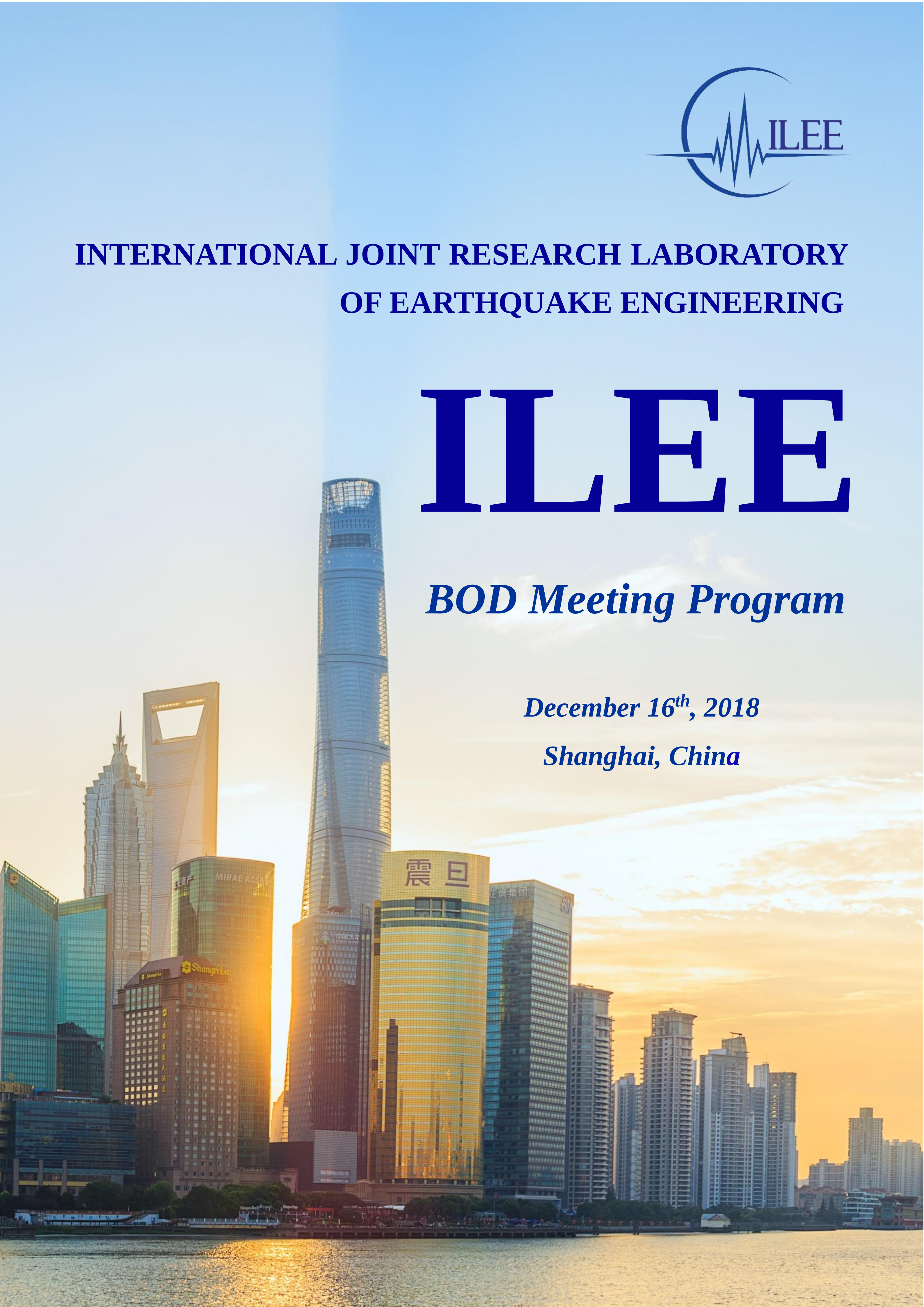


ILEE

INTERNATIONAL JOINT RESEARCH LABORATORY OF EARTHQUAKE ENGINEERING

ILEE

BOD Meeting Program

December 16th, 2018

Shanghai, China

ILEE BOD Meeting Program

Meeting Schedule

Sunday, December 16th, 2018

Location: Room B102, Tongji Design Institute

Time	Project	Presenter
8:30-8:45	Welcome	Prof. Xianglin Gu
8:45-9:00	Innovative self-centering structural systems and hybrid simulation	Prof. James Ricles Prof. Yiyi Chen
9:00-9:15	Innovative Solution for Hybrid Wood-Concrete Tall Buildings	Prof. Carlos E. Ventura Prof. Haibei Xiong
9:15-9:30	Seismic Probabilistic Risk Assessment of Power Energy Structures	Prof. Boris Jeremić Prof. Zhiguang Zhou
9:30-9:45	Experimental studies on collapse prevention of multiple-story building with soft-and-weak first story	Prof. Shyh-Jiann Hwang Prof. Xianglin Gu
9:45-10:00	Experimental and analytical simulations for suspended non-structural systems in the super-tall building under long period and duration earthquakes	Prof. Kazuhiko Kasai Prof. Huanjun Jiang
10:00-10:15	Development of high performance earthquake resilient tall buildings	Prof. Perry Adebar Prof. Tony Yang
10:15-10:30	Real Time Hybrid Simulation Testing of a Curtain Wall System with Online Model Updating	Prof. Khalid M. Mosalam Prof. Wensheng Lu
10:30-10:45	Shake-table testing of a low-damage concrete wall building	Prof. Richard Henry Prof. Ying Zhou
10:45-11:00	Ultimate behavior and design of high-performance inverted L-shaped CFT piers in elevated girder bridges	Prof. Yoshiaki Goto Prof. Yan Xu
11:00-11:15	Investigation on the liquefaction of natural sand with fines in strong earthquakes	Prof. Anthony Tessari Prof. Xiaoqiang Gu
11:15-11:30	Break	
11:30-12:30	BOD Meeting	BOD, PI, CO-PI
12:30-13:30	Lunch (BOD only)	

