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SeismicWaves

How the National Earthquake Hazards Reduction Program Is Advancing Earthquake Safety

Network Hitting Its Stride, Linking More Than Laboratories

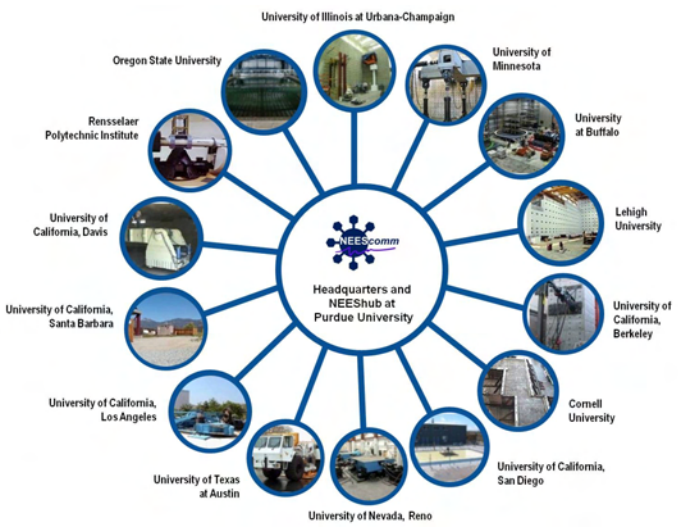
Now entering its eighth year in operation, the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) is accelerating advances in earthquake safety in unprecedented ways. Known for the cutting-edge research enabled by its state-of-the-art network of laboratories, NEES is also helping the earthquake engineering community become more interconnected and collaborative, in the United States and internationally.

As part of its contribution to the National Earthquake Hazards Reduction Program, the National Science Foundation (NSF) funds NEES operations (Award # CMMI-0927178) as well as many of the research projects that are conducted in NEES facilities. NEES operations are managed by the NEES Community and Communications Team (NEEScomm), which is headquartered at Purdue University in West Lafayette, IN, and includes key administrative partners at the University of Texas at Austin, San Jose State University, the University of Washington at Seattle, the University of Kansas at Lawrence, and Fermi National Accelerator Laboratory.

A Unique Presence Both Physical and Virtual

NEEScomm manages a nationwide network of 14 experimental facilities. Each of these university-based equipment sites allows researchers to explore a different aspect of the complex way that soils and structures behave in response to earthquakes and tsunamis. The sites are available not just to researchers at the universities where they are located, but to investigators throughout the country who are awarded grants through NSF's annual NEES Research (NEESR) Program and other NSF programs. Eighty percent of NEESR projects have been led by researchers located at colleges or universities remote from the NEES site used.[1]

NEES laboratories are also used for research conducted or funded by other federal, state, and local agencies, by private industry, and even by international researchers under the partnerships that NEES has cultivated with research facilities and agencies in Japan, Taiwan, Canada, and China. More than 300 multi-year, multi-investigator projects have been completed or are in progress at NEES sites, yielding many advances in earthquake engineering and a wealth of valuable experimental data.



NEES links 14 laboratories containing shake tables, geotechnical centrifuges, large-scale experimental testing facilities, a tsunami wave basin and large wave flume, mobile field testing equipment, and two permanently instrumented field sites.

Linking the experimental facilities to each other, to NEEScomm, and to off-site users is the NEES cyberinfrastructure. This unique system of information technology resources enables researchers participating on-site or remotely to collect, view, process, and store data from NEES experiments, to conduct numerical simulation studies, and to perform hybrid (combined experimental and numerical) testing involving one or more NEES equipment sites. At the center of this system is NEEShub, a platform designed to facilitate information exchange and collaboration among earthquake engineering researchers, educators, students, practitioners, and stakeholders. Accessed via the NEES website, nees.org, NEEShub is powered by HUBzero software developed at Purdue University.

NEEShub features the NEES Project Warehouse, a curated, centralized data repository used to store and share research results. As more NEES research projects have been completed in recent years, the number of files in the warehouse has increased rapidly and now exceeds one million. NEEShub also stores and shares a variety of other earthquake engineering resources, including publications, databases, computational models, simulation software, educational materials, and data management and visualization tools. Some of these have been developed by NEES personnel, while others have been contributed by the

[1] Statistics cited in this article are from NEEScomm's *NEES Self-Study Report* available at https://nees.org/resources/3234/supportingdocs.

earthquake engineering community. NEEScomm solicits and welcomes such contributions from the United States and abroad.

In addition to enabling sharing and collaboration that can accelerate advances in earthquake risk reduction, NEEShub is also helping to disseminate these advances. NEESacademy, a section of NEEShub maintained by NEEScomm's education, outreach, and training (EOT) staff, provides access to varied resources tailored for students, teachers, engineering professionals, and the public.

0.4-scale curved highway bridge model tested recently on shake tables in the Large-Scale Structures Laboratory at the University of Nevada, Reno (UNR) NEES equipment site. Courtesy of UNR Department of Civil and Environmental Engineering.

Accomplishments Providing Near- and Long-Term Benefits

Research at NEES facilities has advanced our understanding of seismic phenomena, such as the characteristics and effects of tsunamis and the potential for soil liquefaction. It has also strengthened our knowledge of how the built environment responds to earthquakes. NEES investigators have studied the responses of a variety of structures, from reinforced concrete columns used in buildings and bridges to wind turbines and port container cranes.

Other NEES research has developed or validated new seismic protection systems, design methods, or simulation tools that enable engineers to improve the seismic performance of structures. For example, NEES projects have validated the improved seismic performance of bridge piers made with innovative polymer materials; of base-isolated designs for steel structures; of reinforced masonry shear-wall structures; and of retrofit techniques for non-ductile, reinforced concrete frames with infill walls. New design methods have been developed for mid-rise wood-framed buildings, metal building systems, precast concrete floors, and reinforced concrete wall systems. NEES research has also produced new simulation tools and fragility data for nonstructural building systems.

Many of these projects have prompted, or laid the groundwork for, improvements in model building codes and in design and construction practices, enhancing societal resilience to earthquakes and tsunamis. Facilitating these outcomes has been the dissemination of NEES findings through publications, NEEShub, and NEES EOT activities. NEES research has been cited in more than 1,500 publications, including rising numbers of refereed journal articles. During the first 10 months following its release in July 2010, NEEShub served 28,447 unique visitors from 57 countries.

Seismic design professionals visiting NEEShub can search and download bibliographic citations (and often copies) of publications describing NEES research findings; access and analyze these findings and use associated tools to improve their designs; and view presentations about NEES findings recorded at conferences and webinars. Practitioners can also attend NEES research presentations at EOT venues such as the annual "Quake Summit" conferences hosted by NEES.

In addition to influencing earthquake engineering practices, NEES is helping to build the workforces needed to discover and implement research findings. EOT staff are developing, and the NEES user community is contributing, learning resources for K–12 and college students that are being disseminated through NEESacademy and NEES community outreach activities. NEES is also enabling students to learn earthquake engineering through involvement in research projects, undergraduates through NEES' annual Research Experiences for Undergraduates program, and graduate students by directly assisting NEES investigators. In a recent survey, NEEScomm found that at least 559 graduate students, including 191 PhD candidates, have been trained through participation in NEES research. Many of those receiving PhDs now hold faculty positions at major research universities worldwide.