RESNET
RESIDENTIAL ENERGY SERVICES NETWORK

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Connecting Resilience, Energy Efficiency, Durability and Sustainability to Design Building Envelopes

Amy Schmidt, LEED Green Associate
Theresa A. Weston, PhD.

DuPont Performance Building Solutions

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Learning Objectives

- Understand what Resilience is and how it relates to buildings
- Understand the connection between Resilience, Energy Efficiency, Sustainability and Durability
- Understand how to incorporate resilience into your buildings
- Understand the material and assembly properties which must be assessed when designing wall systems with increased thermal and moisture performance

Resilience

Merriam-Webster definition:

an ability to recover from or adjust easily to misfortune or change

Interest over Time (Google Trends)

Resilience –the new industry buzz word

Resilience is the New Sustainability

The US Resiliency Council is the nation's leading organization dedicated to helping achieve true community and corporate sustainability through the promotion of resilience based building design.

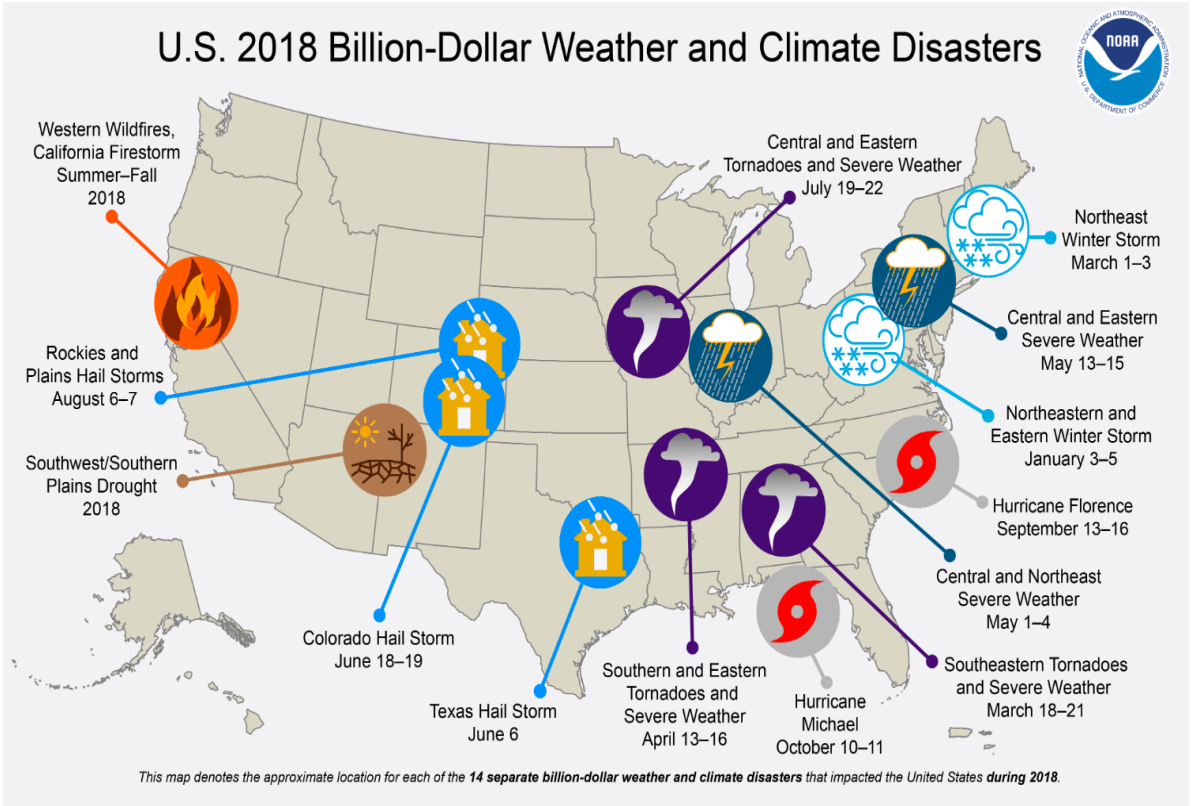
NIST's resilience research focuses on the impact of multiple hazards on buildings and communities and on post-disaster studies that can provide the technical basis for improved standards, codes and practices used in the design, construction, operation and maintenance of buildings and infrastructure systems.

The Uniqueness of ANCR's Community Resilience Benchmark

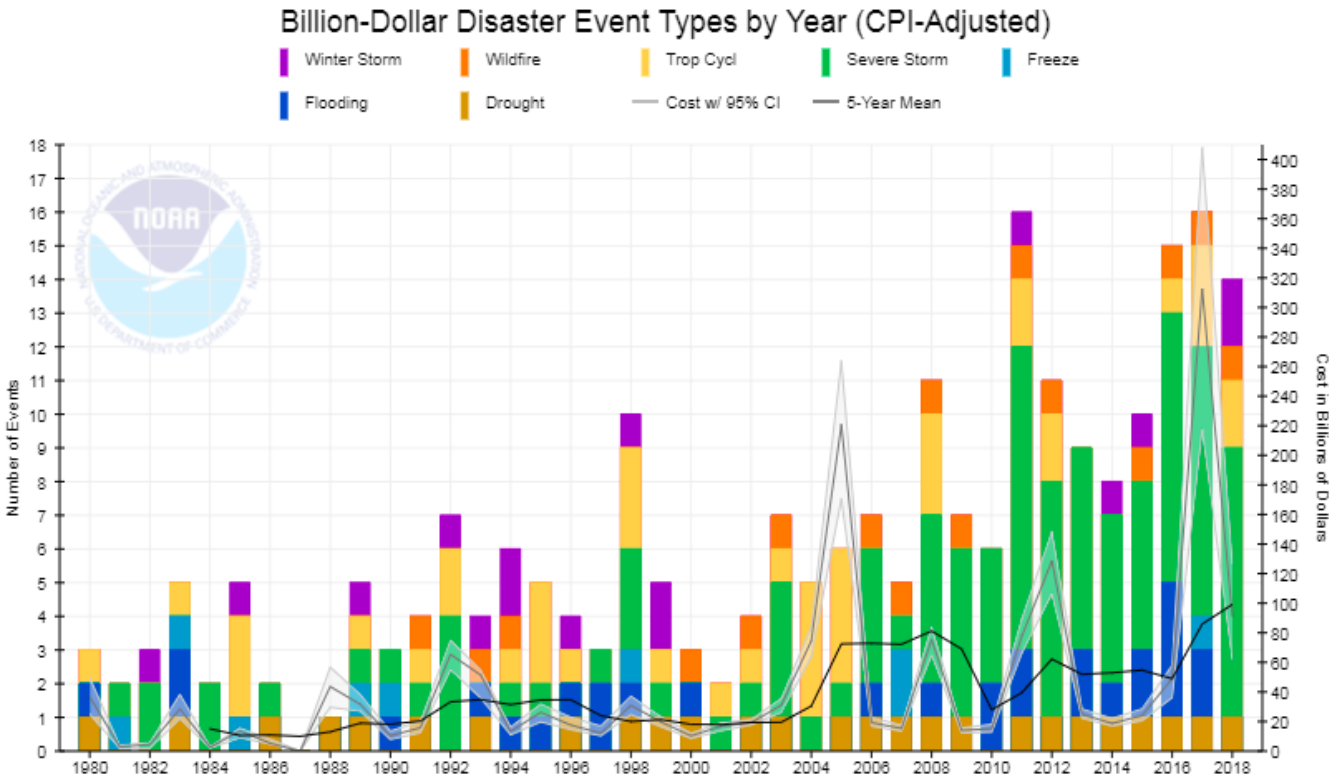
- Will provide a practical, easily understood benchmark for assessing cross-function resilience against which a community may measure itself and identify its strengths and weaknesses.
- Will provide a practical and easily understood pathway for action by identifying which standards, ratings, certifications and best practices a community should achieve or adopt to become more resilient.
- Will look at all aspects of the community's resilience – the built infrastructure, the economy and the social fabric – using a "whole community" approach.
- Will Consider the functions (rather than individual systems) that a community must perform to be resilient thereby inherently addressing the interdependency of critical systems.
- Will primarily uses existing standards, ratings, certifications and best practices to create the benchmark.

"The goal of the Community and Regional Resilience Institute (CARRI) is to strengthen any community or region's ability to prepare for, respond to, and rapidly recover from significant human caused or natural disaster with minimal downtime for the community."

Welcome to the RELi Resilience Action List + Credit Catalog. RELi <pronounced *rely*> combines a comprehensive list of resilient design criteria with the latest in proven integrative process for developing next generation communities, neighborhoods, buildings, homes and infrastructure. RELi is a project rating system similar to LEED®, but with added emphasis on resilience. The Credit Catalog includes *new* resilience-based actions (requisites + credits) pioneered for RELi in 2014. RELi also aggregates action items from other sustainable guidelines that support resiliency.



NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2019). https://www.ncdc.noaa.gov/billions/



NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2019). https://www.ncdc.noaa.gov/billions/

Billion-dollar events to affect the U.S. from 1980 to 2018 (CPI-Adjusted)

DISASTER TYPE	NUMBER OF EVENTS	PERCENT FREQUENCY	CPI-ADJUSTED LOSSES *(BILLIONS OF DOLLARS)*	PERCENT OF TOTAL LOSSES	AVERAGE EVENT COST *(BILLIONS OF DOLLARS)*	DEATHS
Drought	26	10.8%	$244.3 CI	14.6%	$9.4	2,993†
Flooding	29	12.0%	$123.5§ CI	7.4%§	$4.3§	543
Freeze	9	3.7%	$30.0 CI	1.8%	$3.3	162
Severe Storm	103	42.7%	$226.9 CI	13.6%	$2.2	1,615
Tropical Cyclone	42	17.4%	$919.7 CI	55.1%	$21.9	6,487
Wildfire	16	6.6%	$78.8 CI	4.7%	$4.9	344
Winter Storm	16	6.6%	$47.3 CI	2.8%	$3.0	1,044
All Disasters	**241**	**100.0%**	**$1,670.5 CI**	**100.0%**	**$6.9**	**13,188**

†Deaths associated with drought are the result of heat waves. (Not all droughts are accompanied by extreme heat waves.)
§Flooding statistics do not include inland flood damage caused by tropical cyclone events.
The confidence interval (CI) probabilities (75%, 90% and 95%) represent the uncertainty associated with the disaster cost estimates. Monte Carlo simulations were used to produce upper and lower bounds at these confidence levels (Smith and Matthews, 2015).

NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2019). https://www.ncdc.noaa.gov/billions/

Buildings are only one piece of resilience

Necessary Community Functions/Infrastructure:

- Buildings
- Business
- Communications
- Communication Infrastructure
- Culture & Recreation
- Education & Training
- Energy
- Finance
- Governance
- Local Government
- Natural Environment
- Neighborhoods
- Health Care
- Public Safety & Security
- Solid Waste
- Transportation
- Water

If one link is broken the community will not function properly.

An Ounce of Prevention is Worth a Pound of Cure.