BOD Meeting

Board of Directors & Scientific Committee
Xianglin Gu, Director, ILEE
Tony Yang, Executive Director, ILEE
Ying Zhou, Vice Director, ILEE
Jianzhong Li, Vice Director, ILEE
Xilin Lu, Director of Scientific Committee, ILEE
Kazuhiko Kasai, Board of Director, ILEE
Ken Elwood, Board of Director, ILEE
Khalid M. Mosalam, Board of Director, ILEE
Alberto Pavese, Board of Director, ILEE
Carlos E. Ventura, Board of Director, ILEE
Andrew S. Whittaker, Board of Director, ILEE
Shyh-Jiann Hwang, Board of Director, ILEE
Ian G. Buckle, Scientific Committee, ILEE
Akira Wada, Scientific Committee, ILEE
Bozidar Stojadinovic, Scientific Committee, ILEE
Bill Spencer, Scientific Committee, ILEE
Keh-Chyuan Tsai, Scientific Committee, ILEE

Research Project

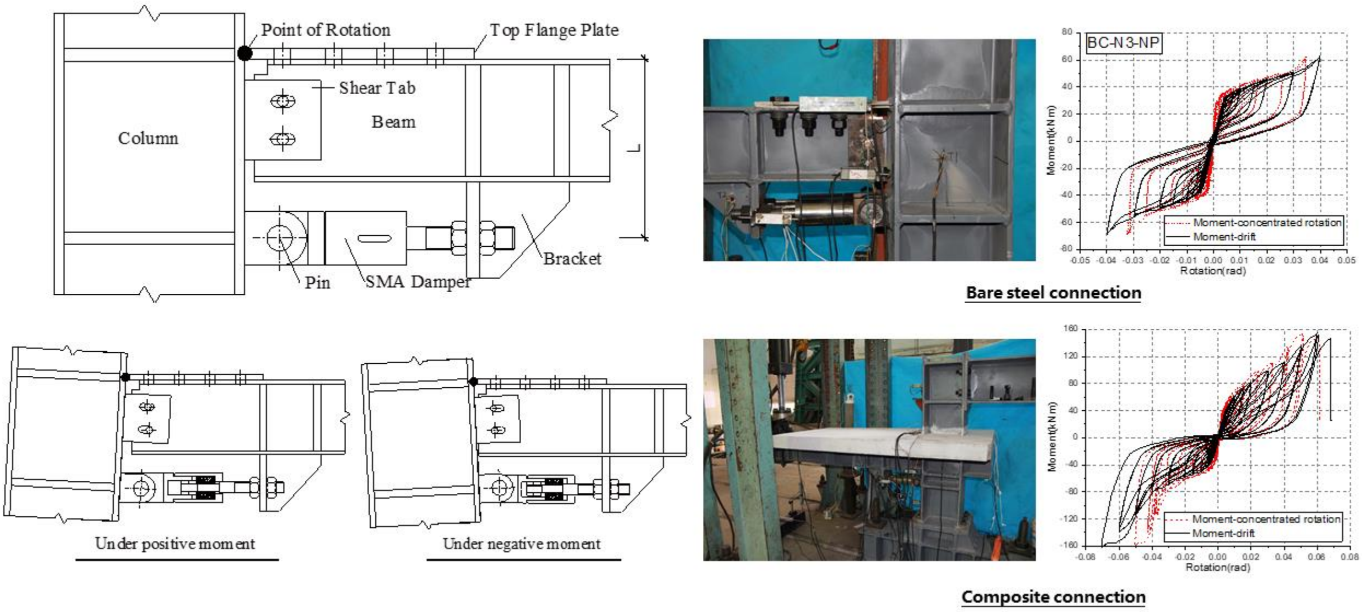
1）Phase I: Innovative self-centering structural systems and hybrid simulation

Principal Investigator: James Ricles; Lehigh University, USA

Co-PI at Tongji University: Yiyi Chen

Abstract:

This study, jointly launched by Tongji University, Lehigh University, and San Francisco State University, puts forth an innovative self-centering/self-healing structural design solution which has great potential for significantly reducing the enormous economic losses related to repair costs, temporary sheltering, business interruption, suspension of building occupation, and building demolition due to irreparable damage in the aftermath of strong earthquakes. The proposed approach utilizes a unique class of metal, shape memory alloys (SMAs), to strengthen key structural components of building structures, and fluid viscous damping technologies are used in parallel to further improve the performance of the SMA-equipped structures. The concept will be verified by experimental, numerical, and analytical investigations, and in particular, hybrid simulation will be employed to significantly reduce the experimental cost demand while keeping the accuracy of the research outcomes. The design concept of this project can upgrade the conventional target levels of vulnerability for structures, and can form an important basis on the next-generation performance-based seismic design framework.



