of Mounting Flange Windows into Walls Utilizing Foam Plastic Insulating Sheathing (FPIS) with a Separate Water-Resistive Barrier (WTB)

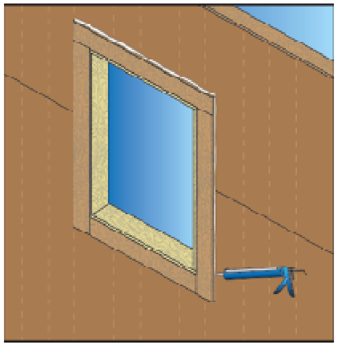
	WINDOW POSITIONING RELATIVE TO EXTERIOR PLANE OF WALL	*FPIS RELATIVE TO WRB*	*WRB/WINDOW SEQUENCE*
A	Window in ROESE in plane with exterior wall.	FPIS interior of WRB	WRB Before and After
B	Window in ROESE in plane with exterior wall.	FPIS exterior of WRB	WRB Before or After is the same
C1	Window mounted directly onto structural sheathing; Outermost plane of the window protruding relative to FPIS exterior by at least ¾".	FPIS exterior to WRB	WRB Before and After
C2	Window mounted directly onto structural sheathing; Outermost plane of the window recessed or protruding by less than ¾" relative to FPIS exterior.	FPIS exterior to WRB	WRB Before and After

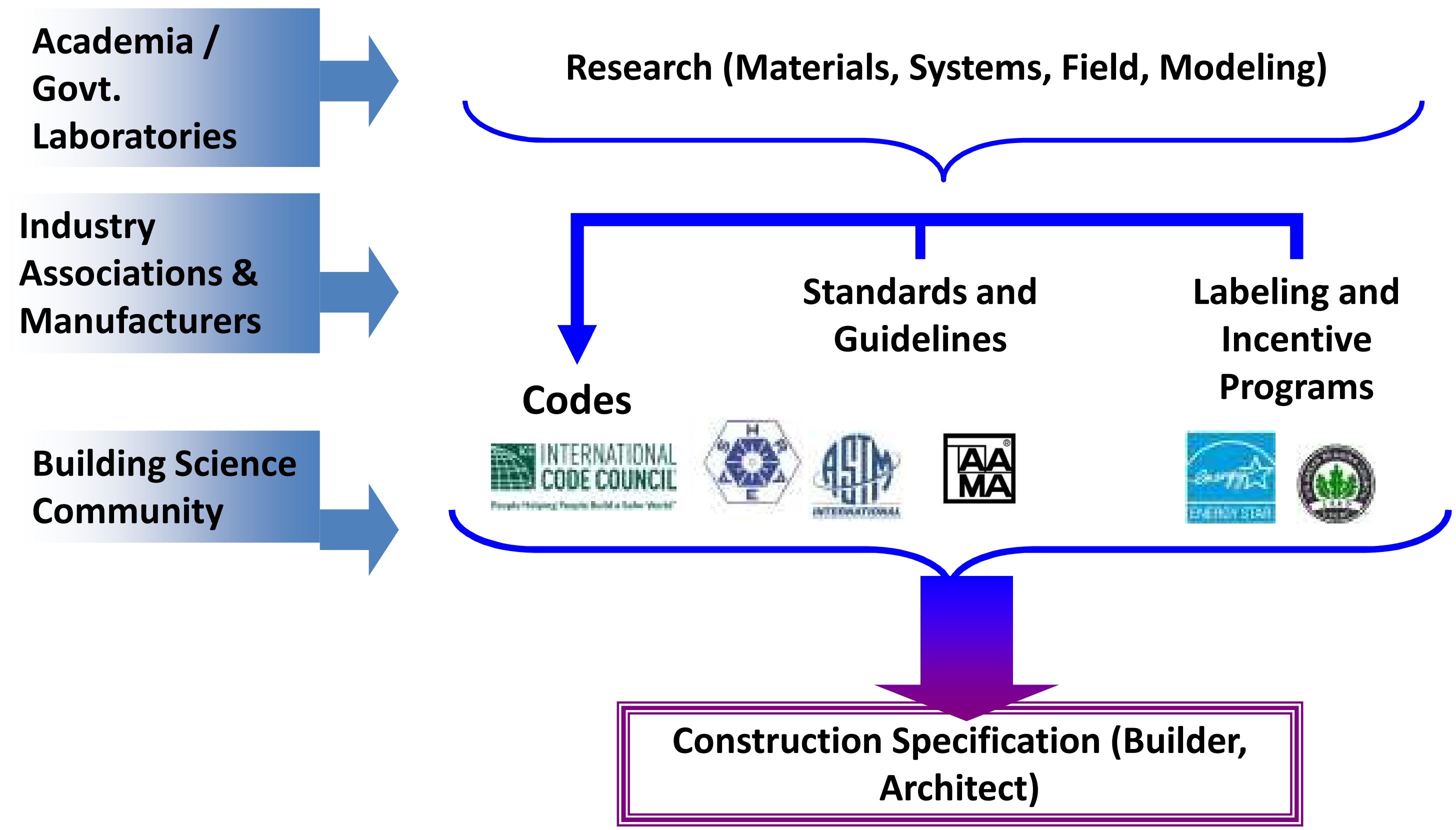
TABLE 1: Summary of Installation Methods

