NCREE Tainan Laboratory Grand Opening Forum

Topic 3: Lessons Learned from Disastrous Earthquakes

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Presentation Outline:

While not all natural disasters can be avoided, their impact on a population can be mitigated through effective planning and preparedness. These are the lessons to be learned from disastrous earthquakes. Therefore, Topic 3 is critically important issue whether we have learned enough or not from past earthquakes. A total number of 20 speakers delivered informative presentations in the forum.

An overall review of lessons learned from disastrous earthquakes was presented by Dr. Stephen A. Mahin which included soil liquefaction, repairing a damaged structure, nonstructural elements life safety, near real time hybrid simulation testing, hybrid shaking table testing technologies. Comparatively, Dr. Santiago Pujol suggested seismic assessment must be effective, rapid and simple.

Dr. Bing Li summarized a large number of research results of seismic simulation using data driven method on reinforced concrete structures including columns, beam-column joints, and cantilever structural walls.

Dr. Chia-Ming Uang shared the experiments of existing braced frames and SMF. Dr. Hitoshi Shiohara explained the difference in the background of past earthquake damage in AIJ code and ACI 318 code.

Dr. Masakatsu Miyajima shared surface faulting, pipelines damage in earthquakes, and pipeline experiments of earthquake resistance across surface faulting. Dr. Insung Kim proposed affordable retrofit techniques, quality control in construction, and confirmation of expected performance.

For the speakers from Taiwan, Dr. Tzou-Shin Ueng covered liquefaction mitigations, minimal damage or quick repairing of lifeline engineering, and correlations among tests of multi-scales.

Dr. Hsieh-Lung Hsu proposed the research in multi-disciplinary domain of rotational effect in ground motions and torsional effect on structures.

Dr. Hung-Jen Lee updated his research on beam-column joints reinforced with high-strength reinforcement.

Dr. Yu-Chen Ou indicated many new street houses were still damaged due to the weak first story, and the Taiwanese code for RC structures does provide methods to calculate the strength of walls with openings although not clear enough.

Dr. Heui-Yung Chang introduced social-economic applications from earthquake engineering research. Dr. Chung-Sheng Lee introduced earthquake disaster reduction for industrial and governmental sectors.

Dr. George Yao completed shaking table testing and FEM model analysis for static smoke barriers (SSB) and suspended ceiling. Dr. Yi-Hsuan Tu showed some problems

remaining unsolved from the 1999 Chi-Chi earthquake to the 2016 Meinong earthquake which attracted significant discussion from the participants.
Dr. Po-Chien Hsiao indicated that more efficient and economical retrofitting strategies are critically important to increase the popularization of seismic retrofitting. Dr. Chui-Hsin Chen indicated that near-field movement may induce asymmetric damage to the structure followed by severe torsional behavior.
Dr. Gee-Yu Liu proposed methods to assess and improve a water supply system through the help from pipe testing. Dr. Yuan-Tao Weng pointed out the importance of efficient and economical strategies for collapse prevention based seismic evaluation and retrofit of mid- to high-rise RC buildings in Taiwan. Dr. Chia-Han Chen introduced foundation failures in disastrous earthquakes, characteristics of near-fault ground motions, and planning large-scale laminar shear box testing using the high-performance shake table in Tainan.

Discussion and Resolution Portfolio:

In the plenary discussion, most of participants agreed with that we did not learn enough from disastrous earthquakes. Because in the past earthquake, we kept the same things happening over and over. Therefore, participants suggested that we need to document more what had happened in the previous earthquakes, e.g., collecting the drawings, the information of material, and data of measurements. Eventually, we need to establish a platform for data sharing. Therefore, we can know the number of inventory structures with similar defects and can think about how we can do to prevent the inventory structures from the same consequences happening again.
Taking the tall building collapsed in the 2016 Meinong earthquake as an example, we know that residential and commercial complex buildings (mostly 7- to 15-story RC structures built before 1999) oftentimes have the problems of soft-weak bottom story, non-ductile detailing, inadequate capacity of beam-column joints, and poor couplers. How to find this inventory is an essential issue; therefore, NCREE has to continually develop more accurate assessment tools for this type of residential and commercial complex buildings. On the other hand, implementation on seismic evaluation and retrofit for existing buildings is a social and political challenge. After the 2016 Meinong Earthquake, Taiwan government had tried to provide financial allowance for structural safety investigation of residential buildings. Most citizens, however, were reluctant to conduct such investigations because their houses or apartments, once diagnosed as seismic deficiency, will face price depreciation. The policy for enforcing structural safety investigation to ensure seismic resilience needs public consensus.

NCREE is a non-profit research institute funded by Taiwan's government. We can provide advanced testing facilities, invent new technologies, and collect the documents and maintain the databank. In the future, we will provide seismic retrofitting technology and assist our government to implement retrofit for the existing residential buildings. Thus, NCREE has proposed several potential research topics in the future which are summarized as follows:

1. Development of Seismic Assessment Methodologies for Existing Residential Buildings:

- Seismic rapid evaluation and detailed evaluation for low-rise residential buildings.
- Seismic rapid evaluation and detailed evaluation for mid- to high-rise residential buildings.

2. Development of Seismic Retrofitting Technologies for Existing Buildings:
   - Partial retrofitting technology for collapse prevention of private buildings.
   - Retrofitting technology for mid- to high-rise buildings with soft-weak bottom story.
3. Geotechnical Hazard:
   - Liquefaction mitigations.
   - Lifeline engineering - seismic design, seismic evaluation, and quick repairing.
   - Soil-foundation-structure interaction: shaking table test of laminar shear box.
4. Lessons learned from earthquakes:
   - Establishment of building database after disastrous earthquakes.
   - Educational outreach for engineers and civilians.