1

About the Course

Learning Objectives

- Recognize the increased risks from natural hazards and how resilient construction can support long-term sustainability by addressing life safety and building functionality
- Identify approaches to mitigate the effects of natural hazards
- Underpin a community's economic vitality and safety through natural hazard mitigation
- Demonstrate the importance of incorporating resilient standards in construction

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Contents

- The Impact of Fire and other Natural Disasters
- Definition of Resilience
- Steps to Disaster Resilience
- Quantifying the Benefits of Resilient Construction
- Case Studies
- Conclusions

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The Impact of Natural Disasters

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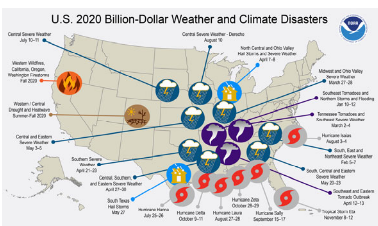
The Impact of Natural Disasters

For millions of people in the U.S., the consequences of natural disasters have become increasingly real, personal, and devastating.

In 2020, there were 22 separate weather and climate disaster events with losses exceeding $1 billion each across the United States.

2020 is the sixth consecutive year (2015-2020) in which 10 or more billion-dollar weather and climate disaster events have impacted the United States.



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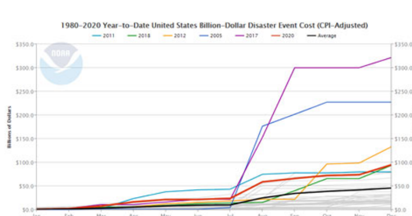
The Impact of Natural Disasters

According to the National Oceanic and Atmospheric Administration (NOAA), 2017 was the costliest year on record for natural disasters in the U.S., with a price tag of at least $306 billion.

Requests for federal disaster aid increased tenfold in 2017 compared to 2016, with 4.7 million people registering with the Federal Emergency Management Agency (FEMA).

These once-rare events are becoming more common and costlier according to NOAA. Hurricane Harvey's record flooding in Houston was the city's third 500-year flood event in as many years.



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Cost of Wildfires

According to Verisk Insurance Solutions, 4.5 million U.S. homes are at high or extreme risk of wildfire, with more than two million in California alone.

According to Munich RE, a reinsurer, there have been $23.1 billion in losses to wildfires in the U.S. over the past five years.

2017 was by far the worst year with $17 billion losses and that number will likely continue to grow due to climate change which is creating warmer and drier conditions.

Photo credit: FrozenShutter / iStock

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Aftermath of Wildfires

According to the Bloomberg Businessweek article *Why Is California Rebuilding in Fire Country? Because You're Paying for It!*, the 1964 Hanley Fire in Sonoma County destroyed 100 homes whereas the 2017 Tubbs Fire, which covered nearly the same area, destroyed more than 5,000 homes and killed 22 people.

The Tubbs Fire was one of 131 across California in October of 2017. By the end of 2017, more than 1 million acres and 10,000 buildings had been destroyed.

Photo credit: Janos Rautonen/Shutterstock

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Wildfire Risk

Although recent attention has been on California because of the major wildfires in 2017, there are wildfire risks in most states.

According to Forest and Rangelands, the map shows the counties with the greatest risk of wildfires characterized by the higher-than-average annual area burned, structures lost, and homes exposed within the wildland urban interface.

U.S. Wildfire Risk

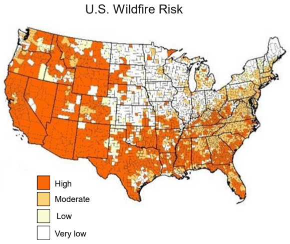

Image courtesy of: https://www.forestsandrangelands.gov/

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Proper Damage Due to Fires

According to NFPA, there were 499,000 structure fires in 2017, causing 2,815 civilian deaths, 12,160 civilian injuries, and $23 billion in damages.

NFPA estimates 262,500 fires occurred in homes resulting in 2,290 deaths, 7,470 injuries, and $6.1 billion in damages, and 95,000 occurred in apartment buildings resulting in 340 deaths, 3,130 injuries, and $1.6 billion in damages. Property damages from fires have been increasing over time.

