Resilient Buildings:
Prerequisite for Community Continuity

Enhancing the resilience of buildings through mandatory requirements that increase robustness, durability, longevity, disaster resistance, and safety should be a priority for every jurisdiction interested in improving community continuity.

In addition to satisfying minimum life safety provisions, incorporating enhanced resilience into building design and construction augments economic viability, addresses societal issues, and helps communities to minimize negative environmental impacts. While enhanced resiliency is beneficial to all communities, this is especially important in disaster prone areas. When disaster strikes, more resilient buildings REDUCE the:

- ✓ time for communities to recover after disasters.
- ✓ demand on emergency response personnel.
- ✓ expenditures required for emergency response.
- ✓ risk of injury or death for emergency responders.
- ✓ owner, occupant, and community expenditures for disaster recovery.
- ✓ amount of resources required for disaster relief.
- ✓ amount of damage and contaminated materials and contents to be disposed in landfills or by incineration.

Even when disasters do not strike communities can benefit from design and construction requirements that enhance resiliency. Robust and durable resilient buildings:

- ✓ minimize the amount of energy and resources required for routine maintenance, repair, and replacement over the life of the building, providing long term benefits for subsequent owners and occupants.
- ✓ provide enhanced safety and security for occupant comfort and productivity.
- ✓ increase design service lives.
- ✓ enhance the operational continuity of the community in which they are built
- ✓ are adaptable for future use and re-purposing to minimize long-term environmental impacts involved with replacement, removal, disposal, and reconstruction.
- ✓ attract and retain businesses and residents.

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PART 1 - RESILIENCE – WHAT AND WHY?

The need for increased resilience through the design and construction of more robust, durable, long-lived, disaster resistant, safe and secure buildings has long been recognized by many entities and identified in many publications and programs. A trend in the United States, especially for structures that are not owner designed, built, and occupied; is to maximize profitability by simply satisfying the least stringent provisions of the local building code. While this generally has little impact on the life safety of occupants, buildings built to minimum provisions of building codes tend to lack the robustness, durability, longevity, comfort, safety, and security necessary for community sustainability while minimizing long term negative impacts on the natural environment.

The need for enhanced resiliency of buildings is becoming increasingly important nationally and globally and is a key component to economic, societal, and environmental viability. A 2011 United Nations report[1] on disaster risk reduction identified that losses from disasters are rising faster than gains made through economic growth across all regions, threatening the economies of low- and middle-income countries as well as outpacing wealth gains across many of the world's more affluent nations. Recent major natural disasters and their impacts on national and global economies have heightened awareness and spurred activity to improve the nation's infrastructure. Not only single

Source: U.S. Navy photo by Chief Petty Officer Johnny Bivera

Katrina Aftermath

Flooding in Vermont

event disasters such as Hurricane Katrina, but also the intense amount of flooding in 2011, have resulted in a flurry of activity in the United States. The U.S. Congress repeatedly works on programs to provide relief after major disasters and continues to work on programs to provide incentives for more resilient construction. The Department of Homeland Security (DHS), Federal Emergency Management Agency (FEMA), and National Oceanic and Atmospheric Administration (NOAA) are some of the agencies that have already begun to implement programs to encourage more resilient construction. To assist in the development and implementation of these inter-operational government programs, the National Institute of Building Sciences (NIBS) reorganized its Multi-Hazard Mitigation Council. Major jurisdictions are conducting risk assessments and devising programs to improve their community's ability to respond to and recover from disasters. The San Francisco Planning + Urban Research Association (SPUR) proposed recommendations[2] for community disaster recovery and to address rising sea levels. In addition to shortening the recovery time for critical infrastructure and emergency housing and support facilities, SPUR recommendations also include shortening the recovery time for residences, neighborhood retail services, and work places from years to months.

Not every jurisdiction has the resources to conduct sophisticated risk assessments like San Francisco. Nor can many jurisdictions even attempt to address the resiliency of much of its existing buildings. However,

[1] ***International Strategy for Disaster Reduction***, United Nations Secretariat for the International Strategy for Disaster Reduction, New York, NY, 2011.

[2] www.spur.org/publications/library/report/part-i-condensed-version

the National Trust for Historic Preservation, based on a study[3] by the Brookings Institute, advises that nearly one third of all existing buildings in the United States will be replaced by 2030 simply because they weren't designed to last any longer. In addition most of these buildings were built since the 1940s. By starting to build better now and to build back better after disasters, more resilient buildings can become the mainstay of the future infrastructure. However, if status quo building to minimum building code requirements remains in place, then we will continue to exhaust resources for disaster recovery and relief and jeopardize community continuity.

To provide a resource for all communities, regardless of size, criteria are presented as a series of prescriptive requirements to augment the local building code. In this way, even small jurisdictions are provided an opportunity to respond to this increasingly important concern and improve the sustainability of its community. Jurisdictions, large or small, may adopt these more stringent building code requirements for the design and construction of new buildings. Not only will such provisions allow the community to be more resilient when disasters occur, it will slow the rate at which newer buildings must be disposed – which can significantly improve economic viability by attracting and retaining businesses, residents, and related revenue; help assure that as neighborhoods age, buildings design and constructed to more stringent criteria will continue to be more suitable for future and even for lower income occupants; and reduce the energy and resources required for routine operation and maintenance, replacement and disposal which significantly reduces negative impacts on the natural environment.

There are many programs and recommendations that provide guidance for designing and constructing buildings that will be more resilient. Such recommendations may be found in publications by the U.S. Government, including but not limited to FEMA and NOAA. The national association representing the insurance and re-insurance industry in the United States, Institute for Business and Home Safety (IBHS) has several programs that have been in existence for decades. One of the most noteworthy programs is the FORTIFIED® program which focuses on the need for more durable and more disaster-resistance construction.

Community-Wide Operational Continuity

The impact of enhanced resilience is not limited to buildings. More resilient buildings can significantly enhance the sustainability of communities. Continuous business operations and residential occupancy provide the economic benefits of a more consistent tax base and generally support continuity of the community's vitality. Further community economic, societal, and environmental benefits result from reductions in resources that would need to be allocated for emergency response, disaster relief, and disaster recovery.

The Missing Link

To date most building code requirements have an emphasis on life safety, i.e. allow major damage or total collapse as long as the occupants can be evacuated prior to or during the event. Excessively damaged buildings slow recovery and may even prevent recovery for some neighborhoods. Most sustainability or green programs, codes, and standards have focused primarily on energy, material, and water conservation; indoor environmental quality; and site selection and development. Each of these is an important aspect of sustainable building design and construction. However, the assumption that the basic building will be resilient is not inherent in these programs. Often minimum requirements in many building codes are focused on life safety and do not provide protection of buildings and their contents necessary for truly sustainable buildings. Unfortunately, this is consistent with the modern day disposable-mentality and results in buildings that satisfy the absolute minimum project requirements at the least possible initial cost.

[3] **Sustainable Stewardship – Historic preservation plays an essential role in fighting climate change**, Article by Richard Moe in T*raditional Building*, Natural Trust for Historic Preservation, Washington, DC – 2008.

Championing Resilience

Many resources and references highlight the need for enhanced resilience. The following seven references are provided as representative examples which capture the most significant aspects:

1. A study of grants awarded by FEMA[4] indicates "**a dollar spent on disaster mitigation saves society an average of $4.**"

2. "When Hurricane Katrina made landfall on August 29, 2005, it caused an estimated $41.1 billion in insured losses across six states, and took an incalculable economic and social toll on many communities. Five years later, the recovery continues and some residents in the most severely affected states of Alabama, Louisiana, and Mississippi are still struggling. **There is no question that no one wants a repeat performance of this devastating event that left at least 1,300 people dead. Yet, the steps taken to improve the quality of the building stock, whether through rebuilding or new construction, call into question the commitment of some key stakeholders to ensuring that past mistakes are not repeated.**"[5] This report indicates that there is a need to implement provisions to make buildings more disaster-resistant.

3. **The average annual direct property loss due to natural disasters in the United States exceeds of $35,000,000,000.**[6] This does not include indirect costs associated with loss of residences, business closures, and resources expended for emergency response and management. These direct property losses also do not reflect the environmental impact due to reconstruction. Enhanced resilience will help alleviate the economic, societal, and environmental impacts of both direct and indirect losses from natural disasters.

4. "Climate changes are underway in the United States and are projected to grow. Climate-related changes are already observed in the United States and its coastal waters. These include **increases in heavy downpours, rising temperature and sea level, rapidly retreating glaciers, thawing permafrost, lengthening growing seasons, lengthening ice-free seasons in the ocean and on lakes and rivers, earlier snowmelt, and alterations in river flows. These changes are projected to grow.**"[7] The report further identifies that the: "Threats to human health will increase. Health impacts of climate change are related to heat stress, waterborne diseases, poor air quality, extreme weather events, and diseases transmitted by insects and rodents. Robust public health infrastructure can reduce the potential for negative impacts." Key messages in the report on societal impacts include:
   - "City residents and city infrastructure have unique vulnerabilities to climate change. "
   - "Climate change affects communities through changes in climate-sensitive resources that occur both locally and at great distances."
   - "Insurance is one of the industries particularly vulnerable to increasing extreme weather events such as severe storms, but it can also help society manage the risks."

   Sustainable building design and construction cannot be about protecting the natural environment without consideration of the projected growth in severe weather. Minimum codes based primarily on past natural events are not appropriate for truly sustainable buildings. Buildings expected to have long-term positive impacts on the environment must be protected from these extreme changes in

[4] ***Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*** National Institute of Building Sciences Multi-Hazard Mitigation Council - 2005

[5] ***Five Years Later – Are we better prepared?*** Institute for Business and Home Safety – 2010.

[6] **National Weather Service Office of Climate, Water and Weather Services** National Oceanic and Atmospheric Administration (NOAA) – 2010. Data source is the NOAA website [www.weather.gov/os/hazstats.shtml]

[7] ***Global Climate Change Impacts in the United States*** U.S. Global Change Research Program (USGCRP) – 2009. The USGCRP includes the departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, Interior, State and Transportation; National Aeronautic and Space Administration; Environmental Protection Agency; USA International Development; National Science Foundation; and Smithsonian Institution.

the natural environment. The provisions for improved property protections are necessary to reduce the amount of energy and resources associated with repair, removal, disposal, and replacement due to routine maintenance and damage from disasters. Further such provisions reduce the time and resources required for community disaster recovery.

5. The previously cited study by the Brookings Institution projects that "**by 2030 we will have demolished and replaced 82 billion square feet of our current building stock, or nearly one-third of our existing buildings, largely because the vast majority of them weren't designed and built to last any longer."** Durability, as a component of enhanced resilience, can reduce these losses.

6. During panel discussions, a representative of the National Conference of State Historic Preservation Officers noted that **more robust buildings erected prior to 1950 tend to be more adaptable for reuse and renovation**.[8] Prior to the mid-1950s, most local jurisdictions developed their own building code requirements that uniquely addressed the community's needs, issues, and concerns—resulting in more durable and robust construction.
7. "The risks posed by natural hazards to the built environment demonstrate the need for disaster preparedness to **assure that buildings and infrastructure are made more resilient and respond better when disaster strikes.**"[9] Supporting statements include that in the first three and one-half months of 2010 there were 31 natural disasters declared in the U.S. and insured catastrophic losses in the 2000s total $138 billion, a 56 percent increase when compared to the amount in the 1990s. One of the seven recommendations is: "Encourage the design community toward greater focus on resilience."

In 2011 FEMA responded to 99 major disaster declarations, 29 emergency declarations In 2011 the disasters and emergencies which qualified for national assistance occurred in all but seven states. In the last decade, 2002 through 2011, there were 792 national disaster and emergency declarations. The fewest nationally declared disasters and emergencies during that decade in any state were 3. In 2011 there were also 114 fire management assistance declarations, nearly 500 in the past decade.