~ Benjamin Franklin

He was referring to the inadequacies of fire safety. This led to efforts to become more resilient. As a result the Philadelphia Union Fire Company was formed. The led efforts to educate the public about fire safety and improved fire fighting techniques.

https://www.ag.ndsu.edu/news/columns/beeftalk/beeftalk-an-ounce-of-prevention-is-worth-a-pound-of-cure/

Modern Building Code Adoption is recognized as an essential criteria for achieving Resilience.

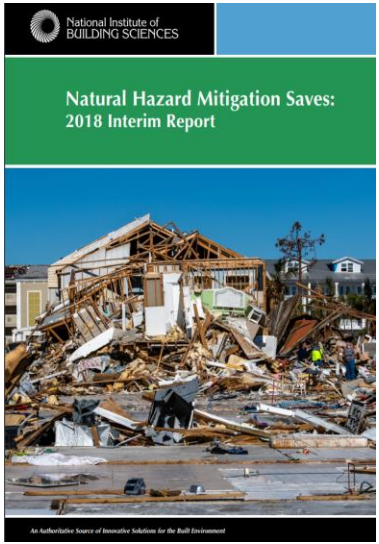
FEMA analysis from 2014 estimated approximately $500 million in annualized loss avoided in eight southeastern states due to do the adoption of modern building codes.

Disaster Recovery Reform Act of 2018 includes grants for updating codes.

Researchers at the Wharton School's Risk Management and Decision Processes Center found that modern and well-enforced building codes in Missouri have reduced hail damage to homes by 10 to 20 percent on average.

Alliance for National Community Resilience Buildings Benchmark Requirement.

An Insurance Institute for Business & Home Safety study following Hurricane Charley found that post-Hurricane Andrew code improvements and code application in Florida reduced the frequency of property damage by 60 percent and the severity of damage by 42 percent for residences.



Benefit-to-Cost Ratio by Hazard and Mitigation Measure.

National Benefit-Cost Ratio Per Peril *BCR numbers in this study have been rounded	Exceed common code requirements	Meet common code requirements	Utilities and transportation	Federally funded
Overall Hazard Benefit-Cost Ratio	4:1	11:1	4:1	6:1
Riverine Flood	5:1	6:1	8:1	7:1
Hurricane Surge	7:1	Not applicable	Not applicable	Too few grants
Wind	5:1	10:1	7:1	5:1
Earthquake	4:1	12:1	3:1	3:1
Wildland-Urban Interface Fire	4:1	Not applicable	Not applicable	3:1

Resilient buildings are a critical component of resilient communities.

Building

Community

What makes a building resilient?

Buildings contribute to all phases of resilience.

Mitigation

- Moisture Management
  - Mold prevention
  - Condensation prevention
  - Decay prevention
  - Flood prevention
- Air Leakage Mitigation
  - Pollutant mitigation
  - Condensation prevention
  - Thermal performance
- Thermal Performance
  - Affordability
  - Comfort
- Structural Performance
  - Wind damage prevention

Response

- Moisture Management
  - Manage bulk rain water
  - Condensation controlled
- Air Leakage
  - Smoke and other pollutants kept out
  - Condensation minimized
  - Thermal performance maximized
- Thermal Performance
  - Ability to shelter in place with power loss
- Structural Performance
  - Roof and exterior material stability under stress

Recovery

- Moisture Management
  - Materials and assemblies that stay dry or dry quickly
- Air Leakage
  - Condensation minimized
  - Thermal performance maximized
- Thermal Performance
  - Ability to shelter in place with power loss
- Structural Performance
  - Easy minor repairs

Alliance for National & Community Resilience

ALLIANCE FOR NATIONAL & COMMUNITY RESILIENCE

Resilience requires a whole community approach. The Alliance for National & Community Resilience is developing the tools to assist communities in evaluating and improving their resilience.

1) Adoption of Building Codes	
Essential Requirements	**Acceptable Evidence**
a) The community has adopted building codes substantially equivalent to the requirements contained in a model code that are no more than 9 years out of date.	• Legislation, regulation, ordinance, or other statute showing adoption of codes that are no more than 9 years out of date relative to the most recently published editions.
Enhanced Requirements	**Acceptable Evidence**
b) The community has adopted building codes substantially equivalent to the requirements contained in a model code that are no more than 6 years out of date.	• Legislation, regulation, ordinance, or other statute showing adoption of codes that are no more than 6 years out of date relative to the most recently published editions.
Exceptional Requirements	**Acceptable Evidence**
c) The community has adopted building codes substantially equivalent to the requirements contained in a model code that are no more than 3 years out of date.	• Legislation, regulation, ordinance, or other statute showing adoption of codes that are no more than 3 years out of date relative to the most recently published editions.

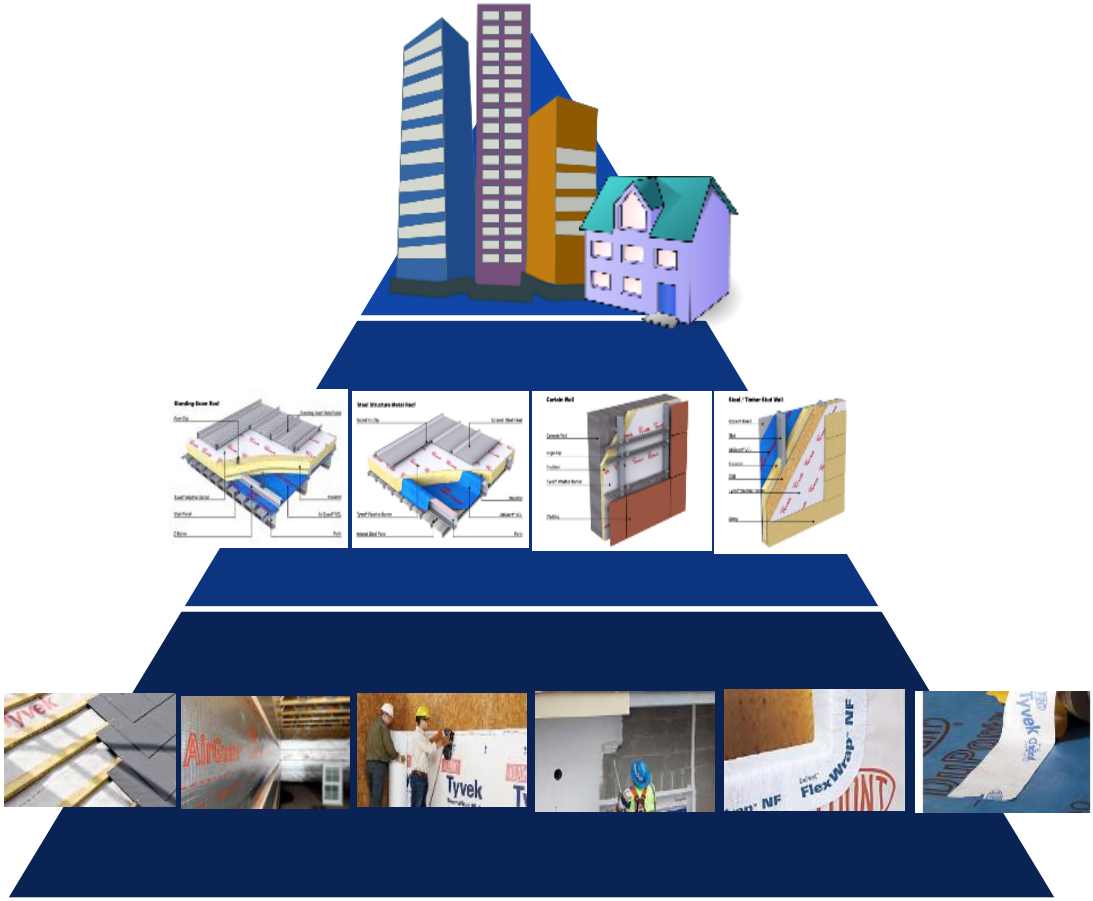
http://www.resilientalliance.org/

- The Buildings Benchmark is published
- The Housing Benchmark us being developed
- There are 8 elements to the buildings benchmark
- Each element has between 1-3 levels of performance (Essential, Enhanced, and Exceptional)
- The requirements and acceptable evidence for the requirements is included under each element
- A commentary provides addition background and explanation of the element

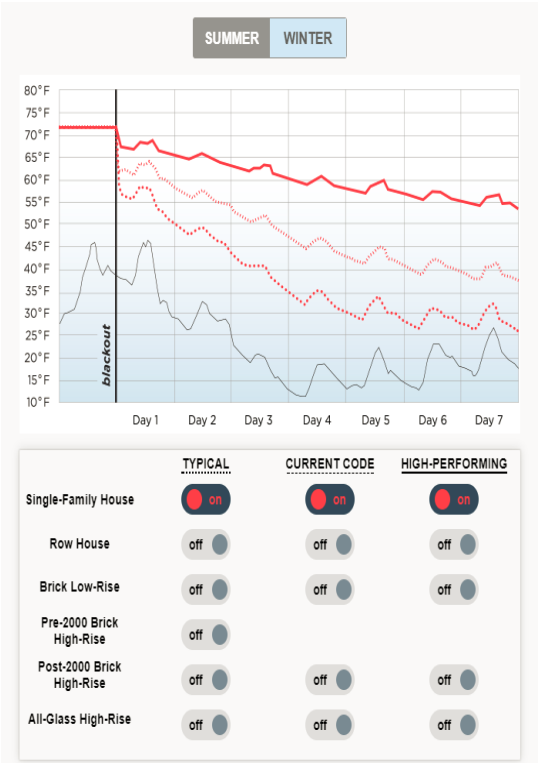
Building Resilience

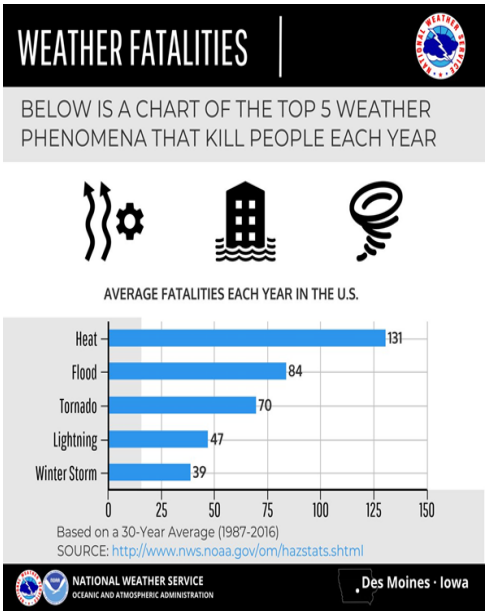
Assembly Performance Quality Installation

Quality Materials Durability Energy Efficient Air & Moisture Management



Energy Efficiency including thermal envelope efficiency is important aspects of Resilience.



