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The John A. Blume Earthquake Engineering Center

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CONGRATULATIONS TO AUTUMN 2000 GRADUATES

The following Structural Engineering and Geomechanics students received their degrees in December. **Babak Alavi-Shustari** received his Ph.D, he is now working for Exponent Failure Analysis. **Paul Philip Cordova**, **Avik Ghosh**, **Seung Je Lee**, **Regina Chee-Kit Pau**, **Lynn Janine Zimmerman** (working for Forell Elsesser) and **Ionna Gitzeni** (URS) all received their Master of Science Degree. Paul and Seung Je are now studying for their Ph.D. at Stanford. **Nuthaporn Nuttayasakul** received his Engineer Degree.

NEW PROJECT AWARDED

Professors Charles Menun and **C. Allin Cornell** along with **Paolo Bazzuro** (MS '91,ENG '93, PhD '98) have been awarded a new PEER lifelines program project whose first year goal is to prepare a set of fragility curve guidelines for experienced structural engineers. They are to start from their static pushover analysis of an existing PG&E building and turn in it to the fragility curve that PG&E needs for their forthcoming system-wide seismic reliability assessment. The limit states to be considered include not only collapse but also "tagging" states (yellow and red) that would reduce or eliminate the functionality of the building and its contents with respect to post-quake power production and distribution.

As in the new SAC/FEMA guidelines for steel moment-resisting frames, both record-to-record randomness and uncertainty in behavior, properties, and modeling will be represented in the fragility curve. A fragility curve is a plot of limit state (exceedance) probability versus ground motion intensity.

CEE PROFESSOR TRAVELS TO INDIAN EARTHQUAKE

Professor Eduardo Miranda traveled to India on February 8 for a post-earthquake reconnaissance investigation.

The Spring Newsletter will have more information about his findings.

BLUME CENTER NEWS

Dr. Steven Winterstein and Ph.D. Candidate **Tina Kashef** recently won the award for best paper, *"Moment-Based Load and Response Models With Wind Engineering Applications"* for the ASME Journal of Solar Energy Engineering.

Professor Ronaldo Borja presented a paper on instability and strain localization in geomaterials at the European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS) in Barcelona, Spain from September 11-14.

Professor Greg Deierlein presented a paper entitled *"A Two-Component Seismic Intensity Measure and Probabilistic Design Procedure for Moment Frames"* at the US-Japan Workshop on Performance-Based Seismic Design Methodology for Concrete Buildings held in Sapporo, Japan on Sept. 12-13, 2001. On the same trip, he traveled to Taipei to present a paper entitled *"Recent Research on Seismic Design and Performance Assessment of Composite Steel-Concrete Moment Frames"* at the International Workshop on Annual Commemoration of Chi-Chi Earthquake (Sept. 18-20).

Professors Helmut Krawinkler, **Allin Cornell**, **Greg Deierlein** and several Blume Center students participated in the PEER Workshop on Critical Ground Motion Parameters for Structural and Geotechnical Performance Indices, held in Richmond, CA on Oct. 27.

Professor Greg Deierlein gave a presentation entitled, *"Towards the Realization of Performance-Based Earthquake Engineering"* at the NAE's First Japan-America Frontiers of Engineering held in Nara, Japan on Nov. 1-4, 2001.

On November 6, **Professor Anne Kiremidjian** made a presentation to the Stanford Alumni Association in Tokyo, Japan.

In November, **Professors Helmut Krawinkler** and **Anne Kiremidjian** attended an international symposium near Kyoto in honor of **Professor Takuchi Kobori** (Nov. 7). Professor Kiremidjian represented the United States Delegation at the symposium banquet and Professor Krawinkler conducted a panel on Perfomance Based Earthquake Engineering. Also attending the symposium were **Professor Haresh Shah** and recent doctoral graduate **Keith Porter**.