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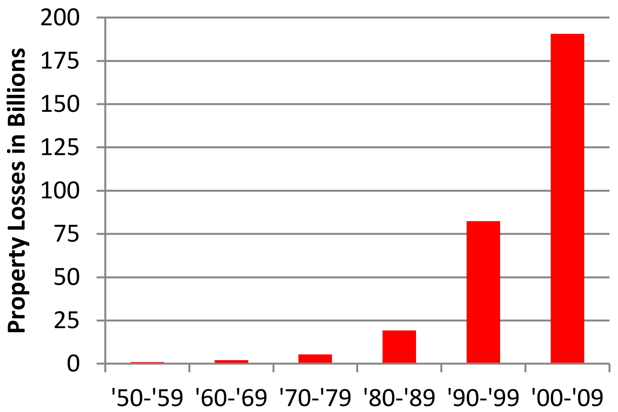
[8] **Opportunities for Integrating Disaster Mitigation and Energy Retrofit Programs** Senate Environment and Public Works Committee Room, Dirksen Senate Office Building, Washington, D.C. - 2010

[9] ***Designing for Disaster: Partnering to Mitigate the Impact of Natural Disasters*** *- Insights Drawn from the National Building Museum's Industry Council for the Built Environment, May 12, 2010 -* Executive Summary

PART 2 - PROPERTY LOSSES

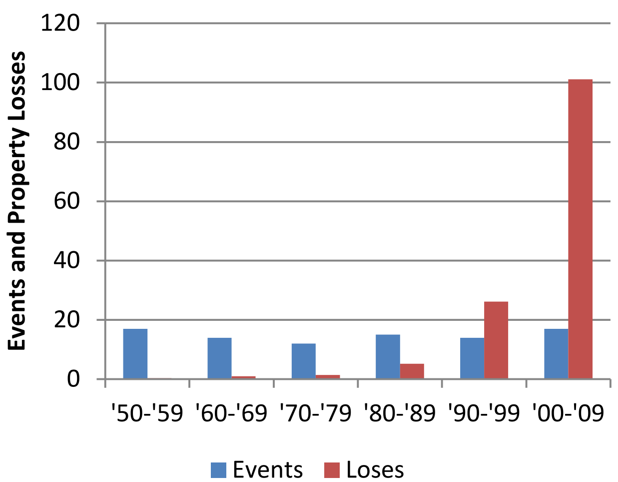
Property losses due to disasters continue to escalate at a staggering rate. Since the 1970s property losses by decade have increased by more than 3500%, as shown below in Figure 2.1.

Figure 2.1
Property Losses[1] due to Natural Disasters[2]
[1]Property losses in billions reported in 2010 adjusted dollars
[2]Natural disasters excluding floods



These property losses are presented with regard to the entities collecting and reporting data the data. Losses due to natural disaster excluding floods are provided insurers. Flood losses are provided using data from the using data and reports generated by the National Oceanic and Atmospheric Administration and private Federal Emergency Management Agency. Structure fire losses are provided using data and reports from the United States Fire Administration and National Fire Protection Association.

Figure 2.2
Tropical Storms[1] and Property Losses[2]
[1]Tropical Storms and Hurricanes making landfall in the United States
[2]Property losses in billions adjusted to 2010 dollars



The largest contributors to property losses in the past six decades have been 1) tropical storms and hurricanes and 2) tornadoes and thunderstorms. It is important to note that the losses are not consistent with the frequency of events. Events are remaining relatively constant while losses increase at a staggering rate, as shown in Figures 2.2 and 2.3.

Figure 2.3
Tornadoes[1] and Property Losses[2]
[1]Number of EF3 to EF5 tornadoes Reported
[2]Property Losses in Billions Adjusted to 2010 Dollars

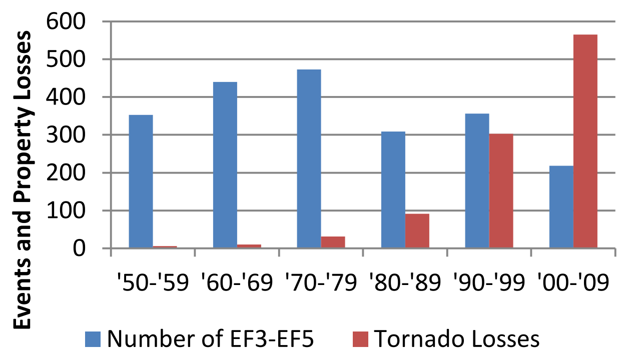
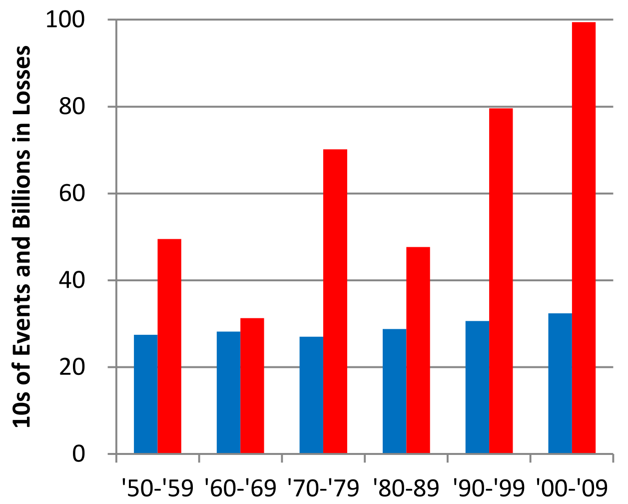


Figure 2.4 indicated the property losses due to flood damage as compared to the number of nationally declared disasters and emergencies by decade. Again, as for most disasters, the frequency per decade remains about the same while property losses adjusted to 2010 dollar increase dramatically.

Although the frequency of disasters does not directly correspond to the increases in property losses, many meteorologists and climatologists suggest that due to global climate change increases in severity of weather events is likely to occur.[10] Anticipating more severe weather events suggests that the current development of design criteria based primarily on past events may

[10] Pielke, Roger A., Jr. and Christopher W. Landsea, 1997. *Normalized hurricane damages in the United States: 1925–1995.* Draft paper. National Center for atmospheric Research, Boulder, Colorado

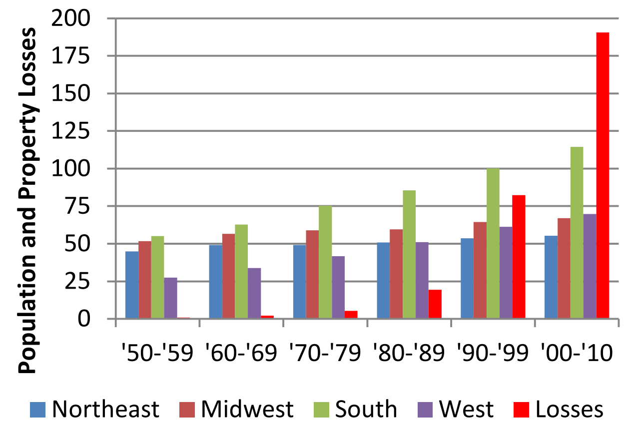
Figure 2.4
Floods[1] and Flood Losses[2,3]
[1]Number of National Declared Disasters and Emergencies
[2]Property Losses in Billions Reported as Adjusted 2010 Dollars
[3]'50-'59 - Data only available for 1953 thorugh 1959



not provide sufficient resiliency for future events. Regardless of the frequency and severity of natural disasters, some[10] argue that increases are thus attributed to shifts in population or construction put-in-place.. While it is clearly recognized that there have been shifts in population to more disaster prone areas, as shown in Figure 2.5, the relatively minor shifts in population are not consistent with the dramatic increases in property losses. Also when disasters occur, the majority of damage is to low-rise buildings.

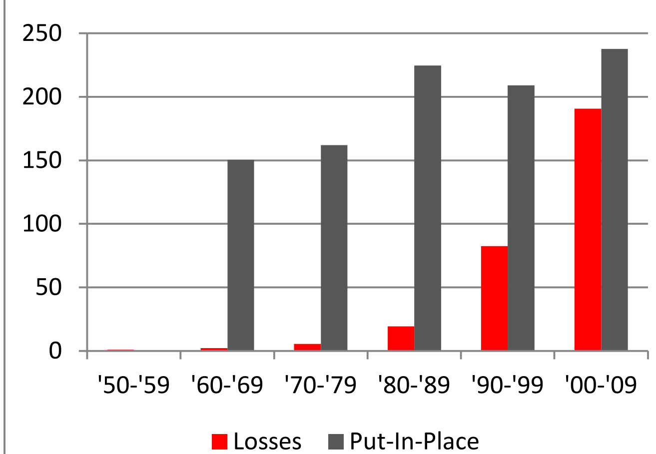
Generally, people gravitate to the more disaster prone areas because of the vistas and other attractions. As these areas increase in popularity, the cost of land increases. Subsequently, low-rise buildings are replaced with mid- and high-rise buildings, which by minimum code requirements must be constructed as the more robust Type I and Type II non-combustible construction. Disaster investigations routinely point out that high-rise and mid-rise buildings perform far better than low-rise buildings during most disasters and generally tend to be more durable have longer design service life. So as population shifts to these more attractive and more disaster prone areas, often they become housed in mid- and high-rise condominiums and apartments and work in mid- and high-rise office buildings in lieu of low-rise structures. This is not factored into the data shown in Figure 2.5.

Figure 2.5
Population[1] and Property Losses[2]
1Population in millions
2Property Losses in Billion of 2010 Adjusted Dollars



While some consider the value of construction put-in-place to be a significant influencing factor for increased property losses. Neither do actual property losses correlate directly with the amount of construction put-in-place. Property losses are shown with census bureau data on non-residential construction-put-in-place in Figure 2.6. The increase in average annual construction put-in-place per decade as expressed in in 2010 dollars does not show a comparable increase in as property losses also shown in 2010 dollars.

Figure 2.6
Losses[1] and Construction Put-In-Place[1,2]
[1]Values in billions of 2010 dollars
[2]C-I-P is based on Census Bureau Data



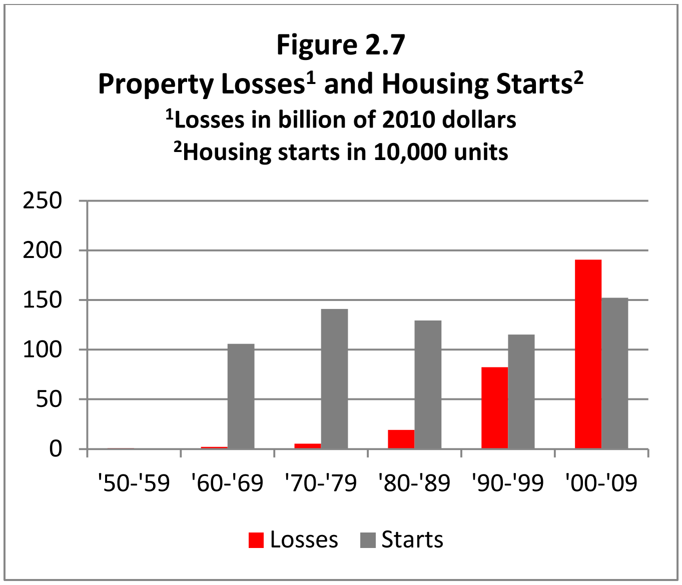


Figure 2.7 shows property losses per decade compared to the average number of annual housing starts per unit. The increase in property losses does not readily correlate to the increases in property losses.

While the volume of construction, shifts in population, and severity and frequency events are all factors that influence property losses, the data suggests that individually and even collectively these factors are not directly attributing to the dramatic increases in property losses.

Clearly something else is influencing the rapid increase in losses with exceeds 3500% since the 1970s. It appears the societal and cultural changes may have a more dramatic impact. De-regulation and relaxation of government criteria for construction occurred in the 1980s with local building code replacing more stringent Federal government construction criteria including those of the U.s. Department of Housing and Urban Development, Farmers Home Administration, Veterans Administration and rural electric program. While de-regulation improved economic growth, it appears that it may have contributed to increases in property losses. In addition over the same time period cultural and societal shifts occurred. Less robust construction materials became acceptable in building codes as meeting the requirements of the code but possibly not the intent of the code. In light frame construction, structural plywood sheathing was replaced by oriented strand board, which in turn was replace by fibrous sheathing which in turn has been replaced by ¼ inch or less foam sheathing. Initial transitions maintained comparable structural integrity and robustness but latter changes did not result in comparable structural integrity and robustness but did substantial reduce initial cost. The trend toward least initial cost as resulted in minimum building cost, the worst building that can be legally constructed, top become the standard of practice for most buildings. It has become a rarity when a building that is not owner, design constructed and occupied exceeds the minimum requirements of the building code.

In response to this trend we see voluntary incentive programs trough the insurance industry and Federal agencies. These programs include the Institute for Business and Home Safety *Fortified* programs and Open for Business programs and the Federal Emergency Management Administration *Resilient Star* program.

