

Meeting Minutes on Underground Structures 9th NEES/E-Defense Planning Meeting

Attendee Names:

Japan: Ikuo Towhata, Yohsuke Kawamata, Takuzo Yamashita, Susumu Yasuda,
Mutsuhiro Yoshizawa, Ryosutie Uzuota, Mamabu Nakayama, Mutsuhiro Yoshizawa,
Kenichi Abe

U.S.: Youssef Hashash, Nick Sitar, Shideh Dashti, Anne Lemnitzer

Recorder: Shideh Dashti & Anne Lemnitzer

Meeting on Saturday August 27, 2011 at E-Defense

Youssef Hashash Presentation Key Points:

- The practice of seismic design of underground box structures in the US. Youssef is willing to provide his slides upon request.
- Disregarding the possibility of ground failure, transient racking displacements in the transverse direction is a critical of deformation mechanism for shallow box structures
- The racking ratio is related to the flexibility ratio, a key parameter used in design.
- Three primary approaches: closed form, free-field, dynamic
- For one-dimensional site response analysis: SHAKE, DEEPSOIL (free to use), or DMOD, ...

Shideh Dashti Presentation Key Points:

- Objective of the study is to investigate the seismic behavior of temporary and permanent shallow underground structures adjacent to mid- to high-rise buildings using a combination of centrifuge testing and numerical simulations
- The specimen will be instrumented using a combination of LVDTs, strain gauges, accelerometers, and flexiforce pressure sensors
- Potential for collaboration with E-Defense: payload instrumentation, selection of ground motions, structural models, and soil properties
- Questions raised:
 1. Soil type and water content.
 2. Foundation system of the high-rise building, the concern was raised that if the soil is medium dense, the assumption of shallow foundations for a high-rise building is unrealistic
 3. Scaling effects of the building (mass). How is the natural period of a building realistically represented in a small-scale model?
 4. How to measure earth pressures? Shideh explained the type of sensors and their applications. Concerns were raised about the dynamic performance of the flexiforce tactile pressure sensors.
 5. What is the ultimate goal of the test? The nonlinear interaction between the underground structure, soil, and an adjacent structure and the effects of the transmitted forces from a tall structure to an adjacent cut-and-cover structure are not well understood. The main goal is to better understand these interactions and provide data from calibrating and enhancing numerical models.
- Suggestions: E-Defense colleagues suggested 2 additional centrifuge experiments specifically focusing on buildings without any underground

structure in place and a test for pure free-field to better have a baseline condition.

Ikuo Towhata

- Rules on data sharing: 900+ channels will be recording in each E-Defense experiment. If the US researcher is residing in Japan with recommendation letters from the Japanese researchers, then the E-Defense rules allow sharing of data. Individuals who want to use the data from E-Defense experiments should register on the E-Defense website (just one registration is needed). After two years, the data becomes available to everyone.
- Intellectual property agreement issues should be discussed among our teams. A contractual arrangement is needed for both sides on data exchange, both between the NEES project and E-Defense and for potential pay-loading of instruments.
- Payloading is difficult, but a simple solution may be to find a Japanese company who will be in charge of the installation of the instruments and the US side can get the data from the company directly.

Yohusuke Kawamata Presentation Key Point

- In mega-cities due to lack of space, there are many existing underground structures connected to each other for convenient usage. But different parts of these underground structures were designed by different firms and at different periods. The **joints** were typically poorly designed. These joints may collapse during a large EQ motion. We need to evaluate with reasonable accuracy how these underground structures will perform during a large earthquake scenario (localized behavior around joints is of particular interest).
- The project includes large-scale model tests at E-Defense and small-scale tests, in parallel to numerical simulations.
- Preliminary tests were done in FY2010: centrifuge small-scale model tests and small-scale 1g shake table tests.
- The centrifuge tests included two vertical shafts. Their bending mode was critical, so their stiffness in bending was modeled carefully.
- Input motion had a PGA of 0.4g. There was some cracking around the pipes, some portions completely detached. Shaft-1 showed the highest amplification of the ground motion, but Shaft-2 was less stiff and did not amplify the motion significantly.
- Youssef suggested also looking at the changes in velocity and displacement. Shideh suggested also looking at the response spectra or Fourier transforms to see what frequencies are amplified in each case.
- Youssef: we are increasingly using flexible joints in the US. In retrofit, we typically see rigid connections that are changed to flexible. Yohusuke: it is difficult in testing to add a flexible joint in terms of instrumentation.
- The shaking table tests will use a cylindrical laminar container (40 laminar rings, 8 m in Diam, 6.4 m in Height). The objectives are to investigate the effects of an adjacent structure, joint type (rigid versus flexible), and the seismic behavior of underground structures. The scale of the model will be 1/20.
- The plan is to use many bolts for the rigid connection in order to prevent failure during small to moderate earthquakes and get failure during the last large earthquake scenario. Youssef pointed out that an unrealistically strong connection may lead to unrealistic results and unwanted failure modes. This may lead to a

