Resilience is the new Sustainability

Disasters show the need to build for the future Part 1

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Sustainability lessons from Katrina

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

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

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

making Katrina the most destructive and costliest natural disaster in the history of the U.S., estimated at $81.2 billion (2005 U.S. dollars), nearly double the cost of the previously most expensive storm, Hurricane Andrew, when adjusted for inflation.[2]

The leveeing of the Mississippi River for purposes of flood control and commerce navigation is the primary reason for the coastal wetland loss. These levees were designed for the needed flood protection, yet prevented vital land-building sediments and nutrients from replenishing deteriorating marshes. Wetlands along the coastline serve as natural speed bumps to approaching hurricanes by starving them of warm ocean water and creating physical barriers to surging floodwater. However, in the last 100 years, the construction of levees and canals has turned 1,900 square miles of Louisiana wetland habitat into open water. In effect, moving the hurricane closer to the city before it can decrease in intensity as it normally does over land.

Here, we see the artifact of progress itself becomes the instrument that undermines security along the Mississippi River communities. The Katrina disaster seemed to bear witness and impart wisdom on a wide range of sustainability issues: environmental deterioration, social justice, climate change, and geographical risk. What is stunning is that the world's richest and most powerful nation was seemingly unprepared for a natural event that occurred year after year. This exemplifies the need to rethink our priorities, our relation with the natural environment and our building practices.

Record Natural Disasters

At the end of 2011, the National Oceanic and Atmospheric Administration (NOAA) said the U.S. has experienced 14 separate disasters, each with an economic loss of $1 billion or more[3], surpassing the record set in 2008. Last year's losses amounted to $55 billion. Globally, insurers lost at least $108 billion on disasters last year. Reinsurer Swiss Re Ltd. said that 2011 was the second-worst year in the industry's history. Only 2005, with Hurricane Katrina and other major storms, was more costly.[4]

Most of the increased disaster losses cannot be attributed to an increased occurrence of hazards. Although some types of events, for example, heavy rains, have increased in frequency since the 1950s, others such as hurricane landfalls in the eastern United States have declined.

Greenburg, Kansas, after an EF5 tornado leveled the town on May 4, 2007.

Natural hazard mitigation is a resilience strategy that saves lives and money. For a building to be truly sustainable it should be resilient.

Instead, they can be attributed to several other factors. In the last several decades, population in the United States has migrated toward the coasts, concentrating along the earthquake-prone Pacific coast and the hurricane-prone Atlantic and Gulf coasts, and the value of their possessions has increased substantially. More than 60 percent of the U.S. population lives within 50 miles of one of its coasts (including the Great Lakes).[5] The high concentration of people in coastal regions has produced many economic benefits, but the combined effects of booming population growth and economic and technological development are threatening the ecosystems that provide these economic benefits. Moreover, many elements of these aged infrastructures are highly vulnerable to breakdowns that can be triggered by relatively minor events.

There is No Natural Disaster

What is a natural disaster? The meaning of the word obviously changes with person, culture and time. As Brad Pitt inferred, it may be inaccurate to use the legal definition of "act of God," meaning any event outside of human control.

There is ample historical evidence to illustrate how disasters result not as much from the destructive agent itself but from the way in which communities are (or are not) prepared, and the socioeconomic conditions of the people. People living in hazardous areas are not equally at risk. Some will have fewer resources, human and material, to deal with the event. The case of Hurricane Katrina and New Orleans provides the most dramatic example of the effects of poverty on vulnerability.

- Pre-Katrina poverty rate was high (about 38 percent of the children lived in households below the poverty rate compared to 17 percent nationwide)[6]
- Like most cities across the country, New Orleans already faced a housing and infrastructure crisis.
- Renters constituted 54 percent of the city population, compared to 34 percent nationwide.
- Decades of neglect and mismanagement had left public housing developments in severe distress.[7]

Disasters happen when the natural system is encroached upon by human development. Every disaster yielding human loss, environmental degradation and political strife can be traced to specific conflict between ecologies, natural and artificial. There is no such thing as a natural disaster. As Hurricane Katrina clearly illustrated, the extent of disruption caused by a disaster is greatly influenced by the degree to which society chooses to fortify for the event.

It is apparent that there needs to be a significant shift in how we address natural disasters, moving away from the traditional focus on response and recovery toward emphasis on **resiliency**, that is, preventive actions to reduce the effects of a natural hazard.

