LOAD TESTS ON RESEARCH LABS

NAGY-GYÖRGY Tamás
Professor

E-mail: tamas.nagy-gyorgy@upt.ro

Tel: +40 256 403 935

Web: http://www.ct.upt.ro/users/TamasNagyGyorgy/index.htm

Office: A219

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Pacific Earthquake Engineering Research Center

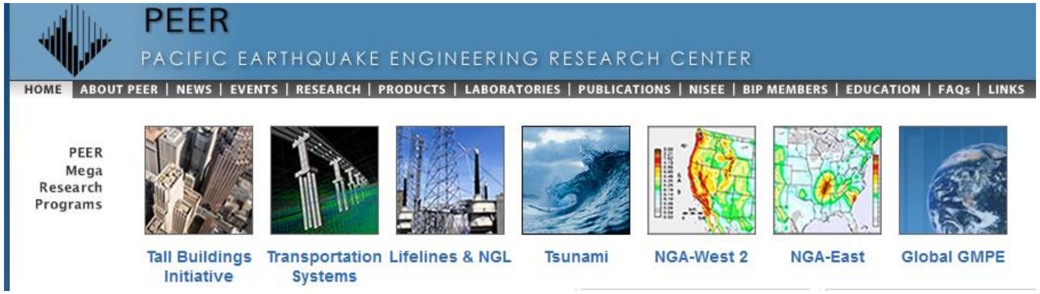
PEES

(multi-institutional research and education center - USA)

→ to develop and disseminate technologies **to support performance-based** earthquake engineering

→ research programs focused on performance-based earthquake engineering in disciplines including structural and geotechnical engineering, geology/seismology, lifelines, transportation, risk management, and public policy

Core Institutions are:
University of California, Berkeley - Lead Institution
California Institute of Technology
Oregon State University
Stanford University
University of California, Davis
University of California, Irvine
University of California, Los Angeles
University of California, San Diego
University of Southern California
University of Washington



Network for Earthquake Engineering Simulation

NEES

transformed to

DESIGNSAFE-CI

NHERI: A NATURAL HAZARDS ENGINEERING RESEARCH INFRASTRUCTURE

→ To develop the **innovations** necessary **to reduce the impact of seismic disasters** - USA

Types of experimental work: geotechnical centrifuge research, shake table tests, large-scale structural testing, tsunami wave basin experiments, and field site research.

14 geographically-distributed, shared-use laboratories : Cornell University, Lehigh University, Oregon State University, Rensselaer Polytechnic Institute, University at Buffalo, SUNY, University of California, Berkeley - Lead Institution, University of California, Davis, University of California, Los Angeles, University of California, San Diego, University of California, Santa Barbara, University of Illinois, Urbana-Champaign, University of Minnesota, University of Nevada, Reno, University of Texas, Austin.

Report download:
https://www.designsafe-ci.org/data/browser/public/nees.public/

Tests on Non-Ductile Beam-Column Joints Experiencing Axial Collapse under Simulated Seismic Loading

→ investigation the **axial collapse** probability following **shear failure** of unreinforced older-type construction corner **beam-column joints** under **high axial load** reversals varying with lateral loads

