THE
TEN MOST WANTED

A SEARCH FOR SOLUTIONS TO REDUCE RECURRING LOSSES FROM NATURAL HAZARDS

An Initiative of the
Institute for Business & Home Safety (IBHS)

Prepared by
the American Society of Civil Engineers (ASCE) and
The Institute for Business & Home Safety (IBHS)
with support from
United States Department of Housing and Urban Development (HUD)
United States Geological Survey (USGS) and USAA

Fall, 2001

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Hurricanes and other severe windstorms

1 The highest priority should be given to research and development on the building's load path and on mitigation measures that protect the roof, all the building façade's openings, and on ways to improve quality of construction related to these elements. The top priority should be protection of the roof system, typically the most vulnerable and most expensive component to replace.

2 High priority should be given to protection of windows, garage doors, and the building envelope. Research on promising new and emerging technologies such as window coverings to prevent penetration by debris should be accelerated.

Earthquakes

3 The highest priority should be given to research and development of mitigation measures that provide a continuous load path and increase the lateral resistance of the structural system to ground shaking.

4 High priority should be given to improving methods for increasing the energy dissipation capacity of the structural system, anchoring the house to the foundation, securing mechanical equipment and contents, and preventing house-chimney interaction and foundation failure.

5 Research on new and emerging technologies should be continued and accelerated, with a focus on active and passive energy dissipation devices, soil remediation techniques, and composite materials. It should be recognized, however, that the results of these technologies might be more applicable to large commercial structures than to residential buildings.

Floods

6 The highest priority should be given to improving maps of the flood plain and developing land use ordinances to avoid construction in flood-prone locations.

7 Equally important are new ways to secure and elevate important equipment inside a building. Current activities sponsored by the Federal Emergency Management Agency's Flood Insurance Program and the U. S. Army Corps of Engineers have increased public awareness and fostered research and development on flood proofing materials and flood protection techniques for application to the foundation and structural systems. One of the most important lessons is that elevation of the structure to improve flood protection is counter productive in earthquake-prone areas because elevated structures are more vulnerable to damage from ground shaking than non-elevated structures are.

Hail

8 The highest priority should continue to be given to research and development of hail-impact-resistant materials for application to the roof system and the building envelope. These materials should be standardized, readily available off the shelf, and economical.

Wildfires

9 The highest priority should be given to research and development of fire-resistant materials for the building envelope, especially when constructing dwellings and commercial buildings in the urban-wilderness interface well known to be susceptible to wildfires. In such areas, research is needed to increase knowledge on controlled burns and use of fire-retardant vegetation. For fire following earthquake, the greatest need is for technologies to prevent ignition of gas lines and other flammable elements during an event, and, if a fire is ignited, for technologies that will suppress it quickly.

Severe winter storms

10 The highest priority should continue to be given to research and development of materials for use in winterizing exposed elements of residential and commercial structures, recognizing that timely application is critical. Technologies for efficient and effective monitoring of ice damming, freezing pipes, and snow loads on roof systems (especially for flat roofs) are needed.

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THE TEN MOST WANTED: A SEARCH FOR SOLUTIONS TO REDUCE RECURRING LOSSES FROM NATURAL HAZARDS

Executive Summary

Forty-two participants, who were nominated by their peers as experts on specific natural hazards and broad aspects of natural disaster reduction, contributed to a two-day workshop on the "Ten Most Wanted: A Search for Solutions to Reduce Recurring Losses from Natural Hazards." The Institute for Business & Home Safety (IBHS) and the American Society of Civil Engineers (ASCE) convened the workshop on 21-22 June 2000. The sponsors were:

1. The United States Department of Housing and Urban Development (HUD), the Federal agency responsible for the development and application of housing technology.
2. The United States Geological Survey (USGS), the Federal agency responsible for applied research in the geologic, seismological, and hydrological sciences; the monitoring and mapping of natural hazards; and the collaborative development and promotion of loss reduction measures.
3. USAA, an insurance and financial enterprise and a member company of IBHS.

The goal was to identify specific areas of research and development for application to residential and commercial buildings as part of the process to reduce recurring and increasing losses from the perils of severe windstorms, earthquakes, floods, hail, wildfire, and winter storms. The objective was to identify and prioritize mitigation measures considered to have the greatest benefit to cost ratio in the shortest period of time.