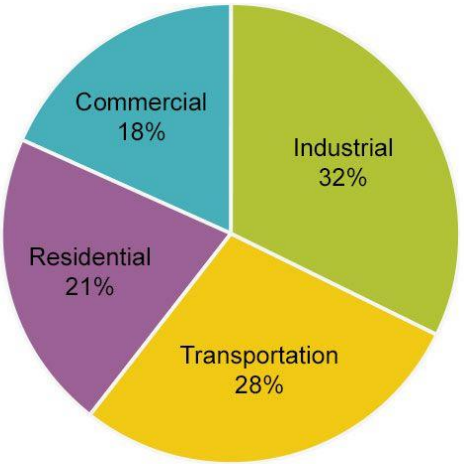


Typical buildings would be between 32°F and 43°F indoors. New buildings are a little better, but still not resilient. A high-performing building that has better windows, fewer air leaks and more insulation would do much better. Without power, these buildings would stay at 54-66°F for a week or more.

Baby It's Cold Inside, 2014 report by Urban Green a Chapter of USGBC, modeling by Atelier Ten

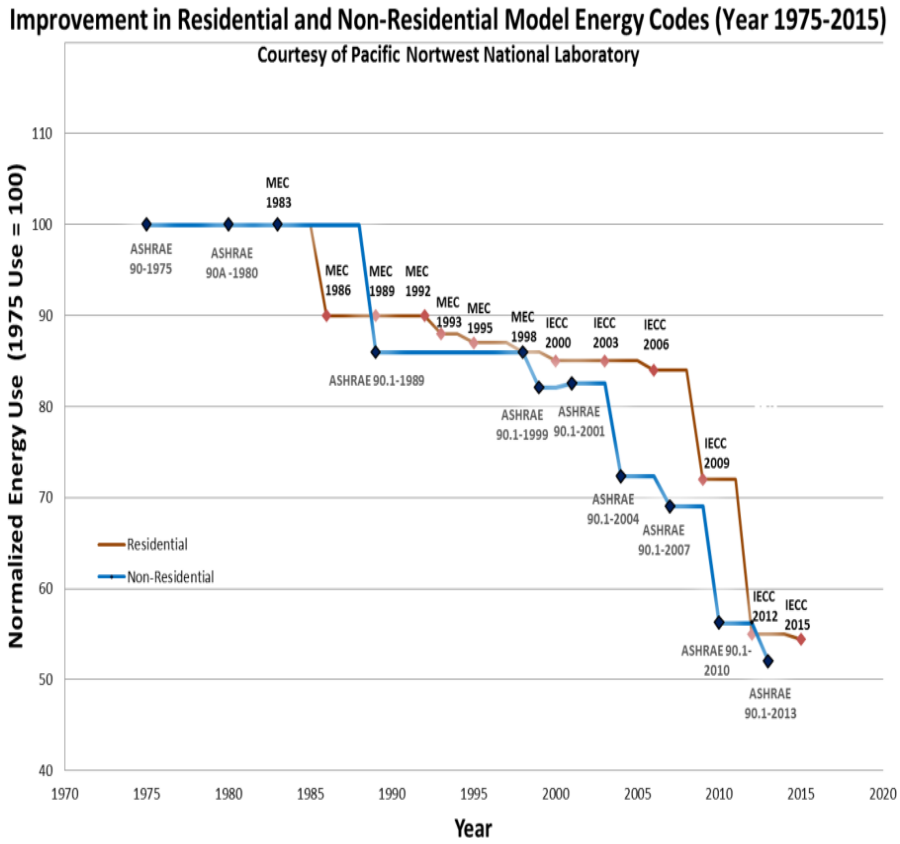
Energy Efficient

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

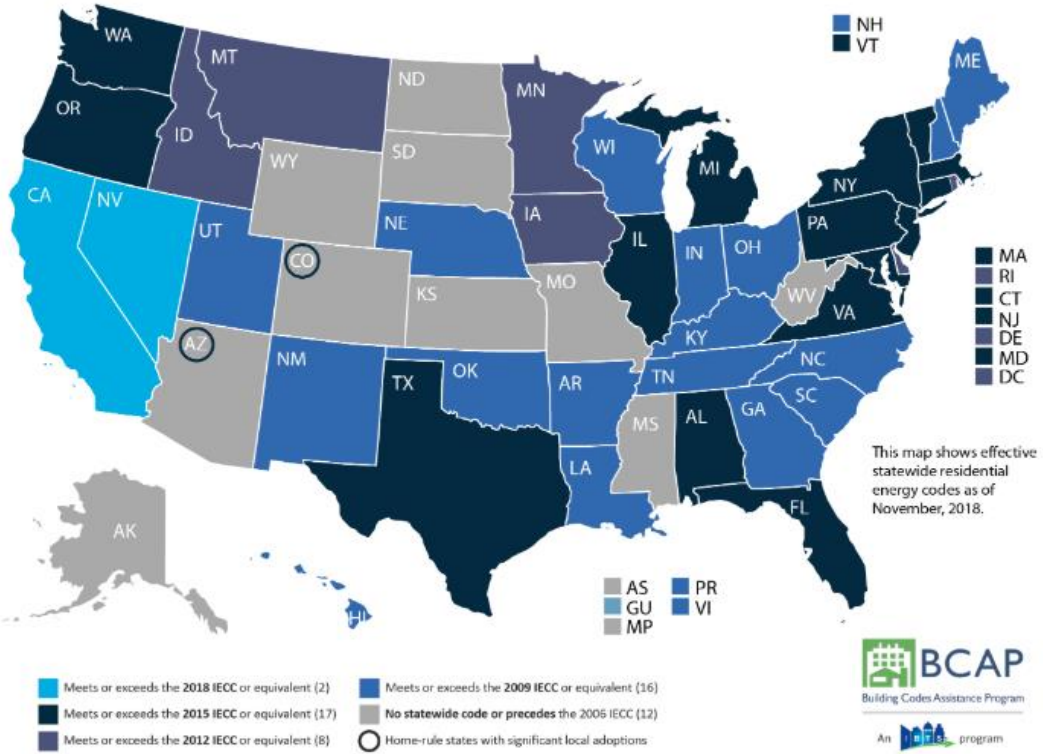


[1]Includes electricity consumption.
Source: U.S. Energy Information Administration, *Monthly Energy Review,* Table 2.1 (April 2013),preliminary 2012 data.

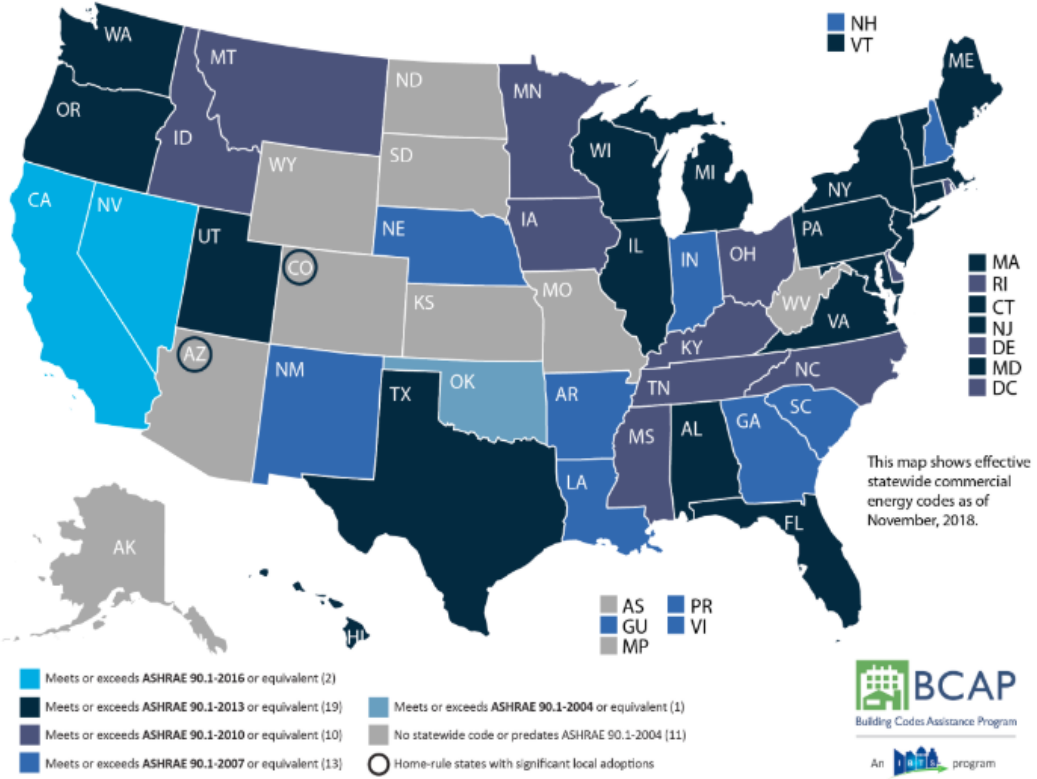
eia


Improvement in Residential and Non-Residential Model Energy Codes (Year 1975-2015)
Courtesy of Pacific Nortwest National Laboratory
Normalized Energy Use (1975 Use = 100)
Year
Residential
Non-Residential
ASHRAE 90-1975
ASHRAE 90A -1980
MEC 1983
MEC 1986
MEC 1989
MEC 1992
MEC 1993
MEC 1995
MEC 1998
IECC 2000
IECC 2003
IECC 2006
IECC 2009
IECC 2012
IECC 2015
ASHRAE 90.1-1989
ASHRAE 90.1-1999
ASHRAE 90.1-2001
ASHRAE 90.1-2004
ASHRAE 90.1-2007
ASHRAE 90.1-2010
ASHRAE 90.1-2013