It appears that least initial cost and the emphasis on economic growth now preempts durable, robust, log-lived and disaster resistant construction. This all places communities at risk through deficiencies related to the normal operation and maintenance of buildings and especially is a disaster should occur. Most communities can no longer absorb the costs of recovery.

Further the programs that available for enhanced resiliency in building design and construction are only available as voluntary programs. Thus those who are knowledgeable enough, can afford upgrades, and influence design and construction can be provided with residency and businesses located in more resilient construction. Unfortunately more small businesses and residents occupy spaces where they have no influence over the design and construction. Ergo , there is clearly a need for enhance building regulatory requirements to provide for the welfare of local businesses and residents as well as helping to assure community continuity.

PART 3 - DESIGN FOR RESILIENCE

BASIS FOR THE CRITERIA

Resilience as presented here is modeled after the concepts of the *Whole Building Design Guide* (WBDG) developed jointly by NIBS and the Sustainable Building Industries Council (SBIC). For building design and construction the WBDG addresses:

Accessibility	Historic preservation
Aesthetics	Productivity
Cost-effectiveness	Security/safety
Functional/operation	Sustainability

The minimum requirements are set to be consistent with the design and construction requirements identified in the IBHS FORTIFIED programs. The design and construction strategies presented are material-neutral. There are a few exceptions, similar to the requirements in current building codes and referenced standards, such as limiting construction below flood elevation to treated wood, concrete, or masonry.

BENEFITS

There are many benefits related to enhancing the resilience of buildings. In addition to long-term environmental benefits, other benefits are better buildings for occupant safety, comfort, and productivity; property protection – both building and building contents; economic benefits for the building occupants, owners, and the community; and societal benefits related to operational continuity for the community. Sufficiently robust and durable resilient buildings:

- ✓ minimize the amount of resources required for routine maintenance, repair, and replacement over the life of the building, with long-term benefits for subsequent owners and occupants.
- ✓ provide enhanced safety and security for improved occupant comfort and productivity.
- ✓ increase design service lives.
- ✓ enhance the operational continuity of the community in which they are built.
- ✓ are adaptable for future use and re-purposing to minimize long-term environmental impacts involved with replacement, removal, disposal, and reconstruction.
- ✓ attract and retain businesses and residents.

When disaster strikes, more resilient buildings REDUCE the:

- ✓ time for communities to recover after disasters.
- ✓ demand on emergency response personnel.
- ✓ expenditures required for emergency response.
- ✓ risk of injury or death for emergency responders.
- ✓ owner, occupant, and community expenditures for disaster recovery.
- ✓ amount of resources required for disaster relief.
- ✓ amount of damage and contaminated materials and contents to be disposed in landfills or by incineration.

USE OF THE RECOMMENDATIONS

These recommendations are intended to proide enhancements to basic minimum building code requirements. They are offered to help designers lessen the environmental footprint of the building core and shell. As previously mentioned the recommendations are modeled after the concepts of the *Whole Building Design Guide* and are consistent with the criteria of the IBHS FORTIFIED programs. Thus, they are presented as minimum enhancements to the provisions of building codes and standards for the design and construction of green or sustainable buildings and are intended to be applicable to high-performance green buildings with design services life of 50 to 60 years. The American Society for Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings* provides for a design service life of 50 years. The design service life in draft ASTM International standards and the International Code Council *International Green Construction Code Public Version 2.0* is 60 years. Naturally, further enhancements to the resilience than those provided here may be appropriate for buildings with longer design service lives.

SCOPE OF RECOMMENDATIONS

Detailed criteria addressing resilience are presented as a compilation of modifications appending the International Code Council *International Building Code*. They are available for free download on the Portland Cement Association website as *Building Requirements* *for Resilient Communities (BRRC)*. The BRRC provide provisions for enhanced resilience in mandatory language for ease of adoption and enforcement by building code departments and ease of use by designers and contractors.

The majority of the recommendations apply to building core and shell and address building components and systems that can be difficult or cost prohibitive to upgrade or strengthen once the building is occupied. While each of the criteria discussed may satisfy multiple aspects of enhanced resilience, they are presented in these main categories:

- **Service Life** - Design service life criteria addressing durability, longevity, re-use, and adaptability.
- **Structural Components** - Enhanced structural load resistance addressing fire, flooding, frost heave, snow loads, wind loads, seismic loads, and storm shelters in high wind areas.
- **Fire Protection Components** - Enhanced protection related to internal structure fires addressing automatic sprinkler systems, fire containment, and potentially hazardous conditions created where recyclables are collected and stored.
- **Interior Components** – Increased robustness that also provides enhanced acoustical comfort and reduction of damage where moisture may be present.
- **Exterior Components** - Enhanced protection related to exterior finishes and systems used to clad the building – addressing wind, impact, fire, rodent infestation, and radon entry resistance.

The following recommendations for enhanced resilience are presented for consideration in the design and construction of buildings where the minimum requirements of the local building code or the *International Building Code*, whichever is more stringent, are satisfied.

Discussion on intent is provided with specific design and construction recommendations. Resources are cited in the end notes to this document. It is noteworthy that a majority of the provisions recommended herein are addressed in building codes and referenced standards that have been readily available for adoption and enforcement by jurisdictions for many years.

North Myrtle Beach, circa 1970

North Myrtle Beach, circa 2008

ACHIEVING ENHANCED RESILIENCY

It is possible to achieve enhanced resiliency. When the 2000 Edition of the international Building Code was published with reference to and criteria from the latest edition of the American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures* the State of South Carolina initially chose not to adopt the new code. The principle argument made was that the new seismic design criteria would result in a no construction in in the Charleston south Carolina metropolitan area because of the region being reclassified in a higher seismic design category. The Federal Emergency Management Administration advised the State of South Carolina that they may be jeopardizing the availability of Federal funds not only for disaster relief and recovery, also but for transportation, education and other Federal government programs. South Carolina reconsidered their actions and adopted the new criteria. There was no moratorium on construction in Charleston and Charleston continued to have prosperous growth. Mandatory criteria for enhanced resiliency are a viable way for communities to improve continuity and sustainability while help to minimize economic losses to their local business and residents.

Overview of Requirements for Buildings Design and Constructed to Achieve Enhanced Resiliency

SERVICE LIFE
Design Service Life – Minimum design service life of 50 years.
STRUCTURAL COMPONENTS
Fire Damage Resistance – Maintain fire resistance ratings of not less than one-hour.
Flood Damage Resistance – Comply with ASCE 24; do not consider levees and flood walls as flood protection; and apply Coastal V Zone V construction criteria for Coastal A Zones.
Seismic Damage Resistance – Increase seismic loads by increasing the importance factors in risk categories II, III, and IV where the 0.2 second spectral response acceleration parameter is equal to or greater than 0.4g. Increases are approximately 15% for Risk Category II and IV and 10% for Rick Category III.
Snow Load Damage Resistance – Increase design snow loads by increasing the importance factors in Risk Categories II, III, and IV.. The increases are approximately 15% for Risk Category II and 10% for Risk Categories III and IV.
Storm Shelters – require storm shelters designed and constructed in accordance with ICC 500.
Wind Damage Resistance – Increase ultimate design wind speed by increasing the importance factors in risk categories II, III, and IV. The increases are approximately 15% for Risk Category II and 10% for risk Categories III and IV. In addition use attachments methods in accordance with UL and FM Global standards.
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.
Storage and Collection Areas – Provide enhanced fire protection of areas intended for collection and storage or separated recyclables.
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
Exterior Fire Damage Resistance – Limit size of openings and the use of combustible materials on exterior walls in close proximity to adjacent structures.
Wildfire Damage Resistance – Satisfy the requirements of the *International Wildland-Urban Interface Code*.
Wind Damage Resistance – Limit the use of exterior cladding materials susceptible to wind damage to locations outside hurricane and tornado prone areas.
Hail Damage Resistance - Limit the use of exterior cladding materials susceptible to hail damage to locations outside moderate or severe hail exposure regions.
Rodent proofing – Satisfy the requirements of Appendix F Rodent proofing of the *International Building Code.*
Radon Entry Resistance – Satisfy the minimum requirements of EPA *Guide to Radon Prevention in the Design and Construction of Schools and Other Large Buildings* or Appendix F, Radon Control Methods, of the *International Residential Code*.

SERVICE LIFE

DESIGN SERVICE LIFE

Intent – High-performance building designs should address building longevity with low operation and maintenance costs throughout the life of the building. A design service life plan helps the designer and owner to evaluate the long-term performance of the building and ensures the choice of materials and building systems minimize long-term costs for repair, maintenance, and replacement. Earlier discussions identified that the more robust buildings designed and constructed prior to the 1950s are typically more adapted for reuse and renovation. This observation, reinforced by the Brookings Institution study[3], suggests recently constructed buildings tend to be more disposable and are being replaced rather than renovated or reused.

Source: Portland Cement Association, photograph taken by Steve Skalko

Robust, more resilient buildings are frequently reused and even re-purposed when downtowns are renovated.

Design and Construction [C, I, M] – The design service life of a building should be no less than 50 years. The general recommendations are that the design service life of the structural components, concealed materials, and materials and components where replacement is deemed impractical or cost prohibitive equal the design service life of the building.

Roofing materials and systems are recommended to have a design service life of not less than 20 years. Mechanical, plumbing, and electrical equipment and systems are recommended to have a design service life of not less than 25 years and for hardscape components, there is a recommendation of at least 30 years. As previously discussed, further enhancements for resilience than those presented here may be appropriate for buildings with longer design service lives.

STRUCTURAL COMPONENTS

FIRE DAMAGE RESISTANCE

Intent - To increase the overall robustness of buildings; to reduce the environmental impacts related to fire, smoke, suppression operations, and emergency response; and to minimize damage due to fires after disasters.

Fire Losses in the United States During 2009, August 2010 by the National Fire Protection Association, shows that property loss due to structure fires in buildings other than one- and two-family dwellings was approximately $4.5 billion. Increased fire resistance of building elements reduces the amount of damage to the building and its contents. This enhances sustainability by minimizing building materials required to restore the building and reducing the amount of materials entering landfills. Additional benefits are enhanced life safety, potentially less demand on community resources, especially for emergency response, and facilities that are more readily adaptable for re-use. The threat of fire after disasters including minor disasters such as power outages and disruptions in water mains can have devastating impacts on communities. Building occupants will resort to open flames for light, heat, cooking and water purification. After disaster the infrastructure to allow access by emergency responders or to automatically suppress fires may no longer be in place. Further, multiple events may consume the available resources.

There are many examples of where noncombustible fire resistive construction as defined by the building code has provided exceptional performance in fire events, allowing buildings to be re-used and often re-purposed.

Two such examples are the Winecoff/Ellis Hotel in Atlanta and 90 West Street in New York City.

Source: City of Atlanta

Image courtesy of the Ellis Hotel, Atlanta, GA: www.ellishotel.com.

The Winecoff Hotel in Atlanta Georgia was constructed in 1913 and completely gutted by fire in 1946. It reopened as another hotel in 1951 and subsequently was used as housing for elderly. After being left vacant for 20 years it reopened as the luxury Ellis Hotel in 2007.

Image courtesy of Multifamily Investor: www.multifamilyinvestor.com.

Several buildings adjacent to the collaping World Trade Center Towers were damaged by falling debris and uncontrolled fires, and either collapsed or needed to be demolished. The office building commonly referred to as 90 West, built in 1907 was damaged by debris and sustained uncontrolled fires for five days. It reopened as an apartment building in 2005.

Design and Construction [G, M] **-** Buildings should be designed so that all structural load-bearing elements (i.e. walls, columns, beams, girders, floors and roofs) have a fire resistance rating of not less than 1-hour, and as the building size increases in height or area the fire resistance of the structural components need to increase accordingly. These enhanced fire resistance features should be implemented in the building design independent of other fire protection design features such as automatic sprinklers. The fire resistance rating of structural elements should not be reduced or building height or area increased simply because sprinklers are present.

Enhanced resilience lends to reusing or even re-purposing rather than disposal due to premature collapse.

FLOOD DAMAGE RESISTANCE

Intent - To minimize the amount of building materials and contents that become contaminated or otherwise irreparably damaged by flood water. Further, flood-resistant construction is less likely to generate debris and contaminants that pollute the downstream environment. Flood resistant design and construction allows development in flood prone areas along river fronts, lake shores, and other bodies of water attractive to businesses and residents.

