IAEE Brainstorming Sessions for Future Directions of Earthquake Engineering

During 17WCEE, in collaboration with JAEE, the Japan Association for Earthquake Engineering, IAEE organized two brainstorming sessions on future directions of earthquake engineering. The sessions took place in a hybrid mode, which permitted online participation from around the globe. The two IAEE brainstorming sessions are summarized in this report.

<u>Session 1</u>

Title: Seismic Design for Minimum Damage (Towards "Earthquake-Proof" Structures)

Date and Time: 9:00 - 11:00, Wednesday, September 29, 2021 (Day 2)

Moderator: Michael Fardis (University of Patras, Greece)

Speakers: Michele Calvi (University School for Advanced Studies IUSS Pavia, Italy)
George Gazetas (National Technical University of Athens, Greece)
Masahiko Higashino (Takenaka Corporation, Japan)
David Mar (Mar Structural Design, USA)

Presentations:

Michele Calvi “Feasibility of minimum-loss seismic design applying a loss-based approach and procedure”

George Gazetas “Unconventional foundation design improves the seismic safety and resilience of the structure”

David Mar “Rocking and resilience discussion”

Masahiko Higashino “Current state of seismic isolation and structural control in Japan”

Summary: The session examined means to control/minimize damage and produce more resilient structures. The scope included earthquake protection systems (structures with energy dissipation devices, base isolation), structures designed for unconventional seismic response (rocking, sliding, use of the foundation soil) and real-life applications. After a brief introduction by the moderator, each speaker delivered a 20-minute presentation. The moderator summarized prior Q&A exchanges between himself and the speakers. Questions were taken from the audience to which the speakers replied. The discussion resulted in the resolutions listed in the following.

Resolutions:

- Current state-of-the-art and already available technology can meet the expectation of modern societies for little (or no) damage under rare, design level, earthquakes, at little (or even zero) additional cost.
- Structures which can sustain strong earthquakes with little damage serve best the goal of resilience.
- The general framework, the approaches and the technology for Performance-Based Design for minimum seismic damage apply very well to retrofitting of existing structures.
- Codes and standards should shift focus from ductility-based design for Life Safety to Performance-Based Design for minimum damage.
- Attention is needed on nonstructural elements.
- Controlled rocking at dry joints or interfaces (including those with the ground) is a very cost-effective option for minimum seismic damage.

- A rational balance of resistance and inelastic action between the soil and the superstructure can markedly reduce structural damage and cost and enhance resilience, without compromising safety.
- Seismic protection is a mature and continuously improving technology, successfully applied in design of new and upgrading of existing structures (high-rise buildings, bridges, tanks, etc.) for earthquake in many seismic regions of the world; however, it has not been used yet to its full potential in all such regions.
- Wider use of seismic protection will reduce in the long-term unit costs of hardware.
- If design for minimum damage enters everyday practice and designers become familiar with it, costs of design will gradually drop.
- If future indirect costs (downtime, relocation, etc.) over the service-life and the value of contents are taken into account, the Net Present Value of the total cost is markedly reduced, when facilities are designed for minimum seismic damage. The benefits to owners, national economies and Sustainable Development will be immense. Those owners who care only about initial construction cost should be tutored about the benefits of investing in long-term seismic performance.
- A service-life-long plan for monitoring/inspection and (where relevant) replacement of hardware should be an essential part of a design for minimum seismic damage.

Session 2

Title: Societal Resilience to Earthquakes and Tsunamis

Date and Time: 9:00 - 11:00, Friday, October 1, 2021 (Day 4)

Moderator: Gregory Deierlein (Stanford University, USA)

Speakers: Haruo Hayashi (Professor Emeritus of Kyoto University, President of NIED, National Research Institute for Earth Science and Disaster Resilience; Japan)

Laurie Johnson (Consultant/Researcher and Chief Catastrophe Response and Resiliency Officer for the California Earthquake Authority and Wildfire Fund, current Past-President of EERI; USA)

David Johnston (Professor of Disaster Management and Director of the Joint Centre for Disaster Research, Deputy Director of the multi-institutional QuakeCoRE research program; New Zealand.)

Topics:

(1) Earthquake and tsunami disasters in respective countries (Japan, USA, New Zealand) and recent research and implementation innovations in respective areas

(2) What we can learn from the COVID pandemic to improve our understanding of societal resilience and inform research, planning, policies, and practices to promote resilience to earthquakes, tsunamis and other geophysical hazards.

Summary: For each topic, short presentations by the moderator and panelists were followed by interactive discussion and question/answer session with the audience (live and online). The discussion resulted in the resolutions listed in the following.

Resolutions:

- The unexpected causes damage. We must learn from the past and think proactively about all potential risks.
- Post-event response and recovery must be planned before the event because the window of opportunity to mitigate long-term, negative impacts, can be very short.
- The social networks of neighborhood communities should be emphasized in post-event

response. Socio-economic vulnerabilities and population displacement can undermine community resilience.

- Changing and implementing public policies takes a long time, whereas people's memories and political will fade quickly. This prevents a major challenge to achieving systemic changes to promote resilience.
- We should not be waiting for the next wake-up call to change human/societal perception. We can do better in sharing the lessons from earthquakes and other natural disasters beyond the affected local community with the larger (national and world) community.
- The key to communicating the risk of natural hazards is to personalize the "local and personal experience".
- Simulated earthquake scenarios have proven to be an effective tool to influence human perception and public policies.
- The Covid-19 pandemic is an on-going world crisis that is providing many lessons to improve our understanding of societal resilience. We should be sure to utilize new knowledge and understanding from this event. A few observations to date:
    - Impact of the pandemic is not uniform: some people and some communities are more vulnerable
    - Essential services and critical building types and uses for society to function, are broader and different from what we have believed them to be.
    - Communities that engage residents in pre-pandemic public health planning have coped better
    - How governments respond to supporting people and community functions (e.g., education, housing) is going to determine the long-term impact on people and communities.