Resilience is the New Sustainability

Resilience can be understood as the capacity to anticipate and minimize potential destructive forces through adaptation or resistance. Basically, addressing changes in the environment, whether gradual (climate change) or more abrupt (such as hurricanes) or immediate (such as a terrorist attack), require actions to mitigate their negative effects. We can consider resilience as:

> "the capability to prepare for, prevent, protect against, respond to or mitigate any anticipated or unexpected significant threat or event, to adapt to changing conditions and rapidly recover to normal or a "new normal," and reconstitute critical assets, operations and services with minimum damage and disruption to public health and safety, the economy, environment and national security."[8]

If we identify resiliency not solely as a state of preparedness for disaster, but as a desired characteristic of a sustainable society, one more in control of its energy and food production, access to water supplies, as well as being one that enables local social capital, we can begin to see the relationship. The term '**sustainability**' usually describes some aspect of maintaining our resources from the environment to the quality of life, over time. It can also refer to the ability to tolerate—and overcome—degradation of natural environmental services, diminished productivity and reduced quality of life inflicted by man's relationship to the planet and each other.

There is growing understanding that climate change is happening now and that human induced greenhouse gas (GHG) emissions are to blame. Disaster resilience must now consider the impact of climate change. Unfortunately, there is less public knowledge of how to adapt to the impacts of this global challenge and the actions necessary to reduce these risks. Here, a disaster is a signal of the failure of a society to adapt to its new environment.

Changing risks facing our housing, transportation and energy infrastructure from climate change adaptation can include:

- Higher average temperatures and higher summer peaks will affect energy production and demand;
- Winter storms can cause flooding, damage to infrastructure and dislocation of communities;
- More drought, fires and intense rainfall events will produce more mud- and landslides;
- Sea-level rise is likely to cause the greatest impacts on infrastructure and trigger the increase of environmental refugees.

Disaster resilience and climate change adaptation are not the same: disaster resilience addresses a much wider range of hazards than those relating to climate, while climate adaption's scope extends to issues beyond disasters, such as loss of biodiversity and changes to ecosystems. Nevertheless, there is a considerable overlap between them: both focus on managing risks and reducing vulnerabilities. Their agendas have also evolved separately and integration between them is crucial if we are to provide a safe and secure future. ■

Be sure to visit the digital edition of Concrete InFocus at www.nrmca.org to read Part 2 of this article.

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Disasters show the need to build for the future Part 2

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Resilience in Green Building

Critical infrastructures and other essential services have enabled societies to thrive and grow and become increasingly interconnected and interdependent from the local to global levels. As a society, we have placed a great deal of emphasis on recycling rates and carbon footprints. We are surprisingly willing to invest considerable amount of upfront capital for a LEED (Leadership in Energy and Environmental Design) Platinum certified building to achieve a mere 14 percent energy efficiency, yet be completely satisfied if the structure meets only the code minimum requirements for seismic or wind load.

Sustainable development entails making long-term use of our resources, including our buildings. It permeates all aspects of infrastructure design, construction and maintenance throughout the life of the structure. Therefore, the life of the building matters. Functional resilience is a building's capacity to provide viable operations through extended service life, adaptive re-use and the challenges of natural and man-made disasters.

The California Green Building Code, the ASHRAE 189.1 Standard and the ICC700 (National Green Building Standard) all cite life-cycle assessment (LCA) as a means to promote sustainable building practices. The latest version of LEED rating system developed by the U.S. Green Building Council (USGBC) introduced special emphasis on regionalization and LCA criteria, but does not recognize disaster resilience as one of its standard criteria. The building service life plan (BSLP) elective by the International Green Construction Code (IGCC) gives credit to proposed projects designed to have a 100-year or 200-year life span as approved by the jurisdictions.

This is a good start as building service life is rarely considered but is critical to any analysis of long-term sustainability. Balancing long-term development plans with the ability to adapt to the needs of a rapidly evolving society is vital to the ultimate success of a building life plan.

Rebuilding Stronger and Greener

On the night of May 4, 2007, a 1.7-mile wide EF5 tornado destroyed 95 percent of the 2-mile wide town of Greensburg, KS. Winds were estimated to have reached 205 miles per hour in the town. The tornado traveled for 25 miles and was on the ground for about one hour. The outbreak did not end there; a total of 84 tornadoes were confirmed reported on May 5 in the same area. Fourteen more tornadoes were confirmed on May 6 in the same general area before the activity subsided. The Greensburg tornado was the strongest to hit the U.S. since the F5 tornado that hit Moore/Oklahoma City, OK, on May 3, 1999.