Design and Construction [A, B, M] **-** The design and construction of buildings in flood hazard areas, including flood hazard areas subject to high velocity wave action, should be designed and constructed in accordance with ASCE 7 and ASCE 24 and the following criteria*:* Where required by ASCE 24 to be built above the base elevations, floors and their lowest horizontal supporting members should not be less than the higher of:

- Design flood elevation
- Base flood elevation plus 3 feet (1 m)
- Advisory base flood elevation plus 3 feet (1 m) or
- 500-year flood if known

Additionally, levees and flood walls designed as protective works should not be considered as providing flood protection.

Source: Federal Emergency Management Agency, taken by David Fine of FEMA

Severe storms and floods damage and destroy homes and businesses.

Source: Federal Emergency Management Agency, taken by Michael Rieger of FEMA

The levee in the foreground though topped with sandbags was still breeched.

Source: Federal Emergency Management Agency, photograph taken by Liz Roll.

Flood damage isn't limited to the building, but debris carried by flood waters damage other buildings and the environment.

Robustness of foundations can also be enhanced by following the design parameters located in Coastal V Zones and applying them to foundations built in the adjacent Coastal A Zones. Increasing the robustness of foundations in Coastal A Zones reduces the likelihood that the buildings and contents will be subject water damage.

STRUCTURAL DAMAGE RESISTANCE

Intent - To reduce the amount of damage when earthquakes, high wind events or snow loads occur. Increasing the stringency of the design criteria of high-performance buildings for such events enhances a buildings ability to respond with less damage. This results in more durable buildings which not only reduces damage to the building, but also to its contents. In addition to better preserving places of business and residency, enhanced sustainability is achieved by minimizing the amount of both replacement materials required to restore the building and damaged materials entering landfills.

Source: Federal Emergency Management Agency

Earthquake damage to personal property.

Design and Construction [A,G,M] **–** Structural design of buildings in accordance with the International Code Council *International Building Code* and American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures* utilize importance factors based on risk category for building type. There are four risk categories briefly summarized as:

Risk Category	Description and Typical Occupancies
I	*Low hazard to human life* Agricultural and temporary structures
II	*Typical buildings and occupancies* All buildings not in Categories I, III, or IV
III	*Substantial hazard to human life* Assembly, educational, day-care, correctional, power generation, water and waste treatment facilities and healthcare where occupants are incapable of self-preservation.
IV	*Facilities housing essential services.* Hospitals; fire, police, ambulance stations; emergency vehicle parking garages; emergency response, preparedness, and communication facilities; emergency shelters; national defense; transportation control facilities; back-up power generation facilities; and buildings containing highly toxic materials.

Structural damage resistance due to seismic, wind and snow loads is enhanced by increasing the importance factors based on risk categories.

Source: Federal Emergency Management Agency

A magnitude 6.7 earthquake caused 72 deaths and destroyed or damaged 114,000 residential and commercial buildings. The direct cost of damage alone was estimated by FEMA to be 25 billion dollars.

Earthquake damage resistance - For enhanced resistance to earthquake damage, where the 0.2 second spectral response acceleration parameter is greater than or equal to 40 percent the minimum recommended importance factors for buildings is increased for Risk Category II, III, and IV. In addition, for high seismic risk buildings a site specific geotechnical report complying with the provisions of ASCE 7 should be provided.

Snow load damage resistance - The National Weather Service reports that U.S. property damage due to winter storms and ice exceeded $1.5 billion in 2009. The importance factor for ground snow loads is increased for buildings classified in Risk Categories II, III, and IV.

Source – Institute for Business and Home Safety

In many instances roof collapse due to snow loads not only results in damage to roof and building contents below but may also remove lateral support, allowing walls to collapse.

Wind Damage Resistance - The last significant hurricane season in the United States was in 2005. The American Society of Civil Engineers reported in *Normalized Hurricane Damage in the United States, 1900 – 2005,* National Hazard Review, ASCE 2008, that property damage from hurricanes was $81 billion in 2005. The importance factor applied to the ultimate wind speed is increased in Risk Categories II, III, and IV.

Risk Category	Snow Load Importance Factor	Wind Load Importance Factor	Seismic Load Importance Factor	
			0.2 sec spectral response less than 40%	0.2 sec. spectral response 40% or more
I	0.80	1.00	1.00	1.00
II	1.15	1.15	1.00	1.15
III	1.20	1.10	1.25	1.35
IV	1.30	1.10	1.50	1.60

In addition to the design for overall structural resistance to wind loads, attention is needed for specific elements associated with the exterior building envelope, such as the roof and wall coverings. Roof coverings and their attachment should be subjected to rigorous tests for resistance to the effects of wind following the protocols of nationally recognized programs such Underwriters Laboratory or FM Global. Where roof coverings depend on structural sheathing for support, give extra attention to the stiffness of the panels and the connections to framing. Vinyl siding, exterior insulation finishing systems (EIFS), and other lightweight exterior wall covering materials should not be used as exterior coverings in hurricane and tornado prone regions.

Source: Federal Emergency Management Agency, photograph taken by Lara Shane of FEMA.

Homes and businesses that are not designed and constructed to provide an appropriate level of resilience are at greater risk in high wind exposures.

Source: Federal Emergency Management Agency, photograph taken by Greg Henshall of FEMA

The center of a town twelve days after it was hit by a tornado with 200 mph winds. FEMA reported that debris removal was moving at a record pace, but reconstruction would likely take years. Such devastation places a large strain on the community and the environment.

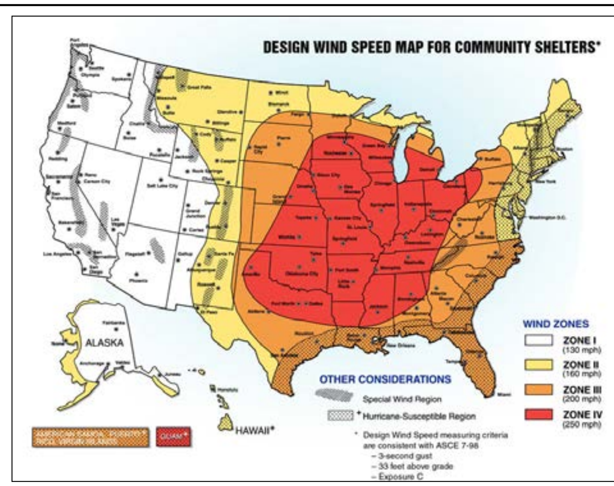
STORM SHELTERS

Intent - To require storm shelters for enhanced life safety of building occupants. Minimizing injuries and related health costs preserves the human component of the community and permits more rapid recovery after disasters. These shelters are havens for protecting people from injury or death due to structural collapse and impact from windborne debris. While the surrounding structure may be lost, the residents of the community will have an increased probability to survive, rebuild, and re-vitalize the community.

Source: Oklahoma Department of Emergency Management

Storm shelters and safe rooms really work

Design and Construction [A, G, H, M] - Storm shelters complying with the requirements of ICC 500 should be provided for occupants of all sustainable buildings in hurricane-prone and tornado-prone areas where the shelter design wind speed is 160 mph or more. When combined hurricane and tornado shelters are needed the more stringent requirements of ICC-500 should be used.



Design Wind speed Map for Community Shelters

Source: Federal Emergency Management Agency, photograph taken by Tim Burkitt of FEMA.
FEMA advises that the storm shelter at this high school will provide near absolute protection for more than 2,000 people in the event of a hurricane or tornado.

FIRE PROTECTION COMPONENTS

AUTOMATIC SPRINKLER SYSTEMS

Intent - To reduce damage due to fire, smoke, and suppression operations and enhance life safety. A building's robustness is enhanced by requiring sprinkler protection. Sprinkler protection and other fire safety systems combined with established fire compartments can reduce damage to the building and its contents from a fire event. Appropriate levels of combined containment with automatic fire sprinkler systems minimize damage from fire, smoke, steam, and water used for suppression and control, Further, the combination reduces the amount of toxic smoke that may be generated by some building materials and building contents when fires occur.

Design and Construction [G, L, M] **–** All buildings, except low fire-risk manufacturing and storage facilities, should be protected with automatic sprinkler systems conforming to the NFPA 13. The presence of sprinkler protection reduces the risk of damage to the building from a fire event. This risk is further reduced when the sprinkler protection is provided in all spaces of the building including concealed spaces such as open-truss floor assemblies and attics constructed of combustible materials. Because NFPA 13R sprinkler systems do not provide sprinkler protection in these concealed spaces, they should not be used. This enhanced sprinkler protection and compartmentation in residential occupancies will tend to minimize the portion of the building and time for which the building cannot be inhabited.

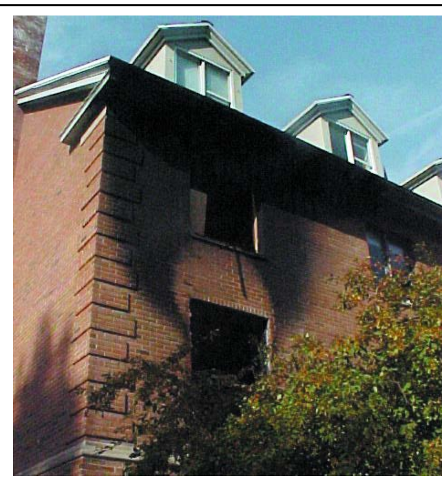
Standpipe and fire alarm system features should not be reduced or modified based on the presence of automatic sprinkler protection. These additional fire protection systems in conjunction with sprinkler protection add to the robustness of the building.

INTERNAL FIRE BARRIERS

Intent - To reduce damage from fire, smoke, suppression, and control operations and generally increase the robustness and durability of the building.

Design and Construction [G, M] - Fire walls are used to create separate building areas for large buildings. They should be constructed entirely of noncombustible materials; have fire resistance ratings of at least 2-hours; and be constructed in accordance with the *International Building Code*.

To further reduce the risk of fire spread within buildings, provide internal fire barriers (walls, shafts around floor openings and horizontal floor systems) to establish multiple fire area compartments and restrict the spread of fire between floors of multi-story buildings. Fire barrier assemblies should be constructed in accordance with the *International Building Code,* have fire resistance ratings of at least 1-hour, and not have the fire resistance rating reduced due to the presence of sprinkler protection.



Source: Northeast Fire Safety Construction Advisory Council
Fire containment achieved with compartmentation minimizes damage due to fire, smoke and water used for suppression.

Robustness is also enhanced through compartmentation using fire barriers to separate dwelling and sleeping units as well as separate these spaces from adjacent non-residential areas in residential occupancies (i.e. hotels, motels, and apartments). These fire barriers should have fire resistances established by the IBC for creating separate fire areas. A compartmentation requirement replacing fire partitions with fire barriers reduces the risk of fire spread. Such containment also reduces damage due to smoke and suppression operations.

More continuous community vitality can result from minimizing damage to adjacent dwelling and tenant spaces and from reducing the potential of conflagrations involving multiple properties. Entire neighborhoods are frequently disrupted by large fires that spread from buildings under construction where automatic fire suppression systems have yet to be installed or activated. Major conflagrations may also result where water supplies are disrupted by natural disasters and power outages.

Finally, designs should provide draftstopping and fire stopping in concealed combustible spaces irrespective of the presence of sprinkler protection. Fires within these concealed spaces can spread quickly and cause damage to larger portions of the building without adequate measures in place.

Source: Northeast Fire Safety Construction Advisory Council

Fire resistant non-combustible materials contain fires, minimizing fire and smoke damage. This damage resistance allows portions of the buildings to simply be cleaned, painted, and reoccupied rather than completely re-constructed.

INTERIOR COMPONENTS

ACOUSTICAL COMFORT

Intent – Enhancement of occupant comfort and productivity by limiting the distractions and disruptions due to sound transmitted through building elements. Increases in sound transmission reductions are particularly important for assembly, business, educational, institutional, mercantile, and residential occupancies. Noise control should be addressed with provisions for external air-borne sound, internal air-borne sound, and structure-borne sound. Generally, requirements for enhanced resistance to sound transmission will result in more robust and durable buildings augmenting not only occupant comfort, but also safety and security. The community benefits by having buildings which provide more comfortable living and more productive working environments, thereby attracting and retaining quality-minded businesses and residents.

