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The John A. Blume Earthquake Engineering Center

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LETTER FROM THE DIRECTOR

Two months ago we moved back into our newly renovated building. Yes, we are back in the Blume Center and we are really excited about it. In addition to being seismically upgraded, the building underwent major programmatic redesign with a new floor added to the south-west wing and the majority of the laboratory space redefined for new use. The Blume Center's original building was built around 1913. The structure had unreinforced masonry walls with concrete pilasters and wood truss roof. Some of the problems were inadequate strength in exterior walls for seismic loads, roof diaphragm shear capacity, roof to exterior wall connection for out-of plane forces, connections between diaphragm and exterior walls, and lack of shear transfer capacity between the two roof diaphragms.

The seismic upgrade features included braced steel frames in the transverse direction, combination of concrete and steel columns in the high bay lab area, a new roof diaphragm, collector beams (all around the perimeter), shotcrete on the exterior walls, and more adequate connections between exterior walls and roof diaphragms. A view of the steel braced frames can be seen in the photo below.

The outcome is a beautiful building with open spaces and light and airy offices. We have added a new advanced technologies laboratory for the development of sensors and new materials testing, a new undergraduate mechanics laboratory for teaching purposes, student and research computer clusters, and a multimedia/library room. We hope all of you will join us for the official rededication of the Blume Center to be held in conjunction with the Haresh Shah Symposium on April 26, 1997.

ANNOUNCING THE SHAH SYMPOSIUM & BANQUET

Editors Note: *CENTER NEWS, which is usually in this location, has been moved to the back page to allow for this special announcement.*

The Department of Civil Engineering is sponsoring a very noteworthy and special event in the spring of 1997. **Professor Haresh Shah** is retiring next fall, so we are holding a Symposium and Banquet in his honor.

The technical Symposium will be held on the campus on Friday and Saturday, April 25 and 26, 1997. The Symposium is titled *Risk Management and Mitigation for Natural Hazards* and will feature invited speakers from the U.S. and many other countries. The Banquet will be held on Friday evening at Hyatt Rickeys in Palo Alto and will be a celebration of Haresh's life and contributions to Stanford. We expect the Banquet to be both exciting and enjoyable, and we are looking forward to seeing many alumni from the Blume Center and the Civil Engineering Department in attendance. Registration for the Banquet and Symposium will be separate, although many people will wish to attend both events. Please mark your calendars now and save the dates.

Haresh Shah, the founder of the Blume Center, is taking early retirement so that he can devote more time to writing, traveling, and continuing his work in the field of risk analysis. As all of you know, Haresh has served the Blume Center, the Department of Civil Engineering, and the University with great distinction for many years. The Symposium and Banquet provide an opportunity to show our appreciation for his many contributions.

As part of the program for the Symposium, we will have an Open House to show off the remodeled Blume Center. The seismic reconstruction of the building is now completed, and we think you will be impressed by the new facilities (besides feeling a lot safer).

Additional information about the Symposium and Banquet is contained in the enclosed flyer, and further information will be mailed to you in the months ahead. If you have questions right now, you can reach us at the Blume Center office or by e-mail at ShahSymp@ce.Stanford.edu. The latest information is also posted on the Blume Center WWW Home Page at http://blume.stanford.edu.

RESEARCH SPOTLIGHT

Multidisciplinary Approach to Urban Earthquake Disaster Risk Assessment and Management

by Anju Gupta, Abhijit Kakhandiki, and Rachel Davidson, Ph.D. Candidates
Research Advisor: Professor Haresh C. Shah

Urban Earthquake Risk

Today, urban earthquake risk is a more complex and dynamic problem than ever. Rapid urbanization has created megacities that are conglomerations of dense population, aging infrastructure, and development in unsafe areas. Northridge and Kobe were only glimpses of what could happen when a major earthquake strikes directly under an urban region. The potential losses in a major urban earthquake are expected to be far greater than experienced in the past. The question that arises then, is why, with all our past research in this area, are we still so far from effectively protecting these cities? The difficulty is that it is beyond the scope of any single discipline to provide a solution independently. Earthquake disasters are caused by a combination of factors from the fields of engineering, earth science, and social science. There is a growing consensus among earthquake professionals that a solution can be found only by adopting a holistic approach, that integrates knowledge from all these different disciplines.

Need for a New Approach

To keep pace with the rapidly changing nature of urban risk, it is necessary to look past the confines of a single discipline and focus instead on the bigger picture. Risk assessment must expand beyond the physical vulnerability of a region. It needs to include the region's social vulnerability, society's response and recovery capacity, and the city's economic and political status in the nation, and the world. Risk management can no longer only develop theoretical solutions for reducing the structural damage and casualties. It must develop solutions that are cost-effective, region and culture specific, and politically and socially acceptable. To keep pace with the dynamic nature of urban risk, we need to understand how the factors affecting the assessment and management techniques vary with time.

