



## **INTERNATIONAL COLLABORATION – NETWORKING THE EARTHQUAKE ENGINEERING RESEARCH COMMUNITY INTO A GLOBAL FRAMEWORK**

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### **ABSTRACT**

This paper provides a brief description of the efforts of NEES to develop international collaborations since its inception in 2004. It also presents activities planned under the stewardship of NEEScomm to strengthen international collaboration. In this paper, it is postulated that using the opportunities provided by access to resources and collaborations in research and education, supported by information technology, NEES will move at an ever-increasing pace as a fully integrated and effective global resource to manage the impacts of earthquakes, and possibly other hazards, on life, property and economy.

### **Introduction**

Earthquakes continue to devastate communities around the world. These tragic events are critical experiments testing technical knowledge and resilience of communities reminding us that the vulnerability and exposure of our built environment are high and the seismic risk cannot be underestimated. The recent events in Haiti and Chile illustrate, that while earthquakes cannot be prevented, the minimization of earthquake damage and casualties should be a global objective of the earthquake community.

The George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) includes a distributed network of 14 advanced experimental equipment sites dedicated to the reduction of earthquake damage and losses. The seminal idea for the NEES network was the creation of an experimental-research infrastructure with state-of-the-art capabilities at different research centers connected with a single purpose through the opportunity provided by information technology. The NEEScomm efforts to deploy a successful user-requirements driven cyberinfrastructure, NEEShub, aim to provide the cortex of the system that enables the required catalysis of ideas, provides opportunities for research collaboration, facilitates delivery of education, and accelerates the implementation of new knowledge in practice. The outstanding research and educational activities conducted by the earthquake community in the network (Fig. 1) have generated once-in-a-generation opportunities to benefit the nation and become a global resource in accelerating hazard risk mitigation (Buckle & Ramirez, 2010).

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***WG-3 on “Data Infrastructure”:** The panel pointed out the importance of the international collaboration in data exchange/access and reached strong consensus that everyone is ready to move ahead. The collaboration, in particular among large research infrastructures, will allow building common understanding and advancing knowledge more rapidly than possible with isolated repositories. Guidelines for data modeling, archiving, and selecting experimental data based on accepted best practices have been individuated as first step for proper networked data infrastructure.*

The Joint Research Center of the European Commission hosted the 2<sup>nd</sup> World Forum in collaboration with the European Network I-SAMCO (International Structural Assessment, Monitoring and Control), which plays a major role in strengthening European and international collaborations. The main scope of the 2<sup>nd</sup> World Forum was to highlight the importance and added value of the international collaborative research in earthquake engineering for boosting the knowledge and the effectiveness of the seismic risk reduction for the population and support the European Organizations in managing and organizing collaborative research in Europe. The 2<sup>nd</sup> WF was organized in three topic areas: Hybrid testing and Distributed Simulation, Data Infrastructure and Distributed Database, and Dissemination of Knowledge, Education and Training in a Distributed Environment.

The participants stated that a major effort should be undertaken to organize the earthquake engineering community in Europe and to inform the European authorities to assist in the development of collaborative research programs in earthquake engineering in Europe and facilitate collaboration with NEES and other international research organizations (2<sup>nd</sup> World Forum Report, 2007). A proposal to establish the Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation (NERA) is currently under evaluation.

### **Partnerships with other facilities**

The network has endeavored to form strong partnerships with other large-scale testing facilities around the globe. The development of a Memorandum of Understanding with The National Research Institute for Earth Science and Disaster Prevention (NIED) on earthquake engineering research using E-Defense and NEES Facilities represents an important accomplishment with significant realizations in the collaborative research arena. Japan's E-Defense shake table, operated by NIED, is the world's largest multi-degree shake table. The Japanese began design of this facility following the devastating 1995 Kobe earthquake and became operational in 2005 shortly after the NEES facilities came online. NSF and NEESinc have developed partnerships to facilitate cooperative research that requires use of both the NEES infrastructure and E-Defense. To facilitate NEES/E-Defense collaboration, NEESinc and NIED signed a memorandum of understanding in August 2005. In September 2005, the NSF and the Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT) signed a memorandum concerning cooperation in the area of disaster prevention research. NSF-supported NEESR projects addressing the seismic performance of midrise wood frame buildings, steel frames, and base-isolated structures utilized both NEES facilities and E-Defense during the 2009-2010 timeframe. An example of the successes is the testing on July 14, 2009, of a six-story condominium building on the shake table at the E-Defense facility, located in the city of Miki, north of Kobe. This was the culminating experiment of the National Science Foundation (NSF) multi-year NEESWood

