MCEER's Resilience Framework

Resilience Concept Drives Development of New Knowledge, Tools & Technologies

Framework is Foundation for Disaster Resilience for Organizations & Communities

Equipping organizations and communities with knowledge, tools and technologies that enable them to stand strong and bounce back when disaster strikes - this is the driving force behind MCEER research, education and outreach programs.

MCEER develops new knowledge, decision tools & methodologies, and advanced technologies for pre- and post-disaster use. These include network modeling tools for lifelines; structural control and nonstructural component anchoring systems for critical infrastructure and building contents; and remote sensing technologies for loss estimation, response and recovery.

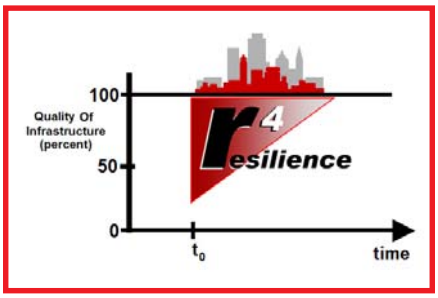
At the foundation of all of these efforts is the center's concept of Disaster Resilience - a concept that provides the basis to:

- *quantifiably assess a current state of resilience,*
- *set specific objectives to improve upon it, and*
- *establish remedial tasks and measure progress toward meeting pre-determined resilience targets.*

The objectives of enhanced Disaster Resilience are to minimize loss of life, injuries, disruption of important services, and economic losses; in short, to minimize any reduction in quality of life due to disaster.

Disaster Resilience Defined

Disaster resilience, as MCEER defines it, is the ability of social units (e.g., organizations, communities) to mitigate hazards, contain the effects of disasters, and carry out recovery activities in ways that minimize social disruption, while also mitigating the effects of future disasters. Consequently, strength, flexibility, and the ability to cope with and overcome extreme challenges, are the hallmarks of disaster-resilient communities.



Resilience is represented by the red triangle above. When disasters strike (t_0), damage to critical infrastructure results in diminished performance. Over time, infrastructure is restored to its original functionality. Four "Rs" - Robustness, Redundancy, Resourcefulness, and Rapidity - represent the fundamental properties of Disaster Resilience.

Characteristics of Resilience

Inherent in the definition of disaster resilience are a number of characteristics that help to make it more tangible and measurable.

Specifically, disaster resilience is characterized by:

- ***Reduced failure probabilities -*** i.e., the reduced likelihood of damage & failures to critical infrastructure, systems and components;
- ***Reduced consequences from failures -*** in terms of injuries, lives lost, damage and negative economic and social impacts; and
- ***Reduced time to recovery -*** the time required to restore a specific system or set of systems to normal or pre-disaster level of functionality.

Based on these characteristics, resilience can be enhanced by reducing the likelihood of failures to critical infrastructure (thereby, reducing their impacts) and speeding the time to recovery.

Disaster Resilience Publications by MCEER Researchers

The following is a brief bibliography of MCEER publications on aspects of Disaster Resilience.

Enhancing the Resilience of Communities against Extreme Events from an Earthquake Engineering Perspective, Bruneau, M., 2006.

Overview of the Resilience Concept, Bruneau, M. and Reinhorn, A., 2006.

Seismic Resilience of Communities - Conceptualization and Operationalization, Bruneau, M. and Reinhorn, A., 2004.

A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities, Bruneau, M., Chang, S.E., Eguchi, R.T., Lee, G.C., O'Rourke, T.D., Reinhorn, A.M., Shinozuka, M., Tierney, K., Wallace, W.A. and von Winterfeldt. D., 2003.

Resilient Community Recovery: Improving Recovery Through Comprehensive Modeling, Chang, S.E. and Miles, S.B., 2003.

Quantification of Seismic Resilience, Cimellaro, G.P., Reinhorn, A. and Bruneau, M., 2006.

Resilience of Lifeline Systems

Assessing the Role of Lifeline Systems in Community Disaster Resilience, Chang, S.E. and Chamberlin, C., 2004.

Measuring Improvements in the Disaster Resilience of Communities, Chang, S.E. and Shinozuka, M., 2004.

Fostering Disaster Resilience through Addressing Infrastructure Interdependencies, Chang, S.E., McDaniels, T.L. Longstaff, H. and Wilmot, S., expected 2006.

Resilient Infrastructure: Lessons from the WTC, Crisis Response, O'Rourke, T.D., Lembo, A.J. Nozick, L.K. and Bonneau, A.L., 2005.

Understanding Sources of Economic Resiliency to Hazards: Modeling the Behavior of Lifeline Service Customers, Rose, A. and Liao, S., 2003.

Business Interruption Impacts of a Terrorist Attack on the Electric Power System of Los Angeles: Customer Resilience to a Total Blackout, Rose, A., Oladosu, G. and Liao, S., expected 2006.

Evaluating the Disaster Resilience of Power Networks and Grids, Shinozuka, M. and Chang. S.E., 2004.