Top flange-rotated self-centering connections

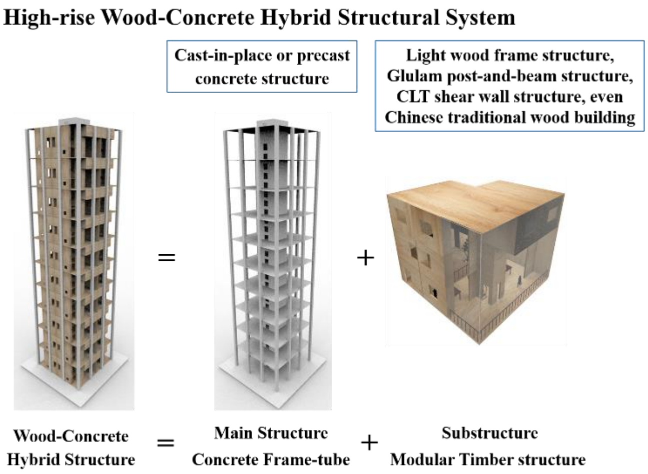
2）Phase I: Innovative solution for hybrid wood-concrete tall buildings

Principal Investigator: Carlos Ventura; University of British Columbia, Canada

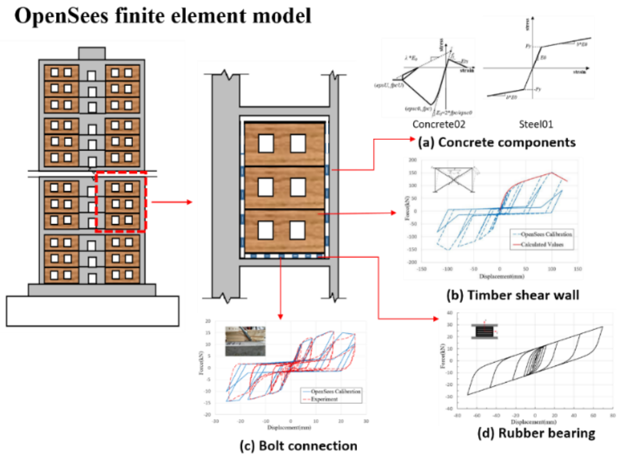
Co-PI at Tongji University: Haibei Xiong

Abstract:

The purpose of this project is to explore the adequacy of an innovative concept for wood-concrete tall buildings. The key idea of the proposed system is to take advantage of the benefits inherent in concrete and wood frame buildings to provide a structural system that will perform well during strong earthquakes and/or strong winds and at the same time it will be economic, easy and fast to build. Additional advantages of the proposed system include the use of sustainable resources, a low carbon footprint, excellent life cycle characteristics and the use of recyclable materials. The work to be conducted in this project includes a series of experimental and analytical studies to determine the seismic resilience of the proposed system. The key idea of the proposed concept is to build a concrete structure, as is normally done but the floor slabs will only occur every three stories. Modular wood frame structures will be used to form the intermediate floors between concrete floors. Due to fire regulations in China, wood frame structures are limited to three-stories high, so as to comply with this regulation the concrete floor spacing will be limited to three stories. The concrete structure will provide the necessary stiffness and strength to resist gravity and lateral loads, as well as, the required fire protection for the occupants of the building. The wood frame modules will be used to create the habitable spaces in the building, and will be used for controlling the lateral vibrations of the building acting as tuning devices. The experimental studies will include component and shake table tests of a building model incorporating the proposed concept. The experimental results will be used for detailed analytical studies of proposed tall buildings. The outcome of the research will be a set of guidelines for design and construction of tall buildings incorporating the proposed concept. Until now, all the numerical analysis has been doing well and shake table test will be conducted in the spring of next year.



Concept of the hybrid building



Finite element model development utilizing OpenSees

Research Project

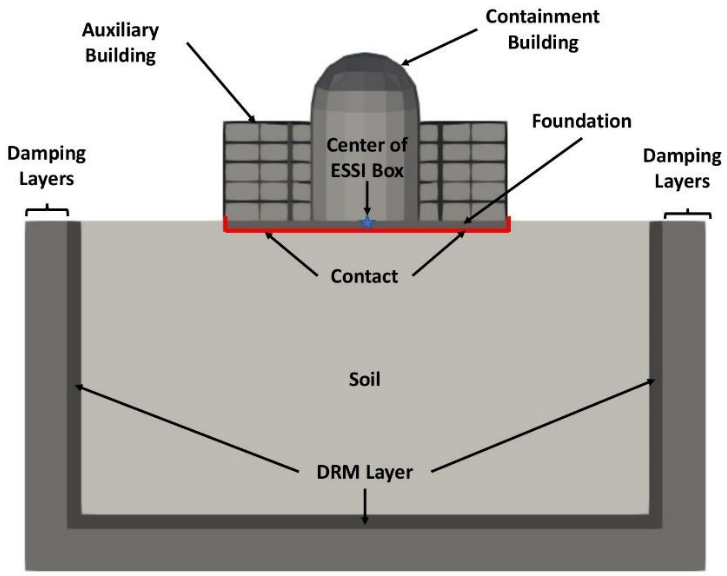
3）Phase I: Seismic probabilistic risk assessment of power energy structures

