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

- 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.

Secure, Durable and Resilient Design 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!!
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.

**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.

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
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 neighborhood.
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

<table>
<thead>
<tr>
<th>Material</th>
<th>Density (kg/m³)</th>
<th>Volumetric specific heat (Wh/m³K)</th>
<th>Temperature rise (°C) from application of 1kW to 1m³ for 1 hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>2100</td>
<td>490</td>
<td>2.0</td>
</tr>
<tr>
<td>Brickwork</td>
<td>1700</td>
<td>380</td>
<td>2.6</td>
</tr>
<tr>
<td>Lightweight concrete</td>
<td>1000</td>
<td>280</td>
<td>3.6</td>
</tr>
<tr>
<td>Plasterboard</td>
<td>950</td>
<td>220</td>
<td>4.5</td>
</tr>
<tr>
<td>Timber (softwood)</td>
<td>600</td>
<td>200</td>
<td>5.0</td>
</tr>
<tr>
<td>Plywood</td>
<td>530</td>
<td>200</td>
<td>5.0</td>
</tr>
<tr>
<td>Fibreboard</td>
<td>300</td>
<td>80</td>
<td>12.5</td>
</tr>
<tr>
<td>Mineral wool</td>
<td>12-40</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Water</td>
<td>1000</td>
<td>1160</td>
<td>0.8</td>
</tr>
<tr>
<td>Air</td>
<td>1.2</td>
<td>0.33</td>
<td>3030</td>
</tr>
</tbody>
</table>

Thermal capacity is the (Specific Heat) \times (Volume)

---

### Volumetric Specific Heat for Building Materials
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

- Glazed window in summer
- Slab to absorb the sun's heat in winter, keeps cool in the summer
- Deciduous tree provides shade in summer and lets in the sun in the winter

Passive Solar Design and Building Techniques
Earthquake Resistance

FEMA Documentation

• Above Code Recommendations

Homebuilders’ Guide to Earthquake Resistant Design and Construction

FEMA 232 - June 2006
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 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.
- ICFs use below grade dimple or adhesive membranes for waterproofing keeping your basement warm and dry.
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.
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
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

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

Quantitative Assessment 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". This 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; rather, it reflects the dependencies between various dimensions, which determine the building's resilience within the context of the surrounding system. The residential building design and construction industry has focused its attention on the physical aspects of resilience, as highlighted in the figure, with a specific focus on the building's response to hazards. At each stage, methodologies are needed to quantify a residential building's contribution to a community's overall resilience.

Approach
The goal of the Hub's research is to develop a methodology to estimate the current state of resilience in residential structures, as a portion of the concept of resilience. Computational simulations against costs will inform decisions and new strategies in the context of alternative designs.

Mitigation Mitigation Assessment Methodologies

Problem
As damage from natural disasters has increased over time, more and more steps are being taken to improve the resilience of buildings to these events. Different tools and processes are necessary to improve the resilience of structures, and these have often been developed in isolation. This can lead to gaps and overlaps between programs, resulting in a lack of effective, coherent methodology that better serves stakeholders.

More
Research presented by Christopher Houghton, supervisory by Louis Graham, and sponsored by the Concrete Sustainability Hub@MIT. For more information, visit the Hub@MIT website or contact the Hub@MIT staff.
Education

• 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
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 ?