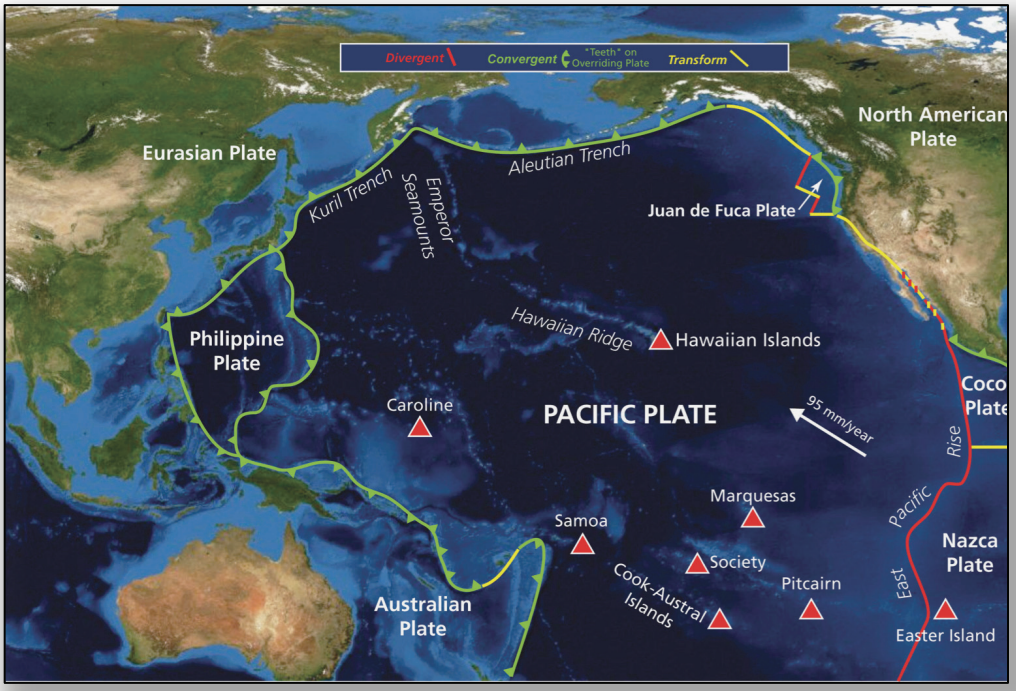
The Earthquake Resilience of Nuclear Facilities

A University of California Pacific Rim Forum

The University Club, California Memorial Stadium

June 8-9, 2015



The University of California at Berkeley has hosted a number of Pacific Rim Forums that have provided a venue for discussions on a broad range of issues associated with the international nuclear energy enterprise. The Forums have particular relevance to the common interests of the nations on the Pacific Rim and have been rich in international participation. In summer 2015, Berkeley will host the latest in the series of Pacific Rim Forums with a thematic on the critical issue of resilience of nuclear facilities including nuclear power systems. Ensuring a resilient system, that adequately addresses safety and response / mitigation concerns for extreme events, is essential to achieving a safe facility and realizing the full potential of nuclear power for addressing the energy and environmental needs of a technologically advancing world.

The Earthquake Resilience of Nuclear Facilities

The overall resilience[1] of nuclear facilities and their concomitant operations is controlled by a combination of the design basis of the facility, the response of the facility to beyond design basis events, and the ability to respond and mitigate any failures or damage associated with an extreme event. Modern, risk-informed, performance-based design standards should strive to achieve appropriate resilience through predictable and controlled amplitude-dependent behavior of the structures, systems and components (SSCs) comprising the nuclear facility. Where damage or failures occur, robust response mechanisms must be poised to address and mitigate any challenges that arise.

The achievement of appropriate resilience is dependent on a number of science, engineering and technology-based activities including:

- Developing an appropriate probabilistic characterization of hazards
- Creating performance-based design standards which correlate and constrain facility damage with amplitude dependent behavior
- Accurately, and with adequate uncertainty bounds, computationally simulating the response of the nuclear facility to various amplitudes of events, including quantifying system ultimate capacities ("cliffs") for margin assessments in beyond design basis events
- Defining response and mitigation measures which can be invoked to address any damage or failures of the facility key SSCs, and ensure public confidence in the safe and secure operations of the nuclear enterprise.