Principal Investigator: Boris Jeremić; UC Davis, USA

Co-PI at Tongji University: Zhiguang Zhou

Abstract:

Seismic Probabilistic Risk Assessment (PRA) provides insights into the strengths and weaknesses of the design and operation of power energy structures. The goal of the project is to assess seismic probabilistic risk of two kinds of representative power energy structures, i.e. Nuclear Power Plants (NPPs) and liquid storage tanks, and research on some key problems correlated to the assessment. The contents include: (1) Shaking table test of a NPP model including dynamic Soil-Structure Interaction (SSI) system, study the seismic behavior of the NPP model on soft, moderate hard and rigid soil foundation. (2) Validation of SSI modeling and simulation using test data from available and planned SSI tests of the NPP Model. This validation is used to show that Realistic Earthquake Soil Structure Interaction (Real ESSI) Simulator System can properly and accurately account for dynamics of the Earthquake, the Soil/Rock and the Structure and their interaction. (3) Study the failure mechanisms of the NPP model and an isolated liquid storage tank model under strong earthquakes, establish seismic damage models, achieve quantitative assessment of overall structural damage and define performance levels for the two models. Using Monte Carlo (MC) simulation to obtain the probability of failure at different seismic intensity levels. (4) Carry out seismic fragility analysis for the two models; choose reasonable seismic hazard models and earthquake damage models to achieve seismic probabilistic risk assessment. The research objective is for practice. The results obtained will provide strong support for establishing reasonable seismic design theories for power energy structures.



Real ESSI model

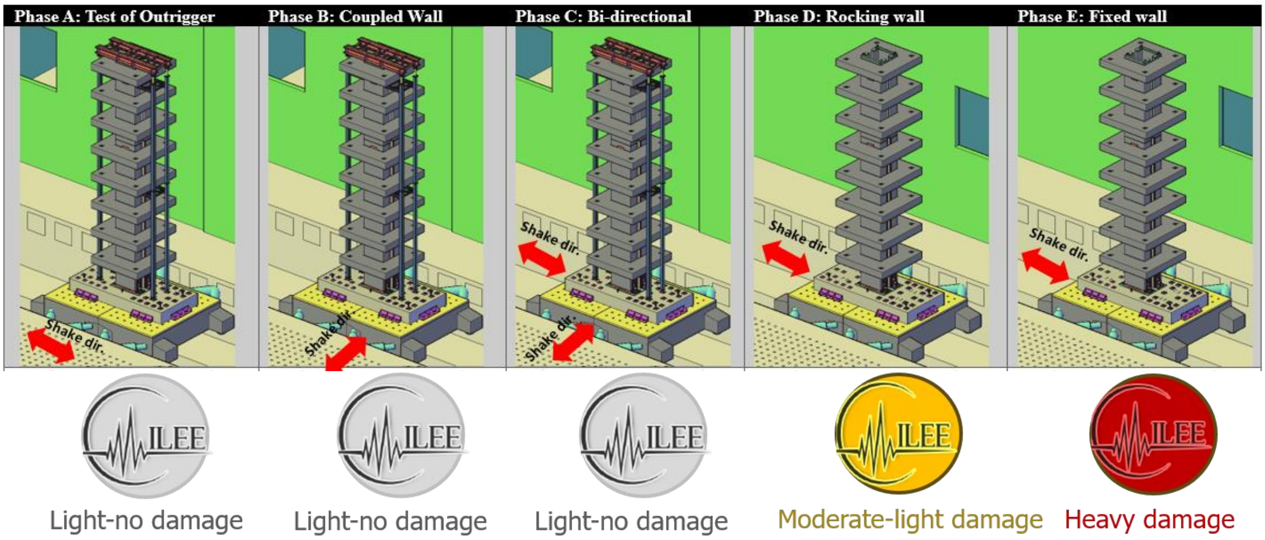
4）Phase II: Development of high performance earthquake resilient tall buildings

Principal Investigator: Perry Adebar; University of British Columbia, Canada

Co-PI at Tongji University: Tony Yang

Abstract:

With rapid population growth worldwide, major cities around the world are seeing an upsurge in high-rise building construction, and many of the new buildings have very irregular architecture. At the same time, there is an increased awareness about the importance of designing buildings so that they will have limited damage due strong earthquake shaking. An innovative structural system is proposed that utilizes an outrigger in combination with a conventional reinforced concrete (RC) core-wall system. The outrigger reduces the bending moment demands on the RC core walls, allowing smaller cores, thereby resulting in significant savings in structural materials and increased useable space within the buildings. To further improve the seismic performance of the structure, innovative fuses are added to the outriggers to dissipate the sudden surge of the earthquake energy. In addition, friction-based coupling beams are used to ensure the structure can have high performance in the coupled wall direction. To ensure the proposed system can be used efficiently by the practicing engineering communities, an energy-based design procedure will be developed for the system. This design methodology allows the engineers to design the proposed high-performance earthquake resilient system to achieve different performance objectives at different earthquake shaking intensities. In this research, innovative structural fuses will be developed through international research collaboration between the Earthquake Engineering Research Facility Canada (EERF-Canada, an ILEE affiliated research center) and Tongji University (headquarter of ILEE center). Full-scale components will be systematically designed and tested at the EERF facility in Canada, while large-scale shaking table tests will be conducted at Tongji University to validate the overall seismic performance of the proposed system. The large-scale shake table test at Tongji University will be designed to permit the innovations to be studied using essentially one test specimen. After the innovative system has been validated, the outrigger will be removed and tested. Finally, the core wall will be tied down to check the performance of the conventional core wall. The proposed research project will significantly contribute to the development of high performance earthquake resilient tall buildings.



