Keynote Speech

Wednesday, September 18th, 09:00 - 09:30 **Conference Hall**

Chair: Ruey-Juin Rau

From Earthquake Observation and Modelling to Forecasting

Jean-Philippe Avouac
Professor, California Institute of Technology, Pasadena, USA

A major goal of seismotectonic studies is to improve methods to assess the probability of occurrence, possible location, magnitude and expected ground motion of the most extreme earthquake. In this presentation, I will discuss the progress that we have made toward that goal since the Chichi earthquake happened in 1999. I will start with summarizing what we have learned from the Chichi earthquake itself and from a number of more recent large events, in particular the 2015 Gorkha earthquake which occurred in a similar tectonic setting. I will discuss how these observations have impacted our understanding of the ‘seismic cycle’ and the success and limitations dynamic modeling in simulating these observations. I will finally discuss the major challenges that need to be addressed to improve earthquake hazard assessment and forecasting.

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A Review of 1999 Chi-Chi, Taiwan, Earthquake from Modeling to Drilling for the Understanding of Fault Zone Dynamics and Ground Motions

Kuo-Fong Ma

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The high quality dense strong motion station deployed priori to the occurrence of the destructive 1999 Chi-Chi earthquake provided the most comprehensive studies on the mechanism of a damaging event. The general consistent feature in spatial slip distribution of the fault as a large slip of ~12m at the northern portion of the fault from fault models and geological observation suggest the importance in the understanding of physics of faulting with large slip, and the long period ground motion. The success of Taiwan Chelungpu-fault Drilling project (TCDP) shed the light on the understanding of the earthquake energy partition by revealing the very fine grain (~nm) fault gouge with slip thickness in a scale of mm for a single event. The dynamic parameters inverted from the kinematic slip inversion suggest a heterogeneous of shear stress distribution, and complexity in stress-time history, and, thus, also slip-weakening curves over the fault. The combined study from surface energy estimated from slip zone identified from fault gouge to the fracture energy estimated from dynamic parameters modeling of strong motion data gives the direct estimation on energy partition of a single earthquake from geological and seismological observations. The low frictional coefficient from temperature measurement after drilling provoked the rapid response drilling after a large earthquake (e.g. 2008 Wencuan, and 2011 Tohoku earthquakes) for frictional heating measurement. With the success of the TCDP drilling with identified slip zone associated with the 1999 Chi-Chi earthquake, an in-situ borehole seismometers as TCDPBHS was installed to monitor the fault zone behavior after a large slip. This cross the fault vertical seismic array helps us to understand the fault zone hydrological structure, its association to fault zone recovery in anisotropy, earthquake nucleation and triggering. From the lesson learnt through the 1999 Chi-Chi earthquake, the earthquake kinematics and dynamics from recent two moderate but damaging 20160206 Mw6.4 Meinong, and 20180206 Mw6.3 Hualiean earthquakes, which both generating long period ground velocity, were examined. The dense low-cost seismometers, P-alert, which developed and installed after the 1999 Chi-Chi earthquake for earthquake early warning (EEW) brought in not just the useful information for EEW, but, also good coverage to the earthquakes as seismic array with high quality waveforms. The array-like analysis to the simulation on the generation of the long period velocity ground motion suggested the important contribution of the near asperity effect from buried fault, rather than near-fault motion from fling effect. These dense strong motion array captured the most direct features on ground motions from earthquake faulting, and important message to the application in hazard mitigation.

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Seismic Design Verification Using Nonlinear Response History Analysis

Jack Moehle
Ed & Diane Wilson Professor of Structural Engineering
University of California, Berkeley, USA

We live in a time when social, environmental, and economic factors in the Western United States favor the development of urban centers populated by high-rise buildings. The design of this new generation of high-rise buildings has benefited from the advancement of performance-based design methods in which structural engineers characterize expected performance for hypothesized earthquake shaking using computer simulation. The design approach has evolved rapidly - whereas a decade ago each project had its own, project-specific basis, today the designs are guided by a set of consensus standards, including a new appendix for ACI 318-19 Concrete Building Code on Seismic Design Verification Using Nonlinear Response History Analysis. Though developed with high-rise buildings in mind, the approach is generally applicable for performance-based designs of buildings of any height or performance category. The presentation will describe the performance-based design approach and will illustrate it through the example of a tall building design in San Francisco.