project under the direction of Prof. John van de Lindt from Colorado State University. The enabling agreement was intended to last five years. NSF continues to support the extension of this program for another 5-year term. NEEScomm is working with NIED on the renewal of the agreement scheduled to expire September 2010.

Korea, the United Kingdom, New Zealand and China are building and networking distributed facilities similar to NEES. Inspired by NEES, in 2004 the Korea Ministry of Construction and Transportation initiated the Korea Construction Engineering Development (KOCED) Program to construct six, large-scale, multi-hazard experimental facilities at the major regional universities, linked with cyberinfrastructure. In 2006, UK researchers at Bristol, Cambridge, and Oxford Universities received national funding to develop UK-NEES, which was modeled after the NEES cyberinfrastructure (<http://gow.epsrc.ac.uk/ViewGrant.aspx?GrantRef=EP/D080088/1>).

The New Zealand Network for Earthquake Engineering Simulation (NZNEES) is a program modeled after U.S. NSF-funded NEES program. The NZNEES@Auckland equipment site is based within the newly established University of Auckland Centre for Earthquake Engineering Research. The aim of the NZNEES@Auckland project is to provide a unique contribution to the integrated experimentation, computation, and simulation capabilities that exist currently in earthquake engineering networks, and foster collaborative research in New Zealand and internationally (Ma et al., 2007). A highlight of this NZNEES node is its Mobile Field Laboratory (MFL) with the following anticipated uses:

- Dynamic destructive testing
- Non-destructive testing
- In situ geotechnical research
- Evaluation of performance of structures subjected to aftershocks

The vision for the facility is to enable large-scale field experiments to be conducted and controlled remotely. The facility will employ state-of-the-art satellite technologies to connect to The Kiwi Advanced Research and Education Network (KAREN) and a state-of-the-art wireless data acquisition system.

### **US-Japan Research Program**

A sustained and successful component of the NEESR program has been a collaborative research effort with E-Defense in Japan. This program is in its 2<sup>nd</sup> Phase. To enable this collaboration, agreements have been established between NSF and the Japanese Ministry of Education, Sports, Culture, Science and Technology (MEXT) and between NEES and NIED. Similarly, there are annual and other meetings of the NEES/E-Defense community to plan the research effort and coordinate efforts, and encourage broad participation in the activities. Dr. Steve Mahin on the US and Dr. Masayoshi Nakashima on behalf of NEID and E-Defense led coordination efforts.

Annual research planning meetings are held that involve the funded NEES/E-Defense research teams, various domain experts who offer advice, younger investigators who may be interested in establishing contacts with E-Defense researchers so they can prepare future NEESR proposals, and federal and state agency representatives. During the first phase, NEESinc funded these meetings. For the second phase, NSF requested a separate coordination proposal and Dr. Mahin is the PI of the award. As a NEES activity, the community has the support of NEEScomm for

activities such as archiving data and others. The coordination is covered in the Memorandum of Understanding through a Joint Technical Coordinating Committee. Planning on the US side is conducted at workshops where working groups make recommendations to NSF as well as to the NEES community. NSF generally includes the input from the workshops in the NEESR solicitation in various levels of detail. During 2009, two meetings were held, one in January 12-13 at NSF in Arlington, VA, and the second one took place September 17-18, in Miki and Kobe, Japan.