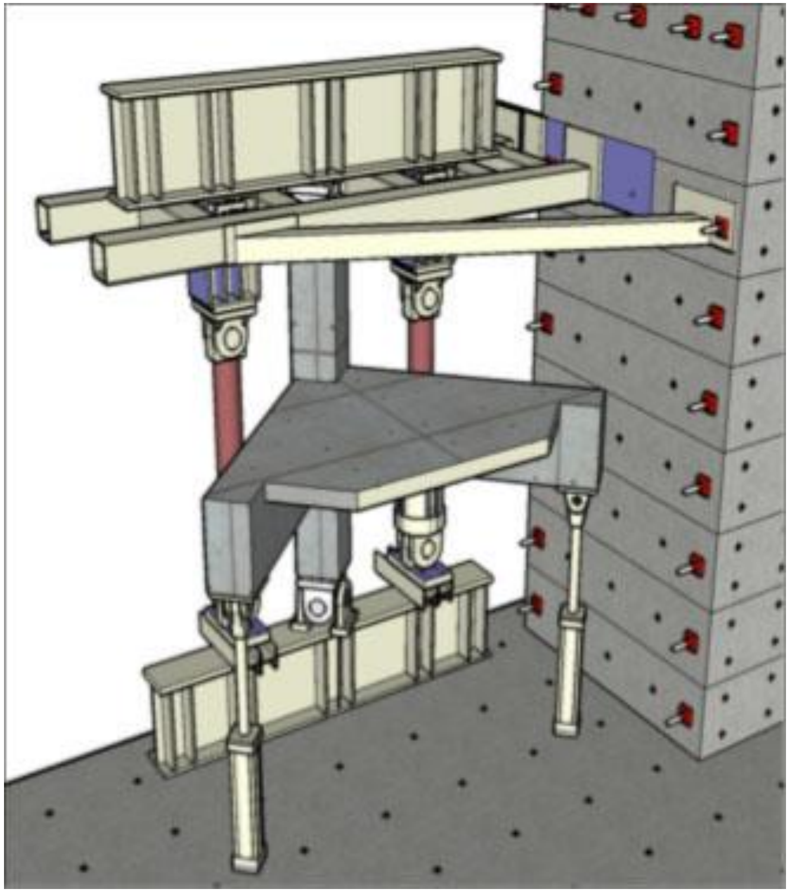
→ four **full scale** corner beam-column joint subassemblies, including floor slabs

→ **realistic boundary conditions**

→ **drift based history** is used to simulate lateral loading. Test parameters are axial load level, joint aspect ratio, beam reinforcement ratio, and loading history (unidirectional vs. bidirectional displacement reversals)

Tests on Non-Ductile Beam-Column Joints Experiencing Axial Collapse under Simulated Seismic Loading

→ investigation the axial collapse probability following shear failure of unreinforced older-type construction corner beam-column joints



