Enhancements in Building Design and Construction: Prerequisites for Resilient Communities

Hot Topic Session: Building Resiliency
ACI Spring Convention
Kansas City, MO
April 12, 2015
Stephen S. Szoke, P.E. F. ACI F.ASCE F.SEI IOM, LEED/AP, CSI-CDT
Senior Director, Codes and Standards
Portland Cement Association
Part 1: DISASTERS AND PROPERTY LOSSES
NOAA, FEMA, Census Bureau, and Insurance Industry Statistics and Data

Part 2: INFLUENCING FACTORS
Demographics, Construction Volume and Practices

Part 3: COMMUNITY RESILIENCE
Opportunities: Voluntary or Mandatory Programs

Part 4: CODE MODIFICATIONS
Overview of Criteria for Enhanced Resiliency

Part 5: CALL TO ACTION
Better Rules and Regulations – Built Back Better
DISASTER RESISTANCE

Earthquake

Flood

Snow and Ice

Wind
DISASTER RESISTANCE

Wildland Fires

Structure Fires

Conflagrations
Fires after Disasters

Hurricane Katrina

Super Storm Sandy
2012 National Disasters and Emergencies

Source: FEMA.gov

Map showing the distribution of disasters and emergencies in the United States for 2012, categorized by severity:
- None: Grey
- 1 or 2: Yellow
- 3 or 4: Red
- 5 or More: Black

States are color-coded based on the number of disasters and emergencies they experienced.
03-12 NATIONAL DISASTERS AND EMERGENCIES

Source: FEMA.gov
**Combined Losses: Tornadoes and Storms**

In Billions of 2010 Dollars per Decade*

<table>
<thead>
<tr>
<th>Decade</th>
<th>Thunderstorms</th>
<th>Hail Storms</th>
<th>Tornadoes</th>
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<td>'50-'59</td>
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<td>'00-'09</td>
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</tbody>
</table>

- **Thunderstorms**: 56.5 Billion
- **Hail Storms**: 3.1 Billion
- **Tornadoes**: 3.1 Billion

*Property Claims Service*
COMBINED LOSSES: HURRICANES AND STORMS

In Billions of 2010 Dollars per Decade*

*Property Claims Service
**Winter Weather Event Losses**

In Billions of 2010 Dollars per Decade*

![Graph showing the increase in winter weather event losses from 1950 to 2009. The graph illustrates a significant increase from 0.5 Billion to 10.3 Billion over the decades.](image)

*Property Claims Service*
FLOOD LOSSES
In Billions of 2010 Dollars per Decade*

*Property Claims Service
FIRE LOSSES
In Thousands of 2010 Dollars per Fire

*US Fire Administration National Fire Incident Reporting System data Complied by National Fire Protection Association
TORNADO LOSSES

Versus Number EF3 –EF5 Tornadoes*

*National Weather Service
HURRICANES AND TROPICAL STORMS LOSSES

Versus Number of Strikes*

Losses in Billions of 2010 Dollars

*National Weather Service
DISASTER LOSSES EXCLUDING FLOOD*

In Millions of 2010 Dollars per Decade

- Earthquakes
- Fire
- Hail
- Hurricanes
- Thunderstorms
- Tornados
- Tropical Storms
- Wildland Fire
- Winter Storms

'50-'59 '60-'69 '70-'79 '80-'89 '90-'99 '00-'09

190.6 billion

5.3 billion

*Property Claims Service
CLIMATE CHANGE

Taken as a whole, the range of public evidence indicates that the net damage costs of climate change are likely to be significant and increase over time.
SEA LEVEL BY 2100

Source: February 2015 National Geographic
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DISASTER LOSSES VS. POPULATION CHANGE*

Population in Millions and Losses in Billions of 2010 Dollars

*U.S. Census Bureau
TYPES OF CONSTRUCTION

Type IA          Type IIIB
Type IB          Type IV
Type IIA         Type VA
Type IIB         Type VB
Type IIIB
Type IIIA
# Types of Construction

