LAFARGE
Building better cities™

Concrete Housing and Sustainability

Julie Buffenbarger, FACI, LEED AP
Lafarge North America

Climate Change and Resilience

- Measurable Impacts
  - Loss of Lives,
  - Damage to Infrastructure
  - Economic Costs

- Implications beyond Measurable Impacts
  - Loss of Elements of Social Capital
    - Identity
    - Culture
    - Historical
    - Community

Resilience Integrated into Sustainability

feature

Resilience is the new Sustainability

Disasters show the need to build for the future
Part 1

By: Tien Peng, Senior Director, Sustainability, Codes and Standards, NRMCA
Lionel Lemay, Senior Vice President, Development, NRMCA
Jon Hansen, Senior Director, National Resources, Mid/Northwest

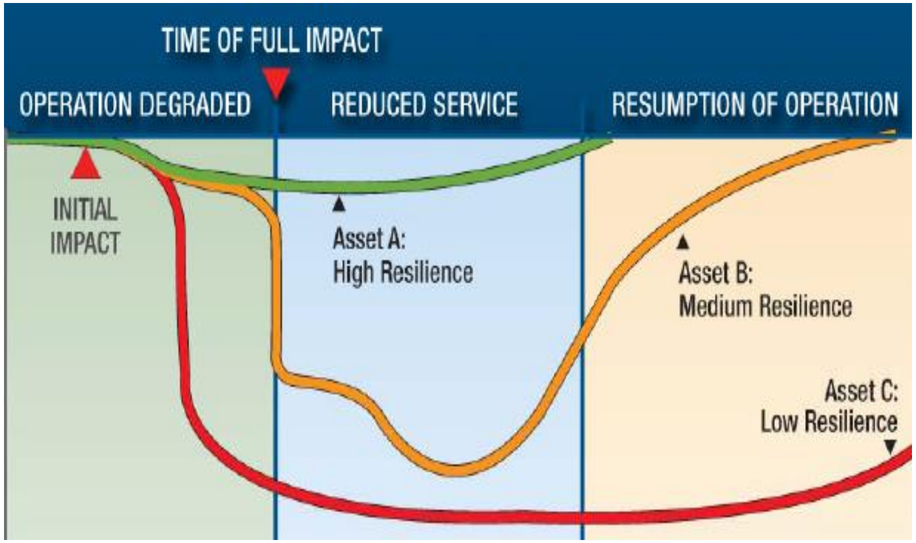
Sustainability lessons from Katrina

"Katrina was man-made," declared Brad Pitt, initiator of the Make It Right Foundation, the organization acting as the catalyst for the redevelopment of the Lower 9th Ward of New Orleans. Mr. Pitt was not addressing the Category 3 hurricane that made landfall on Aug. 29, 2005, killing more than 1,800 people, but the surge protection failures that happened as a result of decades of reckless handling of the levees, combined with the destruction of thousands of acres of buffering potential wetlands.

Katrina's storm surge submerged 80 percent of the city. A June 2007 report by the American Society of Civil Engineers indicated that two-thirds of the flooding was caused by the multiple failures of the city's floodwalls.[1] The storm surge also devastated the coasts of Mississippi and Alabama,

The Sandberg's concrete home survived the devastating effects of high winds and storm surge of Hurricane Katrina.

- **Adoption**
  - **High-performance codes**
  - **Materials**
  - **Innovative practices**



NRMCA, InFocus, Spring 2012; M. Kennett, Resilient Buildings Workshop, November 2012.

Functional and Community Resilience

Resilience is the ability to anticipate risk, limit impact, and bounce back rapidly through **survival, adaptability, evolution, and growth** in the face of turbulent change.

Resilient communities

- **Minimize damage and losses of property, environment and lives**
- **Quickly return citizens to work, reopen businesses, and restore other essential services**

Functional Resilience

- **A structure's durability and competence to maintain its integrity and its function restored.**

Resilience into the Equation

Infrastructure resilience can be characterized by the three R's:

Robustness, resourcefulness and recovery.

<u>Secure, Durable and Resilient Design</u> includes:

Energy Conservation, Environmental, Safety, Security, Durability, Sustainability and Operational Efficiency

After Hurricane Sandy, the ICF home was structurally intact, with only a section of exterior siding missing.

Another home, just three lots down, looked like this following the super storm..

Climate Resilient Buildings

Protection of buildings, cities, infrastructure and lifestyles against risks associated with extreme weather and related social, economic and energy events require

- **Durability**
- **Resilience**

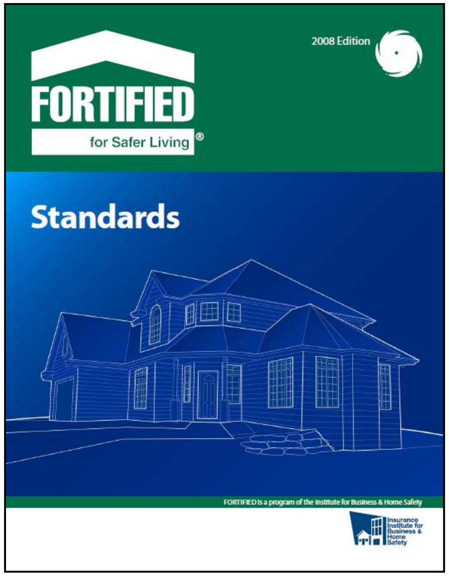
During and After… How are you going to live?

- Live with Family and Friends
- Live in a Hotel
- Stay in a Shelter
- Move to another location and start over?

LIVE IN YOUR OWN HOME… IT'S YOUR INVESTMENT!!