Improved sound attenuation in buildings increases occupant comfort and work productivity. Urban areas with high population densities tend to have smaller carbon footprints per capita than less dense areas. An urban planning concept known as compact development capitalizes on this by aligning higher population-density areas with mixed use commercial zoning and mass transit routes to reduce the reliance on personal automobiles. Enhanced noise control is a necessity for healthy, safe, comfortable, and productive interior environments in these more densely populated and trafficked areas. Provisions need to be integrated

Source: U.S. Department of Transportation

Increased population density results in more noise.

into the building design to reduce the audibility of not just current but also future noises from increased population density and proximity to transportation routes.

Design and Construction [C, D, G, M] – In addition to satisfying the more stringent requirements of the local building code or *International Building Code* all exterior opaque wall and roof/ceiling assemblies should have a composite sound transmission classification (STC) rating of not less than 50 (45 where field tested). All fenestration that is a part of the exterior wall or roof ceiling assembly should have a STC rating of not less than 30 (25 where field tested).

For interior walls, partitions, and floor/ceiling assemblies special consideration should be given to these elements used in educational, institutional, and residential occupancies. For residential and institutional occupancies, the elements separating units and separating units from all other interior spaces should have a STC rating of at least 50 (45 where field tested). In educational occupancies, classrooms should be separated from adjacent classrooms and other interior spaces with elements having a STC rating of at least 50 (45 where field tested). Further, the interior elements separating restrooms and showers from other spaces should have a sound transmission classification rating of at least 53 (48 where field tested) and music rooms, mechanical rooms, cafeterias, gymnasiums, and indoor swimming pools should have an STC rating of at least 60 (55 where field tested).

Floor ceiling assemblies between rooms or units and between rooms or units and public or service areas in assembly, business, educational, institutional, mercantile, and residential occupancies should have impact insulation classification rating of not less than 50 (45 is field tested) when tested in accordance with ASTM E492.

MOISTURE PROTECTION

Intent – Exposure to excess or unnecessary moisture of building materials during construction and during building operation can damage the materials or increase the rate of deterioration. Further, moisture present in organic materials can support the growth of mold and mildew. For high-performance buildings, provisions to minimize the negative effects of moisture not just for the building materials themselves but also as related occupant health and additional resources and energy required for cleaning, treatments, repair, and replacement are crucial.

Source: FEMA - contributed by John Martyny

Organic building materials provide a food source for mold and mildew in building.

This is accomplished with features such as durable, non-absorbent floor and wall finishes, providing extra protection to piping subject to freezing and protecting building materials on construction sites from exposure to high moisture prior to incorporation into the structure. This results in more robust building with reduced risk of damage to the building and its contents from moisture. Several of these modifications will also help minimize the potential for the growth of mold and mildew which reduces the risk to occupant health problems and requires fewer resources to remove, dry, and clean affected building components.

Source: Federal Emergency Management Agency, photograph taken by Dave Gatley of FEMA.

Moisture damage is not just related to flooding. Here, an inspector is seen evaluating water damage when a roof was compromised by wind and rain.

Source: FEMA - contributed by Terry Brannen

Hard, smooth, nonabsorbent surfaces in areas prone to water exposure can prevent damage to adjacent areas and hidden components.

Design and Construction [C, G, M] – During construction, any materials susceptible to damage from moisture exposure should be protected for excess or unnecessary moisture exposure during storage, handling and installation. Any organic materials with visible organic growth should not be installed on or in the building.

In addition to the more stringent requirements of the local code or the *International Building Code*, for the use of smooth, hard, non-absorbent, surrounding surfaces, the requirements for high performance should be augmented. The surface of floors and wall base material, extending upward on the at least 6 inches, should be smooth, hard, and nonabsorbent in all toilet, bathing and shower rooms; kitchens; laundries; and spa areas. Smooth, hard, non-absorbent surfaces might also be considered to reduce maintenance and repair in highly trafficked areas such as corridors, especially those in educational facilities.

EXTERIOR COMPONENTS

EXTERIOR FIRE DAMAGE RESISTANCE

Intent - To reduce building damage from fire events. Enhanced property protection is a crucial component of green construction and thus requirements for enhanced performance of exterior walls and roofs above the minimum requirements in the *International Building Code* are necessary. This recommendation results in the use of more robust exterior walls and limits openings located in close proximity to other buildings.

Also strengthening roof coverings to resist the affect of fire reduces the amount of damage to the building and its contents. *Fire Losses in the United States During 2009* by the National Fire Protection Association, August 2010 shows that property loss due to structure fires in buildings other than one and two family dwellings was approximately $4.5 billion.

Design and Construction [G, M, N] **-** Buildings should be designed so the exterior of buildings are less susceptible to damage when exposed to fire.

Use exterior wall coverings of vinyl siding and exterior insulation and finish systems (EIFS) conforming to the requirements of the *International Building Code* as an exterior finish only where the separation distance to other buildings or to property lines is at least 30 feet.

In addition, any combustible exterior wall coverings should not be installed on exterior walls of buildings with a separation distance of 5 feet or less to other buildings or to property lines.

Further, space openings in exteriors such that sufficient solid wall occurs between openings to limit spread of fire on the exterior of the building. Reducing or eliminating this solid wall area due to sprinkler protection within the building should not be allowed.

Roof coverings that are unclassified in regard to spread of fire should not be used. Roof systems are classified in accordance with UL Standard 790 as A, B, or C, with A providing the best resistance to fire spread. For roofs located in hot dry climates where exposure from wildfires is more prevalent the roof classification should be a minimum of Class A (Also see Wildfire Damage Resistance).

Source: Brick Institute of America Region 9.

Siding on a building nearly 100 feet away from a burning building needs to be replaced.

WILDFIRE DAMAGE RESISTANCE

Intent - To reduce building damage due to wildland fires. According to the National Weather Service the property damage from wildland fires was 110 million in 2009. This proposal requires sites for buildings to be reviewed to see if the site and the surrounding area have characteristics that may contribute to wildfires. If found, the building design should incorporate features that enhance the robustness of the building and reduce the risk of fire spread to other buildings, thereby limiting the extent of fire damage.

Source: Federal Emergency Management Agency

Topography, vegetative fuels and drought contribute to the potential for devastating wildfires

Design and Construction [K, M] - The construction, alteration, movement, repair, maintenance, and use of any building, structure, or premises within the wildland interface areas should follow the provisions of the *International Wildland-Urban Interface Code.* The design and construction of exterior walls should be based on the fire hazard severity value determined for the site.

WIND DAMAGE RESISTANCE

Intent - To minimize property damage during high wind events. Enhanced property protection is a crucial component of green construction and thus requirements for enhanced performance of exterior walls above the minimum requirements in the *International Building Code* are necessary. Property damage from wind was reported to be almost $2 billion in 2009 according to the National Weather Service. The use of exterior wall coverings most susceptible to wind damage should be limited to non-hurricane prone regions.

Source – Portland Cement Association – photo by Steve Skalko

Damage to siding and sheathing as a result of high winds

Source – Institute for Business & Home Safety

Wind damage to lightweight exterior wall covering.

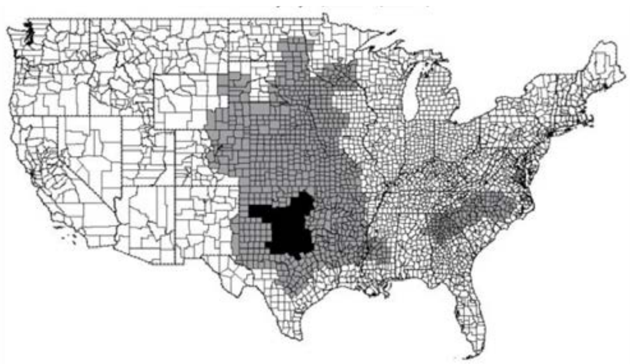
Design and Construction [G, M] - Vinyl siding conforming to the requirements of the *International Building Code* (IBC) and exterior insulation and finish systems (EIFS) conforming to the requirements of the IBC should only be selected as the exterior finish of buildings located outside hurricane-prone and tornado-prone regions as defined in the IBC.

Source: Federal emergency Management Agency, photograph taken by Mark Wolfe of FEMA

Roofs damaged by high winds are evident everywhere blue tarps appear.

Hail Damage Resistance

Intent - To minimize property damage during hailstorms. Requirements for enhanced performance of exterior walls above the minimum requirements in the *International Building Code* are necessary. Property damage from hail was reported to be approximately $1.3 billion in 2009 according to the National Weather Service. To be more robust to hail damage this proposal requires roofs and exterior wall coverings most susceptible to hail damage to be tested, classified, and labeled.



Hail Exposure Map
Dark Areas Indicate Severe and Moderate Exposures

Source National Oceanic and Atmospheric Administration, National Weather Service
Siding needs to be removed, disposed and replaced due to hail damage.

Design and Construction F, G, M, O – Use vinyl siding conforming to the requirements of the *International Building Code* and exterior insulation and finish systems (EIFS) conforming to the minimum requirements of the *International Building Code* only as an exterior finish of buildings located outside moderate and severe hail exposure regions.

Source: National Oceanic and Atmospheric Administration, National Weather Service.
Roof shingles need to be removed, disposed and replaced due to hail damage

Roof coverings and exterior wall coverings of vinyl siding and EIFS intended for use in regions where hail exposure is Moderate or Severe should be labeled accordingly. Labeling should be determined based on testing and classification in accordance with UL 2218 or FM 4473.

Rodent proofing

Intent - Assuring adequate provisions for rodent infestation resistance reduces the potential for damage to the building and contents and to the use pesticides over the life of the building. The use of pesticides may have a negative impact on occupant comfort and health. Adequate rodent proofing will minimize the amount of energy and resources required during the life of the building if means other than pesticides are required to reduce or eliminate infestations.

Source: Image provided with permission from Alternative Building Services: www.altbuildingservices.com.
Building elements in need of repair due to rodent damage. Undetected damage can compromise the integrity of the building thermal envelope and moisture protection.

To provide for increased safety to occupants and minimize the negative impact on the built environment from rodents, requires that buildings be designed and constructed in a manner that at least satisfies the minimum requirements of the Appendix F of the *International Building Code*. Currently, the use of Appendix F is optional and, thus it is not required in many jurisdictions. Minimizing the potential for infestations improves the quality of places to work and live and reduces disruptions in business operations. Significant community and societal benefits result by limiting potential habitats for creatures that spread disease or destroy property.

Source – National Institutes of Health

Extermination and pest control require energy and resources. In addition to the inconvenience, extermination techniques could create unfavorable and unhealthy conditions for occupants, and be major disruptions in productivity and business operations.

Design and Construction [G, M] **-** Buildings should be provided with rodent proofing in accordance with Appendix F of the *International Building Code* or the Code of local jurisdiction, whichever is more stringent.

RADON ENTRY RESISTANCE

Intent - Assuring adequate indoor environmental quality by requiring radon mitigation systems for buildings in high radon potential areas. While radon mitigation is not a mandatory requirement for many building codes provisions to minimize the exposure of occupants of green buildings to radon is an important part of providing an appropriate minimum level on indoor environmental quality.

Design and Construction [E, J, M] **-** Buildings in high radon potential locations as indicated in the respective Environmental Protection Agency document or the *International Residential Code* should be designed in accordance with:

1. Chapter 2 of EPA 625-R-92-016;
2. Appendix F of the International Residential Code.

It can be done. Why not on a larger scale?

Resources

[A] American Society of Civil Engineers *ASCE 7 - Minimum Design Loads for Buildings and Other Structures*
[B] American Society of Civil Engineers *ASCE 24 - Flood Resistant Design and Construction*
[C] American Society of Heating Refrigerating and Air-Conditioning Engineers *ASHRAE 189.1 - Standard for the Design of High-Performance Green Buildings, Except Low-Rise Residential Buildings*.
[D] ASTM International *ASTM E492 - Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine*
[E] Environmental Protection Agency *Radon Prevention in the Design and Construction of Schools and Other Large* Buildings EPA 625-R-92-016
[F] Factory Mutual Global Research FM 4473 - Impact Resistance Testing of Rigid Roofing Materials by Impacting with Freezer Ice Balls [G] International Code Council *International Building Code*
[H] International Code Council/National Storm Shelter Association *ICC 500 - Standard on the Design and Construction of Storm Shelters*
[I] International Code Council *IGCC - International Green Construction Code Public Review Version 2.0*
[J] International Code Council *IRC – International Residential Code*
[K] International Code Council *IWUIC - International Wildland-Urban Interface Code*
[L] National Fire Protection Association *NFPA-13 Standard for the Installation of Sprinkler Systems*
[M] Portland Cement Association *HPBRS - High-performance Building Requirements for Sustainability*
[N] Underwriters Laboratory *UL-790* - Standard Test Methods for Fire Tests of Roof Coverings
[O] Underwriters Laboratory *UL-2218 - Impact Resistance of Prepared Roof Covering Materials*

Achieving Enhanced Resilience with Modifications to the International Code Council 2012 International Building Code

January 19, 2012

APPENDIX L
ENHANCED BUILDING RESILIENCE

The provisions in this appendix are not mandatory unless specifically referenced in the adopting ordinance.