<table>
<thead>
<tr>
<th>Type</th>
<th>Structural Frame</th>
<th>Bearing Walls</th>
<th>Floors</th>
<th>Roof</th>
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<tr>
<td></td>
<td>Exterior</td>
<td>Interior</td>
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<tr>
<td>IA</td>
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<td>IB</td>
<td>2</td>
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<tr>
<td>IIA</td>
<td>1</td>
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<td>IIIA</td>
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<td>IIIIB</td>
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<td>IV</td>
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</table>
### Heights [Stories] and Areas [1000 sq ft]

<table>
<thead>
<tr>
<th>Occupancy and Use</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>IV</th>
<th>Type V</th>
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<td>R-2 Apartments/Dormitories</td>
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</table>
TYPE I AND II HIGH-RISES
Replace Type V Low-Rise
**LOSSES VS. RESIDENTIAL UNITS**

Residential Units in Millions and Losses in Billions of Dollars

*U.S. Census Bureau*
LOSSES VS. COMMERCIAL PUT-IN-PLACE*
In Billions of 2010 Dollars

*U.S. Census Bureau
COINCIDENCE?

• Frequency of Events

• Population Re-Distribution

• Amount of Construction
WHERE’S THE BAR NOW?

• Societal and Cultural Trends
  – Least Initial Cost/Maximum Return on Investment
  – Increased Political Pressure
  – Emotion Versus Technical Substantiation
  – Acceptance of Disposable Products

• Changes in Construction Practice
  – Move to Lighter/Less Expensive Construction
  – Project Management and Value Engineering

• Rules and Regulations
SOCIETAL AND CULTURAL CHANGES

• Maximum Return on Investment
• Competition and Short-Term Ownership
• Political Pressures and Influence
• Economic Development = Revenue
  – Short-Term versus Long-Term Mentality
  – Aging Infrastructure
DEMOlITION* VS. ALL BUILDINGS* BY AGE

Age of Buildings

Percent

>75

51-75

20%

18%

26-50

49%

*The Athena Group
TIMELESS ARCHITECTURE

durable, long-lasting materials and systems
ENHANCED RESILIENCE

Winecoff Hotel Built in 1913

Completely gutted by fire in 1946,
Hotel in 1951,
Housing for elderly,
Vacant for 20 years,
and
Ellis Hotel in 2007
Enhanced Resilience – 9/11
Enhanced Resilience: 9/11

90 West St. Built in 1907

Damage by WTC collapse,
Uncontrolled fire for 5 days, and
Reopened as apartment building in 2005
CHANGES IN CONSTRUCTION PRACTICES

Move to lighter/less expensive construction

- Plywood sheathing
- Oriented strand board sheathing
  - Structurally comparable
  - Comparable impact resistance
- Foam board sheathing
CHANGE IN OWNER’S ROLE

Project Management and Value Engineering

Copper Flashing

Plastic Flashing
DE-REGULATION

► More stringent passive fire protection
► More stringent sound transmission loss criteria
► Etc...
RELAXATION OF MODEL CODES (‘70s & ‘80s)

Height and area tables permitting larger Type V buildings
RELAXATION OF MODEL CODES (‘70s & ‘80s)
Height and area tables permitting larger Type V (wood frame) buildings Avalon Apartments, NJ

Source: 48 new york
Relaxation of Model Codes (‘70s - ‘80s)

- Sprinkler protection required in more buildings.
- Trade-offs in passive protection and egress safety used to offset sprinkler costs.
- Moving away from prescriptive material specific provisions to performance based requirements.
NFPA US EXPERIENCE WITH SPRINKLERS
John R. Hall June 2013

...performance of operating effectively in 87% of all reported fires where sprinklers were present in the fire area and fire was large enough to activate them.
Relaxation of Model Codes (‘97-‘00s)

• The merger resulted in the least common denominator for passive fire protection.