IBHS - Strategy

Insurance Institute for Business and Home Safety (IBHS) criteria that greatly increase a new commercial building's durability and resilience to natural and manmade hazards



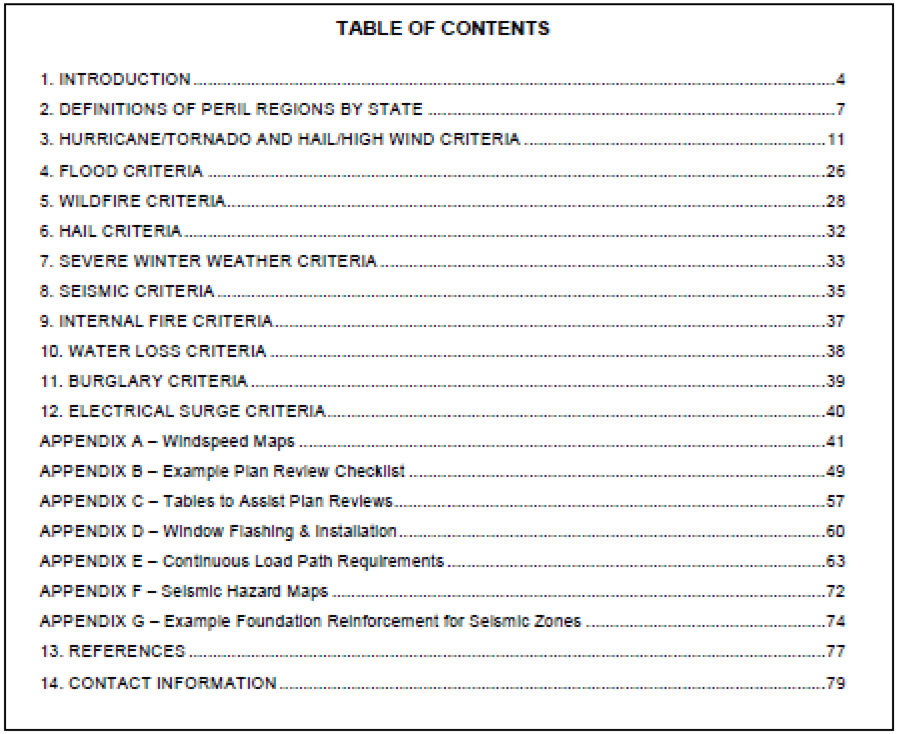


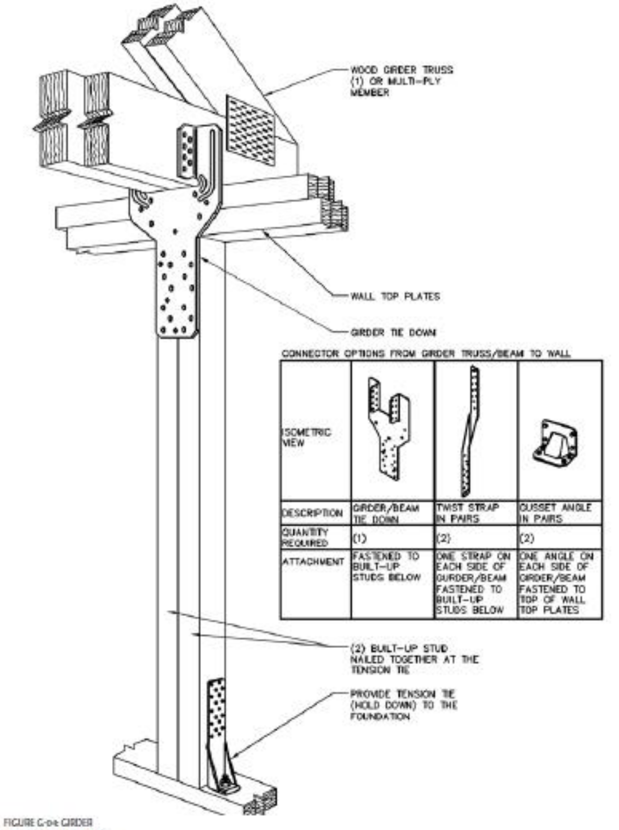
TABLE OF CONTENTS

IBHS FORTIFIED for Safer Business Designation (3 points)

Achieve the Insurance Institute for Business and Home Safety's (IBHS) FORTIFIED for Safer Business (FFSB) designation. To qualify for this credit option the building must meet all design, construction and inspection criteria such that the building receives the IBHS FORTIFIED for Safer Business designation.

Keys to Surviving your Disaster

Leading edge of a derecho-producing convective system.



CONNECTOR OPTIONS FROM GIRDER TRUSS/BEAM TO WALL

ISOMETRIC VIEW			
DESCRIPTION	GIRDER/BEAM TIE DOWN	TWIST STRAP IN PAIRS	GUSSET ANGLE IN PAIRS
QUANTITY REQUIRED	(1)	(2)	(2)
ATTACHMENT	FASTENED TO BUILT-UP STUDS BELOW	ONE STRAP ON EACH SIDE OF GIRDER/BEAM FASTENED TO BUILT-UP STUDS BELOW	ONE ANGLE ON EACH SIDE OF GIRDER/BEAM FASTENED TO TOP OF WALL TOP PLATES

FIGURE G-04 GIRDER TRUSS OR WOOD BEAM TIE-DOWN DETAIL FOR WOOD BEARING WALL.

FORTIFIED ENGINEERING STANDARDS 30

Storm Proofing

- **High Winds, Hail, Hurricanes and Tornados**
- **Straightline Winds**
- **Derecho Winds**

Provides Resistance To Uplift & Lateral Forces, Designed To Help Counter The Effect Of High Wind & Seismic Events

Storm Shelters & Safe Rooms

Flooding

Eastern US, 2007

Keys to Surviving your Disaster

FEMA Guidelines for Coastal Construction

- **Masonry or concrete reinforced foundation walls**
- **Concrete Piers**
- **Concrete Piles**

Pass Christian, Ms., September 27, 2005 -- Mississippi resident Scott Sunberg is building a steel reinforced concrete house using many FEMA building standards that would minimize potential destruction from a hurricane. Hurricane Katrina came through this area and his was the only house still standing in the neighorhood.

