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Holistic approach to learn from wind damage

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SUMMARY
Currently, wind damage documentation conducted by structural engineers focuses on wind loads causing the damage and failure of structural systems with the hope of improving resiliency of buildings and infrastructure that is based on observations. However, improvement in resiliency through design practice has been very slow because the structural engineers depend on standards and codes which are slow in changing. It is suggested that future damage investigation and analysis of damage include disciplines of humanities, arts, and social sciences (HASS). Inclusion of social scientists can focus on human aspects of the disaster such as health system, displaced people from their homes, and recovery from the disaster. Inclusion of architects can articulate changes in aesthetics aspect of a building as well as increase in resiliency. Example of green buildings certification development is a good one where standard of practice is promoted rather than rigid rules of building codes. The disciplines of HASS will help to translate damage documentation research results into policy changes and standard of practice at a more rapid pace to improve resiliency of buildings and reduce human disasters.

Keywords: wind damage, holistic approach, human disasters, policy change

1. INTRODUCTION

In the United States every year many windstorms including hurricanes, tornadoes, and thunderstorms impact urban and suburban areas. As a result, buildings, and infrastructure, such as power, communication, transportation, and water systems, suffer extensive damages resulting into large amount of property losses as well as fatalities and injuries. According to U.S. National Oceanic and Atmospheric Administration (NOAA) catastrophe billion-dollar losses between 2000 and 2019 were US $ 1,330 billion, a total that translates to US $ 66 billion annual average losses. Windstorms cause almost 77% of these losses. Future losses from windstorms are likely to increase because of the growing population in hazard-prone regions, the aging of buildings and infrastructure, and changing climate.

Wind damage documentation has been going on since 1960s and 1970s. During the last 50-year period a large amount of damage investigation has been conducted on-site after a variety of storms. Lessons learned from these efforts have improved design practice, but it is slow and incremental and primarily in the coastal areas where hurricanes make landfalls. The improvement in the design practice is very slow because structural engineers depend on building standards and codes. A specific example is the revision of ASCE 7 standard in 1982, 1988, 1995, and 1998 for wind loads was not adopted by the International Building Code till year 2000, almost a 20-year span. Another example is that the Florida Building Code was not adopted statewide till year 2000 even though Hurricane Andrew in 1992 clearly showed the deficiency in wind loading and debris impact criteria.

This paper suggests involving disciplines of humanities, arts, and social sciences (HASS) in performing and analyzing the damage investigations. Involvement of these disciplines could allow policy changes that is needed to improve design standard of practice. Even though this paper focuses on practices in the United States, the concept is applicable to other countries.

2. CURRENT PRACTICE OF DAMAGE INVESTIGATION

Current practice of damage investigation and documentation is to go to the site of damage as soon as possible before major clean-up occurs. Structural engineering group organized under the National Science Foundation (NSF) National Hazard Engineering Research Infrastructure (NHERI) RAPID provides support for damage investigations. This national effort includes social scientists wherever possible. Before this national effort only structural and/or construction engineers performed damage documentation and investigation. U.S. Federal Emergency Management Agency (FEMA) performed damage investigation under its Building Performance Assessment Team (BPAT) program.

Following damage investigation, the entities doing the work (FEMA, university faculty, trade association, etc.) publish reports pointing out which building components performed well and which ones failed due to wind loads or deficiencies in design or in construction. These results cumulatively are presented to building standard and code committees to make necessary adjustments in structural design practice.

In the United States, standards and codes are consensus documents. Hence, they are slow in developing. They are revised at intervals of four to six years. In addition, consensus process is slow because input is obtained from material associations, trade organizations, and other groups which have economic concerns for their products. Experiences in the past have indicated that it may take up to ten to twenty years to change standard and building codes. There is little room for policy changes or improving the standard of practice.

We, as engineers, document wind speeds (to the extent possible) that cause the damage, the construction material of the building, the structural system of the building, the mode of failure of the components and structural systems, among other technical items. We use these documented materials and try to provide technological solutions to improve resiliency of buildings. In other words, we focus on Science, Technology, Engineering, and Mathematics (STEM). However, windstorm impact is more than technical problem. It involves first responders, caring for people whose homes are devastated, insurance adjustments, emergency shelters, and taking care of men, women and children who have gone through trauma. Unless we integrate disciplines of Humanities, Arts, and Social Sciences (HASS) in documenting the damages and pursue a holistic approach to the lessons learned from the disaster our progress in improving resiliency is likely to be incremental and slow.