The nature of the challenge is characterized by spiraling economic losses to: a) property and casualty insurers, b) the owners/occupants of homes and commercial buildings, and c) local, state, and Federal governments.

The consensus was that holistic solutions are the best ways to meet the challenge faced by insurers and all communities throughout the nation as they seek to reduce well known vulnerabilities in dwellings and commercial buildings. These "thinking out of the box" solutions should integrate research, development, and professional education with improved professional practices and public policies.

The consensus was that the trend of rapidly increasing economic losses and societal disruption from natural hazards can be reversed by taking steps to reduce the well-known vulnerabilities in the roofs, envelopes, and structural and foundation systems of existing residential and commercial structures. These same vulnerabilities should be prevented in the planning stage of all new construction.

The experts' general recommendations included the following:

1. Development of a rating system for existing housing and commercial buildings that will help to assess their "as is" condition and provide a sound basis for decisions about retrofit.
2. Development of educational programs and training to increase the professional capacity of building sub-contractors and building inspectors.
3. Outreach to promote and increase awareness in all sectors of the public of the problems posed by natural hazards and the need for sustained application over time of cost-effective, loss-reduction measures.

The experts recommended ten solution sets and assigned priorities for reducing recurring losses from the disaster agents generated by six kinds of natural hazards. They are:

Hurricanes and other severe windstorms

1 The highest priority should be given to research and development on the building's load path and on mitigation measures that protect the roof, all the building façade's openings, and on ways to improve quality of construction related to these elements. The top priority should be protection of the roof system, typically the most vulnerable and most expensive component to replace.

2 High priority should be given to protection of windows, garage doors, and the building envelope. Research on promising new and emerging technologies such as window coverings to prevent penetration by debris should be accelerated.

Earthquakes

3 The highest priority should be given to research and development of mitigation measures that provide a continuous load path and increase the lateral resistance of the structural system to ground shaking.

4 High priority should be given to improving methods for increasing the energy dissipation capacity of the structural system, anchoring the house to the foundation, securing mechanical equipment and contents, and preventing house-chimney interaction and foundation failure.

5 Research on new and emerging technologies should be continued and accelerated, with a focus on active and passive energy dissipation devices, soil remediation techniques, and composite materials. It should be recognized, however, that the results of these technologies might be more applicable to large commercial structures than to residential buildings.

Floods

6 The highest priority should be given to improving maps of the flood plain and developing land use ordinances to avoid construction in flood-prone locations.

7 Equally important are new ways to secure and elevate important equipment inside a building. Current activities sponsored by the Federal Emergency Management Agency's Flood Insurance Program and the U. S. Army Corps of Engineers have increased public awareness and fostered research and development on flood proofing materials and flood protection techniques for application to the foundation and structural systems. One of the most important lessons is that elevation of the structure to improve flood protection is counter productive in earthquake-prone areas because elevated structures are more vulnerable to damage from ground shaking than non-elevated structures are.

Hail

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Severe winter storms

10 The highest priority should continue to be given to research and development of materials for use in winterizing exposed elements of residential and commercial structures, recognizing that timely application is critical. Technologies for efficient and effective monitoring of ice damming, freezing pipes, and snow loads on roof systems (especially for flat roofs) are needed.

The likelihood of success is enhanced if it involves researchers, practitioners, and community decision makers in a long-term, collaborative process.

The role of researchers is to discover new, less expensive, easy-to-use mitigation measures that are based on state-of-the-art architectural and engineering methods.

The role of practitioners is to use best practices in the application of these mitigation methods in siting, design, and construction in every community.

The role of community decision makers is to enact and enforce improved, state-of-the-art building regulations and land-use ordinances.

BACKGROUND

Workshop

This is the report of the two-day workshop, "Ten Most Wanted: A Search for Solutions to Reduce Recurring Losses from Natural Hazards," convened on 21-22 June 2000 at the World Headquarters Building of the American Society of Civil Engineers in Reston, Virginia. This workshop was an initiative of the Institute for Business & Home Safety (IBHS).

Participants

Forty-two participants (See Annex 1) contributed to the workshop. Each one was invited after being nominated as "expert" by their peers in a comprehensive solicitation process. The collective expertise of the participants was unique, encompassing every professional discipline and a broad knowledge of natural hazards, natural disasters, and natural disaster reduction. The group included representatives of insurers, business, architectural, design and construction firms, professional societies, trade associations, academia, and local, state, and Federal government.