Video 1 - MultiView

Video 2 - Setup-Cam

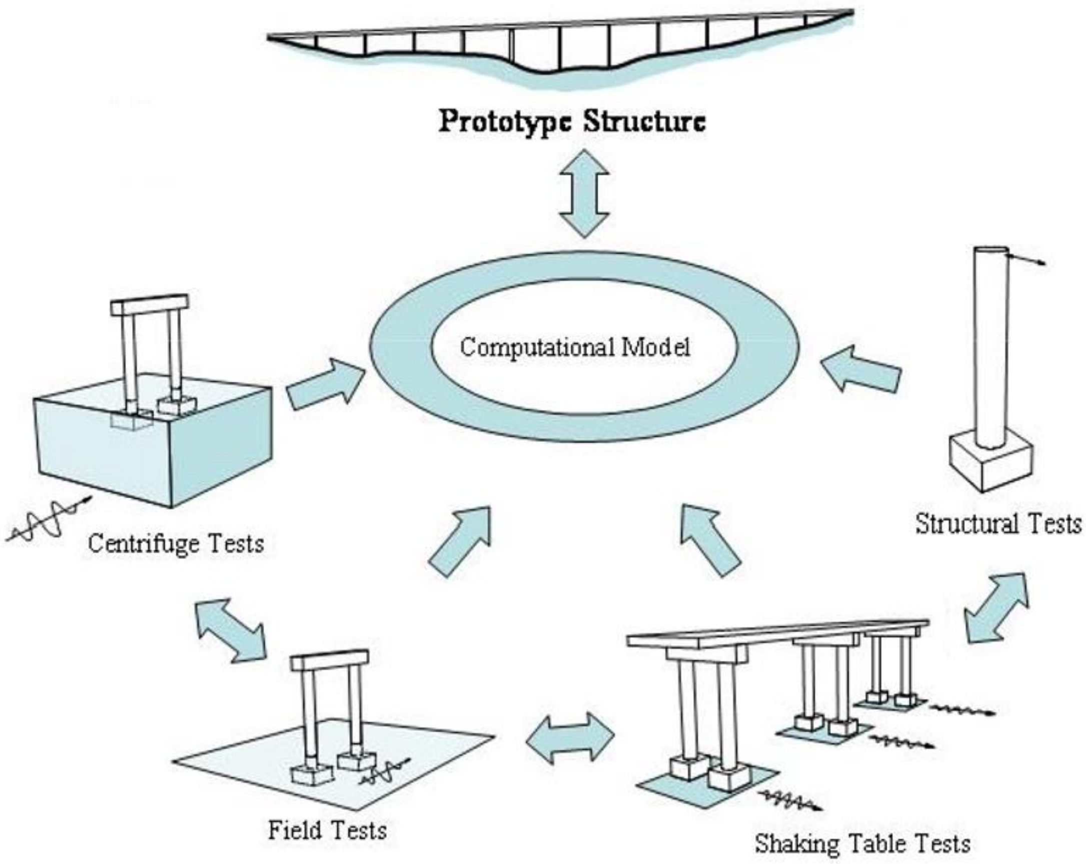
Video 3 - Focus

Video 4 - Axial Collapse 50%Pgrav

Detailed description

Multi-Site Soil-Structure-Foundation Interaction Test (MISST)

MISST concept was developed to provide a **realistic test bed application** with which to verify and extend all components of hybrid distributed simulation as well as all components of the sites taking part in the experiment