• Most aggressive trade-offs for sprinklers were also included from any one code.
CULTURAL/SOCIETAL CHANGE:
Increased Competition and Increased Emphasis on ROI

• Least initial cost is minimum building code or less

• Minimum building code is becoming the standard of practice in the United States

• Design firms advertising alternative compliance to lower initial costs
Trend suggests that the problem of aging buildings will become greater in the future if we do not improve the way we build new buildings today.
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ELEVATED NATIONAL PRIORITY

- Presidential Policy Directives
- Presidential Executive Orders
- Proposed Federal Legislation
- DHS National Resilience Roadmap
- DHS Resilient Star
- NIST National Resilience Framework
POLITICAL VIEWS

• December 2, 2014 – Congressman Daniel Webster, D-FL:
  “Buildings should not fall down during a hurricane or any other disaster.”

• November 22, 2014 – Moore, OK Officials
  “We can’t have our primary focus on ‘affordability’ anymore.”
ROLE OF FEDERAL GOVERNMENT

Portion of total government paid losses

Sources: E. Michel-Kerjan. *Have We Entered an Ever-Growing Cycle on Government Disaster Relief?* - Testimony before the U.S. Senate (2013).
KEY ATTRIBUTES OF ENHANCED RESILIENCE

• Increased Resistance to Disasters
• Increased Longevity
• Increased Robustness
• Improved Sustainability
• Improved Life Safety
• Increased Durability
• Increased Adaptability for Reuse
ENHANCED RESILIENCE VS. LIFE SAFETY

<table>
<thead>
<tr>
<th>Extent of Damage</th>
<th>Time to Re-Occupy</th>
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<tbody>
<tr>
<td>No Damage</td>
<td>Hours</td>
</tr>
<tr>
<td>Resilient</td>
<td>Days</td>
</tr>
<tr>
<td>Life Safety</td>
<td>Months</td>
</tr>
<tr>
<td>Total Loss</td>
<td>Years</td>
</tr>
<tr>
<td></td>
<td>Never</td>
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## San Francisco Target Recovery (SPUR)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Event Occurs</th>
<th>Hours After</th>
<th>Days After</th>
<th>Months After</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>Hospitals</td>
<td>Green</td>
<td>Yellow</td>
<td>Yellow</td>
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<tr>
<td>Police/Fire</td>
<td>Green</td>
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<tr>
<td>Shelters</td>
<td>Green</td>
<td>Yellow</td>
<td></td>
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</tr>
<tr>
<td>Schools</td>
<td>Green</td>
<td>Yellow</td>
<td></td>
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<tr>
<td>Residences</td>
<td>Green</td>
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<td>Neighborhood Services</td>
<td>Green</td>
<td>Yellow</td>
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<td>Residences</td>
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<td>Neighborhood Services</td>
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## Getting Operational

<table>
<thead>
<tr>
<th>Time Frame</th>
<th>Hospitals</th>
<th>Fire/Police</th>
<th>Shelters</th>
<th>Schools</th>
<th>Homes</th>
<th>Services</th>
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<tr>
<td>Immediately</td>
<td>90%</td>
<td>100%</td>
<td></td>
<td></td>
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<tr>
<td>24 Hours</td>
<td>5%</td>
<td>95%</td>
<td>90%</td>
<td>75%</td>
<td>75%</td>
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<tr>
<td>48 Hours</td>
<td>3%</td>
<td>5%</td>
<td>5%</td>
<td>3%</td>
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<tr>
<td>30 Days</td>
<td>2%</td>
<td>5%</td>
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<td>2%</td>
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<td>4 Months</td>
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<td>6%</td>
<td>9%</td>
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<td>36 Months</td>
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<td></td>
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<td>4%</td>
<td>6%</td>
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<tr>
<td>Longer or Never</td>
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<td></td>
<td></td>
<td></td>
<td>10%</td>
<td>5%</td>
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</table>
Risk Assessment

- Any Hurricane
- Category II
- Category III or IV

Event
- Structural Damage
- Non-Structural Damage
Whole Building Design Guidelines
Institute for Business & Home Safety®

FORTIFIED... for safer living.