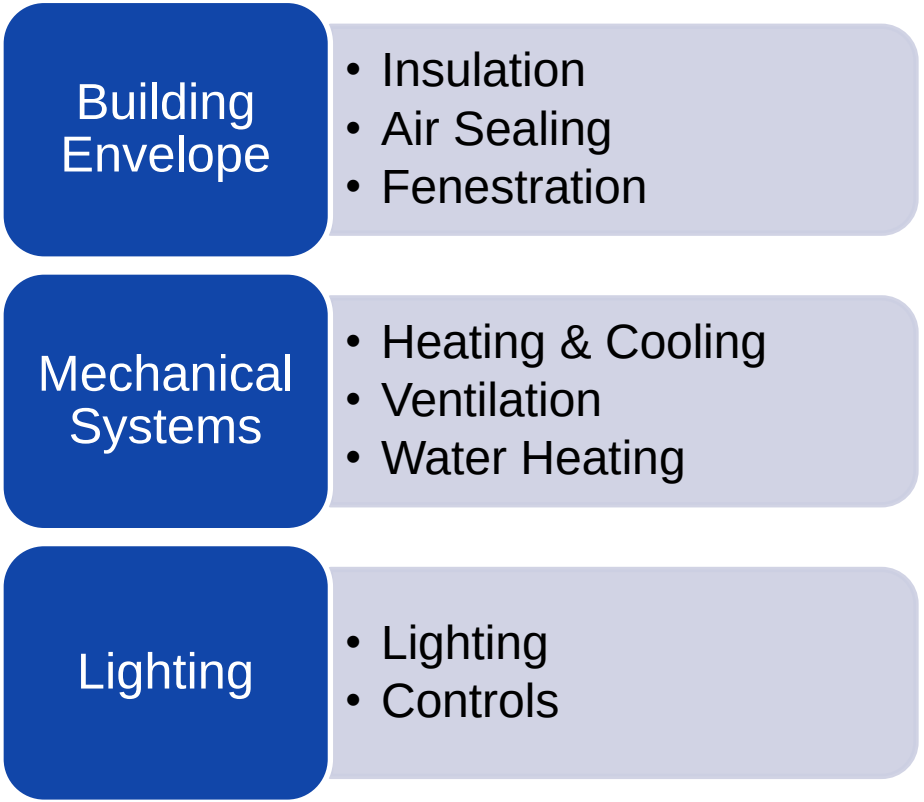
RESIDENTIAL ENERGY CODE ADOPTION



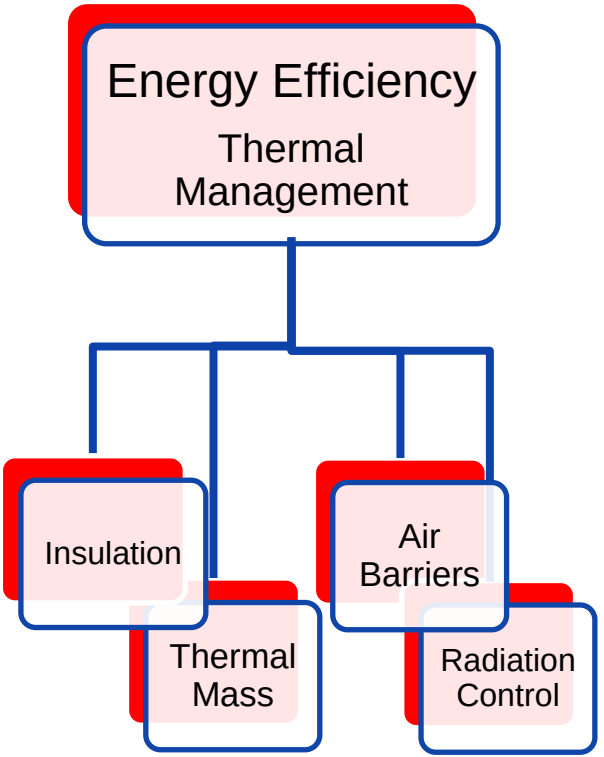
COMMERCIAL ENERGY CODE ADOPTION



Building Energy Efficiency



Building Envelope



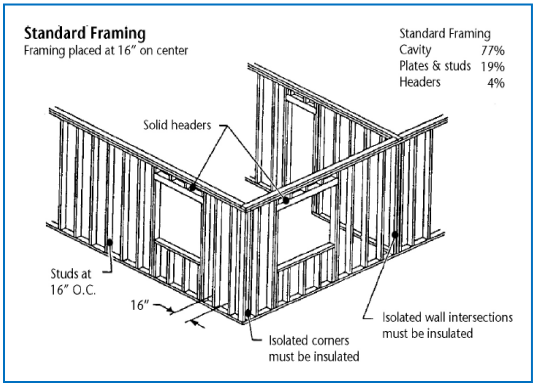
- Increase cavity insulation
- Increase continuous insulation (ci) Reduce thermal bridges
  - Advanced framing
  - Continuous insulation
- Reduce air leakage
  - Air barriers
  - Air impermeable insulation
  - Insulation installation

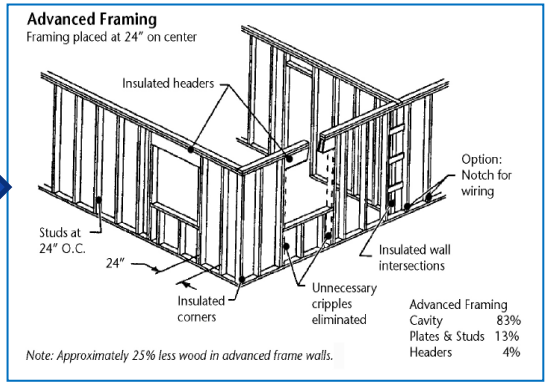
Thermal Bridges

No Exterior Continuous Insulation

With Exterior Continuous Insulation

Reducing Thermal Bridges





Advanced Framing

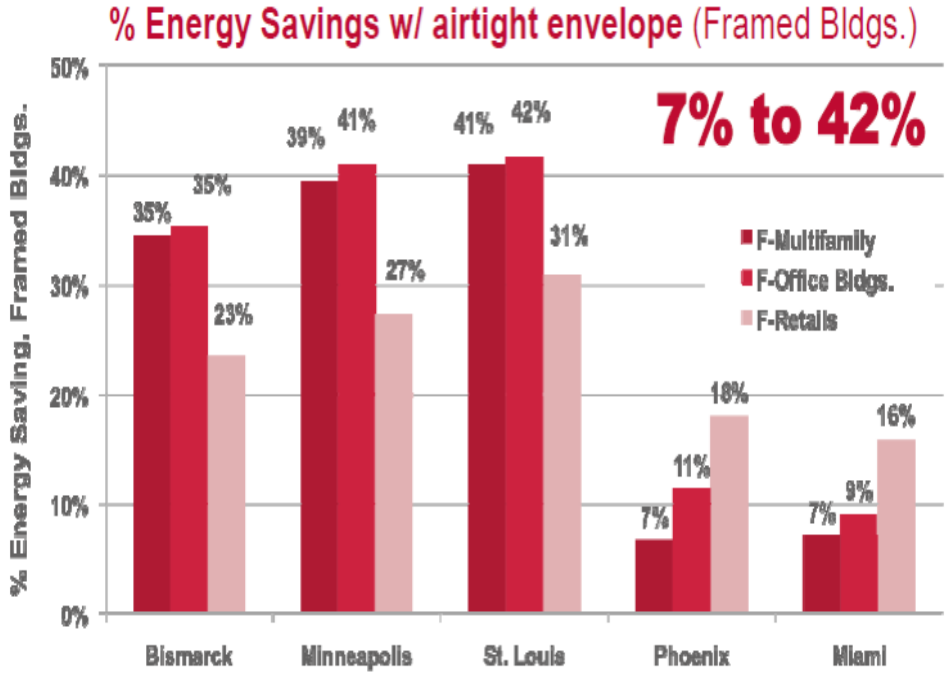
Exterior Continuous Insulation

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

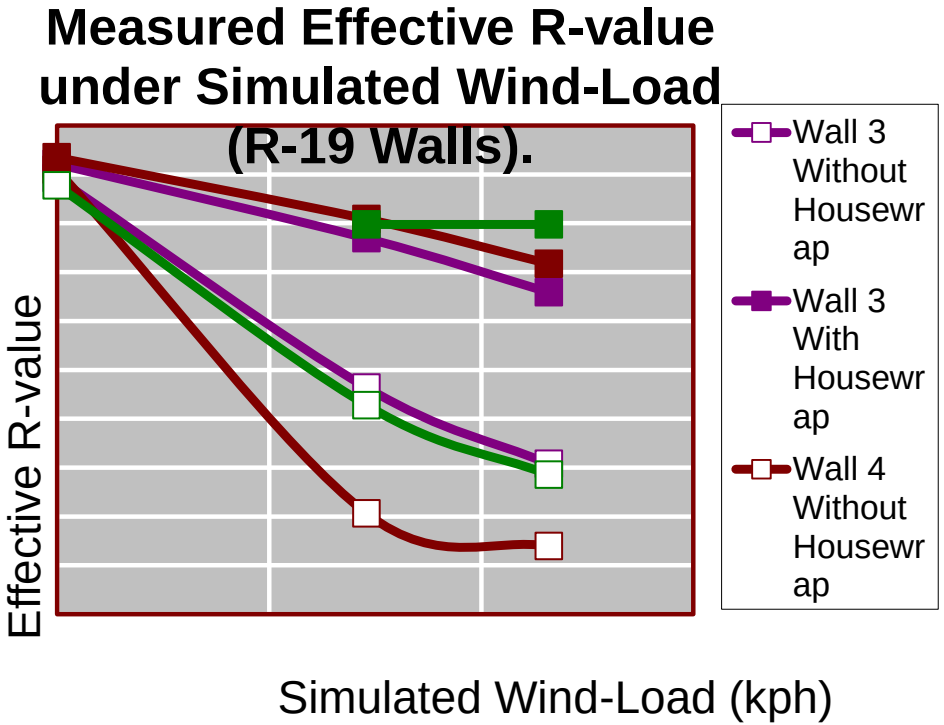
Wall Assembly Component	2x4		2x6		2x4 + c.i.	
	Studs	Cavity	Studs	Cavity	Studs	Cavity
Outside Air Film	.17	.17	.17	.17	.17	.17
Exterior Insulation	n/a	n/a	n/a	n/a	5	5
½" OSB	.62	.62	.62	.62	.62	.62
Stud Wood	3.71	n/a	5.83	n/a	3.71	n/a
Cavity Insulation	n/a	13	n/a	20	n/a	13
½" Gypsum Wallboard	.45	.45	.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%)	**11**		**15**		**17**	
Total Wall (Advanced Framing – 17%)			**17**			

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*

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

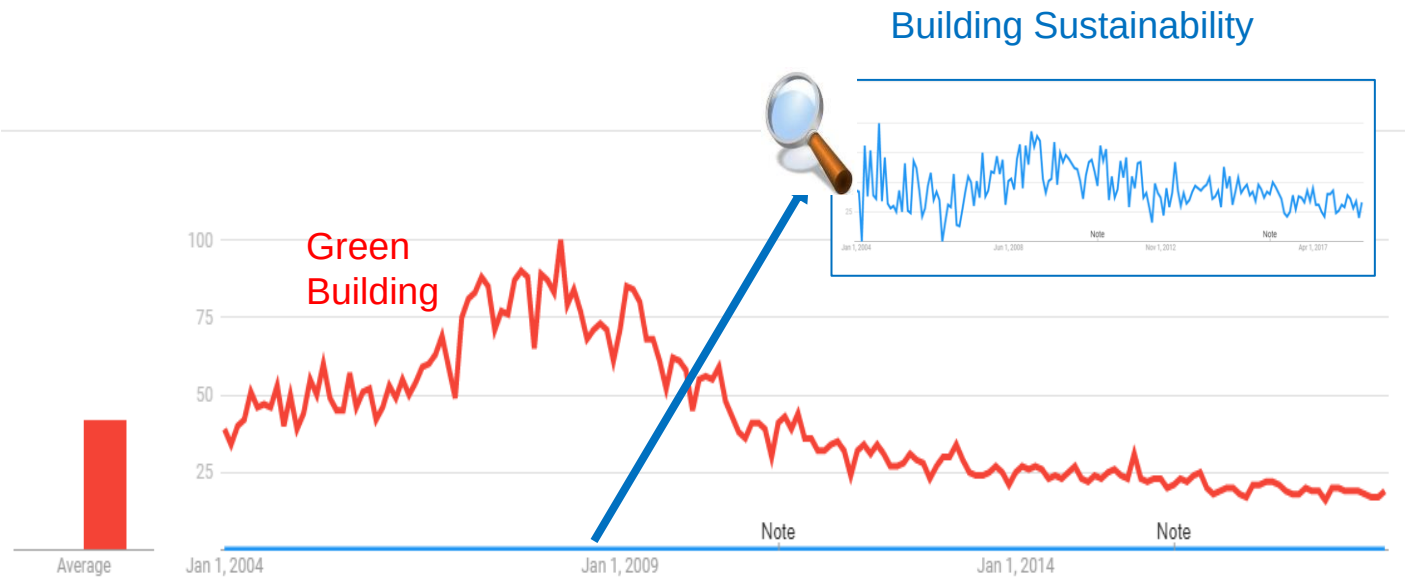


Source: Impact of Airflow on the Thermal Performance of Various Residential Wall Systems utilizing a calibrated hot box, Thermal Envelopes VI/ Heat Transfer in Walls – Principles

