A Multihazard Approach to Building Safety: Using FEMA Publication 452 as a Mitigation Tool

Introduction
Large damaging events in the U.S., such as the terrorist attack of September 11, 2001, and Hurricane Katrina on August 25, 2005, have changed the way in which many design professionals view building design. The need to consider a multihazard approach to include all hazards, that is, earthquakes, floods, winds, and explosive and chemical, biological, and radiological (CBR) attacks, has become paramount and a major National trend.

Since September 11, sites, buildings, and infrastructure at high risk since they may lack appropriate protective measures to resist blast and CBR effects. Introducing building security measures Nationwide can be a complex issue. Many will argue that the probabilities of a terrorist attack are limited, and designing for building security can be very costly. However, rare man-made disasters can be catastrophic and trigger negative social and economic impacts, such as those produced by the collapse and damage of major buildings in the Financial District of New York City.

Hurricane Katrina also triggered a new approach in terms of building design safety. The hurricane made landfall August 25, 2005, causing wide-spread devastation along the Gulf Coast, with southeast Louisiana and the coasts of Mississippi and Alabama bearing the brunt of the catastrophic damage. The greatest damage was caused by Katrina’s storm surge, which precipitated the failure of the levee system protecting the city of New Orleans. The estimated death toll is over 1,000 and economic losses are in excess of $125 billion, making Hurricane Katrina the most expensive natural disaster in the Nation’s history.

The attacks on the World Trade Center and Hurricane Katrina are two unique disasters due to their social and economic consequences. However, other catastrophic disasters which have inflicted grief and caused desolation to large sectors of society can stress the need to consider all hazards when contemplating building safety. Flooding is the most common natural hazard in the U.S., affecting over 20,000 local jurisdictions and representing more than 70 percent of Presidential Disaster Declarations. Several evaluations have estimated that 10 percent of the Nation’s land area is subject to flooding, with some communities almost entirely within the floodplain.

In the United States, we have not experienced a large earthquake recently. However, continuous scientific scrutiny of seismic activity and recent devastating earthquakes around the world, like the 1995 earthquake in Kobe, Japan, demonstrates that earthquakes are a deadly hazard.
Japan, like the U.S., is among the most technologically advanced countries in the world. The Kobe earthquake caused more than $100 billion in direct damage to buildings and facilities and more than 5,500 deaths. The Northridge, California earthquake in 1994 struck a modern urban environment generally designed to withstand the forces of earthquakes. Its economic cost has been estimated at $20 billion.

Concise and cost-effective tools are necessary in building design and rehabilitation to protect against hazards—specifically multihazards—regardless of the locale. FEMA’s Risk Management Series (RMS) provides publications and tools specifically designed to focus on a multihazard approach and include steps to mitigate against a variety of terrorist threats and natural hazards. The FEMA publication 452, Risk Assessment: A How-To Guide to Mitigate Potential Terrorist Attacks, is a unique tool designed for users to conduct risk assessments of both man-made threat and natural hazards with integration into building design and/or building rehabilitation. This publication helps users identify and quantify the value of assets, evaluate the potential vulnerability of the critical assets against a broad range of identified threats and hazards, and determine mitigation measures.

**FEMA 452 and a Five-Step Process**

The risk assessment process within FEMA 452 is based on five critical steps. These critical steps aim at identifying the best and most cost-effective terrorism mitigation measures for a building’s unique security needs. The first step of the assessment process is to conduct a threat/hazard assessment wherein the threat or hazard is identified, defined, and quantified. For terrorism, the threat is the aggressors (people or groups) that are known to exist and have the capability and a history of using hostile actions, have expressed intentions for using hostile actions against potential targets, have current credible information on targeting activity (surveillance of potential targets), or have indications of preparing for terrorist acts. For a natural hazard, the threat is the exposure of the building environment to the range of forces generated by earthquakes, floods, and high wind events. The frequency of events tied to a specific geographical location is a key element of this step.

The second step is to identify the value of a building’s assets that need to be protected. Asset value can be defined as a degree of debilitating impact that would be caused by the incapacity or destruction of an asset. Asset value refers to the criticality of the building in terms of the

1 Data Earthquake Engineering Research Institute  
2 Data U.S. Geological Survey
importance of the building operation to the owner and the locality. This value can be applied to the entire building or significant portions of a very large building. It can also refer to a resource of value requiring protection. Asset value can be tangible (i.e., buildings, facilities, equipment activities, operations, and information) or intangible (i.e., processes or a company’s information and reputation).

After assessing an asset value, the third step is to conduct a vulnerability assessment. A vulnerability assessment evaluates the potential vulnerability of the critical assets against a broad range of identified threats and natural hazards. By itself, the vulnerability assessment provides a basis for determining mitigation measures for protection of the critical assets. The assessment is a bridge in the methodology among threat/hazard, asset value, and the resultant level of risk.