Photo credit: REKINC1980/iStock

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Proper Damage Due to Fires

Developers have increased the use of combustible wood-frame construction for multifamily construction (apartments, condominiums, hotels, dormitories, and long-term care facilities) resulting in a rash of fires across the country that are reducing these buildings to ashes, putting lives and communities at risk.

Photo credit: whiterabbit83/iStock

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Massive Structure Fires

Not only are these wood-frame building fires total losses, but they often cause considerable damage to surrounding buildings and property.

Massive structure fires in multifamily buildings built using wood-frame have become commonplace since the building codes have relaxed the requirements for passive fire protection.

Image courtesy of: Build with Strength, www.buildwithstrength.com/america-is-burning

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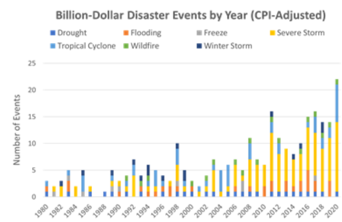
Billion-Dollar Disaster Events on the Rise

You can see in this graph adapted from the NOAA that billion-dollar disaster events are increasing.



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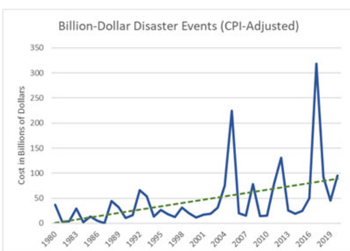
Cost of Billion-Dollar Disaster Events

This graph (adapted from the NOAA) shows the upward trend of the cost of disaster events.



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Why Are Disasters Costing More?

Over 60% of the U.S. population lives within 50 miles of one of its coasts, including the Great Lakes. At the same time, wealth and the value of possessions have increased substantially.

These changes in concentration of population and property values are significant contributors to the increased human and property loss.

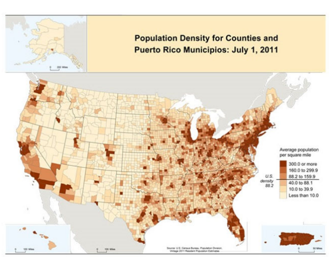

Image courtesy of: www.census.gov

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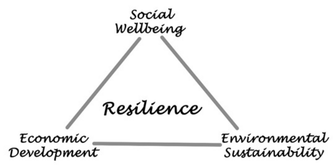
What Is Resilience?

There are several definitions of resilience. The Urban Land Institute (ULI) defines resilience as "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events."

Basically, addressing changes in the environment, whether the changes are natural or man-made, requires actions to mitigate their negative effects and adapt to those changes.



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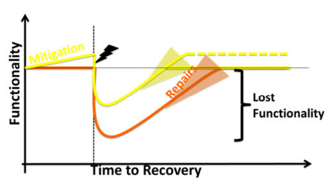
Resilience and Sustainability

For a building to be sustainable, one must consider potential for future use and reuse and design for long-service life with minimal maintenance costs.

There is significant guidance on reducing environmental impacts with green building codes and rating systems such as LEED, International Green Construction Code (IgCC), Green Globes, among others. But the guidance for designing a building to adapt to and mitigate the effects of natural hazards are now only beginning to take shape.



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Evolution to Resilience Based Design

Code Based Design
- Only considers design and construction
- Safety Only
- Capital intensive
- Prescriptive
- Individual buildings only

Performance Based Design
- Only considers design and construction
- Safety, ***Damage, Recovery***
- Capital intensive, ***occasional insurance impacts***
- ***Advanced analysis***
- Individual buildings

Resilience Based Design
- Considers complete life cycle of building
- Safety, Damage, Recovery
- Spreads costs among capital, operations and reserves
- Addresses externalities
- Considers relationship to community/company
- Portfolio assessment
- Part of comprehensive resilience framework

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Steps to Disaster Resilience

Photo credit: Robert Kaufmann/FEMA Photo by Robert Kaufmann

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Steps to Disaster Resilience

The following are steps, combining both voluntary and mandatory mitigation strategies, to achieving disaster resilience:

1. Adopt Updated Building Codes
2. Adopt High Performance Building Standards
3. Incentivize Disaster Resilient Construction
4. Build with Robust Materials

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1. Adopt Updated Building Codes

A common misconception is that a new code-compliant building in the U.S. will be resilient against considerable damage after a major hazard event.

