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National Center for Research on Earthquake Engineering

NARLabs Names New Director General of NCREE

Chiun-Lin Wu, Research Fellow, NCREE
Han-Wei Huang, Assistant Engineer, NCREE

Professor Shyh-Jiann Hwang of the Department of Civil Engineering at National Taiwan University has become the new Director General of NCREE in February. President Yeong-Her Wang of NARLabs chaired the inauguration ceremony. He also suggested that Director General Hwang usher in a new era of accomplishments based on the existing solid foundation to make NCREE a world-class research center in the field of earthquake engineering by taking full advantage of the new NCREE Tainan Laboratory.

Director General Shyh-Jiann Hwang received his PhD degree from the University of California, Berkeley, in 1989, and started to teach in the Department of Construction Engineering at the former National Taiwan Institute of Technology (currently National Taiwan University of Science and Technology) in the same year. Since 2006, Dr. Hwang has been teaching in the Department of Civil Engineering at National Taiwan University. Dr. Hwang served NCREE as the Director of the Building Engineering Division from 2003 to 2013 and as Deputy Director General from 2013 to 2016.

Director General Hwang specializes in mechanical behavior of reinforced concrete and seismic design, evaluation, and retrofit of reinforced concrete structures. Director General Hwang has received a number of honors and awards, including Outstanding Research Awards conferred by the former National Science Council (currently the Ministry of Science and Technology), Engineering Paper Awards conferred by the Chinese Institute of Engineers, Outstanding Teaching Faculty Awards conferred by National Taiwan University, and an Award for Outstanding Contributions in Science and Technology conferred by the Executive Yuan due to the "Development of Seismic Evaluation and Retrofit Methodologies for Existing School Buildings".

NARLabs expects Director General Hwang to bring together domestic and international research taskforces by integrating NCREE's Taipei and Tainan Laboratories to carry out advanced studies on near-fault earthquake engineering, multiple natural hazard mitigation, and advanced hybrid experimental technologies to provide Taiwan a higher level of seismic safety and resilience and to strengthen the link between industry and the academic community for business model innovation on disaster mitigation so that the goal of global excellence and local impact can be fully achieved.



President Yeong-Her Wang of NARLabs supervised the handover of the NCREE official seal by former Director General Kuo-Chun Chang to new Director General Shyh-Jiann Hwang



A Bird's Eye View of NCREE Tainan Laboratory

Introduction of the Bi-Axial Testing System in NCREE Tainan Laboratory

Te-Hung Lin, Assistant Researcher, NCREE
Ker-Chun Lin, Research Fellow, NCREE

Introduction

In recent years, the application of energy absorbing elements and base isolation technologies for earthquake protection in large building construction projects has significantly increased in Taiwan. These earthquake resisting devices are expected to undergo uni-axial or multi-axial large force or displacement responses during an earthquake. Therefore, base-isolation bearings with large vertical load carrying and lateral deformational capacities and braces with large axial load capacities are being increasingly designed. For these reasons, the Taiwan National Center for Research on Earthquake Engineering (NCREE) constructed a multi-axial testing system (MATS) in 2008. The system has been in service ever since. Over its many years of use, the MATS system helped many scholars to carry out more than three hundred sets of experiments. Those research results were fruitful; however, the original configuration of the lateral actuator was a static actuator. The actuator itself is slow, imposing many restrictions on and causing inconvenience for the usage of MATS.

In view of this, NCREE is taking advantage of the construction of the Tainan laboratory in National Cheng Kung University. In addition to setting up a high-speed and long-stroke seismic simulation shaking table that can develop near-fault seismic technology and a strong floor and reaction wall that can carry out large-scale structural experiments, a Bi-Axial Testing System (BATS) was arranged. Similar to the MATS, BATS was designed to apply lateral forces, high-speed lateral displacements, and vertical forces to the test specimen simultaneously in order to meet the requirements of the high-speed and long-stroke test.