SECTION L101

GENERAL

L101.1 Purpose. The purpose of this Appendix is to promote enhanced public health, safety and general welfare and to reduce public and private property losses due to hazards and natural disasters associated with fires, flooding, high winds and earthquakes.

SECTION L102

BUILDING HEIGHTS AND AREA

L102.1General. In order to limit the impact of fires on the *building* the *building* shall comply with Sections L102.1 through L102.5.

L102.2 Height and Area Limitations. Allowable heights and areas for all *buildings* shall be in accordance with Table L102.1 where building height limitations are in feet above grade plane, story limitations are stories above grade plane, and area limitations are determined by the definition of “Area, building,” per floor.

TABLE L102.1

ALLOWABLE HEIGHT AND BUILDING AREAS[a]

Building height limitations shown in feet above grade plane. Story limitations shown as stories above grade plane.

Building area limitations shown in square feet, as determined by the definition of “Area, building,” per story

		TYPE OF CONSTRUCTION					
		Type I		Type II	Type III	Type IV	Type V
		A	B	A	A	HT	A
	HGT (feet)	UL	160	65	65	65	50
GROUP	STORIES (S) Area (A)						
A-1	S	UL	5	3	3	3	2
	A	UL	UL	15,500	14,000	15,000	11,500
A-2	S	UL	11	3	3	3	2
	A	UL	UL	15,500	14,000	15,000	11,500
A-3	S	UL	11	3	3	3	2
	A	UL	UL	15,500	14,000	15,000	11,500
A-4	S	UL	11	3	3	3	2
	A	UL	UL	15,500	14,000	15,000	11,500

TABLE L102.1 Continued

GROUP	HGT (feet)	Type I A UL	Type I B 160	Type II A 65	Type III A 65	Type IV HT 65	Type V A 50
		TYPE OF CONSTRUCTION					
		STORIES (S) Area (A)					
A-5	S A	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL
B	S A	UL UL	11 UL	5 37,500	5 28,500	5 36,000	3 18,000
E	S A	UL UL	5 UL	3 26,500	3 23,500	3 25,500	1 18,500
F-1	S A	UL UL	11 UL	4 25,000	3 19,000	4 33,500	2 14,000
F-2	S A	UL UL	11 UL	5 37,500	4 28,500	5 50,500	3 21,000
H-1	S A	1 21,000	1 16,500	1 11,000	1 9,500	1 10,500	1 7,500
H-2[d]	S A	UL 21,000	3 16,500	2 11,000	2 9,500	2 10,500	1 7,500
H-3[d]	S A	UL UL	6 60,000	4 26,500	4 17,500	4 25,500	2 10,000
H-4	S A	UL UL	7 UL	5 37,500	5 28,500	5 36,000	3 18,000
H-5	S A	4 UL	4 UL	3 37,500	3 28,500	3 36,000	3 18,000
I-1	S A	UL UL	9 55,000	4 19,000	4 16,500	4 18,000	3 10,500
I-2	S A	UL UL	4 UL	2 15,000	1 12,000	1 12,000	1 9,500
I-3	S A	UL UL	4 UL	2 15,000	2 10,500	2 12,000	2 7,500
I-4	S A	UL UL	5 60,500	3 26,500	3 23,500	3 25,500	1 18,500
M	S A	UL UL	11 UL	4 21,500	4 18,500	4 20,500	3 14,000
S-1	S A	UL UL	11 48,000	4 26,000	3 26,000	4 25,500	3 14,000
S-2[b, c]	S A	UL UL	11 79,000	5 39,000	4 39,000	5 38,500	4 21,000
U[c]	S A	UL UL	5 35,500	4 19,000	3 14,000	4 18,000	2 9,000

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2.

UL = Unlimited, NP = Not permitted.

a. See the following sections for general exceptions to Table L102.1:
   1. Section 506.2, Allowable area increase due to street frontage of the IBC.
   2. Section 507, Unlimited area buildings of the IBC.

b. For open parking structures, see Section 406.5 of the IBC.

c. For private garages, see Section 406.3 of the IBC.

d. See Section 4157 for limitations of the IBC.

L102.3 Building Height and Area Increases.

L102.3.1 Increases in building height in accordance with Section 504.2, *Automatic sprinkler system increase,* of the *International Building Code* shall not be permitted

L102.3.2 Increases in building area in accordance with Section 506.3, *Automatic sprinkler system increase,* of the *International Building Code* shall not be permitted

L102.4 Single occupancy buildings with more than one story. Exception 2 of Section 506.4.1, *Area determination* of the *International Building Code* that allows area increases for *automatic sprinkler systems* shall not be permitted.

L102.5 Mixed Use and Occupancy. All buildings containing mixed occupancies shall be in accordance with this section.

L102.5.1 Separation of incidental accessory occupancies. The incidental accessory occupancies listed in Table L102.2 shall be separated from the remainder of the *building* by fire barriers.

L102.5.2 Separation of mixed occupancies. All occupancies except incidental accessory occupancies in Table L102.2.1 shall be separated from each other by fire barriers in accordance with Table L102.2.2

TABLE L102.5,1
INCIDENTAL ACCESSORY OCCUPANCIES[a]

Room or Area	Separation and/or Protection
Furnace room where any piece of equipment is over 400,000 Btu per hour input	1-hour and provide automatic sprinkler system
Rooms with boilers where the largest piece of equipment is over 15 psi and 10 horsepower.	1-hour and provide automatic sprinkler system
Refrigerant machinery rooms	1-hour and provide automatic sprinkler system
Parking garage (Section 406.2 of the Code, *Parking garages*)	2-hour and provide automatic sprinkler system
Hydrogen cut off rooms	2-hour and provide automatic sprinkler system
Incinerator rooms	2-hour and provide automatic sprinkler system
Laundry rooms over 100 square feet	1-hour and provide automatic sprinkler system
Storage rooms over 100 square feet	1-hour and provide automatic sprinkler system
Waste and linen collection rooms other than rooms designated for the collection of recyclables	1-hour and provide automatic sprinkler system
Rooms designated for the collection of recyclables	2-hour and provide automatic sprinkler system
Stationary storage battery systems having a liquid electrolyte capacity of more than 50 gallons, or lithium ion capacity of 1,000 pounds used for facility standby power, emergency power or uninterrupted power supplies	2-hour and provide automatic sprinkler system
Rooms in non-high-rise buildings containing fire pumps	2-hour and provide automatic sprinkler system
Rooms in high-rise buildings containing fire pumps	2-hour and provide automatic sprinkler system

[a] The requirements in this table take precedence over Table 508.2.5, *Incidental accessory occupancies* of the *International Building Code*.

	TABLE L102.5.2 REQUIRED SEPARATION OF OCCUPANCIES (HOURS)								
Occupancy	**A[d]**	**E**	**B**	**I**	**F-2, S-2[b,c], U[b]**	**F-1, S-1, M**	**H-1**	**H-2**	**H-3, H-4, H-5**
A[d]	N	2	2	2	1	2	NP	4	3
E[d]	—	N	2	2	1	2	NP	4	3
B	—	—	N	2	1	2	NP	3	2
I	—	—	—	N	2	2	NP	NP	NP
F-2, S-2[b,c], U[c]	—	—	—	—	N	2	NP	4	3[a]
F-1, S-1, M	—	—	—	—	—	N	NP	3	2[a]
H-1	—	—	—	—	—	—	N	NP	NP
H-2	—	—	—	—	—	—	—	N	1
H-3, H-4, H-5	—	—	—	—	—	—	—	—	N

N = No separation requirement.

NP = Not permitted.

a. For Group H-5 occupancies, see Section 903.2.5.2 of the *International Building Code*.

b. Areas used only for private or pleasure vehicles shall be allowed to reduce separation by 1 hour.

c. See Section 406.3.4 of the *International Building Code*.

d. Commercial kitchens need not be separated from the restaurant seating areas that they serve.

SECTION L103
TYPES OF CONSTRUCTION

L103.1 General. In order to limit the impact of fires on the *building* the *building* shall comply with Section L103.2.

L103.2 Fire-Resistance Rating. Building elements shall have a fire resistance rating not less than that specified in Table L104.1 and exterior walls shall have a fire resistance rating not less than that specified in Table 602, *Fire-Resistance Rating for Exterior Walls Based on Fire Separation Distance* of the *International Building Code*.

TABLE L103.1 FIRE-RESISTANCE RATING FOR BUILDING ELEMENTS (HOURS)[a]									
BUILDING ELEMENT	**TYPE I**		**TYPE II**		**TYPE III**		**TYPE IV**	**TYPE V**	
	A	**B**	**A**	**B**	**A**	**B**	**HT**	**A**	**B**
Primary Structural Frame[g,h]	3[b]	2[b]	1	NP	1	NP	HT	1	NP
Bearing Walls Exterior[f,g] Interior	 3 3[b]	 2 2[b]	 1 1	 NP NP	 2 1	 NP NP	 2 1/HT	 1 1	 NP NP
Non-bearing Walls and Partitions Exterior	See Table 602 of the *IBC*								
Non-bearing Walls and Partitions[e] Interior	0	0	0	NP	0	NP	See Section 602.4.6 of the *IBC*	0	NP
Floor Construction and Secondary Members[h]	2	2	1	NP	1	NP	HT	1	NP
Roof Construction and	1-	1[c,d]	1[c,d]	NP	1[c,d]	NP	HT	1[c,d]	NP

Secondary Members[h]	1/2[b]								

For SI: 1 foot = 304.8 mm.
NP = Not Permitted.
[a] The requirements in this table take precedence over Table 601,*Fire resistance rating for building elements* of the *International Building Code*.
[b] Roof supports: Fire-resistance rating of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.
[c] Fire protection of structural members hall not be required, including protection of roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire retardant wood members shall be allowed to be used for such unprotected members.
[d] In all occupancies, heavy timber shall be allowed where 1-hour or less fire-resistance rating is required.
[e] Not less than the fire-resistance rating required by other Sections of the *International Building Code*.
[f] Not less than the fire-resistance rating based on fire separation distance (see Table 602 of the *International Building Code*)
[g] Not less than the fire-resistance rating as referenced in Section 704.10 of the *International Building Code*, *Exterior structural members*.
[h] See Section 202 of the *International Building Code*, *Definitions*.

SECTION L104
FIRE AND SMOKE PROTECTION FEATURES

L104.1General. In order to limit the impact of fires on the *building* the *building* shall comply with Sections L104.1 through L104.12.

L104.2 Allowable area of openings. The maximum area of unprotected and protected openings permitted in an exterior wall in any story of the building shall not exceed the percentages specified in Table L104.2.

L104.3 Protected Openings. The exception for opening protectives in Section 705.8.2, *Protected openings* of the *International Building Code*, shall not be permitted.

L104.4 Vertical Separation of Openings. Exception 2 that eliminates vertical separation of openings where automatic sprinklers are present in Section 705.8.5, *Vertical separation of openings* of the *International Building Code*, shall not be permitted.

L104.5 Parapets. Exception 5 in Section 705.11, *Parapet construction* of the *International Building Code* that eliminates exterior wall parapets shall not be permitted for Group R-2 occupancies.

L104.6 Fire Walls. Fire walls shall meet the requirements of this section.

L104.6.1 Materials. Fire walls for all types of construction shall be of any approved noncombustible material permitted in NFPA 221.

L104.6.2 Fire Resistance Rating. The fire-resistance ratings shall meet or exceed the ratings provided in Table L104.6.2.

L104.6.3 Exception 3 in Section 706.5, *Horizontal continuity* of the *International Building Code* that allows termination of fire walls at the interior surface of noncombustible exterior sheathing where *automatic sprinkler systems* are present shall not be permitted.

