Blume Center News, continued from page 1

Monitoring and Diagnostics, 26 Feb~2 March, 2006, San Diego, CA.

Professor Ronnie Borja gave a keynote at the Second International Conference on the Mechanics of Unsaturated Soils held in Weimar, Germany on March 7-9, 2007, where he talked about localized and diffuse instabilities in partially saturated soils.

On March 19, **Professors Helmut Krawinkler** and **Greg Deierlein,** and **PhD candidate Abbie Liel** attended and presented material on assessment of earthquake-induced building collapse to the ATC-63 Project Review Panel on the "Quantification of Building System Performance and Response Parameters"

Professor Jack Baker hosted the annual meeting of the Joint Committee on Structural Safety at Stanford University on March 28th.

Professor Jack Baker gave a presentation "Automated identification of velocity pulses in near-fault ground motions," at the Seismological Society of America annual meeting in Kona, Hawaii on April 11-13.

SEAoNC Stanford Student Night

On March 6, the Structural Engineers Association of Northern California welcomed over 40 Stanford students and faculty at their monthly dinner meeting in San Francisco. The meeting featured a presentation by engineers from SGH on their base isolation addition to the 185 Berry Street Building. Prior to dinner, the Palo Alto office of Hohbach-Lewin hosted an office tour to introduce students to the real-world practice of structural engineering.

2006-2007 Graduates

Congratulations to all of our 2006-2007 Graduates. Master of Science degrees in Structural Engineering and Geomechanics were awarded to **JoAnna Billings, Eric Borchers** *(Rutherford & Chekene)***, Adam Chalmers** *(US Army-West Point)***, Kyle Chatman** *(Degenkolb),* **Ashpica Chhabra, Shannon Goff, Elizabeth Grote, Siswi Herlini, Lars Keim, Panagiotis Koklanos** *(Weidlinger Assoc.)***, Ka Chun Kwok, Christopher Larkin, Carrie Leung** *(DASSE)***, Lilian Leung, Tracy Leung, Tze Meng Edwin Lim, Matthew Mester, John Millea** *(TGRWA, LLC)***, Jennifer Moore, Yash Rajiv Ahuja, Laura Russon** *(URS)***, Ryan Sawaski, Joseph Schuster** *(SGH)***, Abraham Sipes** *(Nabih Youssef and Assoc.)***, Guillermo Soriano, Leonidas Stellakis, Evan Stoner** *(Walter P. Moore)***, WaiChing Sun, Jana Tetikova, Jeremy Tillman, Victor Victorsson, Katie Walker** *(LERA)***, Shenming Wang, Joshua White** and **Lai Hung Yip** *(KPFF)***.**

Master of Science degrees in Design/Construction Integration were awarded to **Yunmoon Chang, Yves Frinault, Joseph Jabra, Christopher Larkin, Samuel Newman, Kaustubh Pandya** *(WJE)***, Badawi Qawasmi,** and **Lorraine Young** *(DeSimone Consulting Group)***.**

Doctorate degrees in Structural Engineering and Geomechanics were awarded to **Kyle Douglas** *(CalStar Cement)***, Curtis Haselton** *(Cal State Chico)***, Renee Lee, Won Lee** *(CalStar Cement)***, Jiro Takagi** *(ARUP Japan)***,** and **Polsak Tothong** *(AIR)***.** A doctorate degree in Design Construction Integration was awarded to **Zhen Yin**.

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Risk Assessment and Risk Communication Workshop

On March 26-27th, Stanford hosted 40 experts from ten countries for a Special Workshop on Risk Assessment and Risk Communication. Co-sponsored by the Blume Center, and organized by **Assistant Professor Jack Baker**, the workshop explored tools and approaches for assessing and managing risk in engineered systems such as buildings, dams, highway systems and offshore structures. Developments in performance-based engineering, structural reliability and decision theory have enabled researchers to better predict the reliability of engineered structures, and to make design decisions based on the risks associated with failures. Fully utilizing these abilities requires that criteria for risk acceptability be known or identifiable, and that affected parties be able to understand these risks. The purpose of the workshop was to gather leading researchers to discuss innovations and examples where risk-based analysis procedures have been used in practice, as well as to identify future research needs.