Professor Greg Deierlein attended that AISC Specification Committee Meeting in Chicago on Nov. 9-11 and co-chaired a

Continued on Page 4

RESEARCH SPOTLIGHT

An Internet-Enabled Software Platform for Collaborative Development of Nonlinear Dynamic Analysis Program

By Jun Peng and Kincho H. Law

INTRODUCTION

It is well recognized that a significant gap exists in the state-of-the-art computing methodologies and the state-of-practice in structural engineering analysis programs. Most prevailing structural analysis programs are monolithic in that all the procedures and program kernels are bundled into software packages that are developed by individual organizations. Extending and upgrading these programs to incorporate new developments is a difficult process and more importantly, there is no easy way to link customized components developed by users and researchers separately outside the organization.

With the maturation of information and communication technologies, the concept of building collaborative systems to distribute the services over the Internet is becoming a reality (Han et al. 1999). Following this idea, we have proposed an open collaborative framework for the continuing development of **Open S**ystem for **E**arthquake **E**ngineering **S**imulation (OpenSees) (Peng and Law 2000, Peng et al. 2000). OpenSees is a software framework for simulating the performance of structural and geotechnical systems subjected to earthquakes. A collaborative system is one where multiple users or agents engage in a shared activity, usually from remote locations. Such a collaborative framework can potentially reduce the overhead of continuous upgrade and extension. Users and engineers can select appropriate services and can easily replace a specific module if a superior module becomes available. Developers and researchers can concentrate on developing components and can easily integrate their component to the core through a *plug-and-play* environment.

COLLABORATIVE SYSTEM ARCHITECTURE

The system architecture of the proposed collaborative framework is schematically depicted in Fig. 1. The core server is designed in a modular manner. The *Analysis Core* includes an object-oriented nonlinear dynamic analysis code that was originally developed at University of California, Berkeley (McKenna 1997). New element and material technologies can be brought into the *Analysis Core* module to enhance the functionality of OpenSees. The *User-Interaction* module is deployed to provide web-based interface to the users and developers. The *Registration and Naming Service* is provided for on-line services to register to the core so that these services can be found during analysis. The *Distributed Element Service* is provided for remote access to elements resided in different sites. The *Dynamic Linked Element Service* is implemented to provide a flexible way of dynamically binding elements to the core in real time. Last but not least, the *Database Interface* module can take advantage of a commercial database to provide efficient data access and to enable flexible post-processing.

The mechanics of the collaborative system framework is illustrated in Fig. 2. Users can build their structural model by using a web-based model-building service on the client site. The model can then be sent to the analysis core by using the Internet as the communication channel. Upon receiving the analysis model, the core server will perform the analysis in a collaborative manner. During the analysis, some elements can be obtained locally from the core element library. In order to find other required elements that are not existed in local element library, the *registry* will be queried to find the on-line element services, which have already been pre-registered with the core platform. After the analysis is completed, the results will be returned to the user by generating a dynamic web page in the user's web browser or an application program, such as MATLAB. A query language is provided to facilitate the data access process. In the following, we will focus on discussion of the collaborative on-line service module and the data access module.

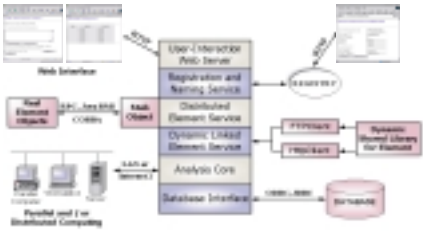

FIG. 1. Collaborative System Modules

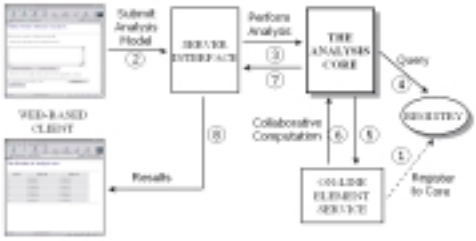

FIG. 2. Mechanics of the Collaborative Model

ON-LINE ELEMENT SERVICES

There is a standard interface/wrapper for communicating the element with the object-oriented analysis core. To introduce new elements into the analysis core generally composes of creating subclasses of *Element* class whose common interface is defined in the analysis kernel (McKenna 1997). In addition to the traditional way of building static element library for new element development, the new elements can also be developed in the form of on-line element service. There are two types of on-line element services, namely distributed element service and dynamic shared library service respectively.