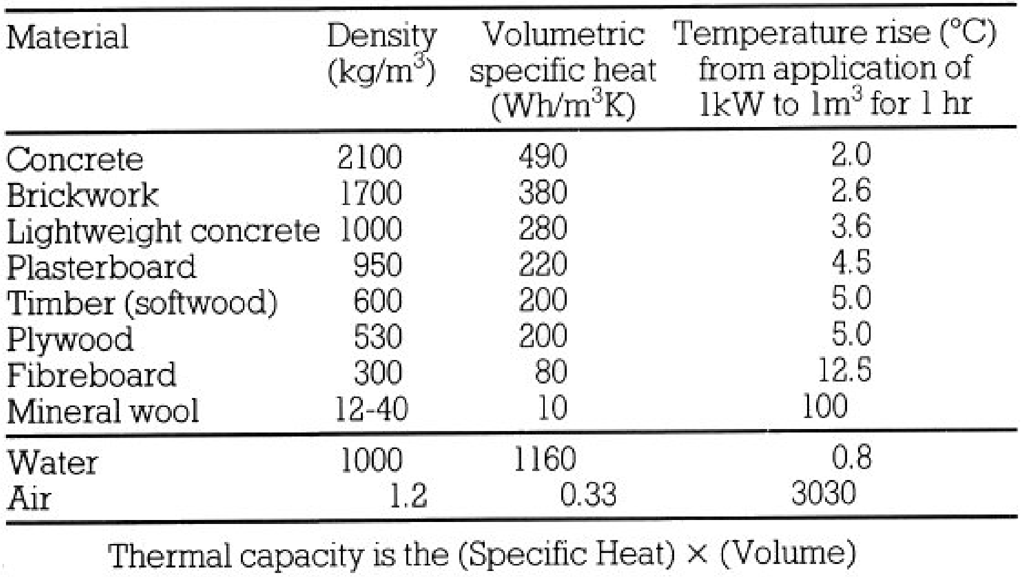
Let it Snow…..

Structural systems can be cast in-place, precast, or post-tensioned.

Because of the relatively high self-weight (dead load) of concrete systems, concrete structures have a low susceptibility to snow-induced failure.

Snow load is the downward force on a building’s roof by the weight of accumulated snow and ice.

Power Outages

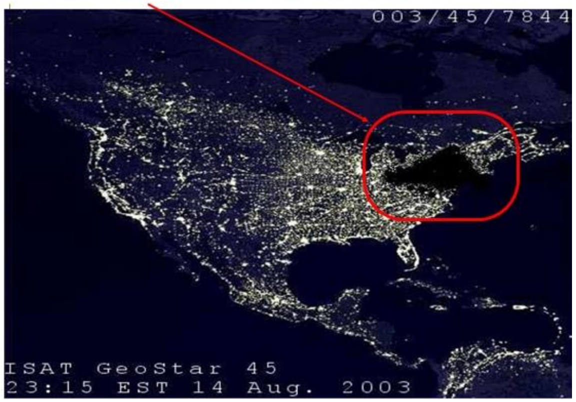


Material	Density (kg/m^3)	Volumetric specific heat (Wh/m^{3}K)	Temperature rise (°C) from application of 1kW to 1m^3 for 1 hr
Concrete	2100	490	2.0
Brickwork	1700	380	2.6
Lightweight concrete	1000	280	3.6
Plasterboard	950	220	4.5
Timber (softwood)	600	200	5.0
Plywood	530	200	5.0
Fibreboard	300	80	12.5
Mineral wool	12-40	10	100
Water	1000	1160	0.8
Air	1.2	0.33	3030

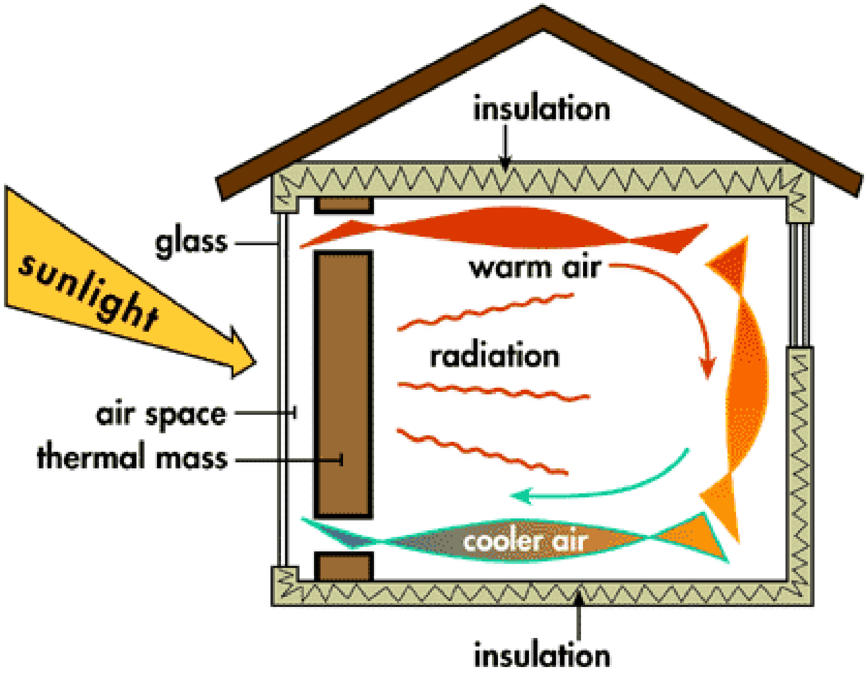
Thermal capacity is the (Specific Heat) × (Volume)