This is not always the case. The building code sets standards that guide design and construction of structures for minimum Life Safety, the first step towards resilience.

However, maintaining the functionality of structures after a disaster is also important and building codes do not address functionality effectively.

Sadly, special interest groups have convinced some state legislatures to reduce the stringency or limit the adoption of the latest building code.

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2. Adopt High Performance Building Standards

The following are programs and standards aimed at incorporating resilient building techniques into construction to provide an optimum level of protection against a variety of natural hazards:

- Enhanced building codes
- FORTIFIED for Safer Living and Safer Business
- USRC Building Rating System
- REDi Rating System
- RELi Rating System for Resilience

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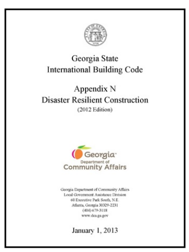
2. Adopt High Performance Building Standards

Enhanced building codes can be developed and adopted through the building code appendices. The appendices are provided in the International Building Code (IBC) and the International Residential Code (IRC) to offer supplemental criteria to the provisions in the main chapters of the code.

After damaging windstorms in 2008, the Georgia Department of Community Affairs created the Disaster Resilient Building Construction (DRBC) appendices to the IBC and IRC, which form the basis for the Georgia State Building Code.

The DRBC appendices offer an affordable, flexible, and simplified approach to improving resiliency at the local level. Local jurisdictions can adopt the complete appendices to improve building resiliency against flooding and high winds, or they can adopt select sections that apply to specific hazards in their geographic area.


Georgia State
International Building Code

Appendix N
Disaster Resilient Construction
(2012 Edition)

Georgia Department of Community Affairs

Georgia Department of Community Affairs
Local Government Assistance Division
60 Executive Park South, N.E.
Atlanta, Georgia 30329-2231
(404) 679-3118
www.dca.ga.gov

January 1, 2013

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2. Adopt High Performance Building Standards

The FORTIFIED for Safer Living and Safer Business are programs of the Insurance Institute for Business and Home Safety (IBHS).

The program provides enhanced design criteria relative to code minimum and the necessary construction and inspection oversight to ensure high performing structures that are truly disaster resilient.

The IBHS is a not-for-profit applied research and communications organization supported by the insurance industry.

FORTIFIED
A PROGRAM OF IBHS ™

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2. Adopt High Performance Building Standards

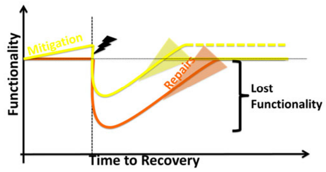
The U.S. Resiliency Council (USRC) is a national organization dedicated to improving the sustainability and resiliency of buildings during earthquakes and other natural hazards.

The performance-based USRC Building Rating System assigns one to five stars along the dimensions of Safety, Damage, expressed as repair cost, and Recovery, expressed as time to regain basic function.

Certified buildings are expected to perform in a manner that will preserve life safety of the occupants, limit damage to repairable levels, and allow functional recovery within a reasonable time period after a major seismic event.

USRC has a rating system for earthquakes and is working on other hazards.

US Resiliency Council
Improving the Built Environment and Promoting Community Resilience



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2. Adopt High Performance Building Standards: The REDi Rating System

The REDi (Resilience-based Earthquake Design Initiative) Rating System is a set of specific design performance criteria which aims to minimize building damage and promote contingency planning for utility disruption and other threats to functional recovery. The success of the resulting design in meeting specific monetary loss and recovery time is demonstrated by performing a modified FEMA P-58 loss assessment developed specifically for REDi.

The RELi standard is a point-based system recently adopted by the U.S. Green Building Council (USGBC). It includes many LEED-centric credits along with risk mitigation credits at the building and neighborhood scale. The intent is to provide greater adaptability and resilience to weather and other natural hazards in the built environment as a compliment to LEED. USGBC is currently refining RELi to provide a comprehensive list of resilient design criteria.