In the distributed element service model, the element code resides on the element service provider's site. Whenever the core needs certain element data, the core sends requests to the service provider through a sequence of remote procedure calls. The meaningful computation is performed at the service provider's site and the requested data are returned back to the server after the computation.

The distributed element model is flexible and convenient, but likely suffers poor performance. The initiation of remote procedure calls is expensive. To improve the performance without losing flexibility, a dynamic shared library service can be used. In this model, the code for the element is built in the form of dynamic shared library conforming to a standard interface. The shared library then will be put into an ftp server or an http server. When the core needs this element, the dynamic shared library can be downloaded from the service provider's site. The downloaded shared library will dynamically link with the analysis core during the run-time of the analysis.

DATA ACCESS SYSTEM

Traditionally, there are two ways of obtaining the requested analysis results from structural analysis programs. One way is pre-defining all the wanted data before analysis and saving these data during analysis. A problem associated with this method is that if the users want certain data other than pre-defined ones, a complete re-analysis has to be performed to generate requested results. For nonlinear dynamic analysis of a large structure model, the re-analysis could be expensive. The other way of obtaining analysis results is simply outputting all the interim and final analysis data into files. These files can be searched during the post-processing phase of structural analysis. Obvious drawbacks of this method are substantial amount of storage space and low performance because of the expensive searching.

To overcome the drawbacks of the traditional ways of post-processing, we proposed an on-line data access system for structural analysis program. Oracle *8i* database system is employed as the backend for the storage of selected analysis results. In the proposed system, only selected results, not all results, will be stored into the database during the analysis. When the user wants to access the results, the request will be forwarded to the analysis core. If the data that the user wants is already stored in the database, the action is no more than a database query; otherwise, the program will automatically instantiate the required new objects to re-compute the requested data. Compared to the tradition way of redoing the whole analysis to obtain certain data, the re-computation should be more efficient and only involves a small portion of the program.

EXAMPLE

To illustrate the Internet-enabled collaborative platform, this section presents a sample example. The analysis model consists of three stories and one bay in each direction, as shown in Fig. 3. Rigid diaphragm multi-point constraints are used to enforce the rigid in-plane stiffness assumption for the floors. Gravity loads are applied to the structure and the 1978 Tabas acceleration records are the uniform earthquake excitation that has been applied to both X and Y directions. The input file of this model can be submitted to the server in a web-based environment and the result is returned to the browser, as shown in Fig. 4.

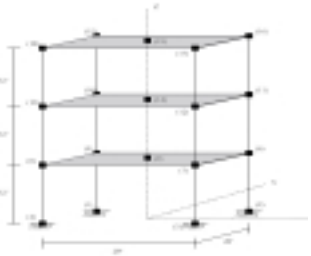

FIG. 3. Three-Dimensional Rigid Frame

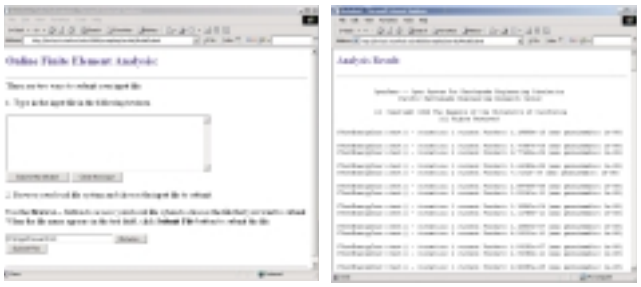

FIG. 4. Web Pages Generated in Client Site

Besides the web-based interface, a MATLAB-based interface can also be used to interact with the server. As an example, after the analysis, the above model can be plotted in MATLAB by invoking *modelplot*, as shown in Fig. 3.