Volumetric Specific Heat for Building Materials

2003 North East Blackout: OOPS!!



Thermal Mass Principles



Solar Gain Example

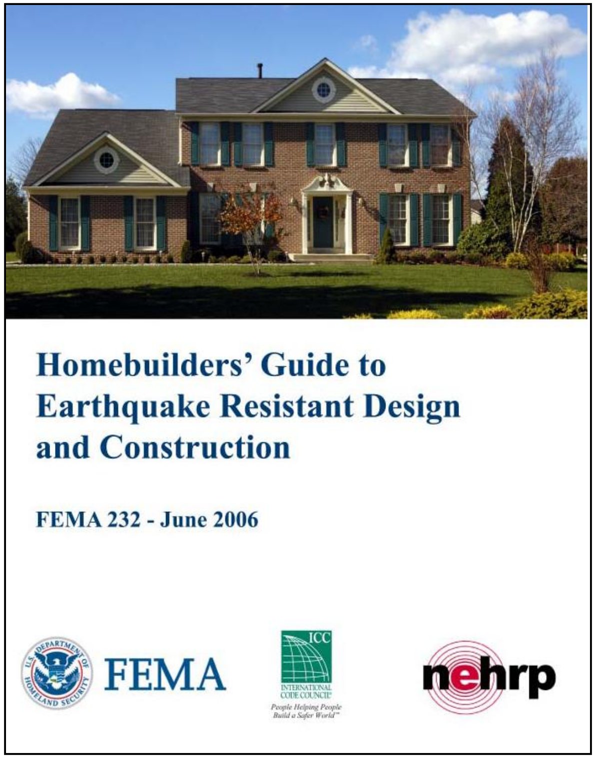
- The sun's heat is collected and trapped in a narrow space between the window and the thick masonry wall (thermal mass) after it passes through the windows.
- This heats the air, which rises and spills into the room through vents at the top of the wall. Cooled air then moves to take its place from vents at bottom of the wall. The heated air circulates throughout the room by convection.
- The thermal mass continues to absorb and store heat to radiate back into the room after the sun has gone.

Basic Passive Solar Design

Earthquake Resistance

FEMA Documentation

- **Above Code Recommendations**



Homebuilders' Guide to Earthquake Resistant Design and Construction

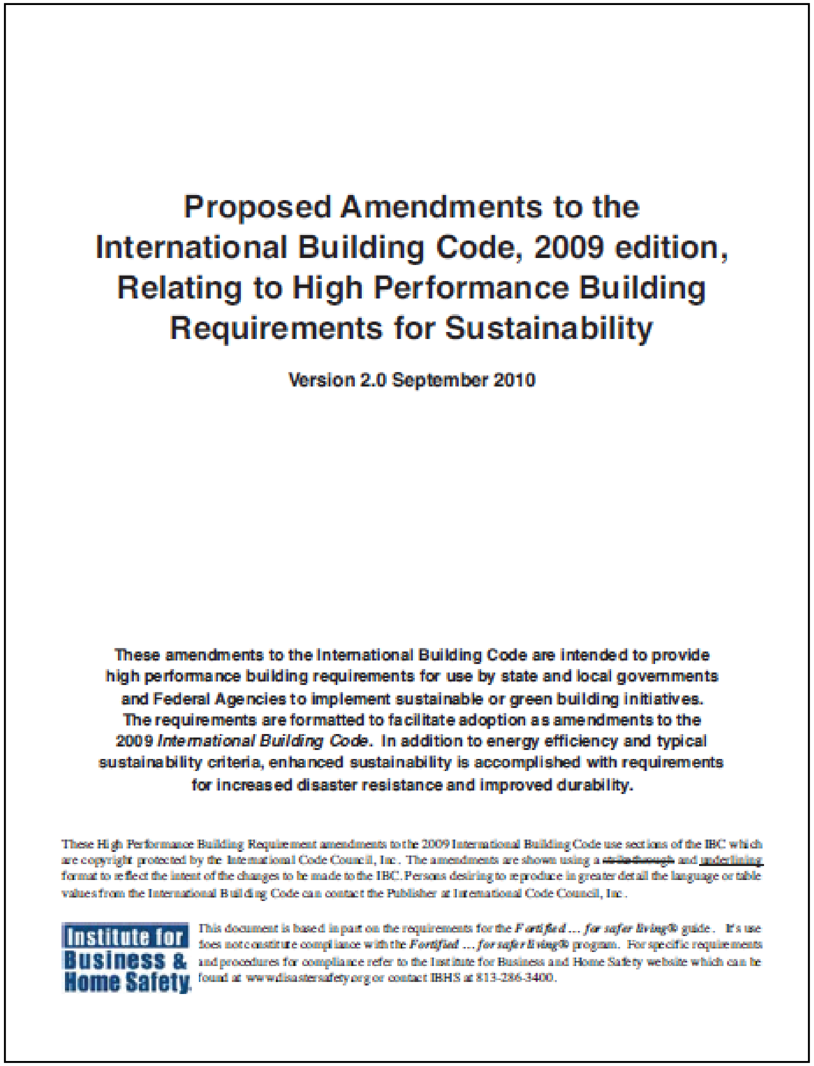
FEMA 232 - June 2006

FEMA

INTERNATIONAL CODE COUNCIL

People Helping People Build a Safer World™

nehrp



Proposed Amendments to the International Building Code, 2009 edition, Relating to High Performance Building Requirements for Sustainability