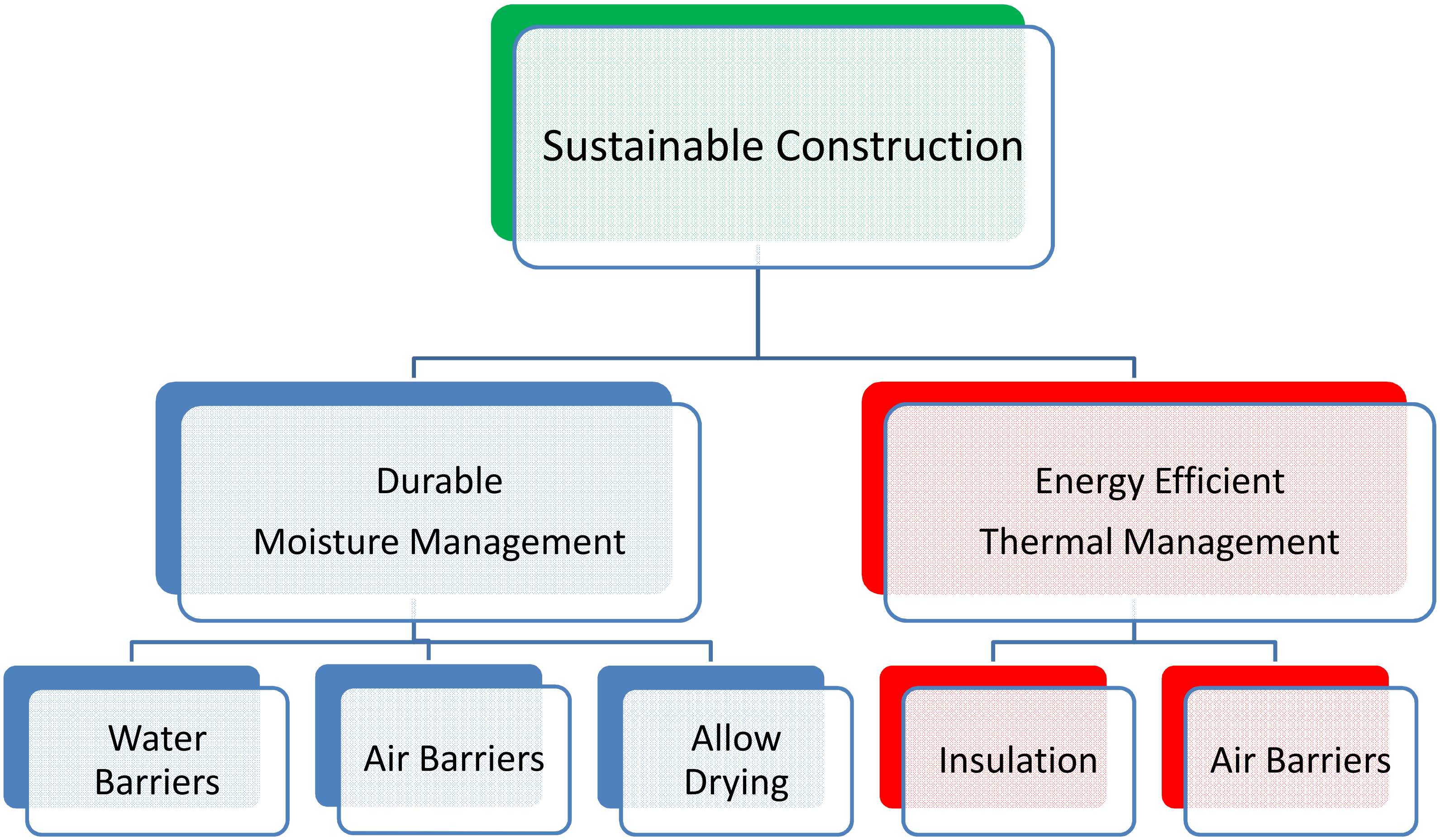
FMA/AAMA/WDMA 500-16

Methods A and B feature a Rough Opening Extension Support Element (ROESE)

Rough Opening Extension Support Element (ROESE), n. – A projection (“bump-out”) or extension to the structural wall framing at the rough opening perimeter. The function of the ROESE is to: 1) support the weight of the window, 2) allow direct structural attachment of the window in order to transfer wind loads to the structure, and 3) enable window alignment with the exterior plane of the FPIS for proper integration with cladding and/or WRB. It shall consist of a material and fastening method capable of maintaining structural continuity between framing and the window.




Academia / Govt. Laboratories
Industry Associations & Manufacturers
Building Science Community
Research (Materials, Systems, Field, Modeling)
Codes
Standards and Guidelines
Labeling and Incentive Programs
INTERNATIONAL CODE COUNCIL
AAMA
Construction Specification (Builder, Architect)


Sustainable Construction
Durable
Moisture Management
Energy Efficient
Thermal Management
Water Barriers
Air Barriers
Allow Drying
Insulation
Air Barriers

"Resilience: Know you can bounce back from anything. Think of criticism as faith in your potential. Rent room for improvement. Remember jet lag is just a temporary thing."

Thank you for your attention.
Please ask any questions.

The miracles of science™