High winds turned the town's infrastructure into flying debris: 961 homes and businesses were destroyed and over 500 were damaged. Out of a population of about 1,500, 11 people died (most were killed by debris while seeking shelter in basements) and 63 were injured. About 800,000 cubic yards of debris were hauled away. The town received soaking rain that night and the following days, leaving many remaining possessions unsalvageable. Hazardous waste was spread around town and oil storage tanks were damaged nearby, causing problems for the local environment and public safety.

What followed the devastation was unprecedented. A few town officials presented the idea for a model "green" community the week after the tornado struck. The Greensburg City Council approved a resolution that required all city building projects to be built according to LEED Platinum criteria. This initiative has put Greensburg on the map and is providing an example for rejuvenating rural America by reducing its environmental footprint while keeping citizens safer from severe weather.

To make buildings safer from future severe storms, every home and public building is also required to have a storm shelter or "safe room," (see sidebar) and all building materials will focus on stability and durability to make them last longer. For example, the concrete grain silo was one of the only buildings still intact after the tornado, so a new Silo Eco-Home has recently been built using the same construction methods.

With the town's goal is to run on 100-percent renewable energy, 100-percent of the time, while reducing energy use, they kept energy independence in mind as well. They chose to create buildings that are less expensive to heat and cool, healthier to live and work in, durable despite occasional hazard conditions, survivable in times of extended power outages or fuel supply interruptions, and far better for the environment.

Would the devastation encountered by this community in lives, cultural and infrastructure costs have been reduced if the community was built this way to begin with? The answer is likely yes. Ultimately, it does not matter whether urban development is wrapped in neo-traditional facades or LEED certified solar panels, if all the structures continue to camouflage the problem of poor hazard-preparedness.

Strengthening Building Codes for All

About 200 years ago, in 1811 and 1812, there were earthquakes that were so powerful in the area 50 miles north of Little Rock that seismologists still talk about it today. All of the quakes were estimated to have been magnitude-7.0 or greater. It is said that those earthquakes opened deep fissures in the ground, caused the Mississippi River to run backwards and that they were felt as far away as Boston. The earthquakes along the New Madrid Seismic Zone (NMSZ) rank as some of the largest in the United States since its settlement by Europeans. The area of strong shaking associated with these shocks were 10 times as large as that of the legendary 1906 San Francisco earthquake. Despite the significant risk, many communities living above the New Madrid fault have not enacted significant earthquake preparedness policies such as the adoption of building codes with more stringent seismic requirements.

Building codes are effective for reducing disaster risk. A building code sets standards that guide the construction of new buildings and, in some cases, the rehabilitation of existing structures. Currently, building codes set minimum construction standards for *life safety.* Maintaining the functionality of structures is important for high-risk areas, but more importantly may be critical for certain groups that are more vulnerable to natural hazards, those who do not have a choice on where they live and work.

Consider again post-Hurricane Katrina in New Orleans. Images of mostly poor people crowded into the Superdome and Convention Center vividly illustrate the argument that disasters disproportionately affect the poor. Many structures that house low-income families are relatively unsafe with respect to natural hazards, either because of poor structural quality or risk-prone locations. Such families are far less likely to have the resources to prepare themselves for catastrophes. Lower income families also commonly occupy rental housing that are often more poorly constructed than owner occupied housing.[1] A building code that sets equal disaster resilience standards for all citizens would clearly offer greater social justice.

To date, among the seven states in the New Madrid Seismic Zone, four (Arkansas, Indiana, Kentucky and Tennessee) have statewide building codes as minimum requirements, but three (Illinois, Mississippi, Missouri) do not and they pass the responsibility to the local jurisdictions to adopt the codes themselves. While all the statewide building codes have adopted the national model codes, one state also adopted amendments that weakened the model codes. Although earthquakes are high-consequence events, seismic mitigation in Mid-America generate little public interest because earthquakes in this region are low frequency.

If we are to take people's vulnerability seriously, we must deploy—and insist on—much greater technical expertise in resilient code adoption. The design community can provide some of the expertise, but its skills are not being effectively considered on the planning and policy level. The key, missing element is awareness among practitioners, the development community and policy makers.

