

NCREE Tainan Laboratory Grand Opening Forum

Topic 2: Innovative Experimental Technologies and Numerical Simulation Methods

Moderators: Shirley J. Dyke and Keh-Chyuan Tsai

Summary prepared by Pei-Ching Chen and Chia-Ming Chang

Presentation Outline:

Experimental technologies and numerical simulation methods have been regarded as the key approaches to evaluate seismic responses of buildings and infrastructures subjected to ground motions. Therefore, Topic 2 has been considered a crucial subject of the Grand Opening Forum in order to achieve sustainable operation and innovative testing for the NCREE Tainan Laboratory. A total number of 20 speakers delivered informative presentations in the forum.

An overall review of innovative experimental technologies in earthquake engineering was presented by Dr. Ian Buckle, which covered current advancement of hybrid simulation, shake table testing, soil-structure-interaction experiments, tsunami simulators, and contactless measurement technologies.

Dr. Shirley Dyke addressed the needs of establishing the theory and expand the capacity of hybrid simulation for multi-hazard engineering.

Dr. David Lau introduced the multi-hazard test facility for built infrastructure protection and resilience in Canada, which specifically focused on a mobile reconfigurable shake table system, and a wind pressure simulation chamber. Comparatively, Dr. Hong Hao introduced the facility for earthquake engineering simulation in China, which could satisfy the needs to conduct full-scale tests with coupled earthquake and hydrodynamic loadings.

Dr. Yi-Lung Mo summarized a large number of research results of seismic simulation on reinforced concrete structures including shear walls, unsymmetrical buildings, and nuclear containment vessels.

Dr. David Sanders indicated the impact of earthquake duration on structural performance from shaking table test results. Dr. Alberto Pavese shared the experiments of base isolation devices that have ever been conducted in EUCENTRE including hybrid simulation of isolated structures in order to assess demand under real input earthquakes.

Dr. Hitoshi Kumagai introduced the new facilities in the advanced earthquake engineering laboratory of Shimizu Corporation and discussed the fling step effect on the structure with natural period longer than the pulse period. Dr. Kazuhiko Kasai indicated the tough requirements for specimens and testing based on the ten-year experience from the E-defense shake table testing.

For the speakers from Taiwan, Dr. Keh-Chyuan Tsai first introduced the finite element analytical methods of steel panel dampers for seismic applications in steel moment frames to evaluate the equivalent cross-sectional properties as well as the effects of inelastic core height ratio on the elastic and post-yield stiffness of the steel panel damper. Dr. Jia-Ying Tu explained the control issue related to real-time hybrid simulation and discussed the effects of parameters on stability, efficiency, and optimization. Dr. Yuan-Sen Yang completed image-based measurements in demonstrative tests utilizing the high-performance shake table in Tainan, which attracted significant attention from the participants. Dr. Chang-Wei Huang proposed multiscale simulation of reinforced concrete structures under near-fault ground

motions. Dr. Shih-Yu Joseph Chu compared the experimental results of shake table testing with real-time hybrid simulation of a building with different types of controllable mass damper and addressed the potential application to multiple hazards. Dr. Tsung-Chin Hou shared the novel ideas about point cloud data information algorithms as well as search and rescue. Dr. Shiang-Jung Wang proposed potential application of distributed hybrid simulation to evaluate real performance of full-scale seismic isolators in an isolation system. Dr. Kung-Juin Wang shared the current hybrid simulation results of a steel panel damper substructure with model updating algorithm using MATS in NCREE, and Dr. Ming-Chieh Chuang elaborated the algorithm details of the model updating technology. Dr. Chia-Ming Chang proposed a nonlinear tuned mass damper whose performance can be validated using real-time hybrid simulation. Dr. Pei-Ching Chen suggested an innovative methodology to reproduce the floor response of high-rise buildings and encouraged the participants to do their researches using newly developed experimental technology.

Discussion and Resolution Portfolio:

In the plenary discussion, the participants reached a consensus that international support groups for advanced experimental technology are essential to promote the application of newly developed testing methods as well as to accelerate the development of novel experimental technologies. Social networks or online communities could provide the space for sharing source codes of software and algorithms. In response to the presentations and discussions, NCREE has proposed several potential research topics in the future which are summarized as follows:

1. Seismic Response Evaluation of Nonstructural Components in High-rise Buildings:
 - Reproduction of long-period responses on high floors through modern control application using a transfer system.
 - Seismic resistance of nonstructural components subjected to large story deformation through real-time hybrid simulation.
2. Hybrid Simulation and Real-time Hybrid Simulation:
 - Network-based hybrid simulation on base-isolated buildings using MATS and BATS with online model updating.
 - Real-time hybrid simulation of a residential building retrofitted by VE dampers.
 - Real-time hybrid simulation of a base-isolated building with online model updating.
 - Small-scale structural laboratory for technical development and validation.
 - Real-time computational method for nonlinear structures with thousands of DOFs.
3. Advanced Non-contact Measurement Methods for Seismic Structural Testing:
 - Image-based measurement methods.
 - Motion capture-based measurement method.
 - Online data analyzing method.
4. International Collaboration for Advanced Experimental Technology:
 - Real-time hybrid simulation for multi-hazard engineering.
 - International technical support groups for advanced experimental technology.
 - Regional center of advanced experimental technology for seismic testing.

5. Advanced Modeling and Simulation

- Deformation with discontinuities.
- Multiscale, multiphysics, and multiresolution modeling.

Lastly, NCREE has been devoting to all the international collaborations with consolidation and innovation for earthquake engineering researches in order to achieve a win-win situation.