Configuration

Figure 1 shows a schematic sketch of the BATS system. The BATS system is composed of a reinforced concrete base, a reinforced concrete side wall, a steel reacting frame, a steel platen, and various kinds of servo-hydraulic actuators.

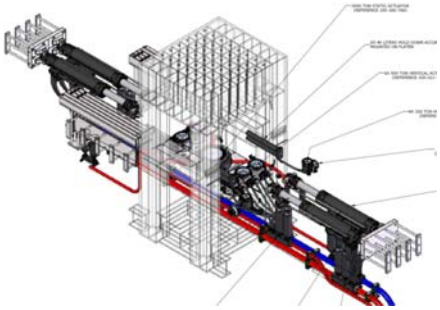


Fig. 1. Schematic sketch of the BATS system

BATS is a bi-axial testing facility; it can apply vertical loads, lateral loads, and a moment to a specimen. The lateral actuators can reach a maximum displacement of ±1.2 m, a maximum speed of ±1.2 m/s, and a maximum force of 4 MN. The vertical actuator is composed of one static actuator and six dynamic actuators, which have the ability to apply a maximum displacement of ±0.075 m and a maximum speed of ±0.15 m/s. The maximum vertical force is 60 MN, including a 30 MN static load and a 30 MN dynamic load. In addition, BATS can apply a maximum tensile force of 8 MN to the specimen through the hold-down actuators.

Analysis and Construction of the BATS

The deformation and the stresses of the steel frame were investigated by conducting finite element analyses using SAP2000. Figure 2 shows the finite element model of the steel frame and part of the reinforced concrete base. Elastic shell and solid elements were used to simulate the steel plate and concrete in the finite element model. The maximum vertical deformation and rotation of the cross beam should be less than 2 mm and 0.001 radians, respectively, and the frequency of the first mode should exceed 20 Hz. The analytical results show that the maximum vertical deformation and rotation of the crossbeam were 1.6 mm and 0.0004 radians, respectively. The frequency of the first mode was 23.36 Hz.

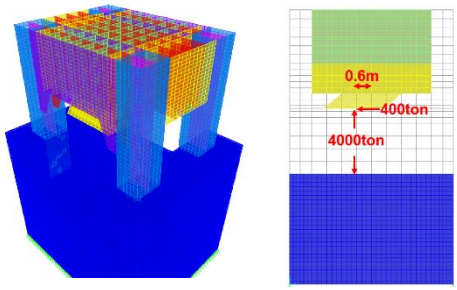


Fig.2. Analysis model of the BATS frame

Construction photos of the BATS system are shown in Figure 3. The steel frame was divided into four parts in the factory. After finishing the welding in the factory, they were transported to the Tainan laboratory and installed in the reserved pit. Then, the reinforced concrete base and side wall with weld the steel frame were constructed simultaneously. Finally, the hydraulic equipment and platen were installed.



Fig.3. Construction of the BATS system

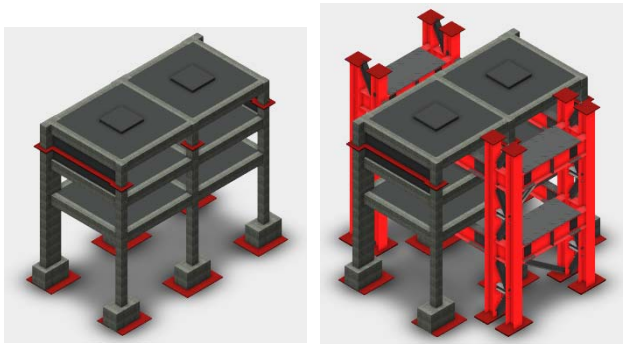
Introduction to Start-up Tests of ½ Scale RC Structures in NCREE Tainan Laboratory

Fu-Pei Hsiao, Research Fellow NCREE

The near-fault effect on buildings and infrastructures is a significant issue of human life and property in Taiwan because there are numerous active faults inside this island. It is well-known that special characteristics with large displacement and high velocity can be observed close to a near-fault. However, it is difficult to reproduce such a near-fault earthquake record by using the existing test facilities of National Center for Research on Earthquake Engineering (NCREE). As a result, the experimental studies on the near-fault effect are rare. The National Applied Research laboratories had planned to establish NCREE Tainan laboratory for years. It equips with a high performance 8mx8m six degree-of-freedom seismic simulation testing system which can simulate the near-fault motions. Since early this year, NCREE Tainan laboratory is completed, NCREE can provide better seismic experimental services to the government agencies, academia and industry which is beneficial to improving public safety against earthquake disasters. We plan to perform a series of start-up tests during the grand opening and an international blind competition with this new facility.