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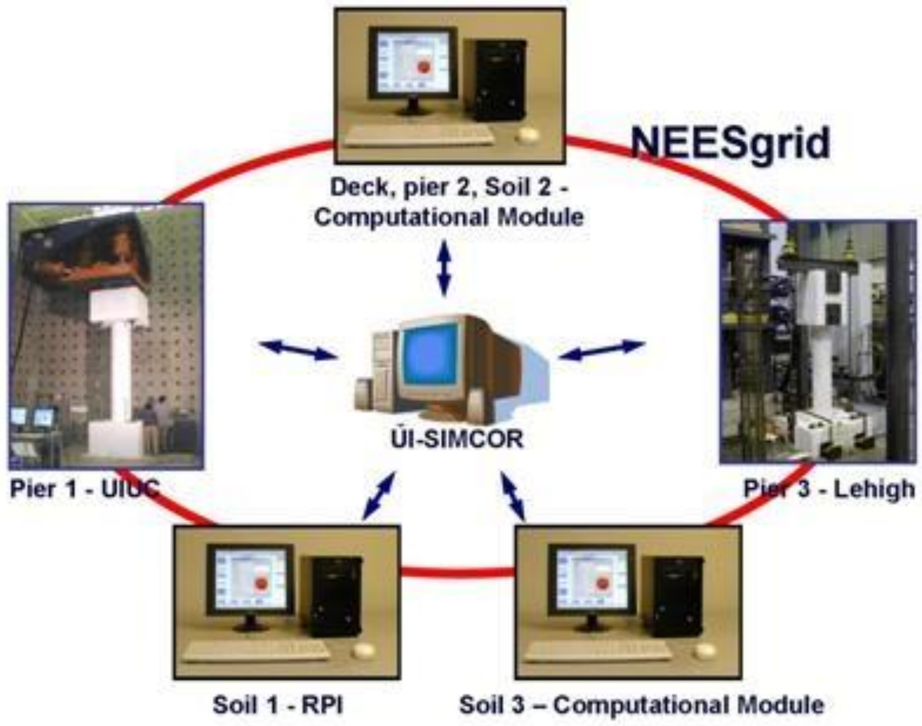
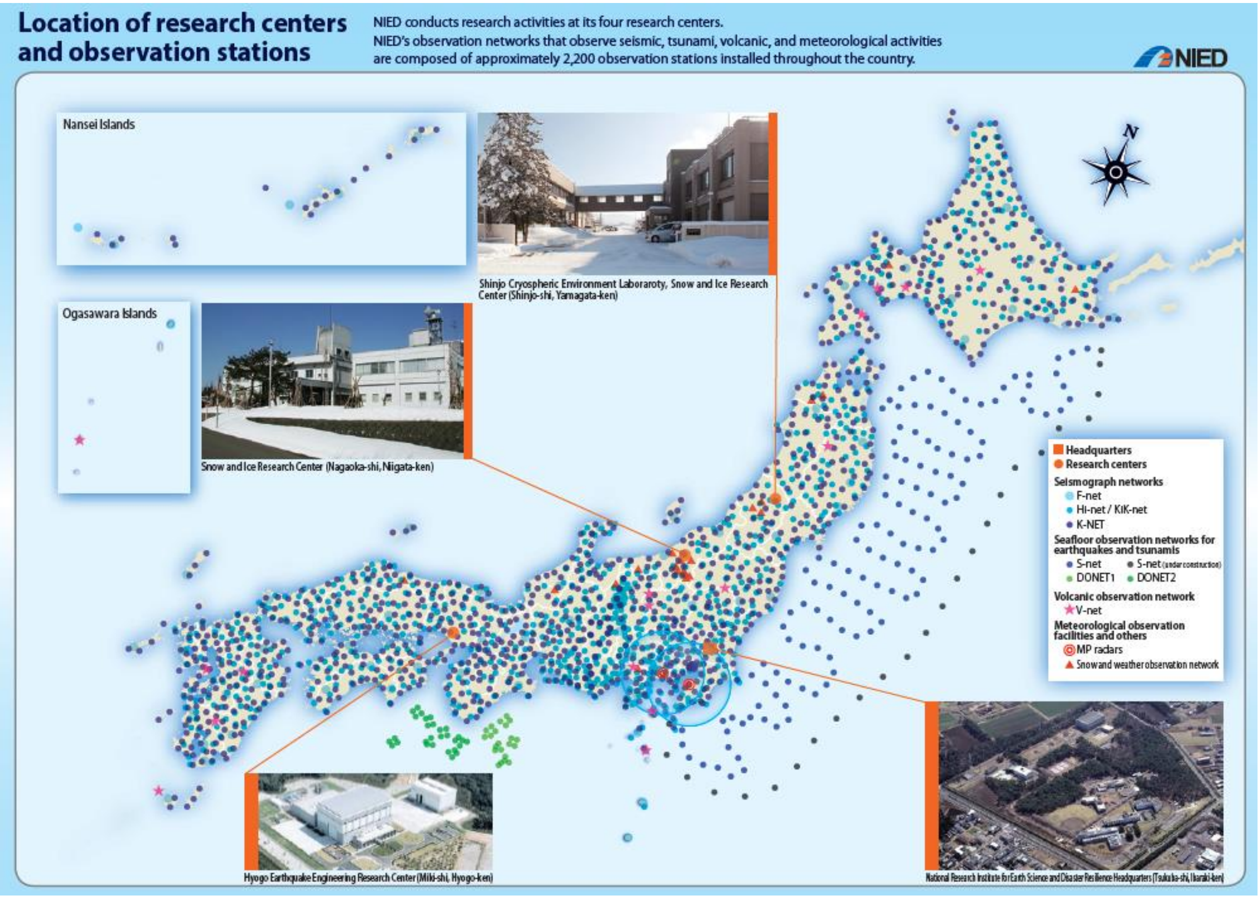
For the distributed simulation → UI-SIMCOR simulation coordinator software. Handles all inter-module communication and hosts the numerical integration scheme.



Video 1 - BRIDGE MISST

National Research Institute for Earth Science and Disaster Prevention NIED - Japan

→ To protect people's lives and properties from **natural disasters** and to prepare society to be resilient to natural disasters, through research on disasters caused by earthquakes, volcanoes, floods, landslides, meteorological changes, snow and ice damages.