Over the course of two days, twenty presentations were given on topics relating to identifying and defining target levels of acceptable risk, risk-based calibration of building codes, resolving variations in societal acceptance of risks from varying sources, and communicating risk analysis results to stakeholders outside of the technical community. Blume Center **PhD student Abbie Liel** gave a talk entitled *"Assessing the seismic collapse risk of reinforced concrete frame structures, including effects of modeling uncertainties,"* coathored by Stanford faculty **Greg Deierlein** , **Jack Baker**, and Blume Center alumnus **Curt Haselton**. Blume Center **PhD student Renee Lee** gave a talk entitled *"Efficient seismic risk assessment and retrofit prioritization model for transportation networks,"* coathored by **Professor Anne Kiremidjian.** Blume Center alumni **Paolo Bazzurro**, **August Boissinnade** and **Farzin Zareian** were also registered participants. A special issue of the journal Structural Safety is in preparation, containing selected technical papers from the workshop.

Helmut's Heroes win Championship

The Blume Center sponsored Division II IM volleyball team (nicknamed Helmut's Heroes) brought home the Championship Title this year! Pictured are the awesome team of **Chris Smith, Joe Schuster, Erik Borchers, Alan Asbeck, Nick Palumbo, Andy Myers**, and **Marc Ramirez** (not pictured, **Pablo Sanz**).

Blume Center News

Professor Sarah Billington was on partial leave from Stanford in the Fall and Winter helping to found CalStar Cement, Inc., a local Start-up developing environmentally friendly cements for the construction industry. She also began serving the first year of a 3-year term as a member of the Board of Directors of NEES Inc.

On Sept. 28-29, **Professors Helmut Krawinkler** and **Greg Deierlein** attended the NEES E-Defense research coordination meetings in Japan and witnessed the collapse test of a full-scale reinforced concrete building on the E-Defense shake table.

Professor Sarah Billington attended 5th National Seismic Conference on Bridges and Highways, San Mateo, California, September 2006. Presented paper on "A Comparative Performance-Based Seismic Assessment of Traditional and Enhanced-Performance Bridge Piers Systems."

On Oct. 12-13, **Professors Anne Kiremidjian**, **Kincho Law**, and **Greg Deierlein** participated in the 4th International Conference on Earthquake Engineering in Taipei. **Law** presented a paper on wireless sensors and control and **Deierlein** presented a paper on collapse assessment of reinforced concrete buildings.

Professor Greg Deierlein and **PhD Candidate Abbie Liel** participated with a presentation on performance-based earthquake engineering at the IRCC Workshop on the Use of Risk in Regulation, held in San Francisco on Oct. 27.

From Nov. 1-3, **Professor Greg Deierlein** attended AISC Specification Meetings in Chicago and presented recent research findings of a study with **Jiro Takagi** (PhD, 2007) on assessing the strength and stability of steel structures under fire.

Professor Jack Baker gave an invited talk "Breaking the Uniform Hazard Spectra into Component Scenario Events: the Effect of Epsilon on Structural Response" at the 2006 COSMOS Annual Meeting Technical Session in Berkeley, CA on November 17th.

Professor Sarah Billington organized a technical session for the ACI Fall Convention in Denver, CO in November 2006 on "Precast Concrete for Bridges in Seismic Regions" and presented recent research on performance-based assessments of self-centering concrete bridge piers.

On Jan. 19-20, several Blume Center faculty and students participated in the PEER 2007 Annual Meeting. **Professor Helmut Krawinkler** made a presentation on "Development and Utilization of Databases on Component Experiments", **Curt Haselton** (PhD) presented work on "Unique Capabilities of OpenSees for Performance-Based Engineering," and **Greg Deierlein** made a presentation on "Assessing Effectiveness of Building Code Provisions."

In conjunction with their work on the PEER Tall Building initiative, **Professors Helmut Krawinkler** and **Greg Deierlein** led working groups at the ATC-PEER Tall Building practitioner workshop on January 30 and have made presentations at LA Tall Building Council Meetings in September and May.