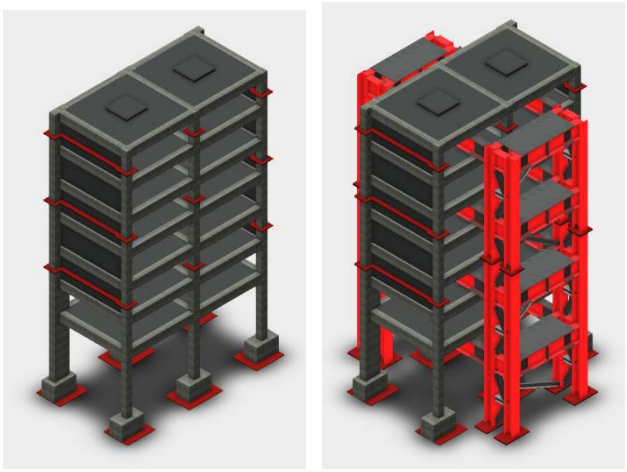
Fig. 1~3 show the test setup with the start-up tests of 3-, 7- and 9-story RC structures (in 1/2 scaling). It is planned to perform the demonstration test with 3-story specimen for the grand opening with NCREE Tainan laboratory on Aug. 9th in this year. The 7-story specimen would be tested for an international blind competition in the next year.

A development platform of collapse prevention technology for mid- to high-rise buildings would be established after this project. Numerical analysis is used to compare with experimental results to understand the structural behavior of reinforced concrete buildings under near-fault earthquake effect. In this study, it focuses on the experimental result of collapse tests and discusses the failure type of specimens. After the shaking table tests, the test result is compared with the existing analytical models. The comparison result can reveal the insufficiency of the existing analytical models. This experiment can offer abundant information of RC frames collapse behavior and help the researchers to upgrade existing analytical models to make better prediction for RC buildings' seismic behavior, also, to raise up the more economical improvement.



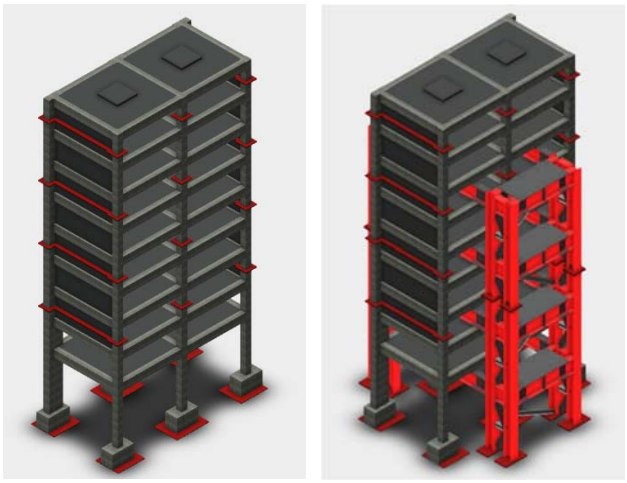
(a) 1/2 scale specimen (b) specimen with collapse prevention frame

Fig.1. Test setup of start-up test of 3-story RC structure



(a) 1/2 scale specimen (b) specimen with collapse prevention frame

Fig.2. Test setup of start-up test of 7-story RC structure



(a) 1/2 scale specimen (b) specimen with collapse prevention frame

Fig.3. Test setup of start-up test of 9-story RC structure

Memorandum of Agreement on Advanced Experimental Technology between NCREE and MTS

Pei-Ching Chen, Associate Researcher, NCREE

The National Center for Research on Earthquake Engineering (NCREE) has become one of the most renowned earthquake engineering research institutes in the world after more than a dozen years of great and devoted efforts from the researchers and technicians in Taiwan. NCREE has integrated experimental and numerical resources, professors and researchers worldwide, and engineering practice and application to accomplish joint projects with the intention that life and property losses caused by earthquakes can be reduced. A large number of international collaborations have been initiated and completed by performing large-scale experiments and applying newly developed experimental technologies in the laboratory.