Testing configurations

Research Project

5）Phase II: Ultimate behavior and design of high-performance inverted L-shaped CFT piers in elevated girder bridges

Principal Investigator: Yoshiaki Goto; Nagoya Institute of Technology, Japan

Co-PI at Tongji University: Yan Xu

Abstract:

Eccentrically-loaded inverted L-shaped bridge piers have to be used in the construction of elevated highways bridges to avoid the existing obstacles in urban areas. However, their complicated seismic behavior has never been investigated in detail. In order to establish a rational seismic design method, the detail behavior of the inverted L-shaped CFT (concrete-filled tubular) piers is examined by conducting a shake table test on an elevated girder bridge model supported on this type of piers. In this test, obvious but uneven local buckling deformation of the outside steel tube occurred near the bottom of the inverted L-shaped CFT pier after the failure of the bonding effect between the steel tube and the concrete, and both the transverse displacement at the pier top and the local buckling deformation were concentrated on the side near the central bridge axis. Meantime, the hysteretic energy-dissipation performance also shows obvious asymmetry in the transverse direction, which may lead to the consequence that the superior seismic performance and energy-dissipation capacity of the inverted L-shaped CFT pier can not be fully utilized. The obtained test data will be beneficial to conduct further researches to establish a rational seismic design method of the inverted L-shaped CFT pier by parametrical analysis and so on.

Two-span elevated girder bridge model

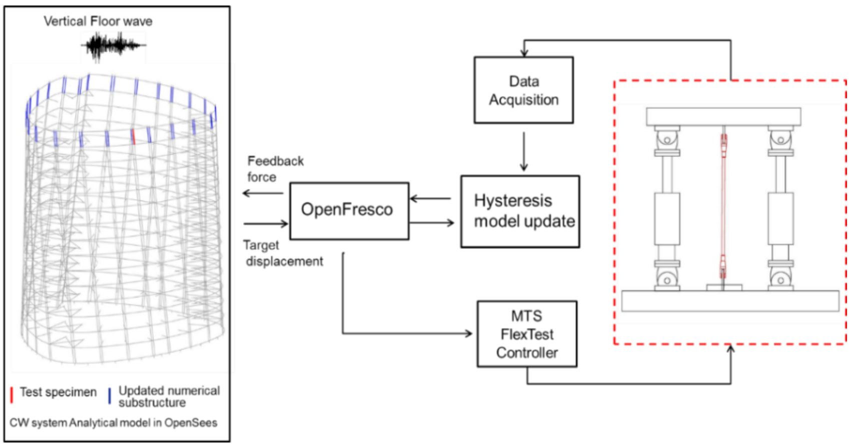
6）Phase II: Real time hybrid simulation testing of a curtain wall system with online model updating

Principal Investigator: Khalid M. Mosalam; UC Berkeley, USA

Co-PI at Tongji University: Wensheng Lu

Abstract:

Real Time Hybrid Simulation (RTHS) with Online model updating increases the application range of hybrid simulation, since it allows reliable and realistic earthquake response investigation of structures consisting of many elements with identical mechanical properties by testing one (or a few) of the elements and analytical modeling of the others simultaneously using the data from the tested elements. The necessity and potential benefits of this method have been demonstrated with the conventional hybrid simulation (HS) of the zonal hanging glass curtain wall (CW) of Shanghai Tower, which was conducted in University of California, Berkeley (UCB), including HS without model updating and HS with off-line modeling updating. This project aims at building up a generic RTHS platform with model updating function (RTSHMU), based on the widely used hybrid simulation tools of OpenSees as the computational platform and OpenFresco as the middleware. In order to build this platform, the numerical simulations of commonly used hysteresis models, such as Bouc-Wen and Giuffre-Menegotto-Pinto, will be conducted firstly using the parameter identification techniques, such as constrained unscented Kalman filter, to develop the intended optimization parameter identification method. The proof-of-concept tests will be conducted to verify and improve the feasibility of the generic RTHSMU system in UCB and Tongji University (TJU). After verification, the RTHSMU system developed on Siping campus will be used to investigate the seismic performance of complicated CW with vertical excitation. Conducted RTHS will also be verified by testing a subsystem of the complete CW system with multi-directional & multi-point excitations, by utilizing the shaking tables of TJU. An analytical model of the curtain wall system will be developed and tuned according to the tests conducted with the RTHSMU system. Performance-based earthquake engineering (PBEE) analyses conducted on the analytical model will be used to evaluate and enhance the proposed ILEE rating system.