Goal and Objectives

The goal of the workshop was to develop consensus recommendations and priorities for future research and development having the goal of accelerating the discovery, improvement, and implementation of cost-effective solutions to reduce recurring losses. This goal calls for innovative actions to eliminate known and perceived vulnerabilities in both the existing inventories of residential and commercial buildings as well as the new dwellings and commercial buildings. Both sets of the existing building stock are at risk from hurricanes, other severe windstorms, earthquakes, floods, hail, wildfire, and winter storms.

The objectives were:

1. To recommend a set of holistic solutions that will reduce the recurring losses from severe windstorms, earthquakes, floods, hail, wildfire, and winter storms within a framework of social, technical, administrative, political, legal, educational, and economic considerations.
2. To analyze the causes of recurring damage to residential and commercial buildings from severe windstorms, earthquakes, floods, hail, wildfire, and winter storms.
3. To identify and characterize the vulnerabilities (i.e., the actual and perceived weaknesses) in residential and commercial buildings in terms of a specific architectural and/or structural system.
4. To engage in a dialogue on some of the current technological solutions being developed by researchers and applied by practitioners in an ongoing effort to reduce known vulnerabilities.
5. To critique some of the promising new "works in progress" and to prioritize research and development activities that will help speed delivery of cost-effective technological solutions to practitioners.

THE PROBLEM

Losses from Recurring Natural Hazards are Increasing

The trend of increasing economic losses from recurring natural hazards is continuing every year, and so is the potential for even greater losses over time. These two situations are placing an unprecedented, enormous strain on insurers. Munich Reinsurance's recent report, "Topics 2000," shows that insured losses (those protected by insurance) from natural hazards reached $22 billion in 1999, the second largest loss during the 1990's to the $26 billion of 1992, the year Hurricane Andrew struck Florida and Louisiana. During the past 50 years, 250 great natural catastrophes in the world claimed the lives of over 1.4 million people and caused economic losses (whether or not insured) of $960 billion.

The disaster data in Munich RE's report, Topics 2000, indicate two facts:

1. The greatest loss of life is associated with severe windstorms and flooding, the same as in the past.
2. Economic losses are almost equally distributed among earthquakes, windstorms, and flooding, but the greatest insured loss is associated with windstorms.

Existing Buildings Have Well-Known Vulnerabilities

The primary focus of the workshop was on the Nation's huge and rapidly growing inventory that exceeds 100 million residential and commercial structures. The aggregate value of the residential and commercial buildings is increasing annually, reaching many trillions of dollars now. Many of these structures have vulnerabilities in their roof systems, building envelopes, structural systems, or foundation systems, which make them susceptible to damage from the agents generated by hurricanes, other severe windstorms, earthquakes, floods, wildfire, hail, and winter storms. As we increase our understanding of these vulnerabilities, over time, we are able to pin down the level of susceptibility of individual residential and commercial structures to damage, loss of function, business interruption, and collapse when subjected to the disaster agents generated in hurricanes, other severe windstorms, earthquakes, floods, hail, wildfire, and winter storms. This understanding is essential for identifying viable options for retrofitting and strengthening of residential and commercial buildings.

The Number of New Residential and Commercial Buildings is Growing

To make the situation worse for property and casualty insurers, the owners of residential and commercial buildings, and the self insured such as communities, and local, state, and Federal governments, throughout the nation, over 1.3 million new residential and commercial units are now being constructed each year. The startling fact is that in spite of increased knowledge, better building regulations, land-use ordinances, and improved construction practices, many new buildings still have the same kinds of vulnerabilities as do those in the existing inventory.

IDENTIFICATION OF VULNERABILITIES

Vulnerabilities in Residential and Commercial Buildings are Similar

Experience has shown that the insured losses in residential and commercial buildings will occur primarily as a consequence of vulnerabilities in the roof, building envelope, structural, and foundation systems and the disaster agents of the specific peril or natural hazard. Damage to non-structural elements and business interruption are also major sources of economic loss.

In this workshop, commercial and residential buildings were analyzed in an integrated manner. The scale of the physical effects and economic losses, not the causes and not the research methods, are the main differences in the vulnerabilities of large commercial buildings and the many residential and small commercial buildings.

The systems and components of commercial and residential buildings that are considered to be the sources of vulnerability and the major causes of damage and loss of function are identified below in terms of the roof, building envelope, structural, and foundation systems. The components of those systems considered to have the highest vulnerabilities are denoted with “High” and are the basis for the “Most Wanted Solutions.”

