NCREE Tainan Laboratory Grand Opening Forum

Topic 1: Structural Safety under Near-Fault and/or Multiple Hazards Threat, and Disaster Mitigation Strategies/Technologies for Enhancing Resilience

Moderators: Masayoshi Nakashima and Kuo-Chun Chang
Summary prepared by Che-Yu Chang and Chun-Chung Chen

Presentation Outline:

Resilience in civil engineering and related areas has been in discussion in recent years and reveals its significance in our everyday lives. As we build up more enhanced and improved technologies, new materials and methodologies, which bring about a safer and more developed society, new knowledge of the previously unknowns, such as recently discovered faults and the effects of global climate changes have led us to the new challenges. These challenges are to conduct a system which could recover from damages back to functionality in a manageable period of time. Taking the bridge structures as an example, they have been designed not to collapse under possible threats such as earthquake, flood, strong wind, etc. to save lives; however, some damages may not only cause temporary interruption of functionality but sometimes permanent failure which can not be repaired. As a result, the consequences could be the cut of lifelines to affect the people living in the suburban, and in addition, it would require billions of dollars to rebuild such structures and place tremendous impact on the economy which may need years to build its way back. Therefore, structural safety under near-fault and/or multiple hazards threat, and disaster mitigation strategies/technologies for enhancing resilience have become the spot-light issue and in need of intense and high level discussions among the professionals worldwide gathering at the NCREE Tainan Laboratory Grand Opening Forum.

Keynote speaker, Professor Jack Moehle, started the Topic#1 session with his point of view on *Earthquake Simulation and Near-fault Ground Motions*. Throughout the development of the earthquake simulation technology and capability, more accurate earthquake simulation leads to better results on structural analysis and could improve current building codes and guidelines.

Professor Julio Ramirez from Purdue University emphasized the importance of coordination with research centers focusing on various areas such as coastal flooding, windstorms, earthquakes and tsunamis. Such partnership of data exchange and share of facilities and experience will level up the ability and continued education of the professional community and increase resilience.

Professor Norman Abrahamson from the University of California at Berkeley proposed to consider multiple hazards in risk space rather than hazard space. In other words, probability of damage to structure from different hazards should be considered instead of the probability of the demands from different hazards.

Moreover, conducting a limited number of shaking table tests to address the probability characteristics of the fragility curve in a cost effective manner is the key matter.

Professor Ahmad Itani from the University of Nevada shared examples of reducing earthquake impact on critical infrastructure lifelines such as using high performance steel and low yield point steel to improve seismic response in energy dissipation.

Professor Tso-Chien Pan from Nanyang Technological University showed the characteristics of Asia's natural catastrophe risks. With the exposure growth of population increase, urban expansion, industry clusters, etc. in recent decades, there are more and more megacities built up in Asia. The risk and loss in fatal and economical aspects are massive challenges to develop a system dealing with multiple hazards and damage mitigation.

Professor Chin-Hsiung Loh from National Taiwan University indicated the importance of the structural health monitoring system which is able to provide reliable information for the safety and integrity of civil infrastructures and to enhance the life-cycle performance of such.

Professor Kuo-Fong Ma from National Central University pointed out the killer pulses observed in Meinong earthquake that revealed from dense strong motion seismic array, which could be one of the key issues that we should pursue for a better understanding of seismic sources.

Professor Ting-Yu Hsu from National Taiwan University of Science and Technology proposed to upgrade earthquake resilience via structural health monitoring which offers fast damage detection.

Professor Hung-Chie Chiu from the Institute of Earth Sciences of Academia Sinica pointed out the lack of consideration of rotational motions in current seismological and earthquake engineering analyses. Although the rotation and translation motions are independent measures, they have close connections and may play an important role in near-fault/extra-large ground motions.

Professor En-Jui Lee from the National Cheng Kung University introduced a physics-based ground motion prediction platform which provides improvements on the velocity model and therefore offers reliable ground motion predictions.

Professor Yin-Nan Huang from National Taiwan University illustrated the impact of near-fault ground motions, such as pulse-like ground motion, large velocity and permanent displacements, on the efficiency of viscous damping systems.

Professor Tzu-Kang Lin from National Chiao Tung University shared his thoughts of disaster mitigation technologies such as real time structural response prediction based on earthquake early warning system and information-theoretic structural health monitoring for improving resilience.

Several professors from National Cheng Kung University shared their experience and thoughts as follows: Professor Kuang-Yen Liu proposed research ideas of structural safety assessment from the offshore wind power generation supporting system, scoured bridge with pile foundation under near fault earthquake, seismic performance of fire affected structure and post-earthquake fire performance of structure; Professor Hsin-Yang Chung also proposed research ideas utilizing the facilities in the NCREE Tainan Laboratory to conduct full-scale tests for steel structures subjected to fire & earthquake disasters; Professor Ching Hung

demonstrated the significance of taking into consideration the seismic response of geosynthetic-reinforced soil walls for designs under near-fault ground excitations; Professor Chung-Chan Hung showed the tests his has conducted indicating the potential of high performance fiber reinforced concrete for damage mitigation and reinforcement detailing simplification.
Researchers from the National Center for Research on Earthquake Engineering echoed with the ideas to further understand near-fault ground motions and develop advanced technologies; for instance, Dr. Juin-Fu Chai emphasized the importance of near-fault effects on the low-frequency nonstructural components and systems in high-rise buildings; Dr. Shu-Hsien Chao addressed the needs of enhancement on ground motion simulation and ground motion model development; Dr. Chun-Hsiang Kuo shared the thoughts of understanding near-fault ground motions from recent large earthquakes; Dr. Min-Lang Lin presented the new development plan of near-fault seismic technology and shaking table test for innovative steel buildings.

Discussion and Resolution Portfolio:

A lively consultation was raised by the session moderators and the participants in the plenary discussion. The critical needs on near-fault effects related research, including issues of terminology definition and how to provide feedbacks of research results into design parameters were firstly mentioned. Then there is a consensus of opinion that it is necessary and helpful to develop new materials and technologies on resilience improvement, as the further study is required for the efficiency of control devices and conducting shaking table tests would be an effective method. And we have to take into consideration the domain knowledge from various areas when the threats are from multiple hazards. It was also recognized that the further investigation on the resolution of resilience enhancement from the design prospect of view is needed. Thus NCREE has proposed the following potential research subjects or actions corresponding to the presentations and the discussions in the first session.

1. Near-fault Characteristics:
    - Further collection, advanced analysis, and simulation methods of ground motion records.
    - Experimental reproduction of near-fault characteristics through shaking table tests.

2. Near-fault Impacts:
    - To conduct pioneer shaking table tests with improved ground motion data collection and analysis for near-fault impact mitigation.
    - To develop reliable and efficient evaluation procedures/tools.
    - To conduct adaptability study of isolation systems and energy dissipation devices.
    - To propose corresponding improvement strategies/retrofitting methods.
    - To develop innovative structural health monitoring technologies.

3. Multiple Hazard:
    - Enhancing resilience when encountering multiple hazards, especially related to earthquake events, by improvement of design guideline for new structures and retrofit strategies for existing structures.
    - Probabilistic study of infrastructures behavior encountering multiple hazards.
    - Expanding international collaboration with laboratories and research institutes of various areas.