PhD Candidate Pooya Sarabandi presented *"Building Inventory Extraction Method Using Remote Sensing for Urban Risk Management,"* at the SPIE 11th Annual Symposium, Nondestructive Evaluation for Health

RESEARCH SPOTLIGHT

Structural and Network Functionality Loss Assessment of the San Francisco Bay Area Transportation System

Evangelos Stergiou and Anne S. Kiremidjian

Introduction

Transportation systems are well known for their exposure and vulnerability to seismic effects. Damage and failure of these systems can seriously hamper emergency response following a disaster and can result in significant economic losses from the physical damage and from reduced functionality of the system. An initial study (Kiremidjian et al., 2005) supported by the Pacific Earthquake Engineering Research Center (PEER) focused on estimating the physical and functionality losses from scenario earthquakes impacting the San Francisco Bay Area transportation system.

A study is currently under way that considers all earthquakes in the region that contribute to the total risk of the system, includes the uncertainty in bridge damage factors and replacement costs, assesses the functional losses from unavailability of the system (Stergiou and Kiremidjian (2006), incorporates ground motion and bridge damage correlations, and provides an efficient algorithms for total risk computation (Lee and Kiremidjian, 2006). In this spotlight, we present the results from the total risk analysis that includes direct structural and reduced system functionality losses from all significant earthquakes in the San Francisco Bay Area.

Methodology

The seismic risk of a transportation system is defined as the annual probability of exceeding the loss from all possible events to which the system is exposed. The main contributors to the loss are damage to network components and traffic time delays. For the direct loss analysis a modified form of the framework PEER equation is formulated:

$$P[L>l]=\iint\iint dF_{L|RC,DF,A}dF_{RC}\,dF_{DF|DS}\,dF_{DS|A}\lambda_A \qquad (1)$$

where L is the total direct loss, F(*) is the cumulative distribution function of *, RC is the replacement cost, DF is the damage factor, DS is the damage state, A is the local ground effect (ground shaking, liquefaction or landslides) and λA is the hazard rate at the site.

Since Eq.1 cannot be evaluated in closed form, a simulation approach is considered. In addition, an approximate integration approach is developed by Stergiou and Kiremidjian (2006). More efficient methods applicable to large systems are currently being investigated by Lee and Kiremidjian (2006).

Equation 1 requires that all possible earthquakes in the study region be defined by their magnitude, rupture location, and probability and frequency of occurrence. Assuming independence between events, the direct losses are computed for each scenario and the annual rate of loss exceedence is:

$$P[L\geq l_k]=1-\prod_{i=k}^{n}(1-p[E_i]) \qquad (2)$$

where L is the loss random variable, λi is the loss for event Ei, P[Ei] is the annual rate of occurrence of event Ei, and n is the total number of events resulting in losses.

In this study bridges are considered as the critical links in the system and damage to these components will result in reduction in traffic flow and/or possible loss of connectivity between travel zones. Thus, network performance is defined as the total travel delay for passenger and freight traffic which is correlated to dollar loss. The functionality and direct loss curves are added to obtain the total annual loss exceedence curve.

Application to the San Francisco Bay Area Transportation Network

The risk assessment methodology is illustrated through an application to the transportation system within five counties of the San Francisco Bay area. The system considered in the analysis has 1125 bridges and 1120 Transportation Analysis Zones (TAZ). Physical and engineering attributes for the bridges were obtained from the CALTRANS bridge database. The TAZ zones account for both intra and inter regional traffic. The earthquake events and the probability of occurrence for each event were evaluated using the information in the Working Group Study (USGS, 2003). Figure 1 summarizes the losses from physical damage to bridges and the corresponding network functionality loss for each scenario event on the San Andreas Fault causing nonzero loss. The contribution of ground shaking, landslides and liquefaction to the overall loss is included in this analysis (see Stergiou and Kiremidjian, 2006 for detail). It was determined that liquefaction is the main contributor to the direct physical loss.

The network functionality losses were evaluated as a function of the time to restore full functionality. The overall operational loss is then evaluated by summing the losses over the time period when the system is 100% functional.