Hybrid simulation is an advanced experimental technology that combines experimental and analytical components into a single simulation to obtain structural responses under seismic loadings. Due to increased internet connection bandwidth, NCREE has developed a networked collaborative experimental framework to facilitate interactions and collaborations among different laboratories. A geographically distributed hybrid simulation was performed in order to evaluate the seismic response of a double-skinned concrete-filled tubular bridge system through the Internet-based Simulation for Earthquake Engineering platform in 2007. This test was one of the most initiative applications of distributed hybrid simulation in the world. On the other hand, real-time hybrid simulation (RTHS) provides an efficient approach to investigate seismic responses of structures with rate-dependent devices. NCREE has proposed an adaptive phase-lead compensator for RTHS. This method was applied to smart structures in which a base-isolated building was numerically simulated and a magnetorheological damper was experimentally tested in 2012. These aforementioned advanced experimental technologies provide cost-effective and efficient approaches to evaluate seismic responses of full-scale structures subjected to earthquake ground motion.

MTS Systems Corporation (MTS) is one of the most reputable manufacturers of seismic testing facilities in the world. MTS has collaborated with the leading universities in the United States to develop a state-of-the-art real-time and quasi-static hybrid simulation solution for earthquake engineering. For instance, OpenFresco, a middleware software framework developed by the Pacific Earthquake Engineering Research Center at the University of California, Berkeley coordinates numerical and experimental components in the laboratory to facilitate hybrid simulation. OpenFresco has been widely adopted for research and educational purposes.

Consequently, a memorandum of agreement on advanced experimental technology between NCREE and MTS has been signed by the director of NCREE, Dr. Kuo-Chun Chang, and the global director of business and market segments of MTS, Dr. Garth Su (Fig. 1). The agreement aims at cultivating the innovative talents, increasing the development efficiency, and consolidating the potential applicability of the advanced experimental technology under the premise of mutual trust. Both NCREE and MTS agree to devote their efforts to this collaboration through technical exchanges. It is expected that NCREE will become one of the benchmark institutes on advanced experimental technology development and application for earthquake engineering under the close collaboration with MTS.



Fig. 1. Group photo of the signing ceremony

Workshop on 2016 Kumamoto Earthquake Reconnaissance

Chia-Chuan Hsu, Assistant Researcher, NCREE

The 2016 Kumamoto earthquakes were a series of earthquakes that included a magnitude 7.0 mainshock that struck at 01:25 JST on April 16, 2016 beneath Kumamoto City of the Kumamoto Prefecture in the Kyushu Region of Japan at a depth of about 10 km, and a foreshock earthquake of magnitude 6.2 at 21:26 JST on April 14, 2016 at a depth of about 11 kilometers. These two earthquakes killed at least 50 people and injured about 3,000 others in total. Severe damage occurred in the Kumamoto and Oita Prefectures, with numerous structures collapsing and catching fire. More than 44,000 people were evacuated from their homes due to the disaster.

In view of this and the large-scale earthquake after the East Japan earthquake that caused a considerable degree of damage in the Kumamoto area, the National Center for Research on Earthquake Engineering (NCREE) and CECI Engineering Consultants, Inc., Taiwan assembled a disaster assessment team to investigate the experiences, cases, and current profiles of the Kumamoto earthquake disaster in Japan. We hope that this workshop will be used to share the topic of discussion with domestic experts.