Most Wanted Solutions: Commercial Buildings

1. **Roof systems** are especially vulnerable to high velocity winds and uplift caused by the pressure gradients generated in hurricanes and tornadoes, hail storms, snow loads, and wildfire. Heavy roofs make a commercial building more vulnerable to earthquake ground shaking than light roofs. The vulnerable components of the roof system and the priorities for research and development are listed below:

- Metal edge flashing **(High)**
- Roof assembly: above deck (covering) and deck (metal and lightweight concrete) **(High)**
- Adhesives
- Fasteners (**High**, spacing and type of attachment are especially important)
- Membranes
- Insulation
- Flammability
- Age
- Weight (**High** for earthquakes)

2. **Building envelopes** (the outer layer of building material on the structure), a major part of the load path, are especially vulnerable to high velocity winds and pressure gradients generated in hurricanes and tornadoes. They are also vulnerable to hail, wildfire, and, depending on the quality of the connections, to strong ground shaking in earthquakes. The vulnerable components include:

- Openings, such as windows, doors, and garage doors (**High**)
- Siding system (depends on the methods and tools used for attachment)
- Elements of metal buildings (**High**)
- Fasteners (**High**) The spacing and tools used for attachment are especially important
- Unusual design
- Flammability of construction materials
- Moisture/drainage

3. **Structural systems,** the most critical elements of the load path, are especially vulnerable to high velocity winds and pressure gradients generated in hurricanes and tornadoes, and to the lateral forces induced by horizontal ground shaking in earthquakes. They are also vulnerable to hail, wildfire, and snow loads. The vulnerable components and priorities for research and development are:

- Continuity of the load path (**High**)
- Connections (**High**)
- Redundancy
- Soil-foundation-structure interaction (**High** for earthquake ground shaking)
- Symmetry
- Type of construction material and its capacity to dissipate energy (**High**. for earthquake ground shaking and unreinforced masonry and concrete block)

4. **Foundation systems,** elements of the load path, are especially vulnerable to the lateral forces induced by horizontal ground shaking in earthquakes and the permanent ground deformation (e.g., liquefaction and landslides) ground shaking can induce. The vulnerable components include:

- Connections between the building and the foundation system (**High** for earthquakes)

5. **Flood protection systems** are essential for keeping the water outside the building and for the protection of valuable equipment in case of inundation

6. **Freeze protection systems** are needed; especially for locations in the South that do not experience freezing temperatures very often.

Most Wanted Solutions: Residential Buildings

1. **Roofing systems** are especially vulnerable to high velocity winds and uplift caused by the pressure gradients generated in hurricanes and tornadoes, hail storms, snow loads, and wildfire. Heavy roofs and masonry chimneys increase the vulnerability of a residential building to strong ground shaking generated in an earthquake. The vulnerable components of the roofing systems of residential buildings include:

- Roof coverings and fasteners (**High**)
- Methods and types of roof fasteners (**High**)
- Roof decking fastened to trusses(**High**)
- Roof trusses fastened to walls(**High**)
- Gable end trusses fastened to other trusses and gable end walls(**High**)
- Aesthetic issues affecting architectural design

2. **Building envelopes,** important elements of the load path, are especially vulnerable to high velocity winds and pressure gradients generated in hurricanes, other severe windstorms, hailstorms, wildfire, earthquake ground shaking, and wildfire following an earthquake. The most vulnerable components and priorities are:

- Openings, such as windows (**High**), garage doors (**High**), doors, including sliders (**High**), skylights (**High**, especially for hail)
- Siding and cladding (**High**, especially for hail and wildfire)
- Brick veneer (**High** for earthquake)
- Aesthetic issues such as cathedral ceilings, use of scissors trusses, ladder rakes, and other features that weaken the structure (**High**)

3. **Structural systems,** the most critical elements of the load path, are especially vulnerable to high velocity winds and pressure gradients generated in hurricanes, hailstorms, wild fire, snow loads, earthquake ground shaking, and fire following earthquake. The most vulnerable components and the priorities are:

- Continuity of load path (**High**)
- Walls and floors connected and anchored to foundation (**High** for earthquake)
- Cripple wall (**High** for earthquake)
- Soil – Foundation- Structure Interaction (**High** for earthquake ground shaking and for locations where a high potential for landslides and liquefaction exists.)
- Type of construction material and capacity to dissipate energy (**High** for earthquake ground shaking and unreinforced masonry and concrete block)

- Connection of the basic structure with other appurtenances, such as screened enclosures and detached garages.