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3. Incentivize Disaster Resilient Construction

According to Munich RE, insurance companies took a $135 billion hit from natural disasters experienced around the globe in 2017.

Half of all losses were in the U.S., and North America representing 83 percent of all insured losses last year.

The three successive Atlantic hurricanes—Harvey, Irma, and Maria—cost major U.S. insurers at least $14.5 billion. This made it the costliest year ever for insurers.

Photo credit: Rawpixel.com/Shutterstock

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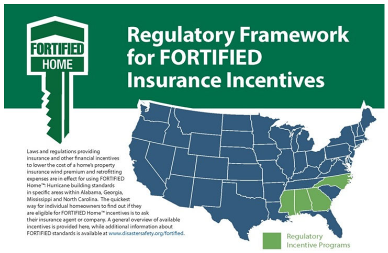
3. Incentivize Disaster Resilient Construction

Resilient buildings reduce the risks associated with property insurance. States can encourage building owners to build resilient structures by legislating insurance premium reductions to all policy-holders if they build to specific resilient design criteria.

Alabama, Georgia, Mississippi, North Carolina, and Oklahoma have enacted such laws. These states now require insurers to lower the cost of property insurance for building to the IBHS FORTIFIED standard.



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3. Incentivize Disaster Resilient Construction

Hazard mitigation increases loan security for lending institutions and decreases business interruptions and improved bond ratings for property owners and communities. Therefore, other potential incentives should be encouraged:

- Building permit rebates
- Property tax reductions
- Accelerated local permitting and inspection procedures for resilient properties
- Zoning benefits, e.g. density or height bonuses
- More-favorable developer agreements for the construction of resilient properties
- Revolving loan programs

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4. Build with Robust Materials

The last step towards disaster resilience is to build with robust building materials. Some of the qualities of robust building materials include versatility, strength, wind and water resistance, seismic resistance, fire resistance, energy efficiency, and durability.

Structural fires frequently occur after a natural disaster. Of all disasters, fire is by far the most common and the deadliest. The U.S. Fire Administration reports that every year, fire kills more Americans than all other natural disasters combined.


Photo credit: Steven Greaves/Alamy Stock Photo

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Insulating Concrete Form System

Concrete building systems are especially suited to provide resistance to natural hazards. Leslie Chapman-Henderson, president of the Federal Alliance for Safe Homes, called concrete homes "the ideal" for withstanding extreme weather. Concrete has the necessary hardness and mass to resist the high winds and flying debris of tornadoes and hurricanes.

Concrete is fire resistant and non-flammable, which means it can contain fires and will not contribute to the spreading of fire. Reinforced concrete framing systems can be designed to resist the most severe earthquakes without collapse. Concrete doesn't rot or rust even if it is subject to flooding.

The image shows a tilt-up concrete wall system.

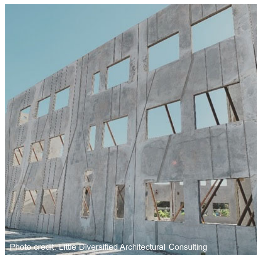

Photo credit: Little Diversified Architectural Consulting

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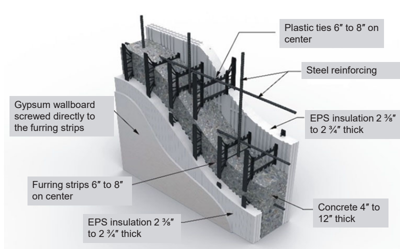
Insulating Concrete Form System

The image shows an example of an insulated concrete form (ICF) wall. In this type of concrete wall, the outer edges are EPS insulation 2 ⅜″ to 2 ¾″ thick. This forms continuous insulation on both sides of the wall.

The interior of the wall is comprised of concrete 4″ to 12″ thick and plastic ties placed 6″ to 8″ on center.

The ties determine the thickness of the total wall as per specs, offer form support during concrete placement, and help to eliminate thermal bridging.