Version 2.0 September 2010

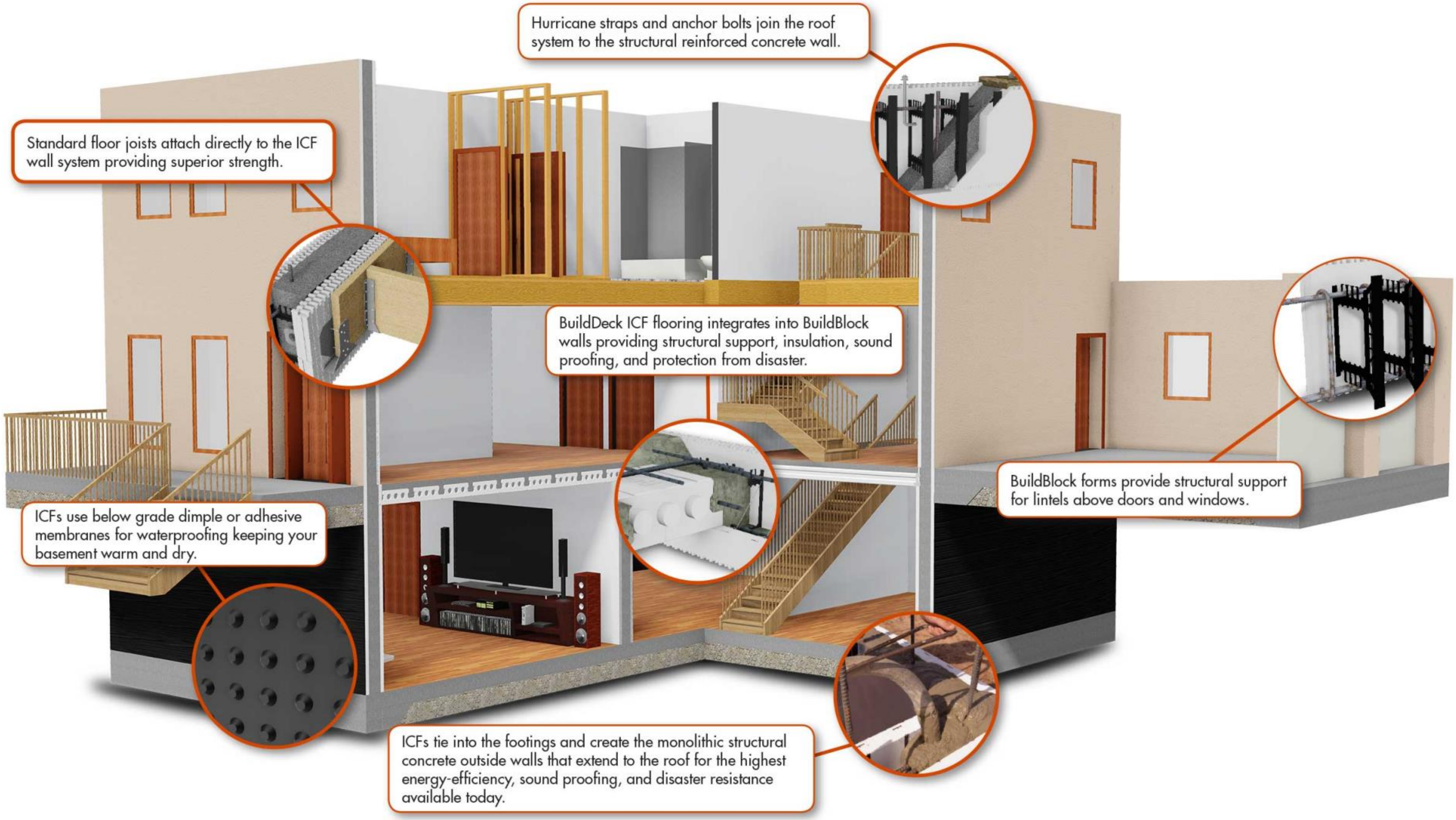
These amendments to the International Building Code are intended to provide high performance building requirements for use by state and local governments and Federal Agencies to implement sustainable or green building initiatives. The requirements are formatted to facilitate adoption as amendments to the 2009 *International Building Code*. In addition to energy efficiency and typical sustainability criteria, enhanced sustainability is accomplished with requirements for increased disaster resistance and improved durability.

These High Performance Building Requirement amendments to the 2009 International Building Code use sections of the IBC which are copyright protected by the International Code Council, Inc. The amendments are shown using a ~~strikethrough~~ and underlining format to reflect the intent of the changes to be made to the IBC. Persons desiring to reproduce in greater detail the language or table values from the International Building Code can contact the Publisher at International Code Council, Inc.

Institute for Business & Home Safety

This document is based in part on the requirements for the *Fortified … for safer living®* guide. It's use does not constitute compliance with the *Fortified … for safer living®* program. For specific requirements and procedures for compliance refer to the Institute for Business and Home Safety website which can be found at www.disastersafety.org or contact IBHS at 813-286-3400.

Earthquake Resistance



Hurricane straps and anchor bolts join the roof system to the structural reinforced concrete wall.

Standard floor joists attach directly to the ICF wall system providing superior strength.

BuildDeck ICF flooring integrates into BuildBlock walls providing structural support, insulation, sound proofing, and protection from disaster.

BuildBlock forms provide structural support for lintels above doors and windows.

ICFs use below grade dimple or adhesive membranes for waterproofing keeping your basement warm and dry.

ICFs tie into the footings and create the monolithic structural concrete outside walls that extend to the roof for the highest energy-efficiency, sound proofing, and disaster resistance available today.

Let it Snow…..

Structural systems can be cast in-place, precast, or post-tensioned.

Because of the relatively high self-weight (dead load) of concrete systems, concrete structures have a low susceptibility to snow-induced failure.

Snow load is the downward force on a building's roof by the weight of accumulated snow and ice.

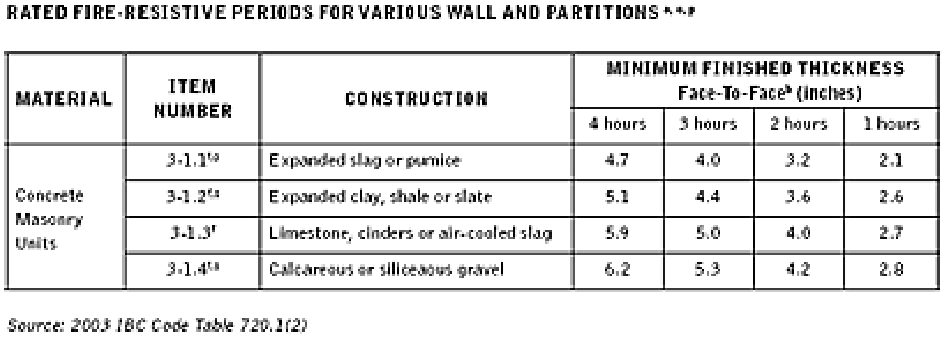
Fire Resistance

Minimum 2 hour fire separation provided by concrete products saves lives and properties from destruction.