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:

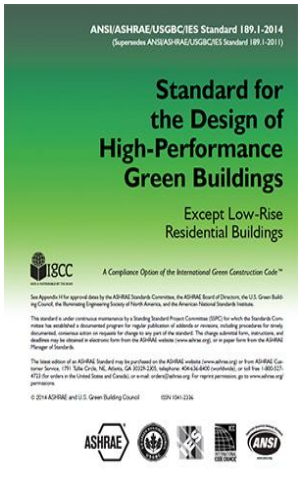
Interest over time: Google Trends

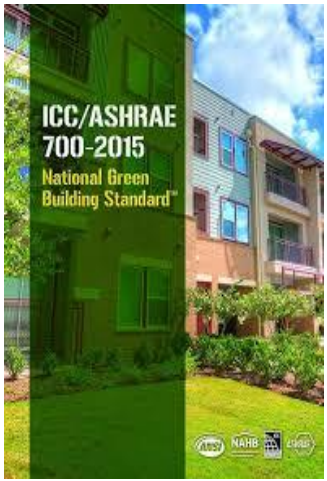



ENERGY
EFFICIENCY


LEED Credit Categories
Sustainable Sites
Water Efficiency
Innovation in Operations & Regional Priority
U.S. GREEN BUILDING COUNCIL
LEED
USGBC
Energy & Atmosphere
Indoor Environmental Quality
Materials & Resources

Building **Site**





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

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

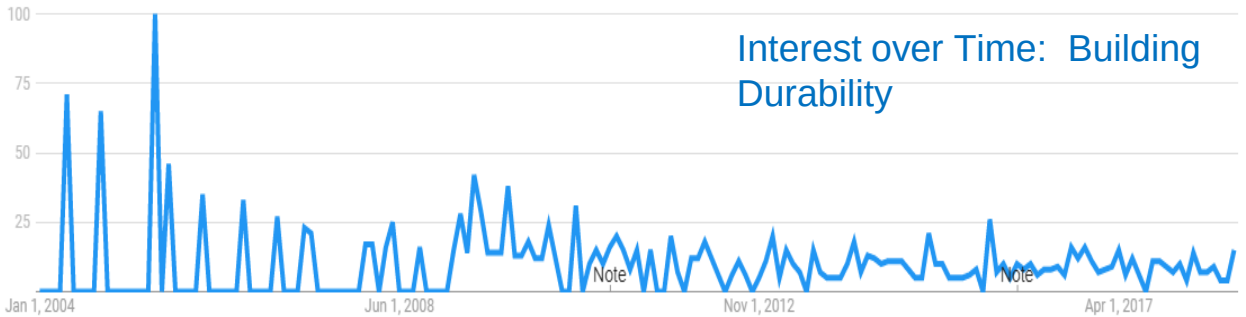
Availability of product to job site 4.16

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.



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

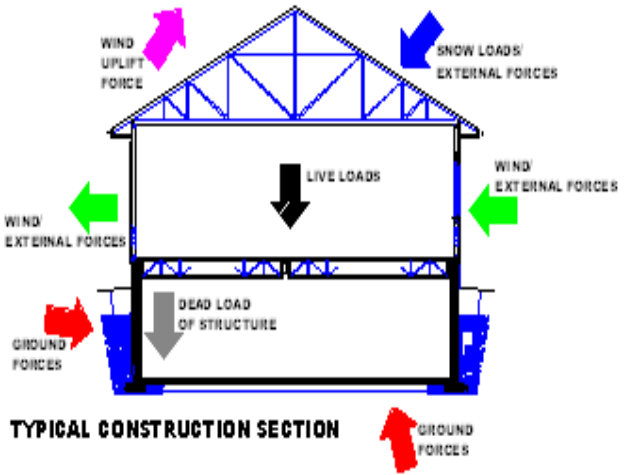


Figure from http://www.kdietrich.com/

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.*"

CSA Durability Standard Development & Canadian Code Adoption

- Canadian Standards Association (CSA) guideline S478 is being converted into a building standard suitable for code adoption.
- Planned incorporation into the National Building Code (NBC) in 2020 and beyond to address building life in the face of harsher climate conditions.
- Building designers will be obligated to create durability plans for new structures once new climate change standards are incorporated.

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.

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)

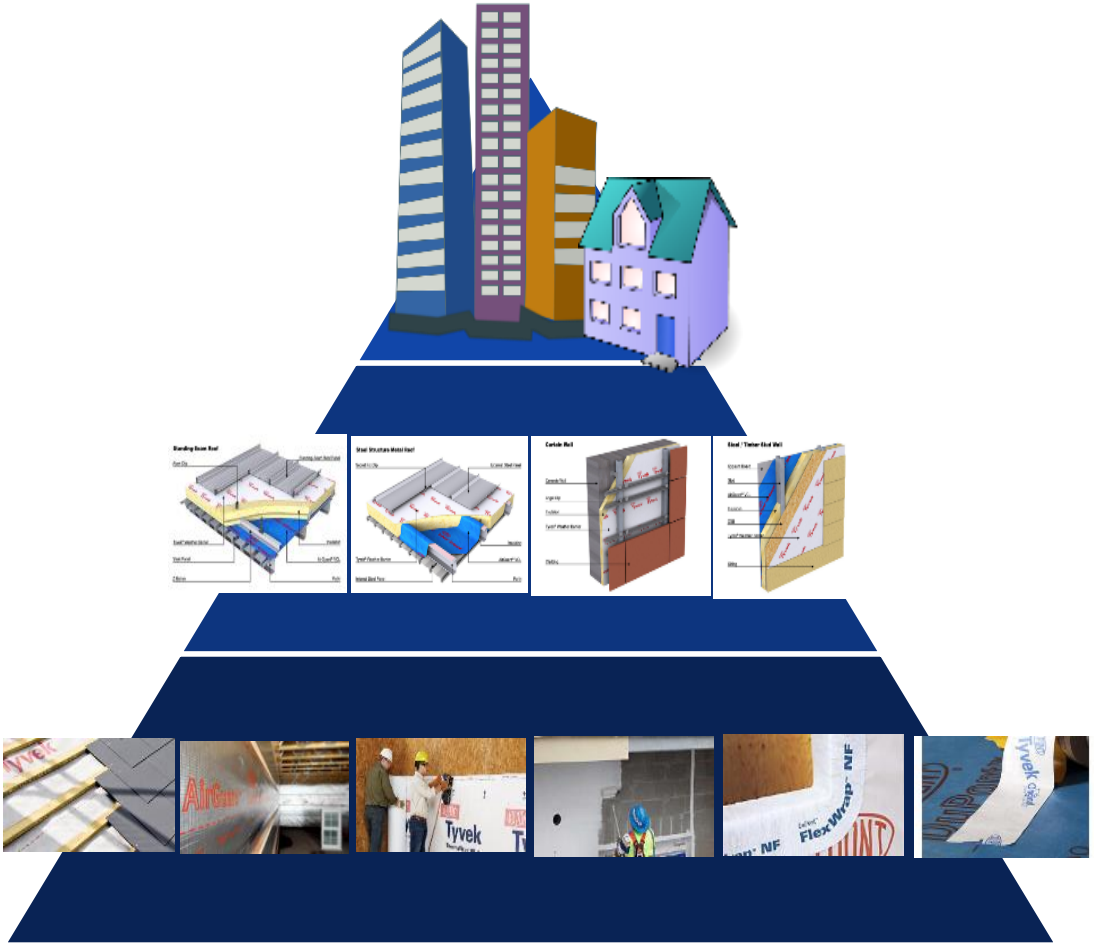
"A memorandum from inspectors at the Berkeley Building and Safety Division says that the deck's severed joist ends -- horizontal, parallel beams that support a ceiling or floor -- looked "extensively rotted" where the structure had ripped from the wall. " (CNN, June 23, 2015)

Photo from L A Times

Building Durability

Assembly Durability

Material Durability



Durability Defined Design Service Life of the Building

Table 2
Categories of Design Service Life for Buildings
(See Clauses 5.2.3 and 6.2.)