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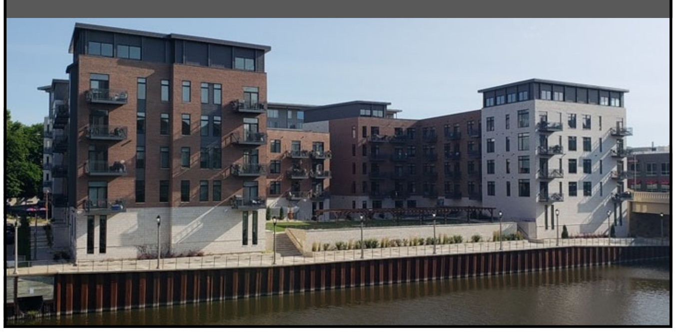
Quantifying the Benefits of Resilient Construction



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Quantifying the Benefits of Resilient Construction

There are several studies that attempt to quantify the benefits of resilient construction:

A. Urban Land Institute (ULI): Returns on Resilience: The Business case
B. NRMCA Insurance Cost Study
C. National Institute of Building Sciences (NIBS)
D. MIT Break-Even Mitigation Percentage Tool

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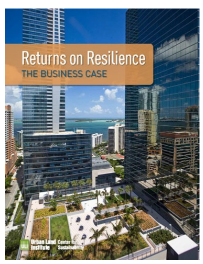
A. Urban Land Institute (ULI)

In their report Returns on Resilience: The Business Case, by the Urban Land Institute, ULI explores the economic benefits of resilient construction. The report presents ten detailed case studies that demonstrate cost savings from implementing resilient strategies.

In all cases, the projects were able to demonstrate economic justification for spending more up front to design and build resilient structures.



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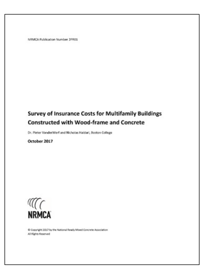
B. NRMCA Insurance Cost Study

The National Ready Mixed Concrete Association (NRMCA) undertook a research study to understand if insurance companies offered lower insurance rates for structures built using noncombustible materials for both builder's risk insurance and commercial property insurance.

According to a report Total Cost of Fire in the United States by the Fire Protection Research Foundation and the National Fire Protection Association, the total cost of fires in 2014 was $328.5 billion, equaling 1.9% of the U.S. Gross Domestic Product.


NRMCA Publication Number 2PR01

Survey of Insurance Costs for Multifamily Buildings Constructed with Wood-frame and Concrete

Dr. Pieter VanderWerf and Nicholas Haidari, Boston College

October 2017

NRMCA

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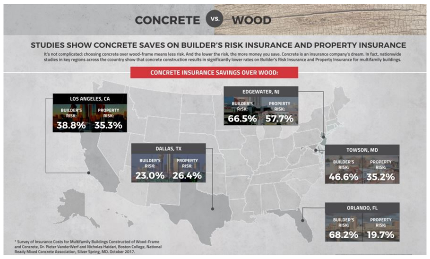
B. NRMCA Insurance Cost Study

The NRMCA study, titled Survey of Insurance Costs for Multifamily Buildings revealed that insurers are aware of the risks of building with combustible construction and the benefits of building with noncombustible construction.



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C. National Institute of Building Sciences (NIBS)

NIBS undertook a study in 2017 to quantify the value of designing buildings to exceed the 2015 IBC or IRC for hazards including riverine flooding, hurricane surge, wind, earthquakes, and wildfires with the objective of reducing losses.

Results revealed that for every dollar spent on building above code, the amount of money saved ranged from $4 to $7 depending on the hazard.