Each individual discipline provides an answer to one part of the problem of how to mitigate urban risk. Earth scientists provide information on the hazard. Engineers develop techniques to construct safer buildings. Sociologists help understand the major concerns and priorities of society, and the cultural limitations within which mitigation needs to be implemented. The political scientist provides input about what information a decision-maker requires to develop a policy, and what issues could make a solution more politically acceptable. Equally important are the practitioners who identify implementation problems.

Thus, to effectively improve the earthquake preparedness of megacities, we need to develop a new approach that combines all these pieces of information into an integrated earthquake risk assessment and management technique. Our research group at Stanford is currently involved in three projects that adopt this new approach. Together, the projects address the three main issues associated with earthquakes: risk assessment, risk management, and risk forecasting. The first project attempts to assess a city's overall level of risk, and the factors that contribute to the risk. The second seeks to compare the cost-effectiveness and feasibility of different mitigation strategies for a city. The third forecasts how the risk, and thus the mitigation strategies, would change over time. Brief descriptions of each project, its scope, and approach are presented below.

Risk Assessment: Disaster Risk Index

The risk assessment study involves the development of a multidisciplinary Earthquake Disaster Risk Index (EDRI) (Davidson, 1996). This composite index will allow us to compare the relative earthquake disaster risk of different cities worldwide, and evaluate the relative contributions of various factors to that risk. The procedure to develop the EDRI involves four basic steps. First, a systematic investigation identifies the factors - geological, engineering, social, economic, political, or cultural - that contribute to the earthquake disaster risk. Second, a framework is created to describe how these factors relate to each other and to the overall disaster risk. Third, the qualitative factors in the framework are linked to simpler, quantitative indicators, such as per capita gross domestic product, miles of road, and population. These indicators allow the various factors to be incorporated into a quantitative analysis. Finally, the indicators are mathematically combined into the composite EDRI.

The EDRI moves one step further from existing practice. While current engineering loss estimation models assess the expected physical impact in terms such as deaths and dollar loss, this study assesses the risk of an earthquake disaster. The social, economic, cultural, and political context of the damage determines whether or not an earthquake will create a disaster situation. In this study, a disaster is considered to be a function of not only the physical impact of an earthquake, but also the response of the affected city, and the relevance of the impact to the city and to world affairs. Presenting the risk as a simple index will make the results of the study easily usable by the public, governments, insurance companies, and other potential

users. The index will allow straightforward comparison of the overall earthquake disaster risk of urban centers worldwide.

Risk Management: Strategy Effectiveness Chart

The risk management study focuses on the development of a Strategy Effectiveness Chart (SEC) that compares the cost-effectiveness of mitigation strategies (Gupta, 1996). The study deals with a variety of parameters such as effect of the strategy (structural, financial, and informational), target groups from implementation (private, public), and policy issues (voluntary, regulatory). Since the level of risk, priorities, and resources vary within society, SEC's are developed separately for each sector in the region, such as residential, commercial, and government. To compare the strategies, a Performance Index (PI) is created. The PI is a measure of the severity of impacts of an earthquake, and the sector's capacity to recover from those impacts. The SEC is a graph that relates the change in PI to the dollar investment in a strategy. The development of the charts is a three-stage process. First, the current performance of each sector (i.e. before any strategy is implemented) in different earthquake scenarios is evaluated. Second, for different levels of investment in mitigation, the PI is reevaluated for the same scenarios. The change in the PI score is a measure of the strategy's effectiveness. In evaluating this change, the likelihood of implementation of the strategies is incorporated. Finally, data are aggregated over different scenarios, and results are plotted in a sector or regional SEC, with the current PI score corresponding to zero cost.

Unlike past research that uses only dollar and life loss reduction to compare strategies, this study incorporates the loss of lifeline services and recovery efficiency. In evaluating strategies separately for each sector, social and economic characteristics that affect the impact severity and recovery capability are incorporated in the SEC. By accounting for the likelihood of implementation of strategies, the PI deals with the often neglected issue of identifying what factors influence whether or not a strategy will be implemented. A sensitivity analysis will delineate relevant parameters that should be the focus for future research in this area. The Strategy Effectiveness Chart is designed to be a comprehensive, yet simple tool, that will allow each sector or the region as a whole, to identify where to invest resources in mitigation so as to maximize their benefits.