Four-story Reinforced Concrete and Post-Tensioned Concrete Buildings – 2010

→ **full-scale** shaking experiments on a **precast** and **post-tensioned** concrete (PPC) structure were conducted to establish **high-quake-resistant**, **productive** and **reparable** concrete buildings. In the experiments, both of the PPC structure and the RC structure were shaken at the same time (the PPC structure at the front and the RC structure at the back of the video). As for the two 4-story buildings, the story height of each floor was 3.0 m, and the long side of the rectangular plane was 14.4 m and the short side was 7.2 m

Imposed ground motions: JMA Kobe record (1995 Hyogoken-Nanbu Earthquake) 50%

JMA - Japan Meteorological Agency

Three-story Wooden Houses – 2009

→ experiments to **verify the design method** for 3-story Wood Houses by Post and Beam **conventional Japanese wood houses.** There were two specimens, both of which were 3-story wood houses with the **same specifications** including floor area and height of each floor **except design of joint parts**. In the experiment, damage and behavior of specimens under strong earthquake were confirmed by inputting a synthetic ground motion in one direction.

Imposed ground motions: Synthetic ground motion 160%

Seven-story Wooden Building – 2009 (NIED – NEES)

→ shaking table experiment on a **full-scale 7-story wood building** was conducted. The **first story** of the test structure was a **steel frame** simulating a basement parking area. **The 2nd to 7th stories** were the **residential area** constructed by the **wood-frame** structure. The test structure was 12.4 m wide, 18.4 m long and 20.4 m high. In the experiment, the seismic motion recorded at Canoga Park during 1994 Northridge earthquake was used. The test structure was shaken by the 180% of the seismic motion, and the response of the structure under the severe input motion was investigated.

Imposed ground motions: Canoga Park record (1994 Northridge earthquake) 180%

Panoramic view from obliquely upward

Inside of a room on the 7th floor

Reinforced Concrete Bridge Pier - 1970s' Pier with Cut-off – 2008

→ A shake table experiment of **full-scale RC bridge pier** was conducted. The pier was designed as a reinforced concrete **bridge column which built in 1970's** and it had termination of longitudinal bars at the mid-height of the pier. The pier had a circular section with a diameter of 1.8 m and the height of the pier was 7.5 m. Its foundation was 7.0 m by 7.0 m and 1.8 m tall. The weight of superstructure was about 300 tonf. Based on the experiment, progress of the damage, which is similar with the damage of the reinforced concrete piers collapsed during the 1995 Hyogoken-Nanbu Earthquake, was reproduced and taken its data.

Imposed ground motion: JR Takatori record (1995 Hyogoken-Nanbu Earthquake) 100%

Reinforced Concrete Bridge Pier - Pier Designed Based on the Current Code

2nd excitation : JR Takatori 100%

3rd excitation: JR Takatori 125%

Seven-story XLam Wood Panel Construction – 2007

→ a shaking experiment of **full-scale 7-story wood structure** was conducted to develop the construction method by cross laminate panel, XLam: 7 cm to 20 cm thick laminated panel made of 2 cm thick piece of wood bonded alternately and thickly without any interspace. A test structure was timber box-frame construction which was 23.5 m height, 7.5 m width, 15 m depth and total weight 285 tonf.

Imposed ground motions: JMA Kobe record (1995 Hyogoken-Nanbu Earthquake) 100%

Panoramic view (skew)

7F (inside of the room)

Four-story Steel Building – 2007

→ A **full-scale 4-story steel building** was repeatedly subjected to ground shaking until it collapsed. The building satisfied the minimum requirements prescribed in the current Building Standard Law of Japan. Composite concrete slabs were provided to complete a very realistic structure. **The building was furnished with a complete set of nonstructural elements** including ALC (AAC) exterior walls, aluminum sash, glass windows, partition walls, and ceiling. The experiment was conducted by **increasing the intensity of excitation gradually** from small to the strongest motion.

Imposed ground motions: JR Takatori record (1995 Hyogoken-Nanbu Earthquake) 40%

Imposed ground motions: JR Takatori record (1995 Hyogoken-Nanbu Earthquake) 100%

Conventional Wooden Houses – 2007

→ a collapse experiment of **full-scale wooden houses** was conducted. The test structures were **constructed based on the previous building standards** which were used until 1981 and whose seismic performance was insufficient. The purpose of the experiment on House C was to **investigate the effect of aging** on the seismic capacity of wooden house. The purpose of the experiment on House D was to verify the **effect of partial seismic reinforcement**.