Benefits of Natural Hazard Mitigation

Natural hazard mitigation is a resilience strategy that saves lives and money. For a building to be truly sustainable it should be resilient. It should consider potential for future use and re-use and have a long service life with low maintenance costs. In addition, a sustainable building should be designed to sustain minimal damage due to natural disasters such as hurricanes, tornadoes, earthquakes, flooding and fire. Otherwise, the environmental, economic and societal burden of our built environment could be overwhelming. A building that requires frequent repair and maintenance or complete replacement after disasters would result in unnecessary cost, from both private and public sources, and environmental burdens, including the energy, waste and emissions due to disposal, repair and replacement.

It doesn't make sense to design a modern building to meet LEED requirements that could be easily collapsed as a result of a hurricane or earthquake. That would mean that all the green technology and strategies used in the building would go to the landfill. What is the point of installing low flush toilets in a home to conserve water if it ends up in a landfill after a tornado blows through?

In 2005, the Multihazard Mitigation Council (MMC) of the National Institute of Building Sciences conducted an independent study for Congress funded by the Federal Emergency Management Agency (FEMA) to study the effectiveness of disaster mitigation. The report, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities,* quantified the future savings, in terms of losses avoided, from government grant hazard mitigation activities from 1993 to 2003.[2] The benefits of mitigation were defined as the potential losses to society that were avoided as a result of investment in mitigation. Those benefits include:

- Reduction in property damage
- Reduction in business disruption
- Reduction in nonmarket damage (environmental damage to wetlands, parks, wildlife and historic structures)
- Reduction in deaths, injuries and homelessness
- Reduction in cost of emergency response (ambulance and fire service)

The study indicates that the natural hazard mitigation grant programs funded by FEMA were cost effective and did in fact reduce future losses from earthquakes, wind and floods. The mitigation programs resulted in significant net benefit to society and potential savings to the federal treasury in terms of future increased tax revenue and reduced hazard related expenditures. The FEMA grant programs cost the federal government $3.5 billion from 1993 to 2003 but yielded a societal benefit of $14 billion. That is, for every dollar spent on mitigation they saved four dollars in avoided future losses.

Hazard Mitigation Strategies

There are essentially two ways to approach mitigation. There are voluntary programs where communities or building owners voluntarily reduce their risk of natural disaster through enhancements in structures, warning systems and education. The second approach is to install mandatory building code requirements such that communities and building owners are obligated to design buildings and infrastructure to be more disaster resilient.

Rebuilding after a natural disaster can be done in a way that prevents future damages and also protects the environment. Concrete is both strong and sustainable.

One way to encourage communities to develop fortified structures, enforce building codes and land-use management measures is to provide insurance premium reductions to all policy-holders in the area based on the stringency of land-use regulations, building code standards and inspection. The more effective a community program is in reducing future disaster losses, the greater the insurance premium reduction. The Federal Insurance Administration created such a community rating system in 1990 as a way to recognize and encourage community flood plain management activities. This model could be applied to other hazards as well.

Another approach, the FORTIFIED for Safer Living and Safer Business program of the Insurance Institute for Business and Home Safety (IBHS) are voluntary programs aimed at incorporating building techniques into construction to provide an optimum level of protection against a variety of natural hazards. IBHS is a not-for-profit applied research and communications organization supported by the insurance industry. Its focus is to reduce or eliminate residential and commercial property losses due to wind, water, fire, hail, earthquake, ice and snow.[3] The programs also address other business continuity issues such as such as interior fire, burglary, lightning protection and electrical surge.

IBHS promotes the need for strong, well-enforced building codes but also realizes that building codes offer minimum life safety standards and often don't have the necessary provisions to provide disaster resilience. For that reason, IBHS developed FORTIFIED programs that provide specific design criteria and the necessary construction and inspection oversight to ensure "code plus" structures that are truly disaster resilient.

Over 250 homes have been designated as FORTIFIED since 2001. The program was battle tested by Hurricane Ike on the Bolivar Peninsula in Texas. Thirteen FORTIFIED homes survived a direct hit from Hurricane Ike, including a 20-foot storm surge in September 2008. These FORITIFED homes were the only structures left standing for miles around, precisely because they were specifically designed and built to withstand extreme wind and water damage.

Mandatory Mitigation Standards

Mandatory mitigation programs involve having local, state and federal governments adopt stricter standards for construction of buildings and infrastructure with the objective of reducing losses from natural hazards. The two primary model building codes in the U.S. are the International Building Code (IBC) and the International Residential Code (IRC). Depending on location, some states and municipalities adopt the model codes for their jurisdictions.