This Pacific Rim Forum will invite the international community of experts and leaders to address the current status of underlying capabilities and the technology gaps that exist to achieving a high state of nuclear resilience. This will include session tracks on:

- Advanced simulation tools for prediction of amplitude-dependent, nonlinear system behavior in coupled soil and structure systems
- Quantification of simulation model uncertainties and casting computational simulation results in an appropriate probabilistic framework
- The current state of risk-informed, performance-based codes and standards and identification of gaps to full realization of performance-based design
- Technologies and monitoring / data analysis capabilities (e.g. sensors, data acquisition, simulations) required to respond to any SSC failures and the most effective means of communication of information for the public and decision makers.

The Forum will include invited international experts and leaders from around the Pacific Rim, and will span a broad cross-section of academic institutions, National Laboratories,

---

[1] Resilience ⇒ '*the capacity to recover quickly from difficulties'*

commercial sector entities, and governmental agencies. The Forum will provide an opportunity to share perspectives on nuclear facility resilience and ideally develop consensus views on technology gaps that present barriers to the full realization of a robust, performance-based design for nuclear systems.

Forum Organizing Committee

Dr. David McCallen
University of California Office of the President &
Lawrence Berkeley National Laboratory, USA

Professor Stephen Mahin
Pacific Earthquake Engineering Research Center
University of California, Berkeley, USA

Dr. Farhang Ostadan
Bechtel Corporation, USA

Mr. Toshiyuki Abe
Itochu Corporation, Japan

Supporting Organizations

American Association for Structural Mechanics in Reactor Technology (AASMIRT)

Japan Atomic Industrial Forum (JAIF)

Pacific Earthquake Engineering Research Center (PEER)

Lawrence Berkeley National Laboratory

Forum Agenda

Monday June 8, 2015 The University Club, California Memorial Stadium		
8:00AM - 8:30AM	Continental Breakfast	
8:30AM – 8:45AM	Welcome and objectives of the Forum	Stephen Mahin Director, Pacific Earthquake Engineering Research Center, USA
8:45AM – 10:00AM	Perspectives on the safety of nuclear facilities	George Apostolakis Head, Nuclear Risk Research Center, Japan Former Commissioner, U.S. NRC Yoshiaki Oka Chairman, Atomic Energy Commission, Japan Toshiyuki Abe A Message from the Japan Atomic Industrial Forum
10:00AM - 11:30AM	Natural hazard characterization	Session Chair – Stuart Nishenko, Pacific Gas and Electric Co., USA • High resolution seismic hazard assessment at Diablo Canyon power plant: A case history (Stuart Nishenko, Pacific Gas and Electric Co., USA) • Technical approach to next generation ground motion attenuation relationships (Yousef Bozorgnia, Pacific Earthquake Engineering Research Center, USA) • Tsunami hazard – state of the art (Hong-Kie Thio, AECOM/URS, USA) • Coastal modeling and tsunami forces on structures (Patrick Lynett, University of Southern California, USA) • Addressing uncertainty in seismic hazard estimates and stability of hazard results for decision making (Norm Abrahamson, Pacific Gas and Electric Co., USA) • Risk-informed design and assessments of Nuclear Power Plants subject to external hazards – implementation of defense-in-depth concept for risk reduction (Tsuyoshi Takada, University of Tokyo)
11:30AM - 12:00PM	Panel Q&A/discussion on technology gaps and needs for hazard assessments	
12:00PM – 1:00PM	Lunch – UC Berkeley Global Campus at Richmond Bay, Terezia Nemeth Development Manager, UC Berkeley, USA	