- Anchorage, protection, and/or vibration isolation of nonstructural systems such as chimneys, water heaters, gas shut-off valves and contents (**High** for earthquakes, hurricanes, and other severe windstorms).

4. **Foundation systems,** important elements of the load path, are especially vulnerable to the lateral forces of horizontal ground shaking and the permanent ground deformation (e.g., liquefaction, lateral spreading, and landslides) induced by the ground shaking in an earthquake. The vulnerable components include:

- Connections, which are needed to keep the house from moving on its foundation during earthquake ground shaking. (**High**)

- The basements of homes, which need to be secure from rupture caused by sand boils. This is especially true in locations in the Mississippi Valley region where a large geographic region is known to be susceptible to liquefaction on the basis of what happened in past earthquakes.

5. **Flood protection systems** are essential elements for keeping the water outside the building and for protecting valuable contents and equipment from inundation.

6. **Freeze protection systems** are especially needed for locations in the South that do not experience freezing temperatures very often. Snow loads, frozen pipes, and ice damming as a result of insulation and ventilation (i.e., moisture evacuation problems) are major causes of damage and economic loss.

CONSENSUS RECOMMENDATIONS

Retrofit of Existing Buildings and Mitigation for New Buildings

The experts set priorities for continuation of research and development for each peril. The priorities were established on the basis of experience and a balanced framework of social, technical, administrative, political, legal, and economic considerations for the application of existing technologies and the development and application of new and emerging technologies. The recommended priorities and actions are considered to be the ones most likely to realize the greatest benefit in the shortest time for an investment of resources.

In view of the known vulnerabilities in the existing inventory of residential and commercial buildings, a major program of retrofit, strengthening, and rehabilitation is needed. Such a program has social, technical, economic, legal and political implications because of the size, value, current use, and importance of these buildings and the inadequacies of existing codes for setting a realistic minimum standard.

New buildings need to be sited, designed, and constructed in accordance with modern building regulations and land-use ordinances with full awareness of the social, technical, economic, legal, and political implications of such regulations and the need for enforcement.

We must keep learning from each new natural disaster in order to improve the science and technology underpinning building regulations, land-use ordinances, and construction practices. When a disaster opens a “window of opportunity” for studies, public policies on mitigation should be improved throughout the nation.

Photographs are provided below to illustrate some of the vulnerabilities and situations that were discussed during the workshop. These situations provide a basis for the recommended priorities for research and development of specific retrofit technologies for application to existing dwellings and commercial buildings and mitigation measures for application to new construction.

Hurricanes and Other Severe Windstorms

The **highest priority** should be given to research and development on the load path and on mitigation measures that protect the roof system and all openings in the building envelope. The building envelope is comprised of many different components, which work together to protect the building, its occupants, and its contents.

A **high priority** for research and development is the roof system, the most vulnerable component and a major contributor to economic losses.

Protection of windows and garage doors should receive **high priority**.

Research on new and emerging technologies such as window coverings to keep debris from penetrating openings and to keep the wind outside the building envelope should be continued; indeed, accelerated.

Hurricane Marilyn, VI, September 25, 1995 - Rebuilding and clean up begin following the devastating hurricane. Eight people died and more than $2 billion in property damage was caused by Hurricane Marilyn.

FEMA News Photo

Hawaii, September 1, 1992 -- The roof and upper floor of this home received major wind damage from Hurricane Iniki.

FEMA News Photo

Securing a roof system. During retrofit of existing buildings or incorporating mitigation in new construction, the type, number, and spacing of fasteners are critically important in keeping the roof system attached and connected to the building envelope.

What one sees on the outside is not always an indication of the quality of construction, which is best determined by an inspection of detailing from inside the structure (See next photo).

Southport, NC. FEMA mitigation specialists Sharon Steen and Diane Earl inspect the hurricane straps that were added to this home. The straps provide additional protection to the home during high winds. Photo By Dave Saville/FEMA News Photo

Importance of fasteners. Again, the type, number, and spacing of fasteners are critically important in keeping the roof system and the building envelope connected.

This building's roof system is vulnerable to high velocity winds, especially when there are flaws in workmanship that have been missed by the inspectors.