The workshop was organized by NCREE on March 2, 2016. We invited experts and scholars involved in the disaster assessment team to give lectures on disaster prevention; discuss the disasters related to buildings, bridges, and the geotechnical engineering; and share the experience gained from Japan after the earthquake for reference and learning. We look forward to the seminar to raise the attendees' understanding about the earthquake disaster prevention and response ability.



Conference on River-Basin-Disaster Prevention: Implementation of Monitoring and Early-Warning Technologies

Bo-Han Lee, Xiao-Qin Liu, Assistant Researcher, NCREE

Due to its geographical location and unique terrain, Taiwan experiences an average of 3.5 typhoon events and dozens of torrential rain events each year, which often trigger severe landslides and flooding. Typhoon-induced flooding imposes substantial threats to river basin bridges as well as river embankments and slopes, causing threat to the people who reside along the rivers. Therefore, development of Taiwan's own river-basin-disaster monitoring and bridge-scouring early-warning technologies is considered urgent.

In Taiwan, disaster prevention is mostly undertaken by the government with unbalanced inputs from social organizations. Moreover, disaster-prevention technologies developed by local academic and research institutes are less likely to become commercial products.

In this context, addressing the current dilemma requires comprehensive collaboration across a wide range of industries. First, we must integrate information and communication technologies (ICT) to develop reliable IoT-based disaster-prevention technologies. Then, we must incorporate services from industries such as engineering and consulting companies, the private security industry, manufacturers, the logistics industry, and the insurance industry to form a novel disaster-prevention industry in Taiwan.

To achieve this goal, NCREE established a research team with members from academia and initiated a project for developing river-basin-disaster monitoring and early-warning systems. Moreover, a conference was hosted by NCREE on Dec 16, 2016 (Fig. 1) to provide a forum for the participants of the project to exchange their thoughts and report their progress. In the conference, the participants also discussed how to seek support and collaboration from potential industrial partners to realize the cross-industry collaboration.



Fig.1. Speaker presenting in the conference

A Workshop for Structural Design and Construction Technology of High-Strength RC (New RC) Structural Systems in Taiwan

Sheng-Jhih Jhuang, Assistant Researcher, NCREE
Ker-Chun Lin, Research Fellow, NCREE

As the population of Taiwan is mostly concentrated in metropolitan areas, the construction of high-rise buildings is one of the most effective methods of reducing demand for building space in urban areas and of creating more comfortable living spaces for people. In Japan, design and construction technology for high-rise reinforced-concrete (RC) buildings with high-strength materials has been successfully developed. Many high-rise RC buildings have been constructed, including a 59-story residential building constructed in 2009. Therefore, it is worth learning from the Japanese experience in Taiwan's construction industry.

In 2010, the National Center for Research on Earthquake Engineering (NCREE) launched an integrated research program, called the “Taiwan New RC Project”, to bring together related construction companies, industrial societies, and academic researchers, called the “Taiwan New RC Group”, for research and development of high-strength RC materials, members, and structural systems. The goal strength of materials at this stage of the Taiwan New RC Project was set as follows: SD 685 steel for main bars and SD 785 steel for transverse bars, and the concrete design strength of 70 to 100 MPa. By the end of 2016, the Taiwan New RC Project finished making a specification draft about high-strength reinforcement and its accessories, and accumulated rich research results from a series of experiments. The research results were compiled into the Design Guidelines for High-Strength Reinforced-Concrete (New RC) Structural Systems. The project has also recently begun developing construction guidelines for New RC.

A workshop was held in the R101 Conference Room of the NCREE on December 9, 2016, which attempted to demonstrate the research results and findings of the Taiwan New RC Group and to present the Design and construction Guidelines for High-Strength Reinforced-Concrete Structural Systems to construction societies in Taiwan. The workshop not only presented high-strength materials such as steel bars and concrete as well as splice and end anchorage devices for bars but also introduced design methodologies for main structural members, including columns, beams, shear walls, and coupling beams. In this meeting, many enthusiastic and positive responses were obtained from Taiwan’s construction societies.



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