Schematic of the application of Hybrid Simulation Model Updating

Research Project

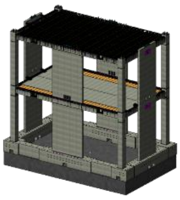
7）Phase II: Shake-table testing of a low-damage concrete wall building

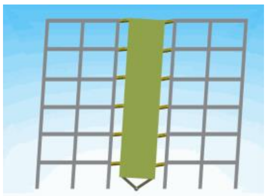
Principal Investigator: Richard Henry; University of Auckland, NZ

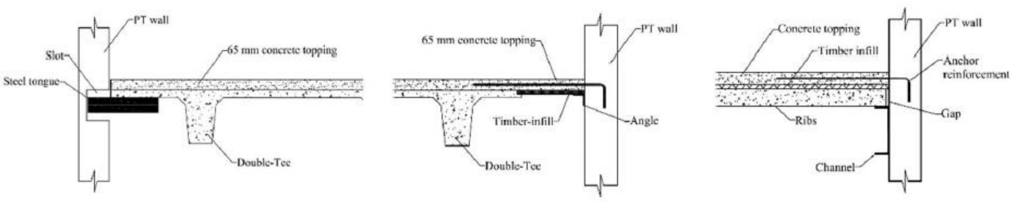
Co-PI at Tongji University: Ying Zhou

Abstract:

The behavior of individual structural members and components are generally well understood, but the interactions between these components in a real building can be complex. Past earthquakes have highlighted the uncertainties in building response, with unexpected behavior often attributed to interactions and the configuration of real buildings. When considering low-damage seismic design, the interactions and system behavior is critical to achieving the intended performance. This project will focus on the full-scale system validation of a low-damage post-tensioned concrete wall building. Bi-directional shake-table testing of a 3-storey building will allow for the structural interactions to be investigated, including the critical wall-to-floor connections. The test will verify existing detailing used in constructed post-tensioned concrete wall buildings and allow for investigation for different floor systems, wall-to-floor connections, and dissipating devices. The outputs will result in a rich dataset to validate numerical models and improve design procedures and guidelines. The project will also contribute valuable data to assist with the development of the ILEE resilient rating system.System level tests of this nature are only possible through international collaboration and access to state-of-art experimental facilities. The ILEE multi-functional shake-table array is a unique facility that can easily accommodate such a large test structure. The project will bring together experts from both New Zealand and China and allow for increased exchange of ideas with academics and researchers working closely together. An industry advisory group has also been established to help guide the research direction and ensure that the test building incorporates realistic design and detailing practice. Funding of 300000 RMB is requested from ILEE with co-funding already secured from the New Zealand Ministry of Business, Innovation and Employment (MBIE) and the Center for Earthquake Resilience (QuakeCoRE). The project funding will cover experimental costs and travel expenses of the research team. Testing will be conducted in mid-late 2017, with data analysis and outputs in 2018. A blind modelling contest will also be held in conduction with the test, allowing researchers from around the world to evaluate their modelling techniques against this one of a kind test structure.







Wall-to-floor connections

8）Phase III: Experimental studies on collapse prevention of multiple-story building with soft-and-weak first story

Principal Investigator: Shyh-Jiann Hwang ; NCREE, Chinese Taipei

Co-PI at Tongji University: Xianglin Gu

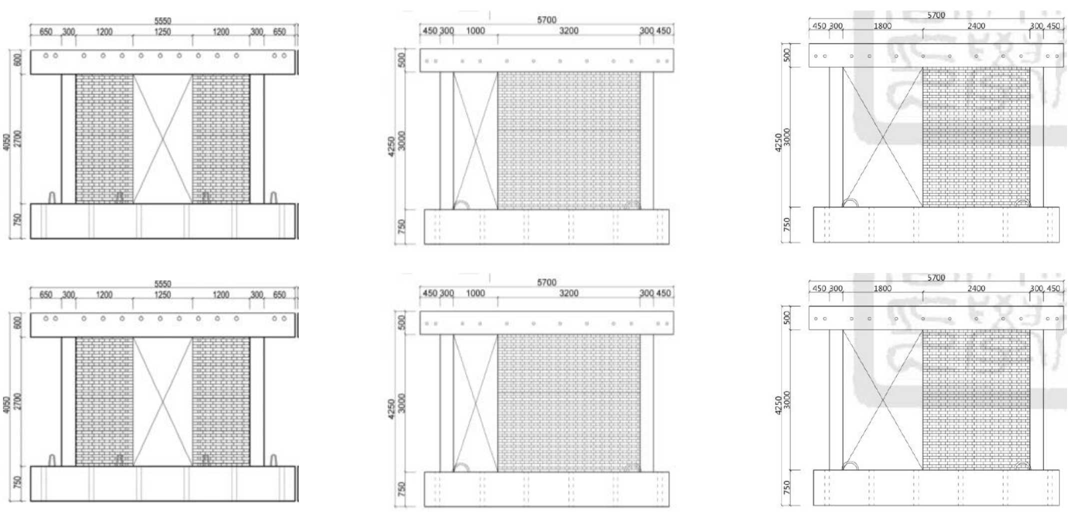
Abstract:

Improvement of the seismic-resistant performance of existing buildings, which could not fully meet the requirements of current seismic design codes, is of great concern in civil engineering community. Reconnaissance report of earthquakes showed that, multiple-story buildings with a soft-and-weak first story are prone to collapse due to an irregularity in stiffness and a discontinuity in load bearing capacity.