Roof systems are vulnerable to uplift caused by the pressure gradients generated in hurricanes and tornadoes, hail storms, snow loads, and wildfire. Heavy roof systems make a building more vulnerable to earthquake ground shaking than light roof systems do.

Earthquakes

The **highest priority** should be given to mitigation measures that provide a continuous load path in the building and increase the lateral resistance of the structural system. Methods for increasing the energy dissipation capacity of the structural system include anchoring the house to the foundation, strengthening “cripple walls,” securing mechanical equipment and contents, and preventing house-chimney interaction and foundation failure. All should have high priorities for continued research and development.

Research and development of better maps of ground shaking, soil amplification, and ground failure for applications on local, state, and regional scales in building and land-use regulations should remain as a **high priority**.

Research on emerging technologies such as active and passive energy dissipation devices, soil remediation techniques, and composite materials should be continued and accelerated. However, the results of this research may be more applicable to large commercial structures than to small commercial buildings or residential buildings.

Seattle, WA, March 5, 2001 -- There is substantial earthquake damage in Pioneer Square, part of Seattle’s historic district. Photo by Liz Roll/FEMA News Photo

A **high priority** should be given to discovering and improving low-cost retrofit and mitigation measures that provide a continuous load path in the building and increase the lateral resistance of the structural system.

The “soft story” weakness (i.e., inadequate bracing in the first story) shown in this photograph is a typical problem that makes many dwellings and commercial buildings vulnerable to earthquake ground shaking.

High priority should also be given to increasing the energy dissipation capacity of the structural system, anchoring the house to the foundation, strengthening “cripple walls,” securing mechanical equipment and contents, and preventing house-chimney interaction, and foundation failure.

San Francisco, CA, 10/89 Loma Prieta earthquake. Rubble from a collapsed Marina District apartment building litters one lot while nearby, a building is shored up. FEMA News Photo

Liquefaction in water saturated sand deposits triggered by the strong ground shaking can rupture the underground utility systems, and both cause fire and reduce the community's capability to fight it. For this reason, research and development of better maps of ground shaking, soil amplification, and liquefaction for applications on local (e.g., zip code), state, and regional scales in building and land-use regulations remain as a **high priority**

Floods

The **highest priority** should be given to improving maps of the floodplain and enforcing land use ordinances which reflect understanding and use of mapping data. Both are tools that can be used to prevent construction in floodplains.

High priority should also be used in retrofit and mitigation efforts to identify new, low-cost ways to secure and elevate important equipment inside buildings.

Research on flood proofing materials and flood protection techniques should be continued and accelerated.

Current activities sponsored by the Federal Emergency Management Agency's Flood Insurance Program and the U. S. Army Corps of Engineers have increased public awareness and fostered research and development on flood proofing materials and flood protection techniques for application to the foundation and structural systems. These activities should be continued and improved, keeping in mind that elevation of the structure to improve flood protection is counter productive for buildings that are also at risk from earthquakes, because elevated structures are more vulnerable to damage from ground shaking than non-elevated structures.

Davenport, IA, May 4, 2001 -- Mississippi River flowed over its banks and flooded the city's downtown riverfront. Photo By David Teska/FEMA News Photo.

Hail

The **highest priority** should be given to research and development of hail-impact-resistant materials for application to the roof system and the building envelope during retrofit of existing buildings and for mitigation of known vulnerabilities during new construction.

These materials should be standardized, economical, and readily available off the shelf.

Hail resistant roofing can significantly reduce the damage shown.

Wildfire

The **highest priority** should be given to research and development of fire-resistant materials for incorporation in the building envelope during retrofit, and in the construction of new buildings. Wise siting of the structure and the use of defensible space will also accomplish much to enhance safety. The urban-wilderness interface is well known for its susceptibility to wildfires. New construction in such areas should proceed with due consideration of the threat and its consequences.

Research is needed to increase knowledge on prescribed or controlled burns and the deployment and use of fire-retardant vegetation.

For fire following earthquake, the **highest priority** is for technologies to prevent ignition, especially of gas lines and flammable materials during an event, and, if a fire is ignited, for technologies to suppress it quickly.

Los Alamos, NM, May 4, 2000 - The fire destroyed homes, vehicles, and personal property, leaving many people with nothing.

Photo by Andrea Booher/FEMA News Photo

Los Alamos, NM, May 4, 2000 - An aerial image shows homes destroyed by the Cerro Grande fire.