In comparison to Figure 1, it can be observed that the functionality losses are consistently higher than the direct losses for all scenario events. In majority of cases the functionality loss is more than 50% higher than the loss from physical damage. The aggregate risk from direct physical and functional losses is shown in Figure 2.

Conclusions

A method for evaluating the risk from direct physical damage and functional loss of a transportation system in a seismic region is summarized that considers various sources of uncertainty. Application of the method shows that the functional loss is of the same order of magnitude as the direct physical loss and somewhat higher than the physical loss. Liquefaction appears to be a major contributor to physical loss pointing to the needed for more detailed studies. The risk curve provides critical information for emergency response, optimal network rehabilitation and design.

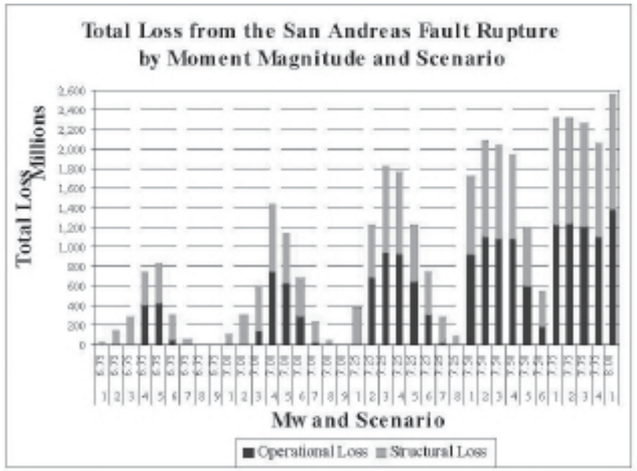

Figure 1. Direct and functionality loss for the San Francisco Bay Area transportation network

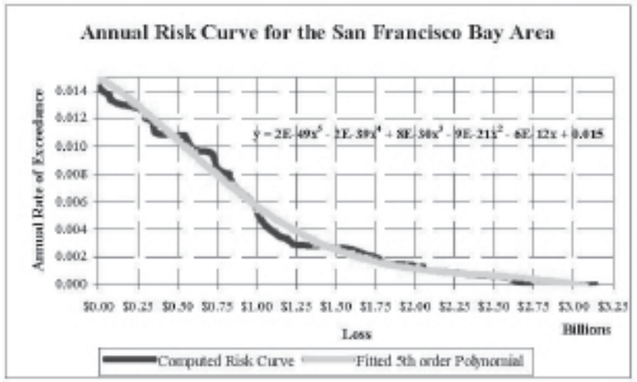

Figure 2. Risk of loss for the San Francisco Bay transportation Network

Acknowledgement

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Lee, R. and Kiremidjian, A. (2006), "Uncertainty and Correlation of Network Component Losses for Spatially Distributed Systems", Earthquake Spectra, in review.

Stergiou, E. and Kiremidjian, A. (2006), "Treatment of Uncertainties in Seismic Risk Analysis of Transportation Systems", The John A. Blume Earthquake Engineering Center Technical Report No. 154, Stanford University, Stanford, CA

Blume Center Alumni Gathering

The Blume Center Alumni have been holding receptions in the area for alumni to meet, network and enjoy each other's company. The last gathering was at Exponent in Menlo Park on March 30. We encourage all local alumni to join us at the next reception which will be held in September at RMS in Fremont. If you would like to be included in the mailing list, please let Racquel know.

Published Papers

Rouse, JM, and Billington, SL, (2007) "Creep, Shrinkage, and Permeability of High-Performance Fiber-reinforced Cement-based Composites," ACI Materials Journal, 104(2):129-136.

Sarabandi P., Kiremidjian A., "Terrain Dependent Correspondence Search for 3D Urban Modeling Using Multiple High-Resolution Satellite Images," URBAN2007, April 11~13 2007, Paris, France.
Presented by Pooya

Cabrera C., Cheung A., Sarabandi P., Nair K. K., Kiremidjian A., "Application of statistical pattern recognition methods for damage detection to field data," SPIE 14th International Symposium, Nondestructive Evaluation for Health Monitoring and Diagnostics, 18~22 March, 2007, San Diego, CA.