This project aims to propose a series of collapse prevention approaches of these buildings.

Quasi-static cyclic tests on full-scale RC frames with masonry infills will be first conducted to investigate the interaction between frame and infill. The effect of brick laying procedure (pre/post-laid) and infill with/without openings will be assessed. Four retrofitting methods will be proposed to strengthen these frames to explore their performance in promotion of seismic resistance. Afterwards, shaking table tests on scaled multiple-story buildings will be performed to study the collapse mechanism of the multiple-story building with a soft-and-weak first story, as well as the efficiency of collapse prevention approaches. In addition, a nonlinear dynamic analysis procedure and a collapse simulation software based on the discrete element method will be developed for the assessment and strengthening design of these structural insufficient buildings by NCREE and Tongji, respectively. All the aforementioned experimental results will be adopted to validate the numerical simulation.

This study will help to clarify the collapse mechanism of multiple-story buildings with a soft-and-weak first story and to develop a rapid assessment system of the seismic-resistant behavior of low-rise RC buildings in ILEE rating system. The retrofitting techniques for brick walls explored in this study could eliminate the collapse risk of multiple-story buildings with a soft-and-weak first story.



Test specimens

ILEE BOD Meeting Program

Research Project

9）Phase III: Experimental and analytical simulations for suspended non-structural systems in the super-tall building under long period and duration earthquakes

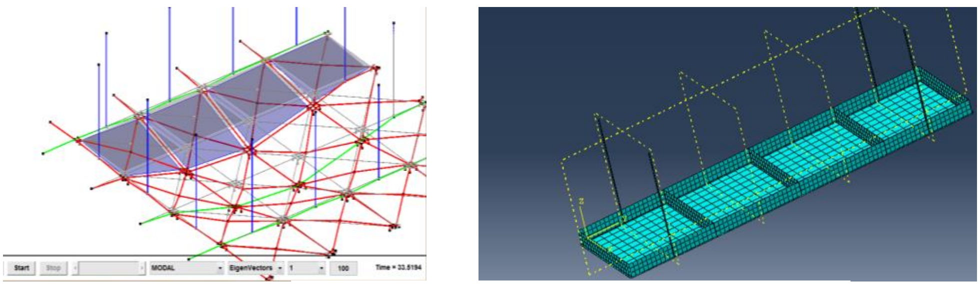
Principal Investigator: Kazuhiko Kasai; Tokyo Institute of Technology，Japan

Co-PI at Tongji University: Huanjun Jiang

Abstract:

Enhanced building performance through better understanding and development of design methodologies that go beyond life safety but also protect the socio-economic values of the building is needed. This is especially true for the large stock of super-tall buildings in Japan and China. Given their high value and importance, the damage or loss of function of these super-tall buildings can cause enormous impact to the local, regional and national economies and society. Shaking of supper-tall buildings in Shanghai, China and Tokyo, Japan occurred during the 2008 Wenchuan Earthquake and the 2011 Tohoku Earthquake, respectively. The buildings were located far away from the epicenters with distance of 1,600 km and 400 km, respectively, and did not suffer any structural damage. However, the ground motions had long period and long duration vibrations, frightening occupants and causing evacuation in a rush, and especially in Tokyo resulting in loss of functions of some super-tall buildings.

For preparation against inevitable future stronger ground motions, super-tall buildings must be protected against function loss, and do not produce large number of evacuees who otherwise would not be able to find transportation to reach home nor temporary safe shelters in the city. Thus, it is necessary to ensure not only the safety of the building structure but also that of the operational and functional components, which are also commonly referred to as the non-structural components. Among the many different non-structural components in buildings, suspended ceilings are common in both commercial and residential buildings. Suspended ceilings, cable tray system and other suspended equipment are typically relatively flexible, long-span and have complex geometry. Failure of these non-structural components not only poses serious safety hazard to occupants of the building, but also causes interruption to the operation/function of the building resulting in heavy economic losses. The proposed research project therefore aims to enhance the performance of suspended non-structural components in super-tall buildings. Experimental and analytical investigations are conducted in order to achieve better understanding of the response characteristics and behavior of suspended ceilings, cable tray system and other suspended equipment under long period and long duration earthquakes. Using the data generated from shaking table tests and computer simulation and prediction models, appropriate evaluation and design methodologies for suspended non-structural components in super-tall buildings will be developed.