Fire Resistance

- Masonry
- Concrete

Clear the area 100 feet around your home of dead grass and leaves. Space out vegetation and trim tree branches.



RATED FIRE-RESISTIVE PERIODS FOR VARIOUS WALL AND PARTITIONS[a, o, p]

MATERIAL	ITEM NUMBER	CONSTRUCTION	MINIMUM FINISHED THICKNESS Face-To-Face[b] (inches)			
			4 hours	3 hours	2 hours	1 hours
Concrete Masonry Units	3-1.1[f, g]	Expanded slag or pumice	4.7	4.0	3.2	2.1
	3-1.2[f, g]	Expanded clay, shale or slate	5.1	4.4	3.6	2.6
	3-1.3[f]	Limestone, cinders or air-cooled slag	5.9	5.0	4.0	2.7
	3-1.4[f, g]	Calcareous or siliceous gravel	6.2	5.3	4.2	2.8

Source: 2003 IBC Code Table 720.1(2)

Innovative Solutions

- **Substructures**
  - **Foundations, Ground Floors**
    - **Energy Pile, Flowable Fill, Jet Grout Foundations, Large slabs**
- **Superstructure**
  - **Frame, Upper floors, Roof, Non-structural walls, Windows and Doors**
    - **Semi-precast double wall, Hollow Column with Air Circulation, Double skin walls, Cement earth block, Floors with void formers, Thermoactive Hollowcore Precast Slabs, etc.**
- **Internal Finishes**
  - **Floor Finishes**
    - **Underfloor Heating with Self-leveling Screed, Colored Concrete**

Renovations

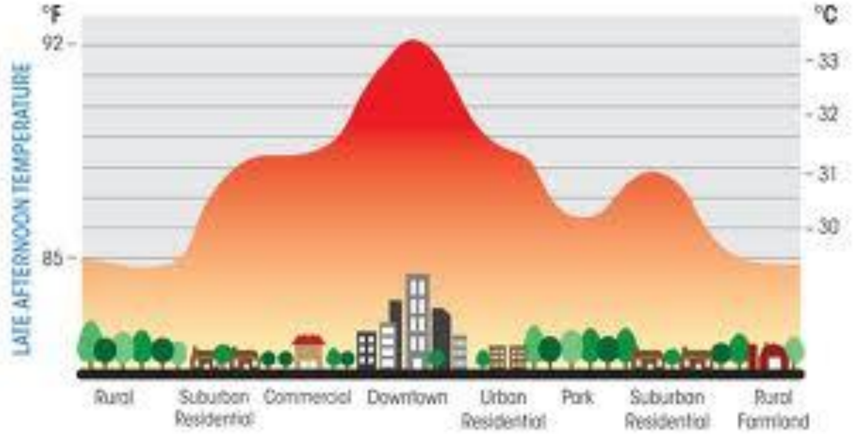
- **Floors and Columns**
  - **Renovating Columns with UHPC**

Services

- **Watertanks**
  - **Watertight Concrete**
- **External Works**
  - **Pavements**
    - **Pervious, Colored Concrete, Open Grid Pavers**
- **Complete Buildings**
  - **Thermal Solutions**
  - **Vertical Villages – Smart Growth**

Climate Adaptation/Mitigation Design

- Cooler Communities
  - Pavements
  - Building Facades
- Energy Efficient Design
  - Building Envelope Design
- Water Efficiency
  - Permeable Concretes
    - Water Storage
    - Return Water to Aquifer