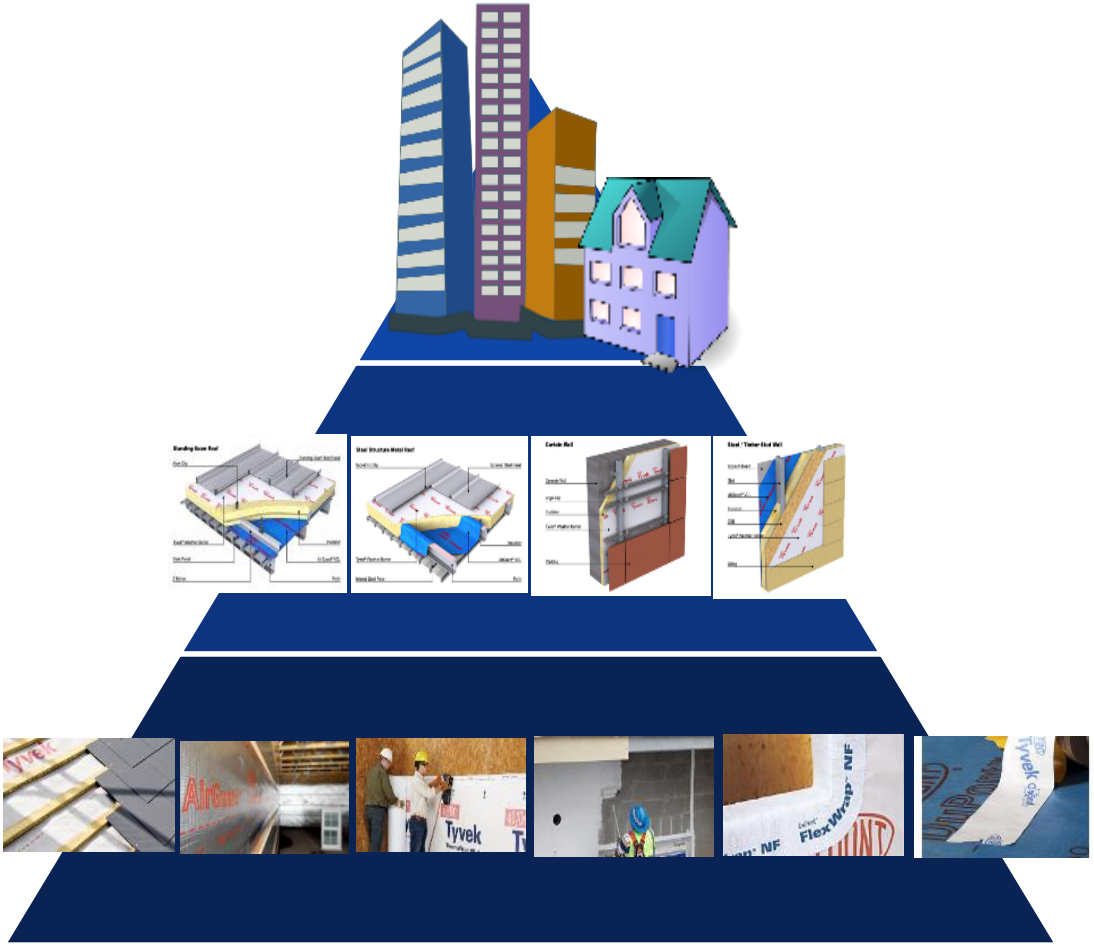
Category	Design service life for building	Examples
Temporary	Up to ten years	• non-permanent construction buildings, sales offices, bunkhouses • temporary exhibition buildings
Medium life	25 to 49 years	• most industrial buildings • most parking structures*
Long life	50 to 99 years	• most residential, commercial, and office buildings • health and educational buildings • parking structures below buildings designed for long life category*
Permanent	Minimum period, 100 years	• monumental buildings (eg, national museums, art galleries, archives) • heritage† buildings

Reference: CSA S478-95 Guideline on Durability in Buildings

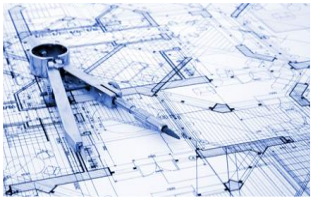
Building Durability

Assembly Durability

Material Durability

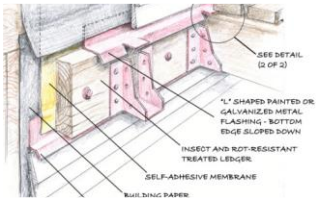


Durability of Assemblies



Design

Construction

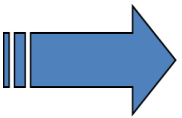


Compatibility at Interfaces

International Residential Code (2018): 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 R703.4.

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 penetrates the exterior cladding.

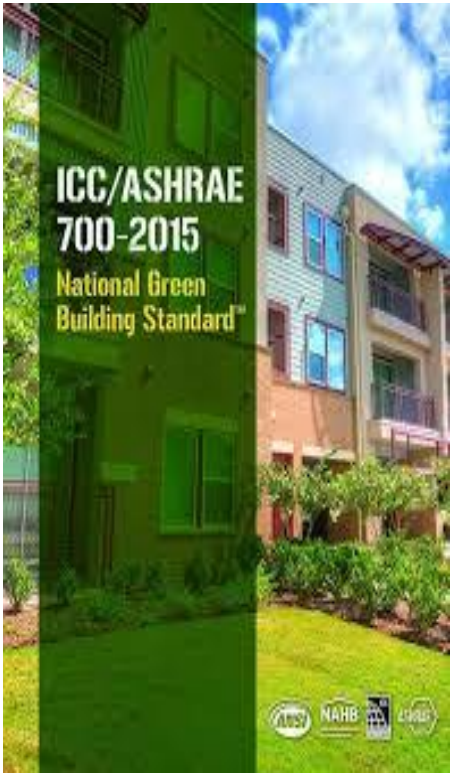


- **Flashing**
- **Water-resistive barrier**
- **Means of draining water**

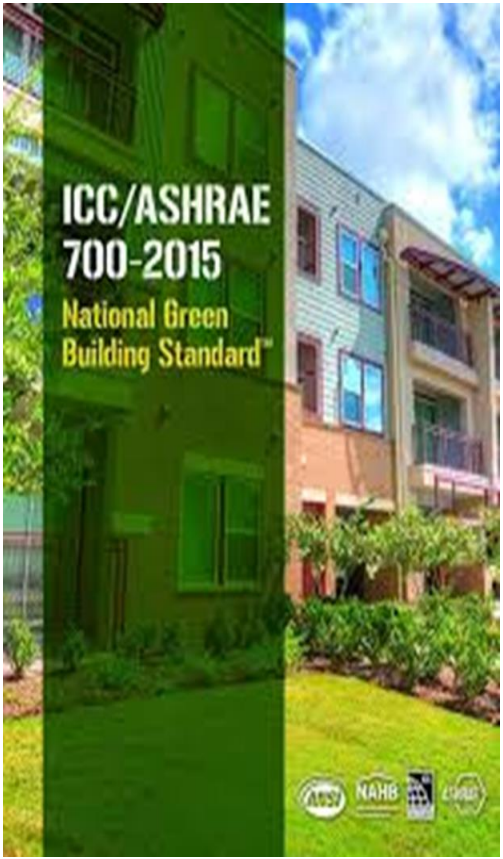
Vapor Retarder Requirements – Interior side of frame walls

Climate Zone	IRC Requirement	IRC Exceptions	IBC - Requirement	IBC Exceptions
1 & 2	No required vapor retarders		Class I or II vapor retarders shall not be provided	
3	No required vapor retarders		Class I vapor retarders shall not be provided	
4 x-marine	No required vapor retarders		Class I vapor retarders shall not be provided	
4 marine	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.	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.	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

ICC/ASHRAE 700-2015 Chapter 6: Resource Efficiency



- Quality of Construction Materials and Waste
- **Enhanced Durability and Reduced Maintenance**
  - **Intent**
  - **Moisture management – building envelope**
  - **Roof surfaces**
  - **Roof water discharge**
  - **Finished Grade**
- 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



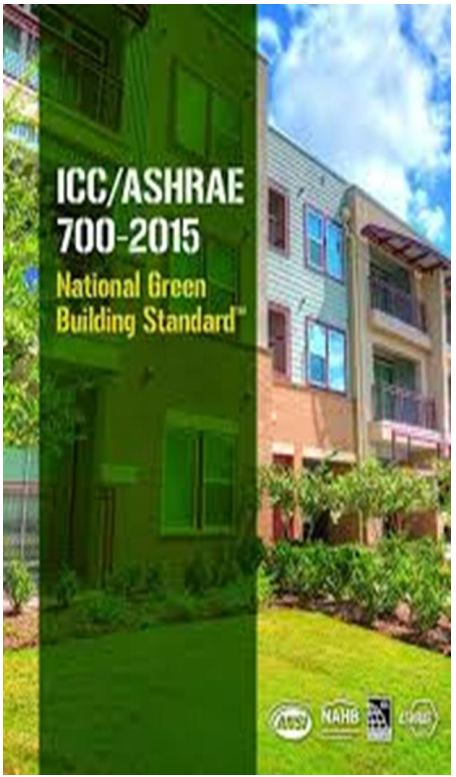
- **602.1.8 Water-resistive barrier**. Where required by the ICC, IRC, or IBC, a water-resistive barrier and/or drainage plane system is installed behind exterior veneer and/or siding
- **602.1.9 Flashing.** Flashing is provided as follows to minimize water entry into wall and roof assemblies and to 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.

Assembly Durable Design Demonstration

Demonstrated Effectiveness

Modelling

Testing

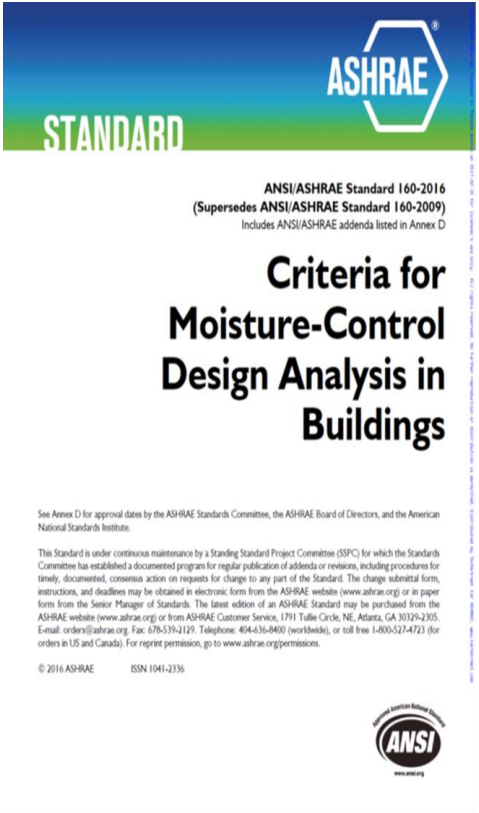


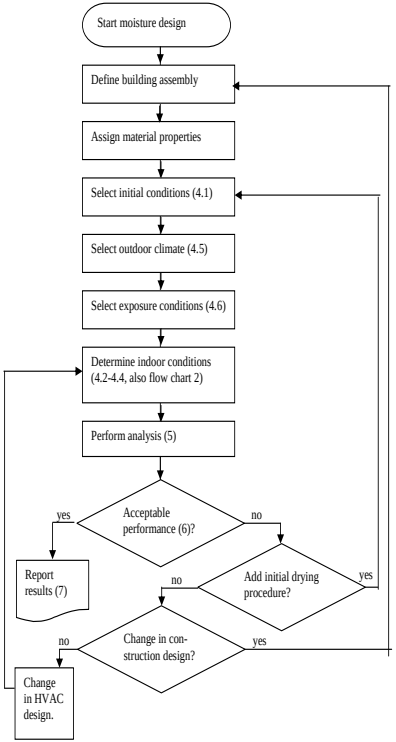
602.1.7.3 Building envelope assemblies are designed for moisture control based on documented hygrothermal simulation or field study analysis. Hygrothermal analysis is required to incorporate representative climatic conditions, interior conditions and include heating and cooling seasonal variation.