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C. National Institute of Building Sciences (NIBS)

Strategies to exceed minimum requirements of the 2015 building codes include:

- For flood resistance (to address riverine flooding and hurricane surge), build new buildings higher above base flood elevation than required by the 2015 IBC
- For resistance to hurricane winds, build new homes to comply with the IBHS FORTIFIED Home Hurricane standards
- For resistance to earthquakes, build new buildings stronger and stiffer than required by the 2015 IBC
- For fire resistance in the wildland-urban interface, build new buildings to comply with the 2015 International Wildland-Urban Interface Code (IWUIC)

National Benefit-Cost Ratio per Peril for Designing Beyond Code Requirements (Adapted from NIBS)	
Riverine flood	5:1
Hurricane surge	7:1
Wind	5:1
Earthquake	4:1
Wildland-urban interface fire	4:1
Overall benefit-cost ratio	4:1

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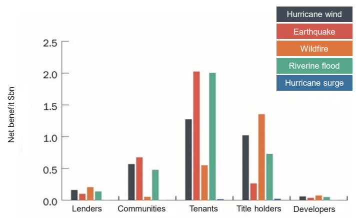
C. National Institute of Building Sciences (NIBS)

The NIBS report suggests that all major stakeholder including developers, lenders, tenants, and communities' benefit from resilient construction.

The greatest benefits are afforded to building owners who don't have to spend as much to repair and rebuild after a disaster, but there are other benefits also.

Tenants benefit from having functioning shelter and places to work after a disaster, and the community benefits from reduced cost of disaster recovery both in terms of reduced loss of life and business continuity.



Stakeholder net benefits resulting from one year of constructing all new buildings to exceed select 2015 IBC and IRC requirements or to comply with 2015 IWUIC. Source: FEMA

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D. MIT Break-Even Mitigation Percentage Tool

According to MIT Concrete Sustainability Hub (CSHub), this is a diagram of the Life Cycle Cost of Hazard Resilience.

Researchers at the MIT Concrete Sustainability Hub (CSHub) have developed a new tool to calculate the economic benefits of investing in more hazard-resistant structures in hurricane prone areas.

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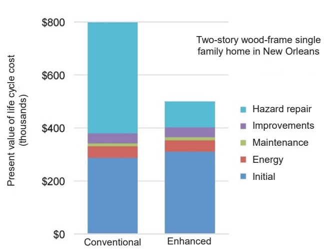
D. MIT Break-Even Mitigation Percentage Tool

MIT's Break-Even Mitigation Percentage (BEMP) tool evaluates the cost-effectiveness of mitigation for a building in a location by factoring in the expected damage a conventional building designed to code would endure over its lifetime.

Then it compares that to the cost of a more resilient, enhanced building design to justify building to a higher standard.



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Case Studies

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Case Study: Concrete Walls Provide Fire Separations at Infill Site

Walker's Landing consists of two buildings, six stories each, with four floors of residential over two floors of parking. The site of was restricted due to a 10-foot setback from a river, a bridge, and two streets, making access for material storage and construction activities tight.

Bedford Development used concrete walls built using insulating concrete forms for Walker's Landing in Milwaukee, Wisconsin for fire resistance, among other benefits.

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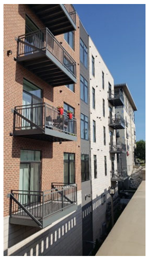
Case Study: Concrete Walls Provide Fire Separations at Infill Site

The project is located on an infill urban site requiring fire rated exterior walls. This is ideal for concrete walls since they provide more than enough fire rating at a significant cost savings over wood frame, especially when compared to many other projects in the city that had to use expensive fire treated wood. For Walker's Landing, the developer used insulating concrete forms (ICFs) for the exterior fire separations.

In addition to fire resistance, the developer chose ICF walls and precast hollow-core floors for thermal efficiency and speed of construction. Construction projects are always on timelines and the developer has found that their install speed has increased significantly by using ICFs since they are fast and efficient to install.



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Case Study: Concrete Apartment Building Survives Blast and Fire

In 2014, a massive natural gas explosion in East Harlem, New York City, destroyed two apartment buildings, vacated four neighboring properties, and shattered windows blocks away. Bricks, wood, and other debris landed on the adjacent elevated Metro railroad tracks, suspending service to and from Manhattan for most of the day.

Nearby, buildings and households affected by the blast had to deal with the cost to remediate elevated levels of lead and asbestos. In total, the devastation caused 8 deaths, 70 injuries and displaced 100 families. Over 250 firefighters, paramedics, and police officers responded. The local utility was responsible for $153.3 million damages, the highest payout for a gas safety incident in state history.