Significant accomplishments have been achieved through the first years of this collaboration. For example, the NEES/E-DEFENSE Collaborative Earthquake Engineering Research on Steel Buildings: <http://www.ce.berkeley.edu/~mahin/NEESeDefenseSteel.htm>

### **Future Plans: Beyond 2010**

#### **Partnerships**

NEEScomm plans to build on the experiences of the two world forums and take a leadership position in facilitating collaboration among international research organizations and NEES. Memorandums of Understanding are presently at various stages of maturity. These include:

- *The Port and Airport Research Institute (PARI) in Japan.* PARI has developed and operates experimental facilities for 1) marine environment and engineering, 2) geotechnical and structural engineering, and 3) construction and control systems in close collaboration with the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan. Among those facilities, are the “Large Hydro-Geo Flume (LHGF)” and an “Underwater Shake Table (UST)” to investigate earthquake and tsunami engineering; a “Large Geotechnical and Hydrodynamic Centrifuge (LGHC)” that will be in operation starting 2010, to investigate the multi-hazards of earthquakes and tsunamis.
- *The Canadian Seismic Research Network (CSRN).* The network was established to undertake research leading to the development of national guidelines for seismic rehabilitation of existing buildings and bridges, microzonation of Canadian urban regions, and scenarios for policy and planning decisions. CSRN, led by Prof. Denis Mitchell, is headquartered at McGill University in Montreal, Quebec, Canada, and coordinates research projects conducted by 26 researchers from eight universities across Canada. Large-scale structural testing is conducted at most of the eight universities and forms an important component of the CSRN research program.

Further, agreements are being explored with The Center for Networked Scientific and Structural Laboratories (CNetSLab) in China, as well as with Mexico, and the European Community. NEESinc also drafted a Memorandum of Understanding with the National Centre for Research in Earthquake Engineering (NCREE), the major earthquake engineering laboratory in Taiwan. For example, collaborations with NCREE include hybrid simulation of tomorrow’s braced frame systems: [depts.washington.edu/neesrcbf/](http://depts.washington.edu/neesrcbf/) and [exp.ncree.org/cbf/](http://exp.ncree.org/cbf/). These agreements will provide U.S. researchers unprecedented access to use the world’s best research facilities and facilitate international collaborations.

## Activities

Earthquake risk mitigation efforts will benefit from a strategy that provides the community access to resources and encourages collaboration. The sharing of research infrastructures among countries is a critical component of this strategy. Access and collaboration can lead to:

- a curated database of past, present and future test data available to the community,
- multi-disciplinary and multi-facility projects,
- networked simulation
- development of new tools for:
  - data collection,
  - developing inventories of physical systems of sufficient fidelity,
  - monitoring and assessing resilience;
  - improved simulation of the resilience of systems at regional scale
- accelerate implementation and technology transfer
- development of new facilities, and
- a global community of earthquake engineering engaged in risk mitigation.

It is envisioned that the NEES cyberinfrastructure, NEEShub, will support the highly diverse earthquake engineering community with tools for archiving and accessing data, for various levels of analysis, for experiments in tele-operation, for educational resources and for accessing worldwide resources (Eigenmann et al. 2010; Anagnos & Brophy 2010). The result would be a global community engaged in the generation and dissemination of a rich set of these tools, and learning and training resources. The NEEScomm approach will be to integrate community resources into the NEEShub and to fill in the gaps with tools developed jointly with the user community.

Disasters have no logic, and sadly are nonnegotiable. The prompt and effective response to disasters such as the recent January 12, 2010 Haiti and February 27, 2010 Chile events are the concern of engineers and scientists focused on risk mitigation efforts. A well-organized global community will be able to efficiently distill valuable lessons to be learned from these unfortunate events. We see a role for NEES in providing information technology support to the research community to collect, store and access data generated at such high cost to society.

It is envisioned that an environment of collaboration could foster the development of institutes for global earthquake research efforts. In these institutes:

- 1) corporations, professional societies, and non-governmental organizations (NGO) interested in protecting society from the harmful consequences of earthquakes could interact with researchers to pursue a more ambitious research agenda;
- 2) academic researchers would be encouraged to interact with the professional engineers in order to accelerate the implementation of new knowledge in practice;
- 3) a global community focused on combating the effects of earthquakes on communities and societies would be nurtured.

In conclusion, using the opportunities provided by access to resources and collaborations in research and education, supported by information technology, NEES will move at an ever-

increasing pace in the pursuit of earthquake and tsunami risk mitigation as a fully integrated and effective resource of the world.

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