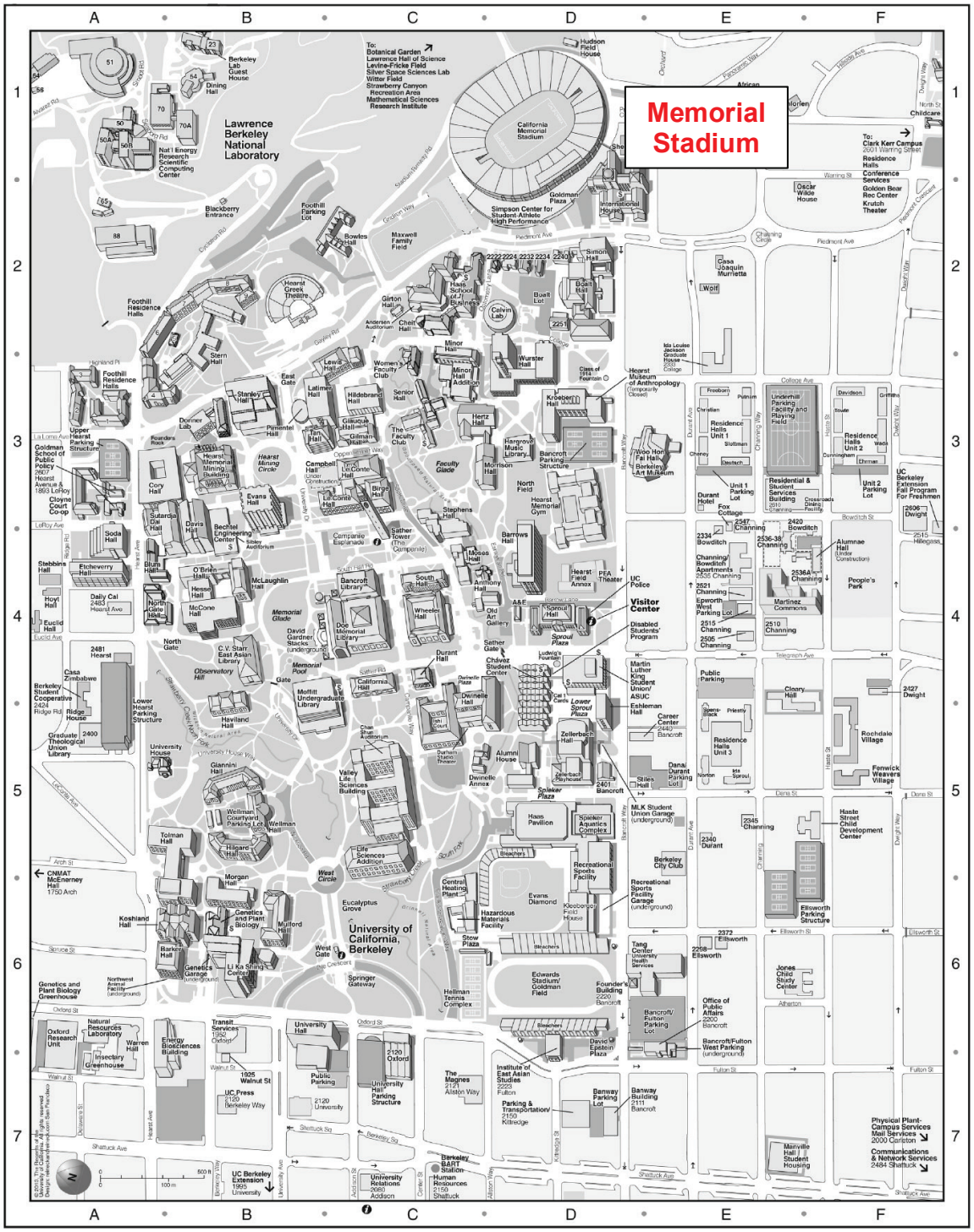
1:00PM - 2:30PM	Risk informed, performance-based design standards for structures, systems and components	Session Chair – Steve Mahin, PEER, UC Berkeley, USA • Developments in probabilistic performance-based optimum seismic design (Joel Conte, UC San Diego, USA) • Risk assessment of non-nuclear critical civil infrastructure: recent developments and challenges (Bozidar Stojadinovic, ETH, the Swiss Federal Institute of Technology Zurich, Switzerland) • The philosophy, logic and approach to performance-based and risk-informed design (Robert Budnitz, Lawrence Berkeley National Laboratory, USA) • Risk informed design and analysis criteria for nuclear structures (Mike Salmon, Los Alamos National Laboratory, USA) • Aspects of U.S. Nuclear Regulatory Commission regulations, guidance and performance goals (Jose Pires, U.S. Nuclear Regulatory Commission, USA)
2:30PM - 3:00PM	Panel Q&A/discussion on technology gaps and needs for performance-based standards	
3:00PM – 3:15PM	Break	
3:15PM - 4:45PM	Simulation tools for enabling performance-based design	Session Chair – David McCallen, University of California Office of the President & Lawrence Berkeley Lab, USA • Integrated earthquake simulations (Muneo Hori, Univ. of Tokyo, Japan) • Nonlinear simulations for soil-structure interaction and performance-based design (Boris Jeremic, UC Davis, USA) • Large-scale experiments for SSI system phenomenon (Ramin Motamed, University of Nevada, USA) • Simulation methods for probabilistic seismic response and fragility evaluation of nuclear structures, systems and components (David Nakaki, Simpson Gumpertz and Heger, USA) • Soil-structure systems: simulation and experimental needs and gaps (Nicholas Sitar, UC Berkeley, USA) • Uncertainty quantification of simulation performance bounds (Francois Hemez, Los Alamos National Laboratory, USA)