L104.6.4 Exception 2 in Section 706.8, *Openings* of the *International Building Code* that allows increased area of openings through fire walls where *automatic sprinkler systems* are present shall not be permitted.

L104.7 Fire Barriers. Fire barriers shall comply with the provisions of this section

L104.7.1 The fire resistance rating of the separation between individual dwelling units and sleeping units, and between dwelling units and sleeping units and other spaces in the building shall have a minimum 2-hour fire-resistance rated construction as required in Table 707.3.10, *Fire-Resistance Rating Requirements for Fire Barrier Assemblies or Horizontal Assemblies Between Fire Areas* of the *International Building Code.*

L104.7.2 Exception 1 in Section 707.6, *Openings* of the *International Building Code* that allows openings in a fire barrier to be larger than 156 sqft where *automatic sprinkler systems* are provided shall not be permitted.

L104.8 Shaft Enclosures. Exception 5 in Section 713.14.1, *Elevator lobby* of the *International Building Code* that allows smoke partitions in lieu of fire partitions to separate the elevator lobby at each floor shall not be permitted.

L104.9 Fire Partitions. Fire partitions shall comply with the provisions of this section.

L104.9.1 Fire partitions in Section 708.1, *General* of the *International Building Code*, shall not be permitted for walls separating dwelling units in the same building.

L104.9.2 Fire partitions in Section 708.1, *General* of the *International Building Code*, shall not be permitted for walls separating sleeping units in the same building.

L104.9.3 Fire partitions in Section 708.1, *General* of the *International Building Code*, shall not be permitted for corridor walls separating corridors from dwelling units or sleeping units in the same building.

L104.9.4 Exception 6 in Section 708.4, *Continuity* of the *International Building Code* that allows elimination of fireblocking or draftstopping shall not be permitted.

L104.10 Horizontal Assemblies. Horizontal assemblies shall comply with the requirements of this Section.

L104.10.1 Horizontal assemblies separating dwelling units in the same building and separating sleeping units in occupancies in the same building shall have a minimum 2-hour fire-resistance rated construction as required in Table 707.3.10, *Fire-Resistance Rating Requirements for Fire Barrier Assemblies or Horizontal Assemblies Between* of the *International Building Code*.

L104.10.2 The exception in Section 711.3, *Fire-resistance rating* of the *International Building Code* that allows a reduction of the fire-resistance rating of separations between dwelling unit and sleeping unit where *automatic sprinkler systems* are present shall not be permitted.

L104.11 Opening Protectives. The provisions of this section shall apply to opening protectives.

L104.11.1 The Exception in Section 716.5.5 of the *International Building Code*, *Doors in exit enclosures and exit passageways* that eliminate the maximum transmitted temperature requirements shall not be permitted.

L104.11.2 The Exception in Section 716.5.5.1, *Glazing in doors,* of the *International Building Code* that eliminates the maximum transmitted temperature requirements shall not be permitted.

L104.12 Concealed Spaces. Exceptions 1 and 2 in Section 718.3.2, *Groups R-1, R-2, R-3 and R-4* of the *International Building Code* that eliminate draftstopping where *automatic sprinkler systems* are present shall not be permitted for Groups R-1, R-2 or R-4 occupancies.

TABLE L104.2 MAXIMUM AREA OF EXTERIOR WALL OPENING BASED ON FIRE SEPARATION DISTANCE AND DEGREE OF OPENING PROTECTION[a]		
Fire Separation Distance (feet)	**Degree of Opening Protection**	**Allowable Areas[b]**
0 to less than 3[c.d]	Unprotected (UP)	Not Permitted
	Protected (P)	Not Permitted
3 to less than 5[e]	Unprotected (UP)	Not Permitted
	Protected (P)	15%
5 to less than 10[g]	Unprotected (UP)	10%
	Protected (P)	25%
10 to less than 15[f,g]	Unprotected (UP)	15%
	Protected (P)	45%
15 to less than 20[f,g]	Unprotected (UP)	25%
	Protected (P)	75%
20 to less than 25[f,g]	Unprotected (UP)	45%
	Protected (P)	No Limit
25 to less than 30[f,g]	Unprotected (UP)	70%
	Protected (P)	No Limit
30 or greater	Unprotected (UP)	No Limit
	Protected (P)	Not Required

For SI: 1 foot = 304.8 mm

UP = Unprotected openings in buildings

P = Openings protected with an opening protective assembly in accordance with section 705.8.2 of the ICC *International Building Code*

[a] The requirements in this table take precedence over Table 705.8, *Maximum area of exterior wall openings based on fire separation distance and degree of opening protections o*f the Code.

[b] Values indicated are the percentage of the area of the exterior wall per story.

[c] For the requirements for fire walls of buildings with differing heights see Section 706.6.1 of the ICC *International Building Code.*

[d] For openings in a fire wall for building son the same lot, see Section 705.8 of the ICC *International Building Code.*

[e] The maximum percentage of unprotected and protected openings shall be 25% for Group R-3 occupancies.

[f] The area of unprotected and protected openings shall not be limited for Group R-3 occupancies with a fire separation distance of 5 feet or greater.

[g] *International Building Code* Includes buildings accessory to Group R-3.

TABLE L104.6.2 FIRE WALL FIRE-RESISTANCE RATINGS	
GROUP	FIRE-RESISTANCE RATING (hours)
A, B, E, H-4, I, R-1, R-2, U	3
F-1, H-3[a], H-5, M, S-1	3
H-1, H-2	4[a]
F-2, S-2, R-3, R-4	2

a. For Group H-1, H-2 or H-3 buildings, also see Sections 415.4 and 415.5 of the International Building Code.

SECTION L105
INTERIOR FINISHES

L105. 1General. In order to limit the impact of fires on the *building* the *building* shall comply with Sections L105.1 through L105.3.

L105.2 Interior Wall and Ceiling Finishes. Interior wall and ceiling finishes and conform to the requirements of this section.

L105.2.1 Finish by occupancy. Interior wall and ceiling finishes based on occupancy shall conform to the requirements in Table L105.1.

TABLE L105.2 INTERIOR WALL AND CEILING FINISH REQUIREMENTS BY OCCUPANCY			
GROUP	EXIT ENCLOSURES AND EXIT PASSAGEWAYS[a]	CORRIDORS	ROOMS AND ENCLOSED SPACES[b]
A-1, A-2	A	A	B
A-3, A-4, A-5	A	A	C
B, E, M, R-1, R-4	A	B	C
F	B	C	C
H	A	A	B
I-1	A	B	B
I-2, I-3, I-4	A	A	B
R-2	B	B	C
R-3	A	C	C
S	B	B	C
U	No Restrictions		

For SI: 1 inch = 25.4 mm, 1 square inch = $0.0929m^2$

[a] Class C interior finish materials shall be permitted for wainscoting or paneling of not more than 1,000 square feet of applied surface area in the grade lobby where applied directly to a noncombustible base or over furring strips applied to a noncombustible base and fire blocked as required by Section 803.11.1 of the *International Building Code*.

[b] Requirements for rooms and enclosed spaces shall be based upon spaces enclosed by partitions. Where a fire-resistance rating is required for structural elements, the enclosing partitions shall extend from the floor to the ceiling. Partitions that do not comply with this shall be considered enclosing spaces and rooms or spaces on both sides shall be considered as one. In determining the applicability of the requirements for rooms and enclosed spaces, the specific occupancy thereof shall be the governing factor regardless of the

group classification of the building or structure.

L105.2.2 Set-out construction. The exception in Section 803.11.2, *Set out construction* of the *International Building Code* for the Class A interior finish materials where *automatic sprinkler systems* are provided shall not be permitted.

L105.3 Interior Floor Finishes. The Exception in Section 804.4.2 of the *International Building Code International Building Code*, *Minimum critical radiant flux* which eliminates the requirement for minimum critical radiant flux for floor finishes and floor coverings in exit enclosures, exit passageways, and corridors where *automatic sprinkler systems* are provided shall not be permitted.

SECTION L106
FIRE PROTECTION SYSTEMS

L106.1 General. In order to limit the impact of fires on the *building* the *building* shall comply with Sections L106.1 through L106.4.

L106.2 Automatic Sprinkler Protection. Except for Group F-2 Occupancies, an *approved automatic sprinkler systems* shall be provided throughout all new buildings in accordance with Section 903 of the *International Building Code*.

Exceptions:

1. All Group F-2 occupancies
2. In Group S-2, Storage Occupancies located in close proximity to a Group F-2, Industrial Occupancy where the noncombustible products that are manufactured in the Group F-2 building are stored, the sprinkler protection shall be permitted to be omitted when *approved* by the *building official.*
3. Spaces or areas in telecommunications buildings used exclusively for telecommunications equipment, associated electrical power distribution equipment, batteries and standby engines, provided those spaces or areas are equipped throughout with an automatic fire alarm system and are separated from the remainder of the building by fire barriers consisting of not less than 1-hour fire-resistance-rated walls and 2-hour fire-resistance-rated floor/ceiling assemblies.

L106.2.1 Automatic Sprinkler Systems. Sprinkler systems shall be designed and installed in accordance with Section 903.3.1.1 of the *International Building Code*, *NFPA 13 sprinkler systems*. Sprinkler systems designed and installed in accordance with Section 903.3.1.2 of the *International Building Code*, *NFPA 13R sprinkler systems*, shall not be permitted.

L106.3 Standpipes. Standpipes shall comply with the requirements of this Section.

L106.3.1 The exceptions 1 and 4 of Section 905.3.1, *Building height* of the *International Building Code*, allowing Class I standpipes where *automatic sprinkler systems* are provided shall not be permitted

L106.3.2 The exception to Section 905.3.4, *Stages* of the *International Building Code*, that allows only a 1-1/2 inch hose connection for Class II or Class III standpipes where automatic sprinkler systems are provided shall not be permitted.

L106.3.3 The exception to Section 905.4.1, *Protection* of the *International Building Code* that allows elimination of the fire-resistance rated enclosure for laterals where *automatic sprinkler systems* are provided shall not be permitted.

L106.4 Fire Alarm and Detection Systems. Fire alarms and detection systems shall comply with the provisions of this Section.

L106.4.1 Exception 2.1 of Section 907.2.8.1, *Manual fire alarm systems* of the *International Building Code* that eliminates fire alarm boxes for Group R-1 occupancies in accordance with, shall not be permitted.

L106.4.2 Exception 2 of Section 907.2.9.1 *Manual fire alarm systems* of the *International Building Code* that eliminates fire alarm boxes for Group R-2 occupancies shall not be permitted

SECTION L107
MEANS OF EGRESS

L107. 1General. In order to limit the impact of fires on the *building* the *building* shall comply with Sections L107.1 through L107.6.

L107.2. Accessible Means of Egress. Accessible means of egress shall comply with the requirements of this Section.

L107.2.1 Exception 1 of Section 1007.3, *Stairways*, of the *International Building Code* that reduces in the clear width between handrails shall not be permitted.

L107.2.2 Exception 2 of Section 1007.3, *Stairways*, of the *International Building Code* that eliminates of areas of refuge shall not be permitted.

L107.2.3 Exception 2 of Section 1007.4, *Elevators,* of the *International Building Code* that eliminates requirements for elevator access from areas of refuge or horizontal exit shall not be permitted.

L107.3 Exit Access. Footnote b to Table 1014.3, *Common path of egress travel*, of the *International Building Code* that increases the length of common path of egress travel in Group R-2 occupancies shall not be permitted.

L107.4 Exits and Exit Access Doorways. Exits and exit access doorways shall comply with the requirements of this Section.

L107.4.1 Exception 1 in Section 1015.1 (1), *Exits or exit access doorways from spaces*, of the *International Building Code* that reduces the number of means of egress shall not be permitted.

L107.4.2 Exception 2 of Section 1015.2.1, *Two exits or exit access doorways*, of the *International Building Code* that counts scissor stairs as two exits shall not be permitted.

L107.5 Exit Access Travel Distance. Exit access travel distance shall comply with the requirements of this Section.

L107.5.1 Maximum travel distance shall not exceed 200 feet.

L107.5.2 Distance limitations through atrium spaces shall conform with Section 404, *Atriums* of the *International Building Code*.

L107.5.3 Exit access in buildings with one exit shall conform to Section 1021.2, *Single exits* of the *International Building Code*

L107.6 Corridors. Corridors shall comply with the requirements of this Section.