Photo by Andrea Booher/FEMA News Photo

Winter storms

The **highest priority** should be given to application of materials to winterize all exposed elements of residential and commercial structures in a timely manner.

High priority should also be given to new technologies for efficient and effective monitoring of ice damming, freezing pipes, and snow loads on roof systems (especially flat roofs).

Research and development of new materials for use in winterizing should be continued.

Photo courtesy of National Weather Service

Heavy snow loads can lead to roof collapse and/or extensive ice dams.

Policy holder photo courtesy of Maine Mutual Insurance.

How many elements can you see in these buildings that are vulnerable to the disaster agents of hurricanes, other severe windstorms, earthquakes, floods, hail, wildfire, or winter storms?

A grading system for rating the “as is” condition and relative vulnerability of existing dwellings and commercial buildings to severe windstorms, earthquakes, floods, hail, fire, and winter storms is an urgent national need. Such a system could be used to guide decisions on retrofit and mitigation measures for new construction.

The availability and universal application of such a grading system could sharply reduce many of the recurring losses faced by insurers.

CONCLUSIONS

The conclusions of the workshop experts are summarized below:

- The trend of rapidly increasing economic losses and societal disruption from natural hazards can be reversed by taking steps to reduce well-known vulnerabilities in the roof, envelope, structural, and foundation systems of existing residential and commercial structures. The need is to apply loss reduction measures based on less expensive materials, improved, easy-to-use methodologies, and state-of-the-art architectural and engineering methods, improved construction practices, and high-quality building inspection procedures.

- A high priority is assigned to the development of a rating system that can be used to assess the condition and vulnerability of existing dwellings and commercial buildings. Such a system would help to determine the extent and type of retrofit that are needed to reduced the potential for losses in future natural hazards.

- Retrofit of existing buildings and pre-disaster mitigation of new construction should start now, proceeding simultaneously with ongoing research and development. Otherwise, the owners of residential and commercial buildings, property and casualty insurers, communities, and local, state, and Federal government agencies can expect economic losses and societal impacts from recurring natural hazards to continue and increase in the future.

- Some aspects of retrofit such as cost/benefit and competing methodologies are controversial. Controversy is expected to dissipate as improved codes and standards are developed to guide professional practice and to ensure quality and high benefit/cost of each retrofit.

- Vulnerabilities in the roof, envelope, structural, and foundation systems of new construction can be prevented through application of modern, state-of-the-art-codes and standards at the time of construction. The Nation can not afford to continue adding as many as 1.3 million vulnerable units each year to an existing inventory of vulnerable residential and commercial structures. Property and casualty insurers can not afford to “bet the company” when they write insurance for the vulnerable new structures. Building owners and homeowners can not afford the premium for a realistic insurance contract.

- Adequate codes, standards, and legislation exist in a global sense now, but they are not always adopted uniformly at regional and local community levels. The pervasive problem is that communities throughout the nation need better-trained professionals to apply them and cost-effective public policies to enforce them.

- Success, which will not be easy, requires a long-term process involving researchers, practitioners, and community decision makers. The role of researchers is to discover and develop new materials and to develop new, less expensive, and easy-to-use mitigation measures that are based on state-of-the-art architectural and engineering methods. The role of practitioners is to use best practices in the application of mitigation methods in siting, design, construction, and retrofit. The role of community decision-makers is to enact and enforce improved building and land-use regulations and to ensure their successful implementation.

- New codes, standards, and legislation are NOT the only elements that need to achieve good building design and construction of new buildings. A holistic solution that integrates and coordinates research and development with professional education and improvements in public policies and professional practices is needed.

- A **high priority** is assigned to the urgent need for outreach to promote and increase awareness, and to improve public policy. The most pervasive problem in the nation is lack of awareness and education. For all building owners in every geographic region of the Nation, these deficiencies encompass: a) why they should retrofit their buildings, b) what is needed, c) what are the options, d) how much will each option cost, and e) what are the benefit/costs of each option. A high priority needs to be focused on meeting the educational needs of the building owner and the entire "community of construction practices," including the designer, contractor, sub-contractor, building inspector, insurer, and owner. These actions will spill over to the public officials who have responsibility for adopting, implementing, and enforcing public policies to protect people and property.

- A **high priority** is assigned to education designed to increase the professional capacity of practitioners to apply cost-effective, retrofit and mitigation measures.