4:45PM – 5:15PM	Panel Q&A/discussion on the technology gaps and needs for advanced simulation capabilities
5:15PM – 6:15PM	Tour and presentation on the seismic retrofit of UC Berkeley Memorial Stadium Chris Petteys and Mason Walters Forell / Elsesser Engineers Inc., USA
6:30PM – 8:00PM	Mixer and dinner at UC Berkeley Memorial Stadium

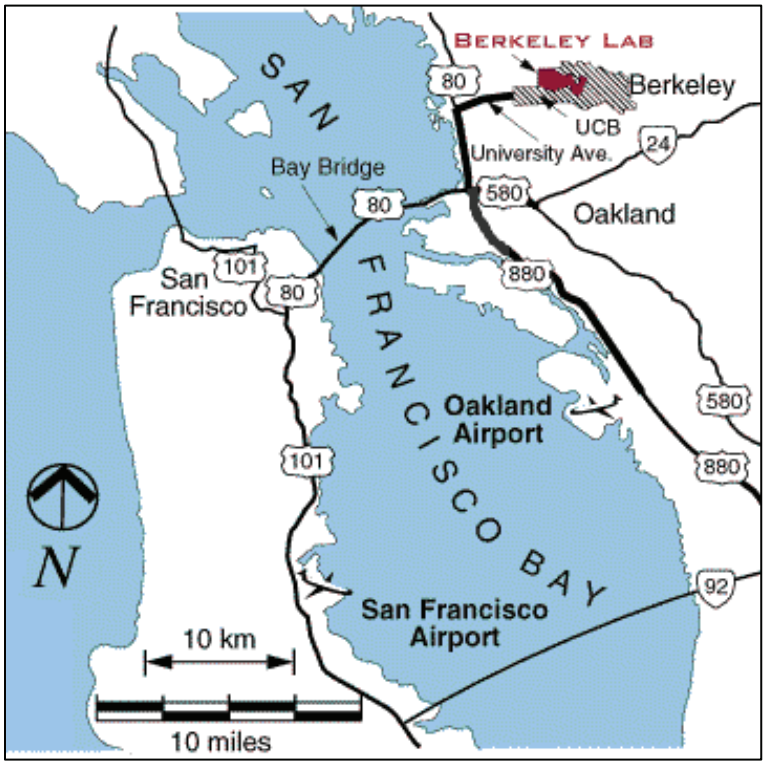
Tuesday June 9, 2015 The University Club, California Memorial Stadium		
8:00AM - 8:30AM	Continental Breakfast	
8:30AM - 10:00AM	Emerging technologies for aseismic design of nuclear facilities	Session Chair – John Richards, Electric Power Research Institute, USA • Seismic base isolation (Steve Mahin, UC Berkeley, USA) • Composite shear wall technologies (Amit Varma, Purdue University, USA) • Technology development of seismic isolation for nuclear facilities (Kanazawa, Hiraki, Nagata and Ohtori, CRIEPI, Japan) • Development of performance criteria of seismic isolation systems for Nuclear Power Plants in Korea (Min Kyu Kim, Korea Atomic Energy Research Institute)
10:00AM - 10:30AM	Panel Q&A/discussion on the technology gaps and needs for advanced technology implementation	
10:30AM - 10:45AM	Break	
10:45AM - 12:15PM	Current challenges for the practitioner and industry	Session Chair – Farhang Ostadan, Bechtel, USA • Suitable calculation of FRS for high frequency motions (Guillaume Herve, ESTP Paris, France) • EPRI program on high frequency testing (John Richards, Electric Power Research Institute, USA) • Challenges for seismic/tsunami PRA at the NRRC (Toshiaki Sakai, Yasuki Ohtori, George Apostolakis, Nuclear Risk Research Center/Central Research Institute of the Electric Power Industry,