(4 points)

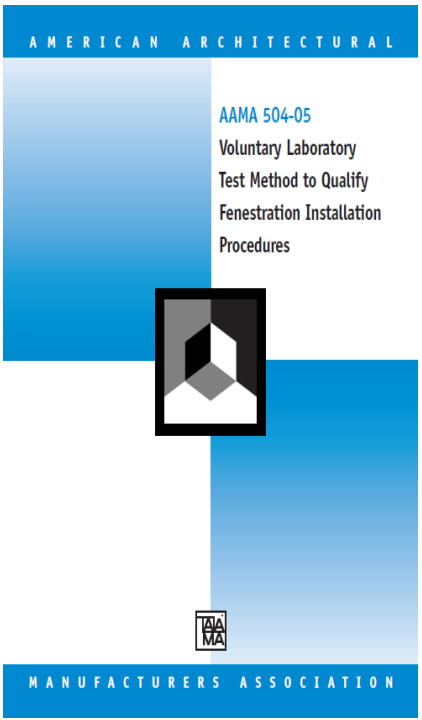
Modelling

- Simulation and Analysis
- Moisture Performance Evaluation Criteria
  - Mold
  - Corrosion





Testing



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)

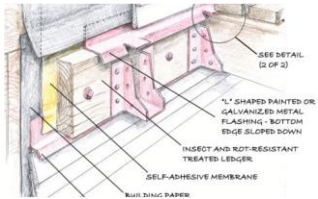
Following cycling, the mockup shall again be tested for air leakage and water penetration resistance

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.

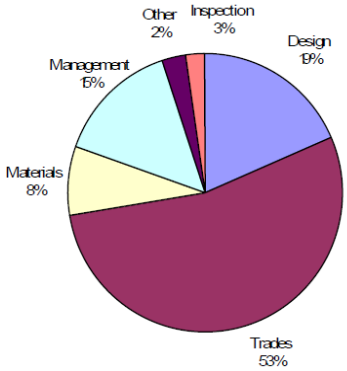
Durability of Assemblies

Design

Construction



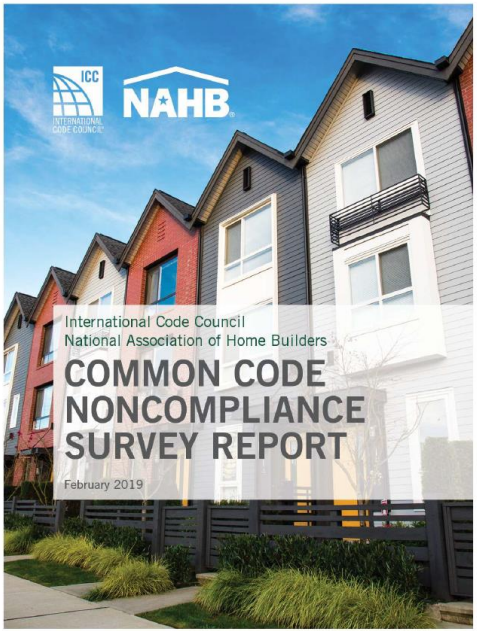
Compatibility at Interfaces



Percentage of construction defect claims by cause

Reference: Grosskopf, K. R. and D. E. 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, Sept 4-5, 2008

Indirect causes for code violations



- "Workers ignoring the manufacturer's installation instructions" (4.81) was the greatest cause of code violations.
- "Inadequate manufacture's installation instructions" (2.95) was rated as the least cause of code violations.

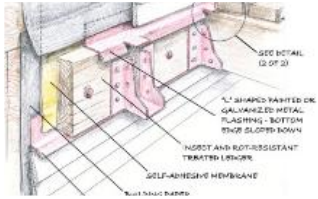
Construction

- Safety & ergonomics during the construction process
- Job-site storage requirements
- Installation dependence on environmental conditions
- Ease of installation
  - installed in a similar way to existing products?
  - can be installed by existing trades?
  - does it require a high level of specialization to install ?
- Reliability & repeatability of the installation.
- Integration with other products
  - can the next group of laborers work easily on top of it?

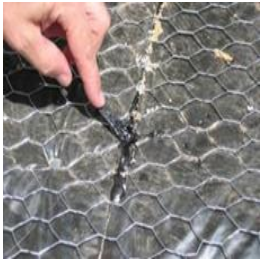
Durability of Assemblies

Design

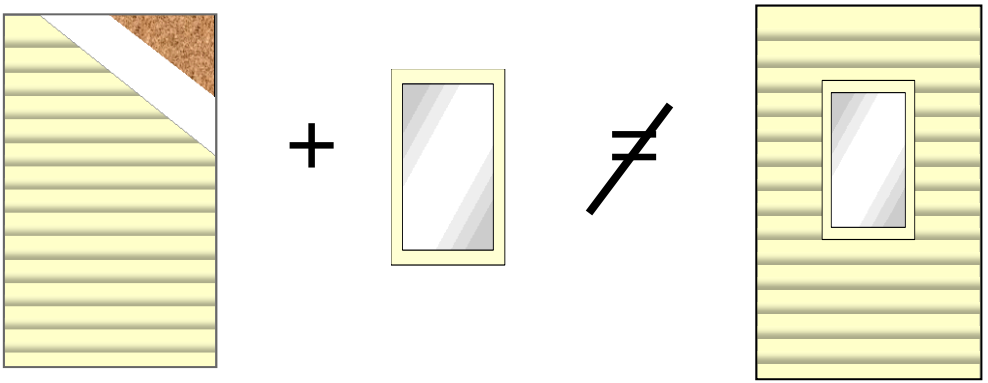
Construction



Material Interfaces

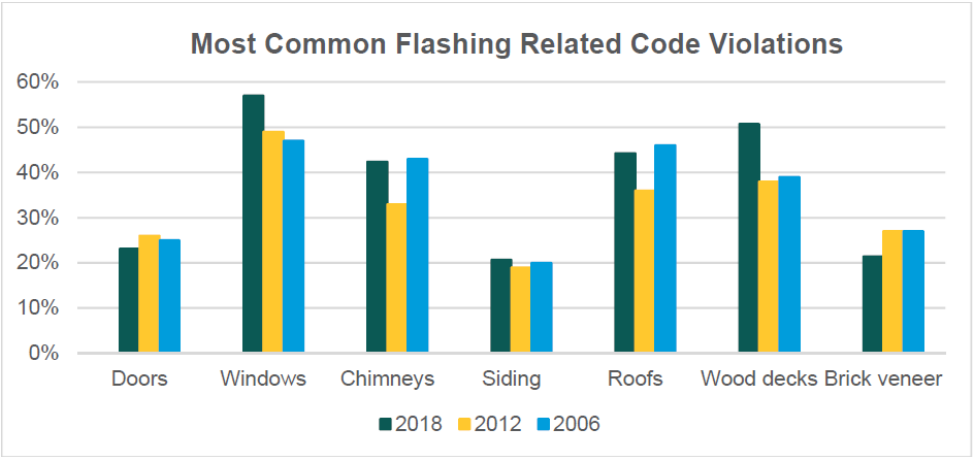


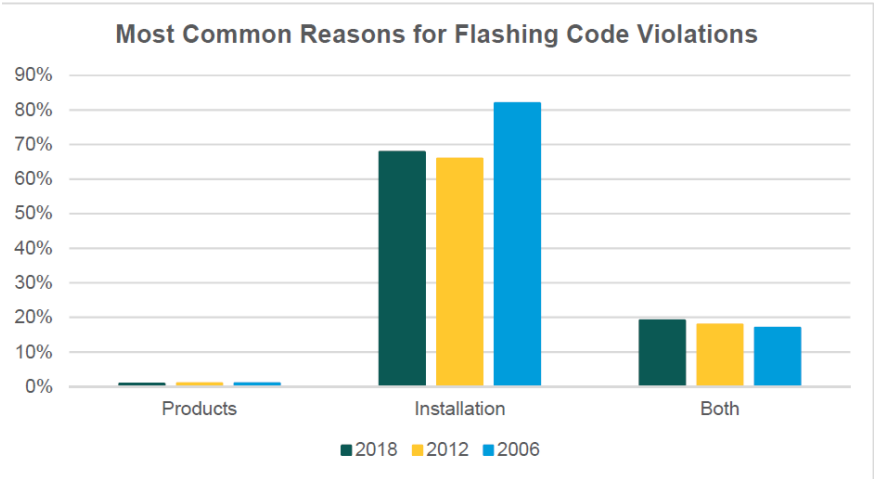
Designing Details



Window and Wall Assemblies should be considered as a system, not individually.


NAHB
International Code Council
National Association of Home Builders
COMMON CODE NONCOMPLIANCE SURVEY REPORT
February 2019

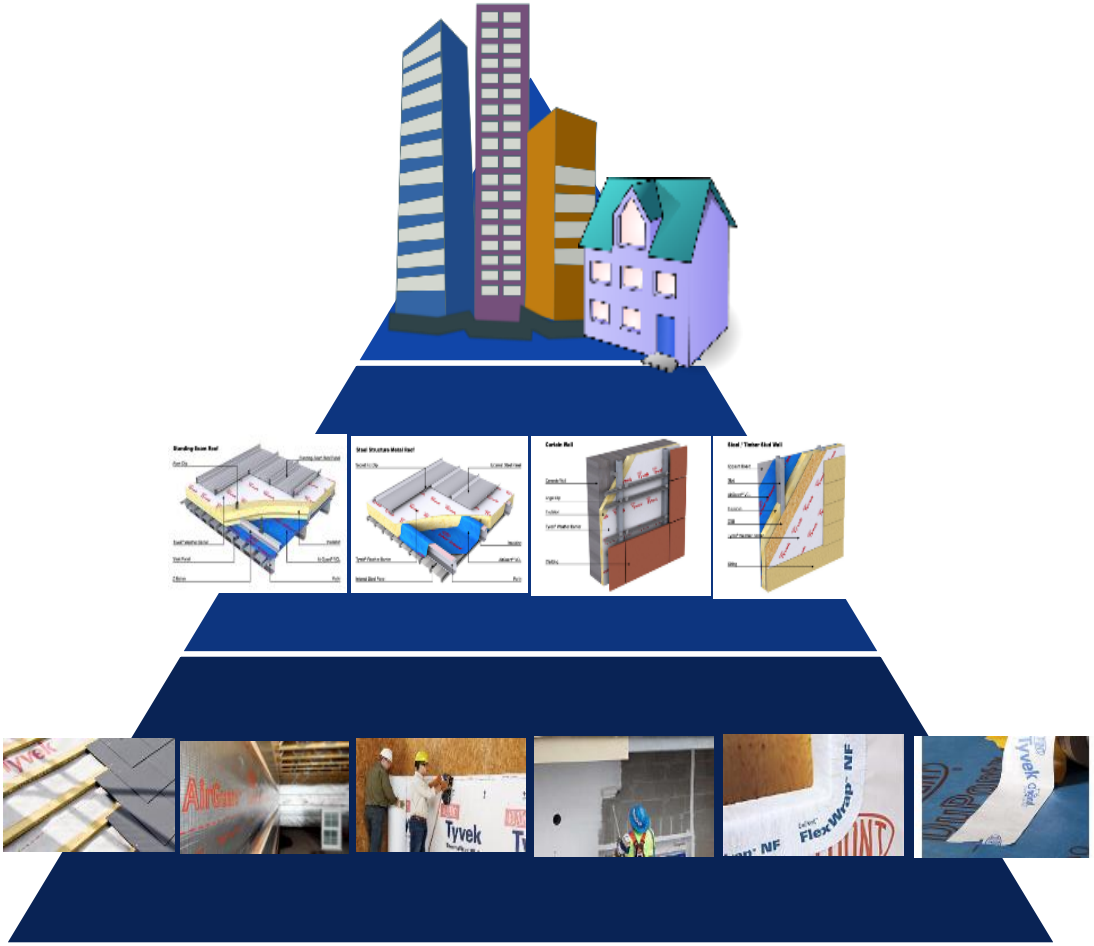

Most Common Flashing Related Code Violations
60%
50%
40%
30%
20%
10%
0%
Doors
Windows
Chimneys
Siding
Roofs
Wood decks
Brick veneer
2018
2012
2006