- The ongoing work to implement and enforce modern, state-of-the-art building codes and standards is incomplete. Continuing improvements can and should be made to existing building codes, through research and the innovative use of each disaster as a laboratory for learning. The elusive goal —- to adequately reflect the risks from the disaster agents generated in hurricanes, other severe windstorms, earthquakes, floods, hail, fire, and winter storms—-has not yet been achieved.

Next Steps

This workshop was convened under the auspices of the Memorandum of Understanding signed by ASCE and IBHS on April 30, 1997. During the workshop, on June 21, James E. Davis, ASCE Executive Director and CEO and Harvey G. Ryland, President and CEO, Institute for Business and Home Safety (IBHS) signed an Addendum to their existing Memorandum of Understanding to work together in facilitating the recommendations of the workshop, and in promoting long-term, cooperative efforts throughout the nation by reducing vulnerability from natural hazards through disaster technical assistance before, during, and after they strike.

IBHS and ASCE will make these recommendations available to HUD and USGS, the public-sector workshop sponsors, as well as to insurers, trade organizations, professional societies, academia, and other government agencies such as NSF, FEMA, and NIST. HUD is the Federal agency responsible for housing development and application. USGS is the Federal agency responsible for applied research in the geologic, seismological, and hydrological sciences including monitoring and mapping of natural hazards and the collaborative development and promotion of loss reduction measures.

ASCE and IBHS will promote the implementation of the recommendations through their members and partners in the broad context of the new ASCE/IBHS agreement.

Consideration is also being given to convening a workshop of “One Hundred Champions of Mitigation.” The work to devise and implement building codes and standards and construction practices that adequately cope with the risks from hurricanes, tornadoes, earthquakes, floods, hail, fire, and winter storms is not yet complete. It must be CHAMPIONED if effective and affordable retrofit technologies are delivered to practitioners working to make existing homes and businesses less vulnerable to these natural hazards. New dwellings and buildings must be sited, designed, and constructed in ways that make them more resistant to damage.

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Annex 1:

Participants in June 21-22, 2000 "Ten Most Wanted" Workshop

Abruzzo, John	Thornton-Tomasetti Engineers
Ansari, Farhad	University of Illinois at Chicago
Asdal, Bill	Asdel Builders
Beavers, James	University of Illinois at Urbana
Bouvin, Erik	Allstate Insurance Company
Bruneau, Michael	Multidisciplinary Center of Earthquake Engineering Research (MCEER)
Cassaro, Michael	ASCE Council on Natural Disaster Reduction
Catherman, Chris	ASCE Staff
Chaker, Amar	ASCE Staff, Transportation Division
Chung, Riley	US Department of Housing and Urban Development (HUD)
Collins, Jan	Institute for Business & Home Safety (IBHS)
Dolan, Dan	Virginia Tech University
Edwards, Scott	ASCE/CERF
Fasking, Dennis	Allstate Insurance Company.
Filiatrault, Andre	University of California, San Diego
Ford, Kenneth	National Association of Home Builders (NAHB)
Freeborne, William	US Department of Housing and Urban Development (HUD)
Gahagan, Karen	Institute for Business & Home Safety (IBHS)
Gaus, Mike	State University of New York at Buffalo
Gnaedinger, John	Researcher
Green, Bob	Johns Hopkins University
Hays, Walter	ASCE staff and Designated Liaison with IBHS
Hester, Norman	Central United States Earthquake Consortium (CUSEC), United States Geological Survey, and former Indiana State Geologist
Laatsch, Edward	Federal Emergency Management Agency (FEMA),
Larkin, Jay	AIMCAL
Manzari, Majid T.	George Washington University
Ogren, John	National Weather Service
Radmaker, Mark	Garco Building Systems
Reinhold, Timothy	Clemson University
Roth Jr., Richard	California Department of Insurance
Russell, James W	Institute for Business & Home Safety (IBHS)
Russell, Jim	Building Code Consultant
Schmelzer, Robert	LMG Property
Sciaudone, Jeff	Institute for Business & Home Safety (IBHS)
Segura, Yvette	USAA
Shoemaker, Lee	MBMA
Spalding, Teri	State Farm Insurance
Sutt, Ed	Clemson University
Takahashi, Ed	WWCOT Architects
Tatinclaux, J.C.	Army Cold Regions Research Lab
Thornton, Charles	Thomas-Tomasetti Engineers
Walker, Daniel	MBMA

Notes:

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