The Portland Cement Association recently developed *High Performance Building Requirements for Sustainability* that go beyond the basic building code and enhance the key concepts of durability and disaster resilience. Essentially, these provisions state that for a building to be considered green, it must not only conserve energy and water, use materials efficiently and have a high-quality indoor environment, but it must also reasonably withstand natural disasters. In other words, a sustainable building must be long-lasting and durable.[4]

In addition, high performance buildings should not be a burden on their communities. They should be sufficiently resilient to disasters to ensure continuous operation and not place excessive demand on community resources such as emergency responders, including fire, police and hospitals. Communities with disaster resilient buildings are more likely to be able to continuously operate hospitals, schools and businesses after a disaster. Stronger homes and buildings mean people will have places to live and work after a disaster. Less disruption for a community means robust commerce and consistent tax revenue.

National Associations such as the National Ready Mixed Concrete Association (NRMCA) and the Portland Cement Association (PCA) continue to work at the national level to make changes to the model codes to incorporate these high performance standards. This process is difficult and could take years. However, local jurisdictions could use the standards in whole or in part to strengthen building codes to address specific hazards for their community.

Concrete's Contribution to Disaster Resilience

Concrete building systems are especially suited to provide resistance to natural hazards. Concrete has the necessary hardness and mass to resist the high winds and flying debris of tornadoes and hurricanes. Concrete is fire resistant and non-flammable, which means it can contain fires and will not contribute to the spreading of fire. Reinforced concrete framing systems can be designed to resist the most severe earthquakes without collapse. Concrete doesn't rot or rust even if it is subject to flooding.

There are many examples of structures built with heavy building materials such as concrete surviving major disasters.

When Hurricane Katrina slammed into the coastal counties of Mississippi with sustained winds of 125 mph and a storm surge that reached 28 feet, the only house to survive along the beachfront of Pass Christian, MS, was the Sundberg home. Scott and Caroline Sundberg were 85-percent complete building their dream home along the Mississippi coast when the Hurricane hit. When the winds died down and the water retreated, the Sundberg home had survived the storm. All other homes on the beachfront were completely destroyed. They built their home using insulating concrete forms (ICFs) for the walls and cast-in-place concrete frame construction for the lower level, floors and roof precisely for this reason—to survive the devastating effects of a hurricane.

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In another example, the beautiful 1907 era terra cotta building at 90 West Street in New York City was damaged during the World Trade Center attacks on Sept. 11, 2001, when the World Trade Center collapse rained fiery debris onto the building tearing deep gashes down its northern face. Fire raged on for five days completely gutting the interior. 90 West's heavy construction, which included steel frame with terra cotta arched floors topped with concrete and terra cotta exterior and interior coverings, helped serve as fireproofing and protected it from further damage and collapse. 90 West was restored and reopened as an apartment building in March 2005 and in 2006 it received a National Preservation Honor Award from the National Trust for Historic Preservation.

Disasters are Inevitable but Their Consequences Need Not Be

Resilience planning offers communities an opportunity to play a major role in determining the essential services and infrastructure needs that underpin their economic vitality, the health and safety of its citizens, and support sustainability. Voluntary methods such as IBHS's FORTIFIED programs are valuable, but the most effective method would be to change model building codes at the national level. By participating in code development so that all model codes include hazard mitigation for water, energy, conservation and land use, a community makes the conscious choice to invest in its own future regardless of socioeconomic status.

The building codes are not a panacea for all problems. Nevertheless, to subject our vulnerable population to the all-too-often, shortsighted political or economic decisions that trump safety considerations is unconscionable when the technology and economic returns of disaster resilience are well understood.

Disaster mitigation works and is cost effective. Spending time and money up front to reduce the likelihood of loss during a natural disaster can bring significant benefits to building owners and communities, including lower insurance costs, higher property values, security to residents, maintaining a consistent tax base, and minimizing the cost of disaster response and recovery.

In the end, no community can ever be completely safe from all hazards. No amount of planning can save a building from a direct blow from a tornado with 300 mph wind speeds, or a jet airliner at 500 mph. But resilience promotes greater emphasis on what communities can do for themselves before and after a disaster, and how to strengthen their local capacities, rather than be dependent on our ineffectual governmental agencies and aging centralized infrastructure. Disasters are inevitable, but their consequences need not be. ■

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