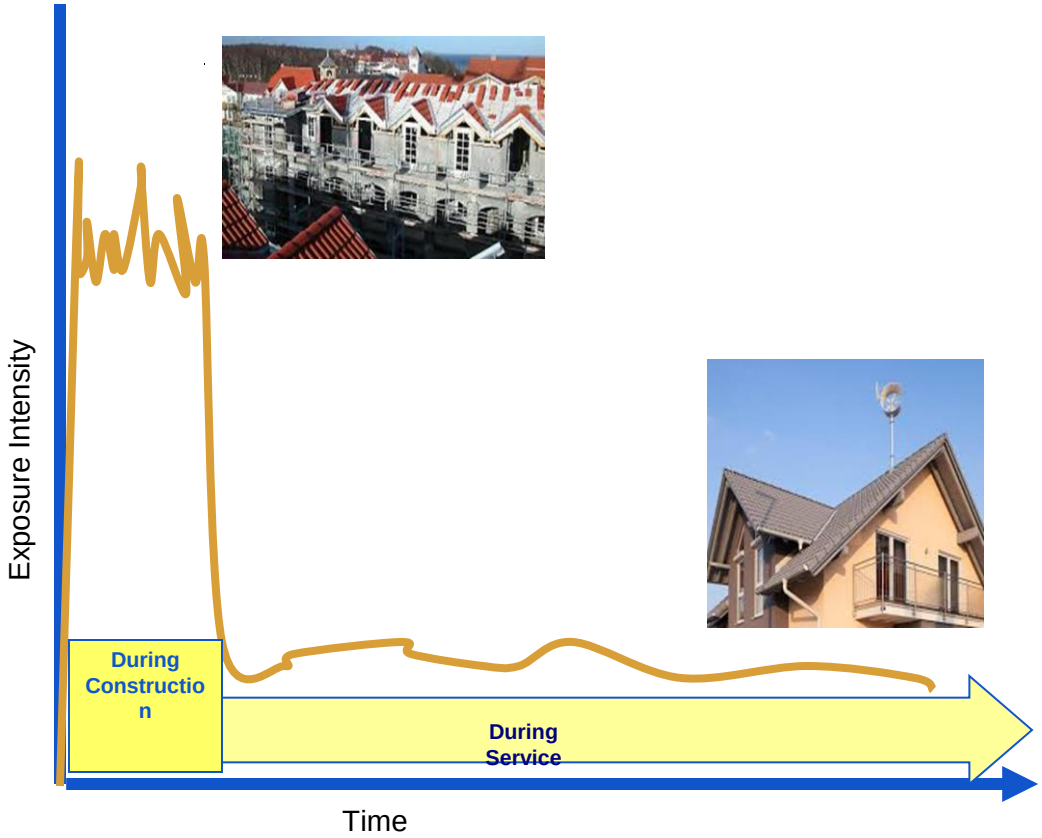

Most Common Reasons for Flashing Code Violations
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Products
Installation
Both
2018
2012
2006

Building Durability

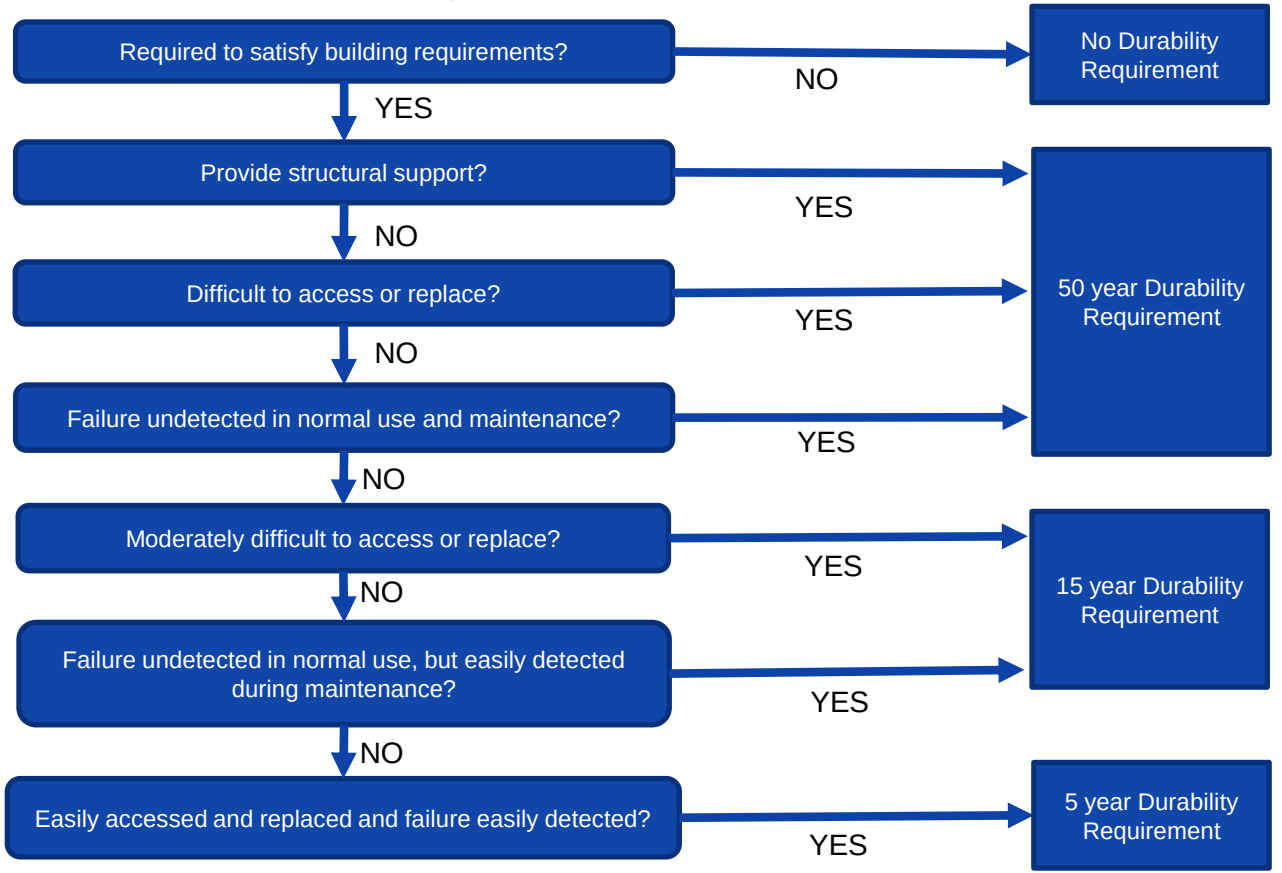
Assembly Durability

Material Durability

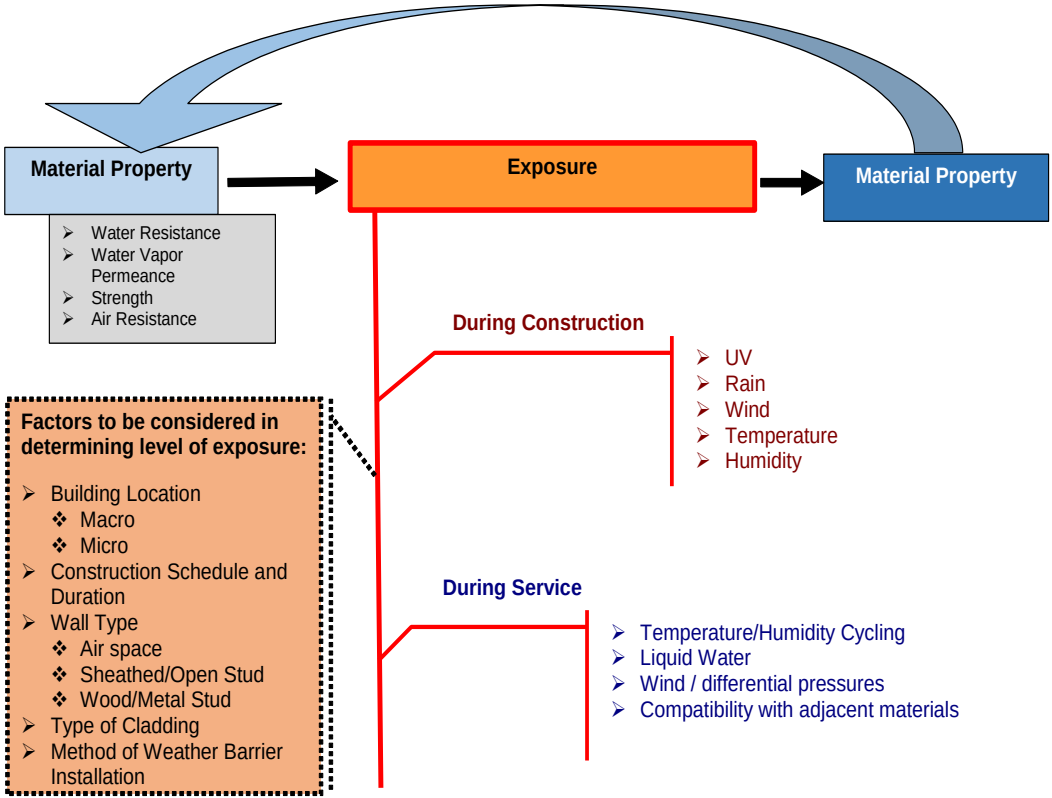



Exposure Intensity
During Constructio n
During Service
Time

Material Durability Assessment



Criteria from NZ Building Code


Material Property
Water Resistance
Water Vapor Permeance
Strength
Air Resistance
Exposure
Material Property
During Construction
UV
Rain
Wind
Temperature
Humidity
During Service
Temperature/Humidity Cycling
Liquid Water
Wind / differential pressures
Compatibility with adjacent materials
Factors to be considered in determining level of exposure:
Building Location
Macro
Micro
Construction Schedule and Duration
Wall Type
Air space
Sheathed/Open Stud
Wood/Metal Stud
Type of Cladding
Method of Weather Barrier Installation

Durability vs Resilience

If you want to be on the cutting edge of defining Resilience check out the following:

Alliance for National Community Resilience
National Institute for Standards and Technology
National Institute for Building Sciences
U.S. Resiliency Council
RELi
ISO 55000
Smart Cities Council
Institute for Building and Home Safety – For Home
ASTM

- E53.07 Sustainable Property Management
- E06 Committee on Performance of Buildings

"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.

DUPONT

Empowering the world with essential innovations to thrive.