To query the analysis result, the *queryresult* command can be used as in the following:

```
□□□□□□□□□□□□□
    □□□□□□□□□□□□□□□□□□□□□□□□
    □□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□
    □□□□□□□□□□□□□□□□□□□□
```

To obtain a graphical representation of this displacement time history, we can issue the command *res2Dplot node19_1.out* to take advantage of MATLAB's graphical processing power. Fig. 5 shows the plotted displacement time history.

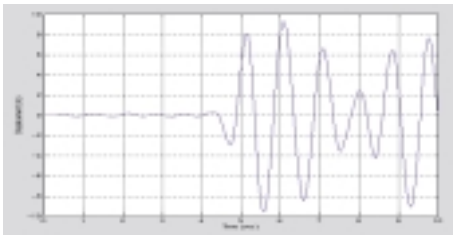

FIG. 5. Displacement Time History of Node 19

SUMMARY

A prototype of the Internet-enabled collaborative platform has been implemented and tested. The collaborative framework has been shown to have greater flexibility and extensibility than the current engineering approaches. A diverse group of users and developers can easily access the platform and attach their own developments to the core. Some avenues to improve the current platform will be further investigated and the implementation will continue to enhance robustness and flexibility.

ACKNOWLEDGEMENT

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PUBLISHED PAPERS

Miranda, E. *"Inelastic Displacement Ratios for Structures on Firm Sites,"* Journal of Structural Engineering, ASCE, Vol. 126, No. 10, Oct. 2000, pp. 1150-1159.

Ordaz. M., Miranda E. and **Aviléz, J.** *"Proposed Design Spectra for the Federal District,"* Proc. XI National Symposium on Earthquake Engineering, Querétaro, Mexico (In Spanish).

Ordaz. M., Miranda E. and Aviléz, J. *"Proposed Modification for the Seismic Criteria of Mexico City,"* Proc. XII National Conf. on Structural Engineering, Leon, Guanajuato, Mexico (In Spanish).

STANFORD'S CLASS OF 2023

Francisco Parisi (MS '00) and his wife, **Jacqueline**, welcomed their first child on November 17. **Laura Patricia** weighed six pounds, one ounce and was 18-3/4" long. Mother and daughter are doing fine.

A baby girl was also born to **Paolo Bazzurro** (MS '91,ENG '93, PhD '98) and his wife, **Sarah**. **Liliana (Lili) Ray Bazzurro** was born on December 11, seven pounds, eleven ounces and according to her proud father is "beautiful".

Ava Jean Fascetti was born on January 12, 2001 to **Sara Wadia-Fascetti** (PhD '91) and her husband, **Mike Fascetti**. Ava was seven pounds, four ounces and measured a "squirmy" 20 inches.

subcommittee that is developing frame stability design provisions for the next edition of the AISC Specification for Structural Steel Buildings.

Professor Helmut Krawinkler spent four days with **Professor Nakashima** at the Disaster Prevention Research Institute of the University of Kyoto, and then attended an International Workshop on Performance-Based Building Structural Design in Tsukuba (Nov. 13-15).

Professors Allin Cornell and **Greg Deierlein** gave presentations at the PEER Performance-Based Earthquake Engineering and Risk Management workshop held on November 16.

In November, **Professor Anne Kiremidjian** traveled to Italy to give a seminar at the National Center for Seismology Research in Milan on November 20, and a seminar at the University of Pavia on November 21.

Dr. Hjortur Thrainsson (PhD '00) presented a joint paper with **Professor Kiremidjian** on "*A Ground Motion Simulation and Spatial Interpolation Method"* at the 6th International Conference on Seismic Zonation, Nov. 12-15, 2000, Palm Springs, CA. Professor Kiremidjian was a speaker and panel member at Panel Session V: Finanacial Risk Management at the same conference. Her presentation was on *Modeling Issues in Loss Estimation.*

2001 AFFILIATES MEETING

The date for the 2001 Blume Center Affiliates Meeting will has been changed to May 6, 2001. More information will be sent out in February.

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