The fourth step of the process is the risk assessment. The risk assessment analyzes the likelihood or probability of the threat or natural hazard occurring and the consequences of the occurrence. Thus, a very high likelihood of occurrence with very small consequences may require simple low cost mitigation measures, but a very low likelihood of occurrence with very serious consequences may require more costly and complex mitigation measures. The risk assessment should provide a relative risk profile. High-risk combinations of assets against associated threats, with the identified vulnerability, allow prioritization of resources to implement mitigation measures.

The fifth and final step is to consider mitigation options that are directly associated with, and responsive to, the major risks identified during Step 4. From Step 5, decisions can be made as to where to minimize the risks and how to accomplish them over time. This action is commonly referred to as risk management. For the identification of mitigation methods, FEMA 452 offers a range of options which include regulatory measures, rehabilitation of exiting structures, and protective and control measures.

Levels of Assessment
An important attribute of FEMA 452 is that it provides users guidance in conducting a variable scale of assessments, ranging from a screening level to in-depth assessment methodologies. The level of assessment for a given building is dependent upon a number of factors such as type of building, location, type of construction, number of occupants, economic life, and other owner specific concerns and available economic resources. FEMA 452 defines a three-tier assessment process as follows:

- Tier 1. A Tier 1 assessment is a “70 percent” assessment. It can typically be conducted by one or two experienced assessment professionals in approximately two days. A Tier 1 assessment will likely be sufficient for the majority of commercial buildings and other non-critical facilities and infrastructure.

- Tier 2. A Tier 2 assessment is a “90 percent” assessment solution. It typically requires three to five assessment specialists, can be completed in three to five days, and requires significant key building staff participation. A Tier 2 assessment is likely to be sufficient for most high-risk buildings such as iconic commercial buildings, government facilities, schools, hospitals, and other high-value designated infrastructure assets.
• Tier 3. A Tier 3 assessment is a detailed evaluation of the building using blast, weapons of mass destruction (WMD), earthquake, flood, and high wind models to determine building response, survivability, and recovery, and the development of mitigation options. The assessment team is not defined for this tier; however, it could be composed of 8 to 12 people. Modeling and analysis can often take several days or weeks and is typically performed for high value and critical infrastructure assets.

The Building Vulnerability Checklist
A core element of FEMA 452 is the Building Vulnerability Assessment Checklist, covering explosives, CBR, earthquakes, floods, and high wind hazards. The checklist can be used to collect and report information related to the building infrastructure. It compiles many best practices based on the latest technologies and scientific research to consider during the design of a new building or renovation of an existing building.

The checklist is organized into 13 sections which are distributed among the assessors according to the expertise of the team member. Typically, each assessment team member will be responsible for completing several sections of the checklist; the amount and detail of information that can be acquired and inputted into the checklist will depend upon the on-site time available and the amount of information that is readily available versus difficult to find.

The Risk Assessment Database
To support the building assessment process, a Risk Assessment Database has been developed as a companion tool of FEMA 452. The database is a stand-alone application that has several functions: import files and folders; display digital photos, emergency plans, and digital floor plans; and provide specific Geographic Information System (GIS) tools. The database can be used to collect and report information related to the building infrastructure.
Benefits and Conflicts of Multihazard Design

FEMA 452 describes the concept of a multihazard design system interaction, highlighting the effects of designing for more than one hazard on the performance and cost of the building, addition, or repair. It includes a six-page matrix with five primary hazards organized in the horizontal rows. The vertical rows include methods of protection for the building systems and components that have significant interaction, either reinforcement or conflict. The hazards described are earthquakes, floods, high winds, blast, and fire. Interactions shown in this matrix are intended to help designers analyze potential conflicts that may emerge when designing buildings against multihazards. The designer is encouraged to use the matrix as a basis for discussion relative to specific projects and to assess the benefits and conflicts of multihazard design depending on local hazards.

An important consideration of designing against multihazards in an integrated approach is that the methods used for design may reinforce one another or may conflict with one another. In the former case, the costs of multihazard design can be reduced, but in the latter, they may be increased. When undertaking a multihazard and multidisciplinary approach, designers need to be aware that reinforcement between hazards may be gained, and undesirable conditions and conflicts can be resolved by coordinated design between the consultants, starting at the inception of design.

Conclusion

FEMA’s RMS publications provide an important opportunity to implement multihazard design. The approach outlined in FEMA 452 and other RMS publications will save on costs, improve efficiency, and promote better performance in buildings. It is imperative that a multihazard approach becomes an integral part of building planning and programming. A multihazard approach is an effective method when protecting new and existing buildings or infrastructure located in areas that are exposed to a variety of natural and manmade disasters. The premise of this approach is that by adopting a multihazard and multidisciplinary approach, cost-savings, efficiency, and better performance can be achieved when programming and planning new buildings and retrofitting existing ones. The prevalence of a multihazard/multidisciplinary approach is certainly to become the new paradigm.