		Japan) • A framework for multi-unit site PSA – issues and considerations (Sujit Samaddar, IAEA, Austria)
12:15PM - 12:45PM	Panel Q&A/discussion on technology gaps and needs for industry and practitioners	
12:45PM - 1:45PM	Lunch – The importance and value of earthquake engineering to the nuclear enterprise Per Peterson, William and Jean McCallum Floyd Endowed Chair and Executive Associate Dean of Engineering, UC Berkeley	
1:45PM - 3:15PM	Emergency response and mitigation	Session Chair – Kai Vetter , UC Berkeley, Lawrence Berkeley National Laboratory, USA • Earthquake early warning (Jennifer Strauss, UC Berkeley, USA) • Tsunami early warning, state-of-practice (Visily Titov, NOAA) • Post-event, environmental measurements and sensing (Kai Vetter, UC Berkeley, USA) • Airborne sensing and visual inspection (Falko Kuester, UC San Diego, USA) • Communicating risk and uncertainty: insights gained from a decade of outreach (Annie Kammerer, Engineering consultant, USA)
3:15PM - 3:45PM	Panel Q&A/discussion on the technology gaps and needs for emergency response and mitigation	
3:45PM - 4:45PM	Path forward and adjournment, followed by light reception	

2227 Piedmont Avenue, Berkeley (map it)
Enter at Gate 2
(public parking info. http://www.maxwellgarage.com/faq/page.php)



Berkeley Campus



UC Berkeley Location

San Francisco from the Berkeley Campus

Lodging Near the Berkeley Campus

(more hotel info at http://peer.berkeley.edu/about/hotels.html and http://www.claremontresort.com/)

Hotels around the UC Berkeley campus

French Hotel

The quaint and beautiful French Hotel is located about 0.5 mile (about 6 blocks) from the UC Berkeley campus, in the "Gourmet Ghetto" with numerous coffee shops, restaurants, and boutiques lining the streets, including the world-famous Chez Panisse! The hotel is about a 9-block walk from the Downtown Berkeley BART station.

1538 Shattuck Ave
Berkeley, CA 94709
(510) 548-9930
Click here to link to website.
Click here for a Map.

****

Berkeley City Club

The Berkeley City is located just a block from the UC Berkeley campus, and about 5 blocks from the Downtown Berkeley BART station.

2315 Durant Avenue
Berkeley, CA 94704
(510) 848-7800 (tel)
(510) 848-5900 (fax)
https://www.reservationpage.com/C00000/H00129/index.asp
Click here for a Map.

Berkeley Hostel

The Berkeley Hostel is located just a few blocks from the UC Berkeley campus, and about 10 blocks from the Downtown Berkeley BART station.

2434 Piedmont Ave.
Berkeley, CA 94704
(510) 849-4800
info@berkeleyhostel.com
http://www.berkeleyhostel.com/
Click here for a Map.

****

Berkeley Travelodge

The Berkeley Travelodge is located within walking distance to campus on University Ave.

1820 University Ave (@ ML King Way)
Berkeley, CA, 94703 US
510-843-4262
http://www.travelodge.com/
Click here for a Map.

Hotel Durant
2600 Durant Avenue
Berkeley, CA 94704
Reservations: (510) 845-8981
http://www.hoteldurant.com/
Click here for a Map.

****

Beau Sky
2520 Durant Ave
Berkeley, CA 94704
510-540-7688
800-990-2328
Fax 510-540-8089
http://beausky.com/
Click here for a Map.

****

Hotel Shattuck Plaza
2086 Allston Way
Berkeley, CA 94704
(510) 845-7300
http://www.hotelshattuckplaza.com/
Click here for a Map.

Bancroft Hotel
2680 Bancroft Way
Berkeley, CA 94704
510-549-1000
800-549-1002
510-549-1070 (fax)
http://www.bancrofthotel.com/
Click here for a Map.

****

Doubletree at the Berkeley Marina

The Doubletree Hotel at the Berkeley Marina is located in the beautiful Berkeley Marina, about 3 miles from the UC Berkeley campus.

200 Marina Boulevard
Berkeley, California, 94710
(510) 548-7920
http://doubletree.hilton.com/en/dt/hotels/services.jhtml?ctyhocn=JBKCADT
Click here for a Map.