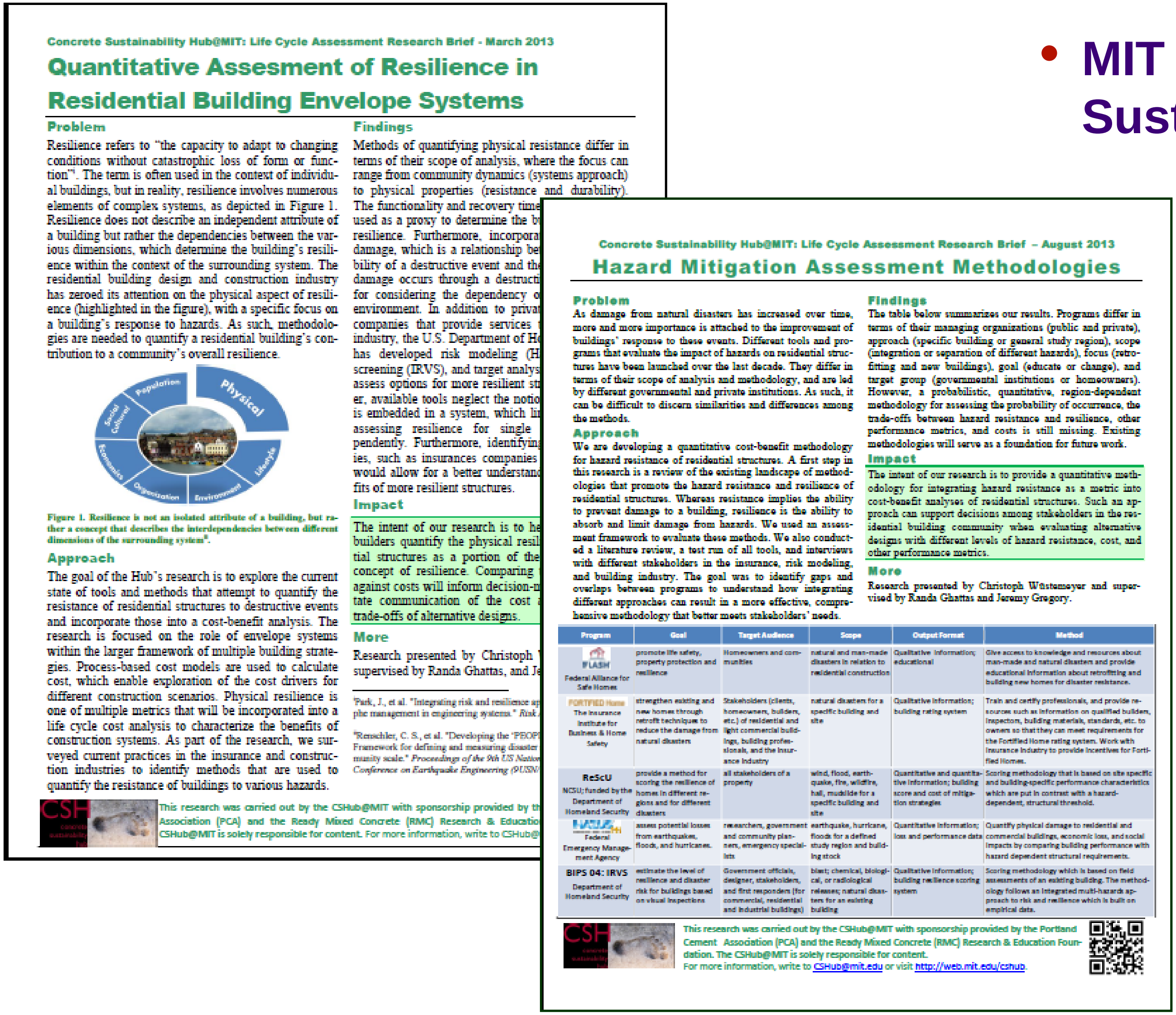
cool communities

Climate Adaptation/Mitigation Design

- Practical design, so that decision makers can not only see clearly what problems they face, but also find the solutions they need, in order to respond to power and water supply needs in a changing climate.
  - **Energy Efficiency**
  - **Water Efficiency**

Understanding Hazard Mitigation

- **MIT Concrete Sustainability HUB**



Concrete Sustainability Hub@MIT: Life Cycle Assessment Research Brief - March 2013

Quantitative Assesment of Resilience in Residential Building Envelope Systems

Problem

Resilience refers to "the capacity to adapt to changing conditions without catastrophic loss of form or function"[1]. The term is often used in the context of individual buildings, but in reality, resilience involves numerous elements of complex systems, as depicted in Figure 1. Resilience does not describe an independent attribute of a building but rather the dependencies between the various dimensions, which determine the building's resilience within the context of the surrounding system. The residential building design and construction industry has zeroed its attention on the physical aspect of resilience (highlighted in the figure), with a specific focus on a building's response to hazards. As such, methodologies are needed to quantify a residential building's contribution to a community's overall resilience.

Figure 1. Resilience is not an isolated attribute of a building, but rather a concept that describes the interdependencies between different dimensions of the surrounding system[2].

Approach

The goal of the Hub's research is to explore the current state of tools and methods that attempt to quantify the resistance of residential structures to destructive events and incorporate those into a cost-benefit analysis. The research is focused on the role of envelope systems within the larger framework of multiple building strategies. Process-based cost models are used to calculate cost, which enable exploration of the cost drivers for different construction scenarios. Physical resilience is one of multiple metrics that will be incorporated into a life cycle cost analysis to characterize the benefits of construction systems. As part of the research, we surveyed current practices in the insurance and construction industries to identify methods that are used to quantify the resistance of buildings to various hazards.

Findings

Methods of quantifying physical resistance differ in terms of their scope of analysis, where the focus can range from community dynamics (systems approach) to physical properties (resistance and durability).
The functionality and recovery time
used as a proxy to determine the b
resilience. Furthermore, incorpora
damage, which is a relationship be
bility of a destructive event and the
damage occurs through a destructi
for considering the dependency o
environment. In addition to privat
companies that provide services
industry, the U.S. Department of H
has developed risk modeling (H
screening (IRVS), and target analys
assess options for more resilient st
er, available tools neglect the notio
is embedded in a system, which li
assessing resilience for single
pendently. Furthermore, identifying
ies, such as insurances companies
would allow for a better understand
fits of more resilient structures.

Impact

The intent of our research is to he
builders quantify the physical resil
tial structures as a portion of the
concept of resilience. Comparing
against costs will inform decision-m
tate communication of the cost
trade-offs of alternative designs.

More

Research presented by Christoph
supervised by Randa Ghattas, and Je

---

[1] Park, J., et al. "Integrating risk and resilience ap
phe management in engineering systems." *Risk*

[2] Renschler, C. S., et al. "Developing the 'PEOP
Framework for defining and measuring disaster
munity scale." *Proceedings of the 9th US Natio
Conference on Earthquake Engineering (9USN*

This research was carried out by the CSHub@MIT with sponsorship provided by th
Association (PCA) and the Ready Mixed Concrete (RMC) Research & Educatio
CSHub@MIT is solely responsible for content. For more information, write to CSHub@

Concrete Sustainability Hub@MIT: Life Cycle Assessment Research Brief – August 2013

Hazard Mitigation Assessment Methodologies

Problem

As damage from natural disasters has increased over time, more and more importance is attached to the improvement of buildings' response to these events. Different tools and programs that evaluate the impact of hazards on residential structures have been launched over the last decade. They differ in terms of their scope of analysis and methodology, and are led by different governmental and private institutions. As such, it can be difficult to discern similarities and differences among the methods.

Approach

We are developing a quantitative cost-benefit methodology for hazard resistance of residential structures. A first step in this research is a review of the existing landscape of methodologies that promote the hazard resistance and resilience of residential structures. Whereas resistance implies the ability to prevent damage to a building, resilience is the ability to absorb and limit damage from hazards. We used an assessment framework to evaluate these methods. We also conducted a literature review, a test run of all tools, and interviews with different stakeholders in the insurance, risk modeling, and building industry. The goal was to identify gaps and overlaps between programs to understand how integrating different approaches can result in a more effective, comprehensive methodology that better meets stakeholders' needs.

