ISSUE NO. 39 SUMMER 2004

THE JOHN A. BLUME EARTHQUAKE ENGINEERING CENTER

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FORMER DIRECTOR OF FEMA PRESENTS FIFTH ANNUAL SHAH LECTURE

James Lee Witt, who was Director of FEMA during the Clinton administration (1993-2001) and now chairs the International Code Council, presented the Fifth Annual Shah Family Lecture at Stanford on April 21. His lecture, "Disaster Risk: The Odds Are Changing In Nature's Favor" examined the increasing risk to natural disasters caused by earthquakes, floods, hurricanes and other extreme events. He recollected several events and initiatives that marked key turning points during his tenure with FEMA, and he discussed approaches that business leaders, government, and citizens should do to protect and mitigate risks due to natural disasters. Prior to his seminar, Witt shared his ideas, anecdotes and insights on government in a lively roundtable discussion on how professional engineers can help influence policy for minimize consequences of extreme events.

BLUME CENTER HOSTS AFFILIATES MEETING

On April 30, the Blume Center hosted its semi-annual Professional Affiliates Meeting. New at this year's meeting was an early morning golf outing, the "Krawinkler Klassic", which we hope to become a regular tradition. On a more technical note, discussions at the meeting focused on the topic of Performance-Based Earthquake Engineering, with short presentations of professional observations by **Chris Poland** and highlights of recent research by **Profs. Greg Deierlein**, **Allin Cornell**, **Helmut Krawinkler** and **Eduardo Miranda**. The meeting included a short affiliate led discussion on "Engineering for Sustainability" and the opportunities it may offer to earthquake and structural engineers and researchers. These formal discussions were followed by a poster session and reception, featuring over twenty-five recently completed and ongoing projects (see written summaries at http://blume.stanford.edu/blume/research.html). Special thanks go to Chris Poland and **John Osteraas**, who helped organize the affiliate representation, and to all our affiliates for their continued interest in and support of the Blume Center.

BLUME CENTER NEWS

Eric Elsesser, Founding Principal of Forell/Elsesser and Stanford alumnus, presented an inspiring two-part seminar entitled "How to Conceive, Design, and Build Beautiful Structures" on April 7 and May 27.

Prof. Sarah Billington delivered a keynote lecture at the 5th International Conference on Fracture Mechanics of Concrete and Concrete Structures in Vail Colorado, April 12-15, entitled "Damage-tolerant cement-based materials for performance-based earthquake engineering: Research needs."

Prof. Greg Deierlein and PhD Student **Paul Cordova** made a presentation on the "Seismic Design and Behavior of Composite Steel-Concrete Building Systems" at the April 13 monthly dinner meeting of the SEAoNC South Bay chapter. On May 25, Deierlein and Cordova also gave a two-part presentation on the large scale testing of a full-scale composite frame (see Spring 2004 newsletter spotlight) at the 2004 ASCE SEI Congress in Nashville.

On April 26, **Prof. Sarah Billington** presented "Assessment of Precast Bridge Piers with Unbonded Post-tensioning and Damage-tolerant Fiber-reinforced Concrete" for the Structural Engineering Seminar Series at the University of Illinois at Urbana-Champaign.

On May 11-12 PEER had its annual NSF site review. **Profs. Greg Deierlein**, **Helmut Krawinkler** and **Eduardo Miranda** and PhD student **Hesaam Aslani** made oral presentations to the NSF review panel. Nine Blume Center PhD students presented research posters during the site visit.

Profs. Helmut Krawinkler and **Eduardo Miranda** made presentations at the International Workshop on Future Directions in Instrumentation for Strong Motion and Engineering Seismology in Kusadasi, Turkey on May 17-21, 2004. During this NATO-sponsored workshop, Prof. Krawinkler presented "The Impact of Near-Fault Pulses on Engineering Design", while Prof. Miranda presented on-going research on "Rapid Assessment of Building Response Using Generalized Interstory Drift Spectra".

On June 7, **Prof. Eduardo Miranda** was invited to give a talk to the EERI student chapter at University of Michigan in Ann Arbor. He made a presentation on the "Assessment of Seismic Demands on Acceleration-Sensitive Nonstructural Components in Buildings". He was hosted by EERI student members and by Prof. Gustavo Parra-Montesinos.

At the June 8 SEAoNC Annual Business Meeting **Prof. Helmut Krawinkler** was awarded Honorary Membership in SEAoNC. Blume Center Affiliate and former Stanford Ph.D. student Dr. Piotr Moncarz introduced Professor Krawinkler with a speech that made his former advisor look much better than most of his former Ph.D. students remember.