OPEN for business®

A program of the Institute for Business & Home Safety
DHS Resilience STAR

DHS launched the Resilience STAR pilot, a voluntary certification program that aims to make homes and buildings more secure and resilient to all hazards. The RESILIENT Homes Pilot brings DHS together with local officials, private sector insurers and builders, and community leaders in risk-prone communities to rebuild private residences recently destroyed by hazards such as tornados and floods.
VOLUNTARY PROGRAMS

• Knowledge / Understanding of Benefits
• Knowledge / Understanding of Consequences
• Ability / Opportunity to Influence
• Commitment to Overcome Barriers / Resistance
• Financial Resources
ENHANCED RESILIENCE

- A must for sustainability
- Essential for community continuity
IBC Minimum Code + Enhanced Resilience = Improved Community Resilience, Continuity, and Sustainability

www.cement.org
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STRUCTURAL COMPONENTS

- **Fire**: Maintain fire resistance ratings of at least one-hour.
- **Flood**: ASCE 24; do not consider levees and flood walls as flood protection; modify coastal zone construction.
- **Seismic**: Increase seismic loads in high seismic areas by 10 to 15%.
- **Snow**: Increase design snow loads by 10 to 15%.
- **Storm Shelters**: Require storm shelters in accordance with ICC 500.
- **Wind**: Increase ultimate design wind speed by 10 to 15%.
2015 International Building Code - Shelters
FIRE PROTECTION COMPONENTS

• **Automatic Sprinkler Systems:** Use sprinklers systems in all occupancies except low hazard manufacturing and storage facilities and do not use NFPA 13 R automatic sprinkler systems.

• **Internal Fire Barriers:** Maintain minimum 2-hr fire separations and provide draftstopping and fire stopping in concealed spaces.
INTERIOR COMPONENTS

• **Acoustical Comfort:** Require STC ratings of at least 50 for opaque walls and at least 30 for fenestrations and require IIC ratings of at least 50 for floor ceiling assemblies.

• **Moisture Protection:** Protect materials susceptible to moisture damage during construction and provide smooth hard non-absorbent surfaces when water is likely to be present during building operations.
EXTERIOR COMPONENTS

- **Fire**: Limit openings and combustible materials in close proximity to adjacent structures.
- **Wildfire**: Adopt *Wildland-Urban Interface Code*.
- **Wind**: Limit the use of exterior cladding materials susceptible to wind damage to locations outside hurricane and tornado prone areas.
- **Hail**: Limit cladding materials susceptible to hail damage.
- **Rodent proofing**: Mandate Appendix F of the IBC.
- **Radon Entry**: Use EPA *Guide to Radon Prevention* or Appendix F, Radon Control Methods, of the *International Residential Code*. 
PART 1: DISASTERS AND PROPERTY LOSSES
NOAA, FEMA, Census Bureau, and Insurance Industry Statistics and Data

PART 2: INFLUENCING FACTORS
Demographics, Construction Volume and Practices

PART 3: COMMUNITY RESILIENCE
Opportunities: Voluntary or Mandatory Programs

PART 4: CODE MODIFICATIONS
Overview of Criteria for Enhanced Resiliency

PART 5: CALL TO ACTION
Better Regulations – Built Back Better
STATE AND FEDERAL REGULATIONS

• Require all government owned, leased, or financially supported (HUD mortgage insurance loans etc.) to:

  1) Min. follow FEMA guidelines

  or

  2) IBHS plus FEMA guidelines plus passive fire protection
STATE AND LOCAL REGULATIONS

• Have mandatory provisions that require compliance with IBHS plus FEMA guidelines plus passive fire protection
  1) All buildings
  2) All government buildings
  3) Designated buildings

• Have optional provisions that require compliance with IBHS plus FEMA guidelines plus passive fire protection
ACHIEVING ENHANCED RESILIENCY

Collapse Avoidance = Life Safety

Collapse Avoidance = Minimized Damage
ALL OTHER DISASTERS

Evacuate!
From Structure
To Shelter
Out of Disaster Area

Evacuation ≠ Minimized Damage
THANK YOU!

- Better Buildings
- Better Communities
- Better Environment

Building Stronger Communities One Building at a Time