Risk Forecasting: Future Earthquake Risk

The final study estimates how the earthquake disaster risk of a city varies over time, and evaluates how the mitigation strategies affect this risk in a dynamic setting (Kakhandiki and Shah, 1996). The technique is based on a systems approach. The time variation of risk is depicted through a dynamic simulation. Each component of a city's behavior is represented by a set of variables that are functions of time. The interactions among the components are characterized by equations that relate those variables. By solving the equations sequentially, starting with values at the current time step, the values of the variables at subsequent time steps will simulate future earthquake risk. Implementation of mitigation policies is modeled by changing the initial values of the variables. The risk model will incorporate the behavior of, and interactions among, the region's socioeconomic characteristics, such as demographics, inter-industry dependencies, and capital flow.

The study incorporates analysis techniques and principles from a variety of disciplines. The goal of the study is to develop a decision-making support tool that will aid policy-makers understand future implications of their mitigation policies. Currently, mitigation efforts are primarily reactive. Each time an earthquake occurs, previous mitigation strategies are evaluated on the basis of the degree and nature of the impact, and unanticipated problems are identified and resolved for future events. Such postmortem analyses provide valuable information, but with a reactive approach, earthquake professionals remain a step behind. By forecasting the change in the earthquake risk, this study attempts to anticipate problems in future earthquakes, so that they can be addressed more proactively.

Conclusion

Rising losses in recent urban earthquakes such as Northridge and Kobe have shown that there is a widening gap between the increase in urban risk and our efforts to mitigate that risk. Data from future earthquake scenarios indicate that the consequences of the next major urban earthquake are going to be far greater than experienced in the past. As a result of rapid urbanization, the nature of the risk and response capacities of cities are changing. Factors from different fields of study come together to create this risk. To protect cities against an earthquake disaster, we need to develop a new risk assessment and management approach that can deal with this dynamic and complex situation. Such an approach must focus on the unique issues of urban risk, adopt a holistic multidisciplinary perspective, and develop results that are feasible to use and implement.

The three projects described above are attempting to develop one such approach to help understand and mitigate the urban risk. These projects integrate information from a variety of disciplines. Instead of focusing on the individual parts of the problems, such as the infrastructure, society, economy, and recovery, they look at the bigger picture. Together the projects help understand, how these different components interact to create the disaster risk, which are the most cost-effective strategies to mitigate this risk, and how the risk varies over time.

References

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CENTER NEWS

Several Blume Center researchers participated in the 11th World Conference on Earthquake Engineering held in Acapulco, Mexico in June, including **Professor Anne Kiremidjian**, **Professor Haresh Shah**, **Professor Helmut Krawinkler**, **Dr. Stephanie King**, and Ph.D. students **Maya Belubekian**, **Anju Gupta**, and **Rachel Davidson.** At the conference, **Professor Anne Kiremidjian** presented an invited lecture at the Emilio Rosenbleuth Symposium, and the Blume Center hosted a reunion dinner for alumni and affiliates of Stanford University and the Blume Center.

Professor Allin Cornell was recently appointed as a member of the National Academy of Science Research - Committee on the Science of Earthquakes. The committee's objective is to review the past and forecast the next 10 years of progress in earthquake science and its application.

During the summer, the Blume Center hosted three visiting scholars: **Professor Masakatsu Miyajima** from Kanazawa University in Japan, who received a research fellowship from the Ministry of Education, Science, and Culture of Japan; **Professor Tore Haavaldsen** from the Norwegian University of Science and Technology, who is currently working at Makerere University in Uganda; and **Corine Frischknecht**, PhD candidate at the University of Geneva, who is working in the Department of Mineralogy.

Erik Straser and **Alex Barron**, Ph.D. students working with Professor Anne Kiremidjian, spent the summer conducting research at Los Alamos National Laboratory in New Mexico.

In June, **Dr. Renate Fruchter** and **Professor Kincho Law** organized and co-chaired the 4th International Conference on Artificial Intelligence in Design at Stanford University.

Professor Anne Kiremidjian and PhD students **Rachel Davidson**, **Anju Gupta**, and **Abhijit Kakhandiki** participated in the 21st Annual Workshop on Hazards Research and Applications held in Denver, Colorado in July.

In July, Emeritus **Professor Jim Gere** and his wife, Janice, celebrated their 50th wedding anniversary.

Professor Kincho Law and **Dr. Renate Fruchter** participated in the International Conference on Information Technology in Civil and Structural Engineering Design held in Glasgow, Scotland in August.

Armin Schemmann, a Ph.D. candidate working with Professor Allison Smith, and his wife, Joanne, welcomed the birth of their son, Oscar Maxwell, on July 17.

Blume Center Associate Director **Stephanie King** [M.S. '90; Ph.D. '94] and her husband **Chris Rojahn** [M.S. '67, Eng.D. '68, Executive Director of ATC, welcomed the birth of their first child, Jonathan James, on September 18.

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