Model of non-structral system

Research Project

10）Phase III: Investigation on the liquefaction of natural sand with fines in strong earthquakes

Principal Investigator: Anthony Tessari; MCEER, USA

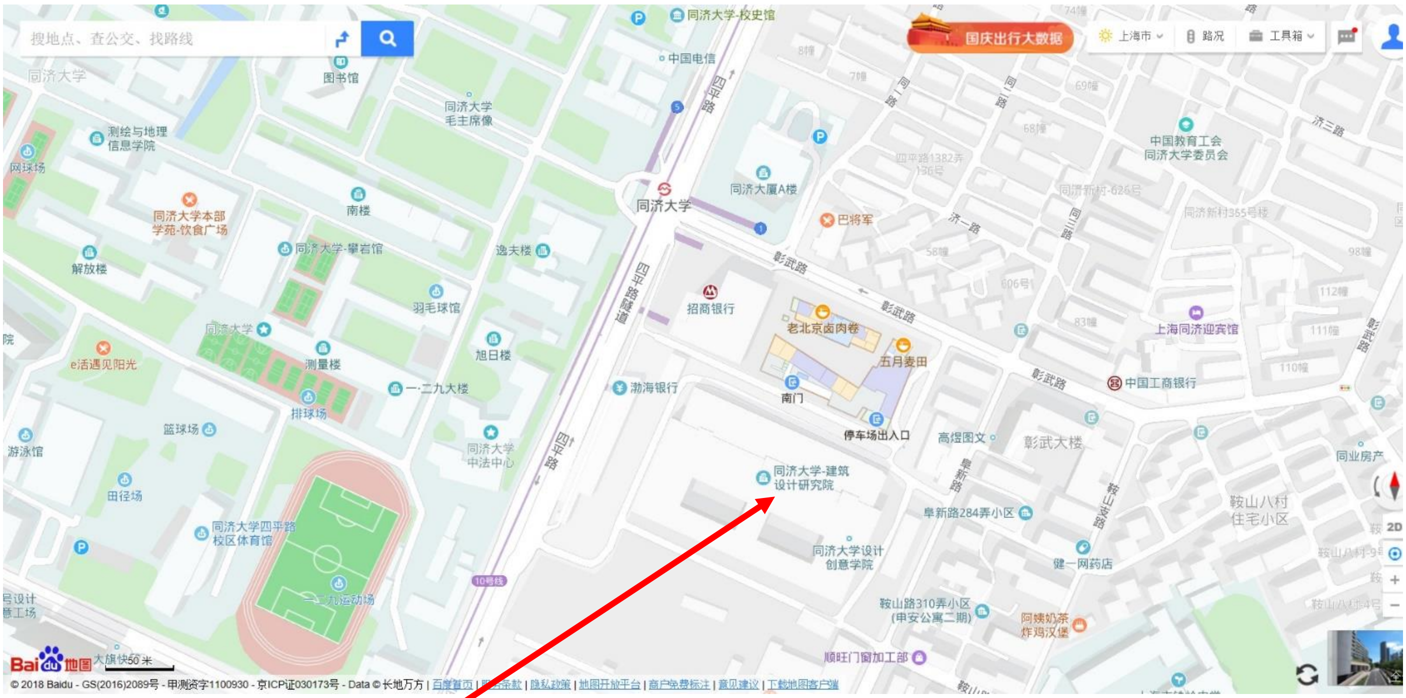
Co-PI at Tongji University: Xiaoqiang Gu

Abstract:

Liquefaction of saturated sand is a significant hazard caused by earthquakes, initiating instabilities of foundations, ground subsidence, collapse of structures, and destruction of urban lifelines. Although numerous research works have been carried out on liquefaction in the past several decades, the effect of fines (i.e., particle diameter less than 74μm) in natural sands on pore pressure generation and liquefaction resistance is still not fully understood. Advances in knowledge of transitional soils will lead to the design of safer infrastructure and allow for retrofitting of existing sites deemed at risk. To better understand the role of fines on the liquefaction of natural sands, cyclic triaxial tests will be performed to evaluate the liquefaction resistance of sand with differing amounts of fines. The types of fines will include non-plastic silt particles and plastic clay particles. Bender elements will be installed in the cyclic triaxial apparatus to measure the effect of fines on the shear wave velocity. The proposed research will link shear wave velocity with liquefaction resistance, as shear wave velocity can be conveniently measured in the field and is used to evaluate the liquefaction resistance of sand in practice. In current practice, the effect of vertical shaking (P-wave) on liquefaction is ignored, not because it is insignificant but primarily due to a knowledge gap in this domain. It should be noted that vertical peak acceleration may be very large or even larger than the horizontal peak acceleration, especially near the epicenter. Therefore, cyclic hollow cylinder testing will be performed to evaluate the liquefaction resistance of sand simultaneously subjected to the vertical shaking and the horizontal shaking. The test results will clarify the effect of vertical shaking on liquefaction and advance the current knowledge on sand liquefaction under multi-directional loading. Finally, centrifuge shaking table tests will be performed to study the liquefaction behavior of natural sand ground subjected to the seismic loading. The shear wave velocity of the natural sand will also be measured and the relationship between it and liquefaction resistance established in element tests will be examined and modified based on the centrifuge shaking table results. Moreover, the performance of foundations in liquefied or partially liquefied soil will be also evaluated using the centrifuge, which will significantly contribute to the ILEE rating system. Upon finishing the project, the effect of fines on the shear wave velocity and liquefaction resistance of natural sand will be clarified. The relationship between the shear wave velocity and the liquefaction resistance of natural sand with fines will be proposed for evaluating liquefaction potential in practice. Recommendations on the rating of foundation performance in earthquakes will be proposed.

Test of soil box

Map Information



Meeting Venue: Tongji Design Institute

Lunch Venue: Kingswell

Notes


HSBC