3. WHAT CAN INTEGRATION OF HASS ADD?

Windstorm impact is a human disaster for the society. It involves people. First responders and health systems are the first ones involved in recovery following a disaster. First responders have the responsibilities of providing rescue of people irrespective of the condition of a building or accessibility of damaged area. Their job in a disaster is not a long-term commitment. If a building has sustained minimum damage, resources needed for first responders are not high. One of the messages that can be conveyed by engineers and first responders together to the decision makers is that if buildings are made more resilient, resources needed for first responders can be reduced.

Health system is crucial after a windstorm impact. Hospitals and clinics should continue to function for the patients who are in it as well as be able to take on new patients. Design and construction of hospital buildings and supporting services should be above and beyond other buildings, such as office buildings. Even the pathway to hospitals should be such that they can be accessed with debris strewn in the streets. This message should be conveyed to emergency department of cities and not depend on just the requirements of a standard or a building code.

Emergency operations require swift actions to provide shelter and food to people who may have found their homes unhabitable. A home or a building is not usable or occupiable if there is wind and water damage to the interior. Emergency shelters along with acceptable services are in the hands of emergency department of the community. If buildings and homes are made resilient to damage and prevent water intrusion, emergency shelter requirements can be reduced. This message can be conveyed to city governing bodies by emergency managers.

Aesthetics of a building has a significant impact on the society. At times architectural requirements create a weak link for wind damage in a building system. One of the weak links was observed in facia plate at the connection of roof to the wall. Performance of the metal plate (cleat) depends on the quality of installation. In a large building where there is long linear footage of cleat it may not be possible to provide perfect installation. If not properly anchored at every foot, the wind initiates the damage at a weak location and propagates along the roof exposing interior to wind and rain. Architects can also help reduce wind induced pressures with addition of features at the roof edge, if acceptable aesthetically. In addition, architects are very good at articulating need for improving standard of practice. Involvement of architects in damage documentation and analyses has a large potential of improving resiliency of buildings.

Insurance adjusters can play a critical role in recovery following a disaster. People who have lost household items and are not able to stay in their homes would like to return to their homes as soon as possible. A quick and equitable insurance payout will assist the people to move back to the community. Same thing holds true for businesses including restaurants. If repairs to eateries take a long time, the places have tendency to close. This closing is a loss not only to the owner of the restaurant but also to the community with limited places to eat. Insurance/reinsurance companies can convince the decision makers on advantages to make the community more resilient.

An example of rapid implementation of standard of practice is green building certification in the United States. Green building is defined as “the practice of 1) increasing the efficiency with which buildings and their sites use energy, water, and materials, and 2) reducing building impacts on human health and the environment, through better siting, design, construction, operation, maintenance, and removal — the complete building life cycle (OFEE, 2003).” American Institute of Architects developed the idea of “Leadership in Energy and Environmental Design (LEED)” certification. In the United States Green Building council (USGBC), a non-profit organization develops the criteria for LEED certification. By considering holistic design of a building, the LEED has four categories: Certified, Silver, Gold, or Platinum. Criteria for certification is evolving rapidly where it started with V1 in 2002 (Gissen, 2002) and updated to V4 in 2016. What is unusual about LEED certification is that the owners of the building are requesting higher certification of their building and willing to pay for upgrades rather than building code criteria that are imposed on the design of a building. Structural resiliency of buildings can be upgraded with implementation of standard of practice, similar to LEED, rather than by rigid building code requirements.

4. CONCLUDING REMARKS

National Academies in USA has a report on integration of the Humanities and Arts with STEM fields in education (NASEM, 2018). The report is primarily for education of undergraduate students. But it points out that the same arguments are valid for graduate education and could be for research and practice. Kaye Fealing, Dean of Liberal Arts at Georgia Institute of Technology also makes a case that integration of two fields of STEM and HASS is needed to make progress in 21st century (Fealing, et al, 2022). For windstorm damage, integration of the two fields in documenting and analyzing will help in humanizing the disastrous events, in understanding the need for improvement in resiliency, and in articulating the need to decision makers. Humanizing and articulating the need to reduce impact of windstorms is necessary to improve standard of design practice and resiliency of buildings in a short period.

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