Prof. Faruk Karadogan, who was a visitor at the Blume Center from September to December 2003, has been elected as President of the Technical University of Istanbul, Turkey. We extend our most sincere

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RESEARCH SPOTLIGHT

Dynamic FE Analysis of South Memnon Colossus Including 3D Soil-Foundation-Structure Interaction

Sara Casciati and Ronaldo I. Borja

Introduction

The Memnon Colossi are two huge monolithic statues (18m high) located on the east bank of the river Nile, in Luxor, Upper Egypt (Figure 1). Historically, they were built in the 14th century B.C. to resemble the Pharaoh Amenhotep III. The north statue was believed to have partially collapsed during an earthquake in 27 B.C., and was reported to have been restored two centuries later by the Romans [1]. The interest in the south statue arises from its original and unaltered but severely damaged state. In particular, the base of the structure is severely fractured into stone blocks, which must be fastened together or the entire structure could topple during a strong earthquake. Remedial measures have been proposed to fix the problem, including stitching the blocks together by shape memory alloy devices in the form of wires. However, planning a good retrofit operation requires careful and accurate modeling of the seismic response of the structure. The objective of the present study is to identify regions of stress concentration in the structure in order to be able to quantify the seismic demands on whatever new materials may be introduced into the retrofit program. The technique used for analyzing the seismic response of the south statue includes nonlinear finite element modeling of the dynamic soil-foundation-structure interaction, or SFSI. The scope of the present study is limited to the seismic response of the unaltered structure and does not include the assessment of any proposed stabilization measure.

Figure 1. Photograph of South (left) and North (right) Memnon Colossi

Methodology

Based on a seismic hazard analysis of the Luxor site, we generated artificial reference or base ground motions using a hybrid stochastic approach based on a modified Boore method with a Brune source spectrum. The result of this procedure, described in detail in [2], was the ground motion expected at the Luxor bedrock (outcropping) following an earthquake of magnitude 5.5 at a distance of 100 km. To account for more severe ground motions, the hybrid stochastic procedure was repeated for earthquakes of higher return periods. The artificially generated earthquake was applied at the base of the soil for site response analysis.

Geotechnical investigations at the Memnon Colossi site revealed a bedrock made of limestone covered by a 6 m thick silt layer that could amplify the base ground motion [1]. Furthermore, the site is subject to regular flooding, and thus the soil could potentially undergo liquefaction during very strong earthquakes. However, the seismicity in the Luxor area suggests that very strong earthquakes enough to liquefy the underlying soil deposit are highly unlikely at the site, and thus in this study we simply assumed that the soil deposit would not liquefy. Preliminary site response analyses using the code SHAKE [3] and assuming different levels of drainage were carried out. Results of the analyses suggested that undrained condition is most critical, and hence this condition was assumed throughout the remainder of the analysis. The resulting displacement time history was obtained by integrating the acceleration-time history response, which was then considered as the free-field ground motion for the site. The free-field motion was applied at the boundary nodes of an adequately large finite element mesh of the soil deposit that also contains the statue, as shown in Figure 2. This particular modeling procedure is similar to that described in [4,5].

To construct a 3D model of the statue, we utilized a photogrammetric drawing provided by the German Cultural Center, which is currently working at the site for the rescue and restoration of the remains of the destroyed temple. The Center has provided a jpg image of the south statue in raster form, and from this information we have superimposed polylines to each level line, manually assigning the supporting points and using the software Autocad14 to construct a 3D image. A geo-reference of the images, which pertains to the identification of common points between two planar pictures representing the front and lateral views of the statue, was necessary for an accurate rendering of the 3D images of the solid. The FE analysis was carried out using the computer code MARC [6], which runs on SUN workstations SUN Ultra1 and SUN-Blade 1000 under Solaris OS. We selected this program because of its CONTACT option, among others, which allows the simulation of stick-slip behavior between the base of the statue and the top of the pedestal, and between the bottom of the pedestal and the supporting soil (note that the statue is merely

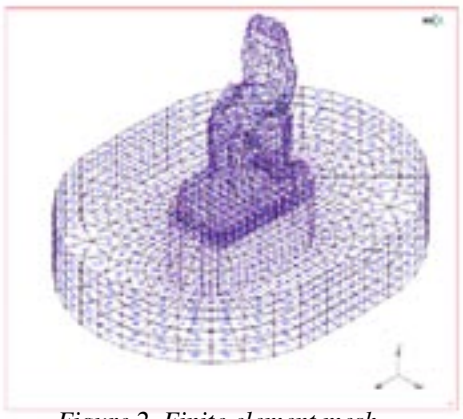

Figure 2. Finite element mesh

resting on its base pedestal, and not monolithically attached to it, so any relative movement between the two blocks is resisted by simple friction). Eight-noded isoparametric bricks elements with trilinear interpolation functions were used. The resulting refined mesh for the structure, shown in Fig. 2, contains 1144 nodes and 757 elements, see [7,8] for further details.