Findings

The table below summarizes our results. Programs differ in terms of their managing organizations (public and private), approach (specific building or general study region), scope (integration or separation of different hazards), focus (retrofitting and new buildings), goal (educate or change), and target group (governmental institutions or homeowners). However, a probabilistic, quantitative, region-dependent methodology for assessing the probability of occurrence, the trade-offs between hazard resistance and resilience, other performance metrics, and costs is still missing. Existing methodologies will serve as a foundation for future work.

Impact

The intent of our research is to provide a quantitative methodology for integrating hazard resistance as a metric into cost-benefit analyses of residential structures. Such an approach can support decisions among stakeholders in the residential building community when evaluating alternative designs with different levels of hazard resistance, cost, and other performance metrics.

More

Research presented by Christoph Wüstemeyer and supervised by Randa Ghattas and Jeremy Gregory.

Program	Goal	Target Audience	Scope	Output Format	Method
FLASH Federal Alliance for Safe Homes	promote life safety, property protection and resilience	Homeowners and communities	natural and man-made disasters in relation to residential construction	Qualitative information; educational	Give access to knowledge and resources about man-made and natural disasters and provide educational information about retrofitting and building new homes for disaster resistance.
FORTIFIED Home The Insurance Institute for Business & Home Safety	strengthen existing and new homes through retrofit techniques to reduce the damage from natural disasters	Stakeholders (clients, homeowners, builders, etc.) of residential and light commercial buildings, building professionals, and the insurance industry	natural disasters for a specific building and site	Qualitative information; building rating system	Train and certify professionals, and provide resources such as information on qualified builders, inspectors, building materials, standards, etc. to owners so that they can meet requirements for the Fortified Home rating system. Work with insurance industry to provide incentives for Fortified Homes.
ReScU NCSU; funded by the Department of Homeland Security	provide a method for scoring the resilience of homes in different regions and for different disasters	all stakeholders of a property	wind, flood, earthquake, fire, wildfire, hail, mudslide for a specific building and site	Quantitative and quantitative information; building score and cost of mitigation strategies	Scoring methodology that is based on site specific and building-specific performance characteristics which are put in contrast with a hazard-dependent, structural threshold.
HAZUS-MH Federal Emergency Management Agency	assess potential losses from earthquakes, floods, and hurricanes.	researchers, government and community planners, emergency specialists	earthquake, hurricane, floods for a defined study region and building stock	Quantitative information; loss and performance data	Quantify physical damage to residential and commercial buildings, economic loss, and social impacts by comparing building performance with hazard dependent structural requirements.
BIPS 04: IRVS Department of Homeland Security	estimate the level of resilience and disaster risk for buildings based on visual inspections	Government officials, designer, stakeholders, and first responders (for commercial, residential and industrial buildings)	blast; chemical, biological, or radiological releases; natural disasters for an existing building	Qualitative information; building resilience scoring system	Scoring methodology which is based on field assessments of an existing building. The methodology follows an integrated multi-hazards approach to risk and resilience which is built on empirical data.

This research was carried out by the CSHub@MIT with sponsorship provided by the Portland Cement Association (PCA) and the Ready Mixed Concrete (RMC) Research & Education Foundation. The CSHub@MIT is solely responsible for content.
For more information, write to CSHub@mit.edu or visit http://web.mit.edu/cshub.

Education

42.5 Threat Level

32.6 Building Score

-9.9 ReScU Score

FLASH®
FEDERAL ALLIANCE FOR SAFE HOMES

- **FLASH – Federal Alliance for Safe Homes**
- **FEMA – Federal Emergency Management Agency**
- **CARRI – Community and Regional Resilience Institute**
- **ReScU - Resilient Scoring Utility for Homes by Homeland Security**
- **IBHS – Institute for Business and Home Safety**
- **NIBS – National Institute of Building Sciences**
- **Mitigation Movement**

FORTIFIED™
A program of the Insurance Institute for Business & Home Safety

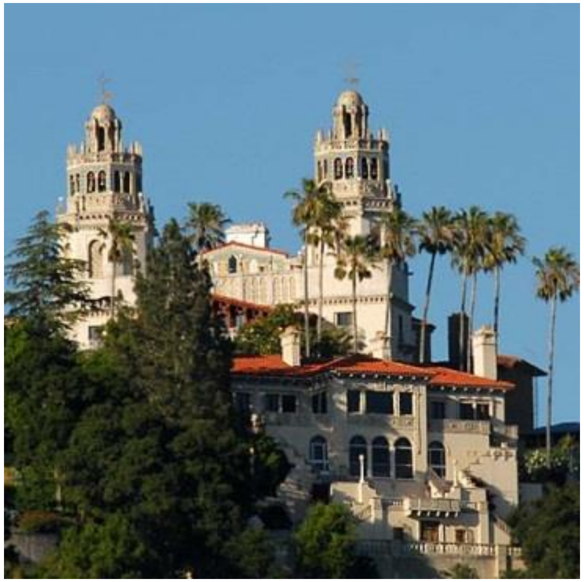
Community & Regional RESILIENCE Institute

Ideas, information and resources for disaster mitigation and recovery

MitigationMovement.org is more than a website. It's a community created by and for members of the disaster mitigation movement to facilitate collaboration and cooperation. Connect to access free, community-developed consumer education campaigns, academic research, technical resources, long-term recovery information and more. Add your organization to the list of partners working every day to make homes stronger and safer. Share your ideas and resources to help us open source and accelerate disaster mitigation to families and communities worldwide.

Resilience Concrete Strategy

- Concrete systems offer unmatched resistance to major devastation
  - Strong wind resistance
  - Greater stiffness than ordinary frame construction
  - Heavier
  - Reduced uplift
  - Reduced overturn
- Better wind driven debris protection
- Unequaled passive fire resistance



Hearst Castle: Reinforced Concrete Built from 1919-1947; Suffered no damage in 2003 from four earthquakes .

Questions ?