L107.6.1 The fire-resistance rating of corridor walls shall be at least 1-hour.

L107.6.2 Exception 2 in Section 1018.4, *Dead ends*, of the *International Building Code* that increases the length of dead-end corridors shall not be permitted.

SECTION L108
EXTERIOR WALLS

L108. 1 General. In addition to the requirements for Exterior Walls in Chapter 14 of the *International Building Code,* the exterior wall coverings shall also comply with Sections L108.2 through L108.4.

L108.2 Exterior wall covering limitations for reduced damage from fire. Exterior wall coverings shall comply with L108.2.1 and L108.2.2 to reduce damage from fire exposure

L108.2.1 Vinyl siding and Exterior insulation and finish systems (EIFS). Vinyl siding conforming to the requirements of Chapter 14 of the *International Building Code* and Exterior insulation and finish systems (EIFS) conforming to the requirements of Chapters 14 and 26 of the *International Building Code* shall only be permitted to be installed on exterior walls of buildings with a minimum fire separation distance of 30 feet.

L108.2.2 Fire Separation 5 Feet or Less. Combustible exterior wall coverings are not permitted on exterior walls having a fire separation distance or 5 feet (1524 mm) or less.

L108.3 Exterior wall covering limitations for reduced damage from hail. Vinyl siding conforming to the requirements of Chapter 14 of the *International Building Code* and Exterior insulation and finish systems (EIFS) conforming to the requirements of Chapters 14 and 26 of the *International Building Code* shall comply with sections L108.3.1 and L108.3.2.

L108.3.1 Hail Exposure regions. Hail exposure regions in Figure L108.3 shall be as follows:

- **(a) Moderate** - One or more hail days with hail diameters greater than 1.5 in (38 mm) in a twenty (20) year period.
- **(b) Severe** - One or more hail days with hail diameters greater than 2.0 in (50 mm) in a twenty (20) year period.

L108.3.2 Exterior wall coverings subject to hail exposure. Wall coverings used in regions where hail exposure is Moderate or Severe, as determined in accordance with Section L108.3.1 and Figure L108.3, shall be tested, classified, and labeled in accordance with UL 2218 or FM 4473.

L108.4 Exterior wall covering limitations for reduced damage from wind. Vinyl siding and Exterior insulation and finish systems (EIFS) conforming to the requirements of Chapter 14 of the *International Building Code* shall only be permitted to be installed on exterior walls of buildings located outside hurricane-prone regions as defined in Section 1609.2.

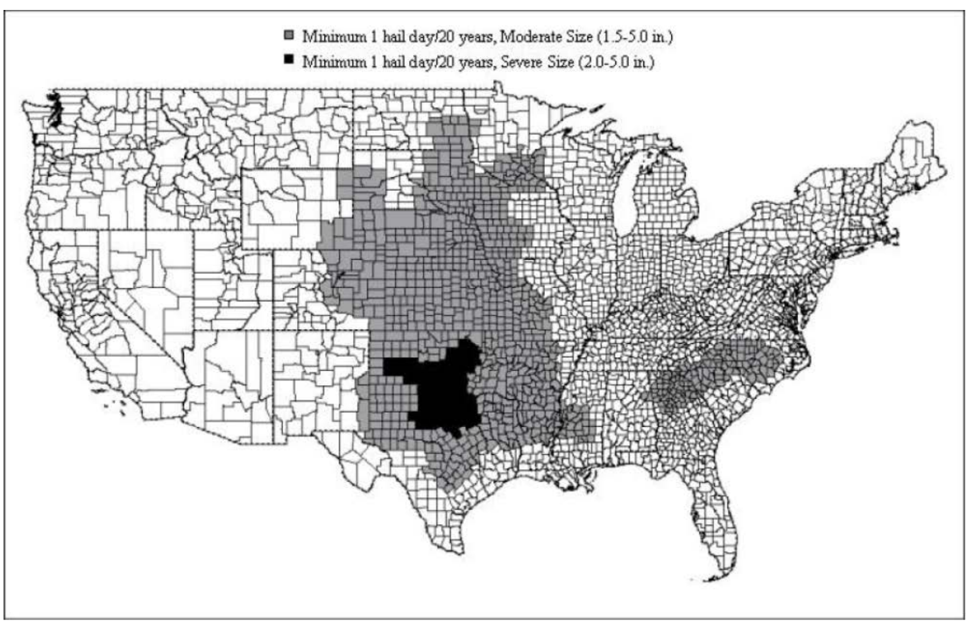


FIGURE L108.3

SECTION L109
ROOF ASSEMBLIES

L109.1 General. In addition to the requirements for Roof Assemblies and Rooftop Structures in Chapter 15 of the *International Building Code,* the roof coverings shall also comply with Sections with Sections L109.2 through L109.4.

L109.2 Non-classified roofs. Non-classified roof coverings in accordance with Section 1505.5 of the *International Building Code* shall not be permitted on *buildings.*

L109.3 Roofs in Warm and Dry Climates. Roofs in climate zones 1, 2, 3, 4, 5B (dry), and 6B (dry) of the *International Energy Conservation Code (IECC)* shall have a Class A roof covering or Class A roof assembly according to UL 790. For roof coverings where the profile allows a space between the roof covering and roof decking, the space at the eave ends shall be firestopped to preclude entry of flames or embers.

L109.4 Roof coverings subject to hail exposure. Roof coverings used in regions where hail exposure is Moderate or Severe, as determined in accordance with Section L104.4.1 and Figure L102.3, shall be tested, classified, and labeled in accordance with UL 2218 or FM 4473.

L109.4.1 Hail Exposure regions in Figure L108.3 shall be as follows:

- **(a) Moderate** - One or more hail days with hail diameters greater than 1.5 in (38 mm) in a twenty (20) year period.
- **(b) Severe** - One or more hail days with hail diameters greater than 2.0 in (50 mm) in a twenty (20) year period.

The following references are added to Chapter 35 as follows:
UL 2218, *Impact Resistance of Prepared Roof Covering Materials. UL 2218, Impact Resistance of Prepared Roof Covering Materials*.
FM 4473, *Specification Test Standard for Impact Resistance Testing of Rigid Roof Materials by Impacting With Freezer Ice Balls*.

SECTION L110
STRUCTURAL

L110.1General. In order to limit the impact of natural disasters on the *building* and occupants the *building* shall comply with Sections L110.1 through L110.5.

L110.2 Snowloads. In order to limit the impact of snow on the *building* the *building* shall comply with Section L110.2.1

L110.2.1 Ground snowloads. The ground snowloads to be used in determining the design snow loads for roofs shall be equal to 1.2 times the ground snowloads determined in accordance with ASCE 7 or Figure 1608.2 for the contiguous United States and Table 1608.2 for Alaska in the *International Building Code*. Site-specific case studies shall be made in areas designated “CS” in Figure 1608.2. Ground snow loads for sites at elevations above the limits indicated in Figure 1608.2 and for all sites within the CS areas shall be *approved*. Ground snow load determination for such sites shall be based on an extreme value statistical analysis of data available in the vicinity of the site using a value with a 2-percent annual probability of being exceeded (50-year mean recurrence interval). Snow loads are zero for Hawaii, except in mountainous regions as *approved* by the *building official*.

L110.3 Wind loads. In order to limit the impact of wind on the *building* the *building* shall comply with Section L110.3.1

L110.3.1 Determination of wind loads. Wind loads on every building or structure shall be determined in accordance with Chapters 26 to 30 of ASCE 7 or provisions of the alternate all-heights method in Section 1609.6. The type of opening protection required, the ultimate design wind speed, *Vult*, and the exposure category for a site is permitted to be determined in accordance with Section 1609 or ASCE 7. The design wind pressure, *p*, and design wind force, *F*, determined in accordance with ASCE 7 or 1609.6 shall be based on a design wind speed equal to the basic wind speed (or locally adopted basic wind speed in special wind zones, if higher) determined in accordance with Section 1609.3 as follows:

1. Ultimate design wind speed from Figure 1609A plus 20-mph.
2. Ultimate design wind speed from Figure 1609B plus 10 mph
3. Ultimate design wind speed from Figure 1609C.

Component and cladding loads shall be determined for the design wind speed defined assuming terrain Exposure C, regardless of the actual local exposure. Wind shall be assumed to come from any horizontal direction and wind pressures shall be assumed to act normal to the surface considered.

L110.4 Flood loads. Buildings designed and constructed in flood hazard areas defined in Section 1612.2 of the Code shall comply with the following.

L110.4.1 Floors above base flood elevation. Floors required by ASCE 24 to be built above base flood elevations shall have the floor and their lowest horizontal supporting member not less than the higher of the following:

(a) Design flood elevation,
(b) Base flood elevation plus 3 feet, or
(c) advisory base flood elevation plus 3 feet, or
(d) 500-year flood, if known

L110.4.2 Flood protective works. Buildings designed and constructed in accordance with ASCE 24 shall not consider levees or floodwalls for providing flood protection during the design flood.

L110.5 Earthquake loads. In order to limit the impact of seismic events on the *building* the *building* shall comply with Section L110.54.1 and L110.5.2

L110.5.1 Seismic design importance factor. Where the ASCE 7 mapped 0.2 sec spectral response acceleration parameter, S_S, shown on Figures 1613.3.1(1), 1613.3.1(3), 1613.3.1(4) or 1613.3.1(6) of the *International Building Code*, is greater than or equal to 40%g, the importance factor, I, in Table 11.5-1 of ASCE 7 shall be:

1. Not less than 1.15 for Occupancy Category II buildings
2. Not less than 1.35 for Occupancy Category III buildings
3. Not less than 1.6 for Occupancy Category IV buildings

L102.4.2 Seismic Design Categories C, D, E and F. If the *seismic design category* is determined to be C, D, E or F in accordance with Section 1613.3.5 of the *International Building Code*, a site specific geotechnical report complying with the provisions of ASCE 7 Section 11.8 is required, and the building shall be designed by a *registered design professional*.

L110.6 Storm Shelters. *Buildings* and structures shall be provided with storm shelters conforming to the requirements of Section 423 of the *International Building Code* where required by Sections L110.6.1 through L110.6.2 of this code.

L110.6.1 Storm shelters required. Storm shelters shall be provided for occupants of buildings in accordance with Sections L110.6.1.1, L110.6.1.2 and L110.6.2.

Exceptions:

1. *Buildings* meeting the requirements for shelter design in ICC/NSSA 500.
2. Where storm shelters within 1/4-mile of the proposed *building* are available and have adequate size to accommodate the added occupant load of the proposed *building*.
3. Where the code official determines the *building* size, location or occupant load does not warrant shelters.

L110.6.1.1 Hurricane areas. In hurricane-prone regions as defined in Section 1609.2 of the *International Building Code,* the following buildings shall be provided with storm shelters:

1. Community halls, gymnasiums and libraries assigned to Group A3 occupancy classification.
2. Civic administration facilities assigned to Group B occupancy classification.
3. Buildings assigned to Group E, I-1, I-2, I-3, M or R occupancy classifications.
4. Buildings assigned to Risk Category I in accordance with Section 1604.5 of the *International Building Code.*

L110.6.1.2 Tornado areas. In areas where the shelter design wind speed for tornadoes of Figure 304.2.(1) of ICC/NSSA 500 is 160 mph or greater, tornado shelters shall be provided, except that such shelters shall not be required for buildings classified as Group U occupancies or classified as Risk Category I according to Table 1604.5.

L110.6.2 Combined hurricane and tornado shelters. Where combined hurricane and tornado shelters are provided the shelter shall comply with the more stringent requirements of ICC/NSSA-500 for both types of shelters.

L110.7 Wildland In order to limit the impact of wildland fires on the *building* the *building* shall comply with Sections L110.7.1 through L110.7.3

L110.7.1 Wildland Fires. The provisions of the International Code Council (ICC) *International Wildland-Urban Interface Code* shall apply to the construction, alteration, movement, repair, maintenance and use of any building, structure or premises within the wildland interface areas in this jurisdiction.

L110.7.2 Exterior walls. Exterior wall requirements shall be based on the Fire Hazard Severity specified in Table 502.1 in the *International Wildland-Urban Interface Code*.

L110.7.3 Smoke Detection. An automatic smoke detection system shall be installed throughout buildings located within areas designated by the jurisdiction as being a wild land urban interface area.

*** END Appendix L ***