Representative Results

As the free-field motion is applied to the boundary of the mesh of Figure 2, the soil-foundation-structure system responds dynamically, and some sliding takes place between the statue and the supporting base, and between the supporting base and the soil. Figure 3 shows the cumulative plastic slips of the contact nodes at the rear bottom corner of the base relative to the underlying foundation soil, as functions of time and earthquake amplitude. The cumulative plastic slips are obtained by summing the absolute values of the incremental plastic slips experienced throughout the duration of the numerical simulation. Note that the cumulative plastic slip is not the final distance that one block moves relative to the adjacent block, but instead represents the total excursion or distance that the two blocks have traveled relative to each other. The simulations also predicted cumulative plastic slips developing between the statue base and the top of pedestal, not shown in this article but presented in detail in [7,8].

Acknowledgments

Financial support for this research was provided in part by National Science Foundation under Contract No. CMS-02-01317. Funding for the first author was provided by a research assistantship from the John A. Blume Earthquake Engineering Center.

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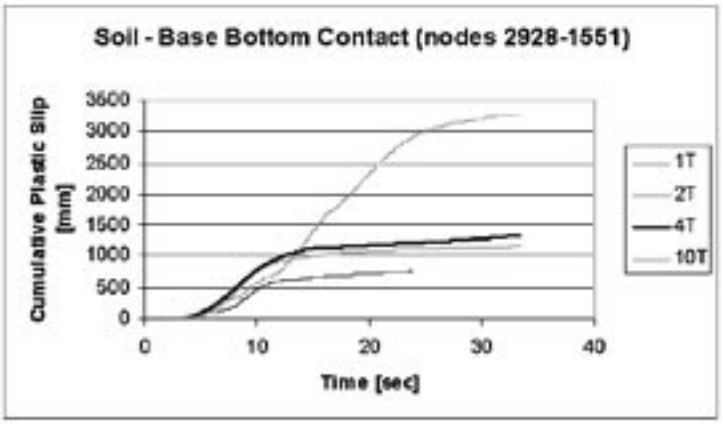

Figure 3. Cumulative slip at interface between bottom of base and supporting soil

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congratulations to a colleague who has become a good friend of many of us.

The RECALL technology invention - "System and Method for Indexing, Accessing, and Retrieving Audio/Video with Concurrent Sketch Activity" developed by **Dr. Renate Fruchter** jointly with Dr. Sam Yen and Prof. Larry Leifer from the ME Department was issued a patent in April 2004.

Annual Blume Center Hiking Trip

On April 24, Blume Center students, staff, faculty and friends enjoyed a beautiful hike along the Monterey coastline at Point Lobos. Afterwards they checked out the San Andreas fault at San Juan Bautista and had a delicious dinner before heading back to Stanford. *(See pictures at http://blume.stanford.edu/blume/hiking)*

Professor Kiremidjian Presented with ASCE Duke Award

Professor Anne Kiremidjian received the ASCE Martin Duke Lifeline Earthquake Engineering Award, given in recognition of outstanding contributions which have served to advance the art, science, and technology of lifeline earthquake engineering.

Alumni, Affiliates and Friends of the Blume Center are encouraged to send news items about yourselves to racqueh@stanford.edu for inclusion in the next newsletter.

Spring 2004 Graduates

The following students graduated in Spring with a Master's Degree in Civil and Environmental Engineering from the Structural Engineering and Geomechanics Program: **Wesley Braun, Henry Burton** *(Degenkolb)*, **Matthew Coelho** *(RMS)*, **Benjamin Fell** *(PhD program, UC-Davis)*, **Joseph Frega** *(T&M Assoc.)*, **Timothy Goshi** *(Sato & Assoc.)*, **Carmen Ho, Michael Hom, Dorit Kahen** *(Brandow & Johnson)*, **Dimitrios Lignos** *(PhD program, Stanford)*, **Sabrina Neufeld, Gerald Ng, Jason Pisano** *(DASSE Design, Inc.)*, **Nicholas Robertson, Mark Sorhouet, Evangelos Stergiou** *(Eng. program, Stanford)*, **Sarah Vaughan** *(Simpson Gumpertz & Heger)*, **Michael Wise, Sorabh Gupta** *(Rutherford & Chekene)*; and the Design-Construction Integration Program: **Oisin Heneghan**, **Weijie Hong**, **Molly Morse** (*PhD Program, Stanford)*, **Leonardo Renovato** *(Webcor Builders)*, **Ben Tang** *(Arup SF)*, **Karl Telleen** *(Rutherford & Chekene)*, and **Matthew Tsui.**

Receiving their PhD degree in Structural Engineering and Geomechanics were **Peter Demien**, **Rohit Kaul** *(Exava)*, **Dimitris Pachakis** *(Weidlinger Assoc.)*, and **Medji Sama** *(Exponent Failure Analysis-LA)*.

Published Papers

S. Casciati, R.I. Borja, "Dynamic FE analysis of South Memnon Colossus including 3D soil-foundation-structure interaction," *Computers and Structures*, 82 (2004), 1719-1736.

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