Imposed ground motions: JR Takatori record (1995 Hyogoken-Nanbu Earthquake) 100%

1st excitation: JR Takatori 100%

2nd excitation: JR Takatori 100%

4th excitation: JR Takatori 100%

Six-story Reinforced Concrete Building – 2006

→ a shaking table experiment of **full-scale 6-story reinforced concrete** (RC) building had been conducted. The test specimen was 12 m long, 17 m wide, 16 m tall, 6-story building and its weight was around 1,000 tonf which was the heaviest test structure ever since E-Defense started running. The structure was designed **based on the code of design and practice in 1970's**. The test specimen was subjected to the record of the 1995 Hyogoken-Nanbu Earthquake and the behavior was studied to obtain necessary data for upgrading earthquake-resistance improvement technology of RC building

Imposed ground motions: JMA Kobe (1995 Hyogoken-Nanbu Earthquake) 100%

Imposed ground motions: JMA Kobe (1995 Hyogoken-Nanbu Earthquake) 60%

Office Space in High-Rise Buildings – 2008

Imposed ground motions: Synthetic ground motion from a scenario Nankai earthquake

→ A large-amplitude floor response of a high-rise building was reproduced by using 5-story steel frame test structure with two amplifying layers comprised of rubber bearings and concrete slab. Realistic conditions of residential room as well as office room were reproduced and a tuned synthetic ground motion was input to the shaking table. The large-amplitude floor response corresponding to the maximum displacement of 1.5 m was reproduced in the test structure of 5-story frame. The response of the test structure was tuned to represent the floor response of the 30th floor of a 30-story high-rise building which was subjected to synthetic ground motion for Nagoya from a scenario Tokai-Tonankai earthquake. Dangerous phenomena in the office room, residential room, kitchen and living room were clarified and the resistant measure prepared in the same type of rooms showed significant improvement in terms of safety

Functional Maintenance of Medical Facility – 2009

Comparative video of aseismic and a seismic isolation structure

→ Shaking table experiments had been conducted to evaluate ability of functional maintenance of medical facilities under earthquake disaster. A full-scale 4-story reinforced concrete building specimen simulating a hospital which contained a stuff station, a dialysis room, an operating room and a patient's room each furnished with real medical equipment and furniture was set up to reproduce function of the medical facility more faithfully. Two hospitals of different kind of structure each, one for a base-fixed structure and the other for a seismic isolated structure, were compared and evaluated their functional maintenance by shaking table experiments. Comparative video of the experiments shows risk of the aseismic hospital and ability of functional maintenance of the seismic isolated hospital under a near fault earthquake ground motion.
But even a seismic isolated structure which widely reduces damages against earthquake in general can be exposed to risk by long-period, long-duration earthquake ground motion such as synthetic ground motion for Sannomaru area, Nagoya from a scenario Tokai-Tonankai earthquake if one fails to take earthquake countermeasures. Results of the experiments are going to be used to upgrade ability of functional maintenance of medical facilities in the future.

Multistory Steel Building -Effect of Supplemental Dampers – 2009

→ The test structure was designed to reproduce the seismic response of an 80-m-tall, 21-story building. The lower four stories of the test structure were constructed as an actual steel frame. Substitute layers, which consisted of concrete slabs and rubber bearings, were placed above the steel frame to simulate the 5th to 21st floors of the building. The structure was subjected to a series of synthetic long-period ground motions: one for Tokyo from a scenario Tokai earthquake and another for Nagoya from a scenario Tokai-Tonankai earthquake.

Imposed ground motions: Synthetic ground motion for Nagoya from a scenario Tokai-Tonankai earthquake

Meeting room on the roof level corresponding to 19th floor

Office room on roof level corresponding to 19th floor

Dining room on roof level corresponding to 19th floor