Resilience of Integrated Power and Water Systems, Shinozuka, M., Chang, S.E., Cheng, T-C., Feng, M., O'Rourke, T.D., Saadeghvaziri, M.A., Dong, X., Jin, X., Wang, Y. and Shi, P., 2004.

Properties of Resilience: The Four "Rs"

In an effort to enhance these disaster resilience characteristics, MCEER's concept of resilience considers four fundamental properties. They are:

- ***Robustness*** **-** strength, or the ability of elements, systems, and other units of analysis to withstand a given level of stress or demand without suffering degradation or loss of function;
- ***Redundancy*** **-** the extent to which elements, systems, or other units of analysis exist that are substitutable, i.e., capable of satisfying functional requirements in the event of disruption, degradation, or loss of function;
- ***Resourcefulness*** **-** the capacity to identify problems, establish priorities, and mobilize resources when conditions exist that threaten to disrupt some element, system, or other unit of analysis (resourcefulness can be further conceptualized as consisting of the ability to supply material - i.e., monetary, physical, technological, and informational - and human resources to meet established priorities and achieve goals); and
- ***Rapidity*** **-** the capacity to meet priorities and achieve goals in a timely manner in order to contain losses and avoid future disruption.

MCEER's research program focuses on improvements in robustness of critical infrastructure via advanced structural control and other technologies. It likewise addresses characteristics of resourcefulness and rapidity through development of analytical tools for utility lifeline performance and remote sensing for response and recovery.

The challenge to organizations and communities is to build upon the four "Rs" by developing specific metrics to assess the current state of each, and setting precise objectives and actions to improve upon each.

Dimensions of Resilience

In addition to the aforementioned properties of resilience, MCEER's framework includes the following Dimensions of Resilience. These can be used to help quantify measures of resilience for various types of physical and organizational systems.

- ***Technical*** **-** the ability of physical systems (including all interconnected components) to perform to acceptable/desired levels when subject to disaster;
- ***Organizational*** **-** the capacity of organizations - especially those managing critical facilities and disaster-related functions - to make decisions and take actions that contribute to resilience;
- ***Social*** **-** consisting of measures specifically designed to lessen the extent to which disaster-stricken communities and governmental jurisdictions suffer negative consequences due to loss of critical services due to disaster; and
- ***Economic*** **-** the capacity to reduce both direct and indirect economic losses resulting from disasters.

The performance of Technical and Organizational systems impacts a community's Social and Economic systems in times of disaster. For example, loss of electrical power (Technical) will negatively impact the way of life of community residents (Social) and businesses (Economic). Thus, resilience objectives for Technical and Organizational dimensions should result in specific tasks that improve performance in each of these dimensions, thereby lessening negative impacts on communities. Likewise, Social and Economic performance measures can be defined that improve a community's ability to withstand and recover rapidly from disaster.

MCEER studies continue to build upon this foundational framework for disaster resilience for earthquakes and other extreme events.

(See "Disaster Resilience Publications by MCEER Researchers" for a short list of publications.)

Publications (cont'd.)

Resilience of Acute Care Facilities

Decision Models: Approaches for Achieving Seismic Resilience, Alesch, D.J., Dargush, G.F., Grigoriu, M., Petak, W.J. and vonWinterfeldt, D., 2003.

Exploring the Concept of Seismic Resilience for Acute Care Facilities, Bruneau M. and Reinhorn, A., 2006.

Operationalizing the Concept of Seismic Resilience for Acute Care Facilities, Bruneau, M. and Reinhorn, A., in press.

Seismic Resilience of a Health Care Facility, Cimellaro, G.P., Reinhorn, A., and Bruneau, M., 2005.

Enhancing the Resilience of Acute Care Facilities: An Overview of MCEER Research, Filiatrault, A., Bruneau, M., Alesch, D., Constantinou, M., Dargush, D., Grigoriu, M., Lee, G., Maragakis, E., Mosqueda, G., Petak, W., Reinhorn, A., and von Winterfeldt, D., 2006.

Technology-Aided Situation Awareness: A Key to Organizational and Community Resilience in Disaster Management, Petak, W.J., 2006.

Resilience of Response & Recovery

Resilient Disaster Response: Using Remote Sensing Technologies for Post-Earthquake Damage Detection, Eguchi, R.T., Huyck, C.K., Adams, B.J., Mansouri, B., Houshmand, B. and Shinozuka, M., 2003.

Networks and Resilience in the World Trade Center Disaster, Tierney, K. and Trainor, J., 2004.

Multi-Hazard Resilience

White Paper on the SDR Grand Challenges for Disaster Reduction, Bruneau, M., Filiatrault, A., Lee, G.C., O'Rourke, T.D., Reinhorn, A.M., Shinozuka, M. and Tierney, K., 2005.

For More Information

If you have questions about MCEER's Foundational Framework for Disaster Resilience or if you would like to discuss how MCEER might help put it to work for your organization, please contact MCEER at the University at Buffalo.

MCEER
EARTHQUAKE ENGINEERING TO EXTREME EVENTS

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