- different failure mechanism than what is of interest. To test this at different levels, the joints can be constructed in a way that it is easy to replace the bolts.
- Shideh suggested using force sensing bolts, so forces on these bolts at the joints can be measured.
 - Element tests are planned by E-Defense for evaluating the friction angle between the tunnels and sand.
 - Real-time videos will be made available to the public, but the image speed is one image every 5 sec. There will be more cameras inside the tunnel that will not be made available real-time.
 - Numerical simulation competition is only open to Japan and US, as a part of NIED-NEES joint research works. Professor Uzuoka at the Tokushima University is the chair of the competition committee. In early September a webpage for this competition will be opened.

Meeting on Sunday Aug 28, 2011

- The objective of this meeting was to plan the simulation competition and how to move the collaboration forward.
- Prof. Youssef Hashash provided a summary of the meeting on Friday.
- Prof. Towhata: E-Defense rules on payload: the contractor will be decided on the shaking table and that company can be hired from the US side to install sensors and then the recorded data will be exchanged between the company and the US side.
- E-Defense rules for the exchange of data: after two years all data becomes available but in Japanese. Within the two years, if there is an official contract, the data can be exchanged.
- Prof. Nick Sitar: in order to judge the simulation competition, some of the data should be released. If the attendees have to wait for two years for the data, they will likely not want to participate. Even when the data is released, to fully understand it one needs to be intimately familiar with the test setup.

Key Points of Numerical Simulation Competition:

- The competition will be closed only to US and Japan. International participants will be allowed upon the recommendation of Profs. Sitar and Hashash. The results from this competition will be published in a special issue of a journal. The information will be provided on the website and maintained by the Japanese side.
- All participants should provide simulation results for Class-A and Class-B predictions.
- Definition of Class-A and Class-B predictions was discussed and what can be shared on the E-Defense data to make it a true Class-B. The two sides need to make clear what information exactly will be provided to the competition participants for both Class-A and Class-B.
- The properties of the soil should be measured with bender elements or geophones before the application of each ground motion and that should be a part of the data provided for Class-B competition participants.
- The numerical simulations are going to be performed in 3-D.
- Prof. Sitar: the deadline for submitting Class-A predictions is too early for the US side. Because of the regulations on data release, can we extend the competition deadline for Class-A submission? As long as data is not released to the participants, it is still a Class-A prediction. Alternatively, it may be more realistic for participants to only submit Class-B predictions.
- With flexiforce sensors, the sampling rate is too low (around 100Hz) for centrifuge testing but it's adequate for shaking table testing. Nick Sitar and Anne will work with the Japanese colleagues on the choice of the pressure sensors.
- Intellectual independence and right of publication contracts should be written between the academic institutions who participate in the numerical simulation competition and E-Defense.
- Prof. Towhata will provide a list of the competitors to Prof. Hashash and Sitar. Nick, Youssef, Anne, and Shideh will take care of the US and international coordination.
- The upcoming conference in Japan is in early March of 2012. The upcoming shaking table tests are planned in late February. The participants in the conference can arrange to see the shaking table tests a few days prior to the conference.

Key Points of Numerical Simulation Competition:

- Collaboration on the NEESR project (PIs: Shideh Dashti and Youssef Hashash) and E-Defense will continue through regular online meetings every few months. Prof. Dashti will arrange these meetings between the US team (University of Colorado, Boulder and University of Illinois, Urbana Champaign) and Prof. Towhata on the Japan side.