Seismic Design for Minimum Damage

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

So far, the focus of seismic design and seismic codes was on Collapse Prevention/Life Safety through ductility and hysteretic energy dissipation in the structure. However, ductility means damage, which, in advanced economies, is becoming unacceptable. Society demands a change in paradigm to focus on avoiding or, at least, minimizing damage. This session will examine means to control/minimize damage and produce more resilient structures. The scope includes earthquake protection systems (structures with energy dissipation devices, base isolation), structures designed for unconventional seismic response (rocking, sliding, use of the foundation soil to seismically-isolate the superstructure) and real-life applications.

Moderator: **Michael Fardis (University of Patras, Greece)**

Speakers:

Michele Calvi (University School for Advanced Studies IUSS Pavia, Italy)
Performance-based design was first envisaged in the early 1990s and has become a mantra in conceptual seismic design. However, practical approaches to be possibly introduced in codes of practice are not readily available, to say the least, though some can be found in the literature. What is essentially missing is some correlation between structural response parameters and expected monetary loss, at a level of simplicity comparable with the force- or displacement-based approaches applied in everyday practice. The basics of a formulation that may evolve into such a practical loss–based approach will be discussed, with a focus on some essential practical questions: is it possible to design for very low expected loss and what will be the associated parametric investment cost?

George Gazetas (National Technical University of Athens, Greece)
The answer to the question is positive: indeed, it is quite feasible to achieve this goal by reducing over-conservatism in seismic foundation design. Whereas today's "capacity design" considerations lead to oversized footings and often require large piled foundations, by limiting, ignoring, or even reversing such capacity considerations we arrive not only to more economical but also to safer structures. The resulting smaller foundations may experience slippage, uplifting, bearing capacity mobilization — one, two, or all of these. This type of in-ground "plastic hinging" offers the weak link in the soil–foundation–structure system, preventing above-ground structural damage. The consequences for the foundation may be made acceptable by design, and in any case can be computed reliably.

David Mar (Mar Structural Design, USA)
Thanks to the many contributions of researchers, the design profession now possesses the analytical tools and guidance (such as ASCE 41 in the US) to achieve high-performance design. While the performance-based design process takes longer than a conventional code-based prescriptive design, in my experience, the difference is decreasing rapidly with each implementation. Furthermore, the relative cost of the engineering effort is very low when compared to the overall project cost. Investing in performance-based design is a great value to the project due to future benefits of lower repair costs and maintaining the use of the structure after a major earthquake. In some cases, improved performance can be achieved at a very low

construction cost premium. My presentation will feature a completed project that achieved enhanced performance at close to the same cost of the conventional structure, designed in parallel. The project is a concrete wall structure with flat slab floor construction. The performance-based design allows the walls to rock at the foundation. The foundation and elevated slabs were proportioned to both yield and allow the walls to re-center under gravity loads. In two of the walls near the edge of the foundation, energy dissipation was enhanced with lead-extrusion dampers anchored to the foundation.
https://www.marstructuraldesign.com/

Masahiko Higashino (Senior Research Fellow, Takenaka Corporation / Vice President, Japan Society of Seismic Isolation, Japan)
Seismic isolation and structural control have employed often as aseismic measures in Japan now. He will introduce state of the art of seismic isolation and structural control in Japan. Engineers came to have interest in these technologies in early 80s. The technologies became very popular, not only in engineering society but in general Japanese society, since Kobe earthquake in 1995. Now people do know these wordings and these are listed in Dictionaries of Japanese language. Japan Society of Seismic Isolation was established in 1993. The society consists of professors of academy and practicians. The society communicates between these members and government, who legislates aseismic provisions. The society played significant role in popularizing these technologies. His presentation will also include the most present examples of seismic isolation and structural control.
https://www.takenaka.co.jp/takenaka_e/services/research/