A concrete building survived a blast and fire in New York City and reopened after repairs.


Photo credit: The Bluestone Organization

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Case Study: Concrete Apartment Building Survives Blast and Fire

Through it all, the adjacent four-story concrete building stood strong. The New York Building Department engineer's report said that amazingly, "there was no structural damage at all," and the blast was located "inches, not feet" from the concrete walls, yet the building was in remarkably good-shape.

Damage to the concrete building was caused by falling debris from the blast next door which penetrated the roof membrane resulting in water damage from firefighting efforts. The building, built using insulating concrete form walls, was reopened after repairs.

Chicago and New York City both employ Fire Districts to limit combustible construction within dense urban boundaries. The City of Sandy Springs, Georgia and other adjacent communities have enacted similar ordinances to preserve the health, safety, and welfare of its citizens.


Photo credit: The Bluestone Organization

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Case Study: Resilience to Tornadic Activity, South Warren Middle and High School, Bowling Green, KY

At the time of construction, South Warren was the largest K-12 school building in the state of Kentucky. Comprising 332,000 square feet, the building sits on an 85-acre site.

This was the first educational project anywhere to utilize ICF construction for the entire structural wall system of the building, both exterior and interior bearing walls.

The school includes a gymnasium which has 40-foot-tall ICF walls, two "cafetoriums" with 35-foot-tall walls and a performing art center with a compound curve, the 8-inch and 12-inch ICF wall system provides students a safer building even during the severe tornadic activity that is common during Kentucky's spring and summer seasons.

The inherent core strength of the concrete in the ICF wall system, coupled with the hollow-core concrete plank floor system, created a building structure capable of resisting 250-mph winds.

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Conclusion

- There are increased risks posed by natural hazards from weather related, seismic and fire events.
- Resilient construction can address these risks by addressing asset protection and building functionality in addition to life safety.
- A number of approaches exist to mitigating the effect of natural hazards including adoption of updated building codes and high-performance standards, incentivizing disaster resilient construction, and building with robust materials.
- A/E professionals can re-consider minimum code performance and design for improved building performance and natural hazard mitigation, resulting in overall cost savings for the building cycle.

West Village Student Housing at Texas Tech University, Lubbock, Texas built using Insulating Concrete Forms. Photo: Courtesy of Mackey Mitchell Architects

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www.buildwithstrength.com/design-center

- Structural system recommendations
- Cost comparisons
- Specification review
- Design/construction team collaboration

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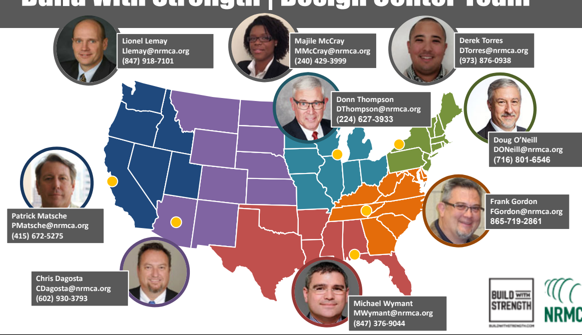
Build with Strength | Design Center Team



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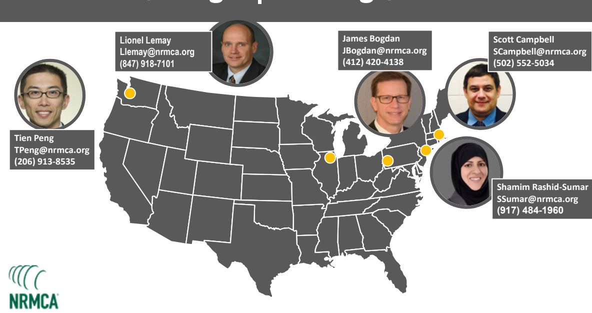
Build with Strength | Building Codes Team



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BUILD WITH STRENGTH
Thank you
ssumar@nrmca.org
BUILD WITH STRENGTH
NRMCA

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