Multidisciplinary Assessment of Critical Facility Response to Natural Disasters

The Case of Hurricane Katrina

Edited by Adam W. Hapij, P.E.

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MULTIDISCIPLINARY ASSESSMENT OF CRITICAL FACILITY RESPONSE TO NATURAL DISASTERS

THE CASE OF HURRICANE KATRINA

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Preface

Certain dates are associated with such tragedy that they have become permanently etched in the American psyche. Two examples are December 7, 1941, and September 11, 2001. For many Americans, another is August 29, 2005. On that date Hurricane Katrina made landfall near Buras, Louisiana, as a Category 3 storm with sustained winds of 125 mph, a central pressure of 920 mbar, and hurricane-force winds extending over a 120-mile radius. Based on size and intensity, Katrina became the fourth (now fifth) most severe hurricane to make landfall in the Gulf of Mexico since 1960. If Katrina had made landfall just a few hours earlier and just a few miles to the west, it would have come ashore as a Category 5 storm that likely would have surpassed all others in severity. Nevertheless at more than $100 billion in damage, it has become the costliest natural disaster in the United States.

Hurricane Katrina brought devastation to the coasts of Louisiana, Mississippi, and Alabama. The most severe impact was to the city of New Orleans, where more than 1,500 lives were lost and about 80 percent of the city was flooded for an extended period of time. Some of the flooding rose to a depth of 10 ft. and thousands of homes were destroyed. Public and private property damage in and around New Orleans exceeded $28 billion. Perhaps more importantly, Katrina caused the largest redistribution of people in U.S. history. Prior to Katrina, the population of New Orleans was estimated to be 454,863. The city lost about 50 percent of its residents for two years or more, and probably lost at least 25 percent of its residents permanently. In addition, approximately 125,000 jobs were lost as the local economy unraveled. Recovery from this record-setting disaster has been and will continue to be slow, expensive, and uncertain.

Engineers always learn more from their failures than from their successes. Consequently, the U.S. Army Corps of Engineers (USACE), the American Society of Civil Engineers (ASCE), and many other organizations sent study teams to New Orleans to determine what went wrong, why it went wrong, and how these failures might be prevented in the future. The focus of most of these studies was on the flood protection system, which turned out to be a system in name only. In actuality, it was an assemblage of miss-matched elements that had been designed, constructed, and maintained by numerous parties over several decades. Many of these elements were poorly designed, others were shoddily constructed, and very few were properly maintained. No one person or organization was in charge of the overall system, which had become a chain with multiple weak links. All of this led to an inordinate amount of risk, which was never fully understood nor effectively communicated to the public. Consequently, several hundred thousand people lived in the New Orleans area with a false sense of security. While these are some of the lessons learned from studying the flood protection system, what could be learned from studying other systems?

Architectural engineers view buildings as systems comprised of interactive elements, somewhat analogous to the human body. The building envelope serves as the skin, the structure as the bones and muscle, the plumbing as the digestive system, the mechanical system as the heart and lungs, the electrical system as the brain and nerves, and so forth. Like the human body under stress, damage to one element can cause damage to other elements and, with enough damage, overall failure. The failure of a building is not limited to catastrophic fire or collapse. For example, if a building is intended to serve as a storm shelter but subsequently becomes uninhabitable for any reason, it can be deemed to have failed.

Essential buildings, such as hospitals, facilities for the elderly, and facilities intended as storm shelters, are expected to be minimally damaged and remain operational during extreme events. How did the essential buildings in New Orleans perform during and after Hurricane Katrina? ASCE's Architectural Engineering Institute (AEI) sent a multi-disciplinary study team to New Orleans in December 2005 to answer this question. With limited resources and restricted access, they were able to study five facilities: two hospitals that were intended to serve as storm shelters, two elderly care facilities that were evacuated, and a college dormitory that ended up serving as a storm shelter even though it was not intended to do so.

Only one facility, the East Jefferson General Hospital, performed successfully as a storm shelter during Hurricane Katrina and for an extended period of time thereafter. The other four facilities failed, typically due to a lack of water or power. Perhaps the overriding lesson learned is that any facility whose operation is required both during and after an extreme event cannot be dependent on outside utility services. Instead, the facility must have captive, substantive, and redundant sources of water, electricity, fuel, and communications. In addition, it must have adequate on-site systems to ensure security and to provide waste disposal.

This report presents the findings of the AEI study team. The report is organized into a series of chapters addressing the performance of mechanical/electrical/plumbing (MEP) systems, building envelopes, structural systems, fire protection and life safety systems, and communications systems. Like any well-thought-out presentation, the best part of this report has been saved for last. Chapter 7, and the two appendices which follow it, present the application of a relatively new approach to multi-disciplinary risk assessment. This methodology, and the data collection forms which feed it, represent a valuable contribution to the state of the practice in evaluating the performance of buildings following extreme events. Regrettably, Hurricane Katrina will not be the last devastating natural or manmade disaster in the United States. Building evaluations in the aftermath of future events should adopt and build upon the multi-disciplinary risk assessment methodology presented in this report.

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Richardson, Texas January 2010

Acknowledgements

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With the exceptions noted, all the photos in this report were taken in December 2005 in New Orleans by the team sent by the Architectural Engineering Institute of ASCE to study the aftermath of Hurricane Katrina.

Adam W. Hapij, P.E.

Table of Contents

Chapter 1: Introduction

Amar A. Chaker, Ph.D.
Adam W. Hapij, P.E.

Background

Beyond the suffering and devastation major disasters cause, there is an opportunity for design and construction professionals to learn from the performance of the built environment and to advance the knowledge and practice in their fields. This narrative documents the steps taken by the AEI Board of Governors and the Task Committee for the Study of the Aftermath of Hurricane Katrina it created to study the aftermath of Hurricane Katrina.

Shortly after Hurricane Katrina made land fall, it became apparent that extensive loss of life and devastating damage to the built environment had taken place. In particular, buildings were subjected to extreme winds, airborne debris, rain, storm surge, waterborne debris, flooding, and even fire, and numerous buildings failed in the disaster area. The flooding that occurred when several levees in New Orleans were breached brought a new level of distress to the population and to the built environment.

From media reports and Web sites, it was clear that the failures ranged from total collapse to breaching of the building envelope (walls, façade, glazing, curtain wall, cladding, roof, and such), extensive damage to the architectural engineering systems (HVAC, plumbing, fire protection system, electrical system, and such), and the inundation of building interiors. It also appeared that in some cases satisfactory performance occurred under these same extreme circumstances.

AEI Initiative: Katrina Task Committee

It was immediately clear to the AEI leadership that this event created both a duty and an opportunity to investigate the performance of buildings and their architectural engineering systems under such extreme conditions. There was an urgent need to document what happened, understand why it happened, and—from observations, investigations, and analyses—extract lessons learned and formulate recommendations for improving building design and construction.

Investigating and documenting the performance of architectural engineering systems under extreme conditions has the potential to generate the knowledge necessary to assess the adequacy of our current design procedures, models, and codes; to assess our current construction, operation, and maintenance practices; and to confirm their validity or formulate changes. This would advance the Architectural Engineering Institute's knowledge and practice, enhance the disaster resiliency of buildings, and ultimately contribute to reducing the risks from natural hazards.

By the end of September 2005, the AEI Board of Governors voted unanimously to create a task committee to study the performance of architectural engineering systems during Hurricane Katrina. In particular, the AEI Board asked the task committee to examine the following aspects:

- response of the different architectural engineering systems and their components inside and outside buildings;
- response of the building envelope;
- building management during and after disasters;