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How the National Earthquake Hazards Reduction Program Is Advancing Earthquake Safety

The Mid-America Earthquake Center: Managing Seismic Risks from Source to Society

This is the second in an intermittent series of articles about three earthquake engineering research centers funded over the past 10 years by the National Science Foundation. All three centers are "graduating" from the Foundation's engineering research centers program and are transitioning into the next chapters of their organizational lives. These stories briefly review the centers' accomplishments and plans for the future. This article focuses on the Mid-America Earthquake Center; a future story will spotlight MCEER, and an article on the Pacific Earthquake Engineering Research Center is available at http://www.nehrp.gov/pdf/SeismicWavesFeb08.pdf.

Seismic hazards present unusual challenges in the central United States. Major earthquakes in this area occur at time intervals longer than those in California, but impact much larger areas that are much less prepared. Despite facing similar risks from such earthquakes, midwesterners are generally less aware of them than are Californians since the smaller earthquakes that serve as reminders of seismic hazards are less frequent in the Midwest.

These challenges prompted the National Science Foundation (NSF) to establish the Mid-America Earthquake (MAE) Center in 1997, and to support the Center through its first decade in operation under grant award EEC-9701785. The Center is a consortium of nine core institutions headquartered at the University of Illinois at Urbana-Champaign (UIUC).

The MAE Center has developed an approach called Consequence-based Risk Management (CRM), for managing the risks posed by earthquake hazards in the central and eastern United States. It has also led the development of a comprehensive new software system, MAEviz, that employs the CRM approach. The Center has conducted targeted research that has generated the fundamental knowledge and enabling technologies needed to develop CRM and MAEviz. And it has tested CRM and MAEviz in real-world applications both in the United States and overseas.

Consequence-based Risk Management

CRM has applicability wherever seismic hazards confront populations whose concern for the risks posed is tempered by resource scarcities and the relative infrequency of earthquakes. The approach helps draw attention to seismic risks through rigorous scientific assessment of the likely consequences of earthquakes. The physical, economic, and social impacts expected from earthquakes are clearly visualized and evaluated against those considered acceptable by societal stakeholders.

MAE Center Core Institutions

- University of Illinois at Urbana-Champaign
- George Washington University
- Georgia Institute of Technology
- Texas A&M University
- University of Memphis
- University of Michigan
- University of Puerto Rico, Mayaguez Campus
- University of Texas, Austin
- Washington University

When expected consequences exceed those deemed acceptable, CRM calls for either (*a*) further assessment of the hazard to refine expected impacts, (*b*) reconsideration of what is acceptable, or (*c*) reduction of expected consequences through mitigation. Mitigation options are visualized so that stakeholders can compare their effects on earthquake consequences and the levels of associated uncertainty. When expected consequences reach acceptable levels, CRM calls for the development of earthquake response and recovery plans tailored to these impacts. The hallmarks of CRM are the comprehensive scope of its risk assessments, which extend from the geologic sources of earthquakes to their societal consequences, and the broad range of consequences that are assessed, from physical impacts on the built environment to economic and social impacts on affected populations.

MAEviz

The MAE Center has developed MAEviz as a comprehensive cyberinfrastructure application capable of supporting hazard risk management in general, and CRM implementation in particular. MAEviz software comprises a suite of Web-enabled methods, models, and data, developed in close cooperation with UIUC's National Center for Supercomputing Applications, designed for integrating, visualizing, and assessing an unprecedented array of earthquake impacts—from conventional effects on buildings and bridges to impacts

relating to static and dynamic traffic modeling, utility network interactions, and assignment of temporary housing. Over the past decade, as the MAE Center has completed the research required to implement CRM, it has incorporated the products of this research into MAEviz. The result is a fully functional, state-of-the-art impact assessment tool that builds upon earlier earthquake loss-estimation technologies.

Research Thrusts and Test Beds

MAE Center research has brought dozens of faculty and students from the Center's core partner institutions and other affiliated universities together with numerous stakeholders from government and the private sector, both in the United States and abroad. The research team is multidisciplinary, with participants from the fields of engineering, earth sciences, social sciences, urban planning, and information technology. Their research has focused on understanding the seismic hazards facing the central and eastern United States; developing ways to better estimate the physical impacts that these hazards are likely to generate; determining the social and economic consequences likely to result from physical damage; and facilitating improved understanding and use of seismic-risk information among societal stakeholders.

The products of this research are many and varied. In the engineering sphere, they include fragility analyses that can be used to better assess the seismic vulnerability of various types of buildings, bridges, and interdependent lifelines. MAE researchers have also enhanced technologies used to inventory buildings in the community, and have developed SIMCOR, a system that many earthquake engineers now use to conduct joint studies simulating the physical impacts of earthquake effects.

Social scientists from the MAE Center have created some of the first quantitative models linking the physical impacts of earthquakes to their social and economic consequences. Consequences modeled include direct economic losses, reductions in local tax revenues, and population dislocation and associated sheltering requirements. This work has expanded the scope of earthquake impact assessment and helped to connect social science researchers and their findings to the earthquake engineering community.

Through several test-bed projects, the MAE Center has secured cooperation, support, and input from earthquake risk-reduction stakeholders and has designed, tested, and refined CRM, MAEviz, and individual research products. The Memphis project enabled the Center to apply its full array of CRM capabilities to a central U.S. locality (Memphis and suburban Shelby County, TN), in cooperation with community leaders, utilities, and other local stakeholders. The Center's work in adapting dynamic traffic modeling to earthquake impact assessment was utilized in the transportation test-bed project, in which researchers and local officials evaluated the seismic vulnerability of the transportation network in and around Charleston, SC.

In the emergency management test-bed project, MAE researchers completed an extensive statewide earthquake impact assessment for the Illinois Emergency Management Agency, and partnered with universities in Turkey to develop HAZTURK, a customized version of MAEviz now being used to assess buildings and utility networks in Istanbul. The MAE Center also participates in a project team assembled by the Federal Emergency Management Agency, which is helping emergency management agencies and other stakeholders in the New Madrid Seismic Zone prepare comprehensive earthquake impact assessments and response plans.

The Road Ahead

The MAE Center has emerged from the years of support provided by NSF as a self-sufficient consulting entity offering a unique mix of expertise, resources, and experience. In recent years, through its test-bed projects and other business development efforts, the Center has successfully reached out to agencies and organizations that can benefit from its research capabilities and products and has secured medium-term support from a number of stakeholders.

Current and potential MAE customers include emergency management agencies, utility companies, transportation agencies, engineering firms, risk-management companies, international aid organizations, and others. The Center will continue to focus on technically challenging and societally beneficial research. Although the Center will maintain its emphasis on earthquake risk management in the central and eastern United States, its work has and will continue to benefit other regions facing similar hazards and the earthquake risk-reduction community worldwide.

Additional information about the MAE Center is available at http://mae.ce.uiuc.edu/.