Abstracts for Invited Talks

Horizon Ballroom, Hilton Palm Springs Resort

September 10-11, 2007

Tall Building Design – Challenges and Opportunities

John Wallace (UCLA)

September 10th, 09:30

In early 2007, more than 53 tall buildings greater than 20 stories were either under construction or in various design/planning stages in the City of Los Angeles. A significant number of the proposed tall buildings are being designed using so-called "alternative" structural systems using UBC 1997 S1631.6.3, which requires peer-reviewed by a panel of experts. The peer-review process has led to substantial debate within the profession related to appropriate ground motion selection, as well as structural modeling and acceptance criteria. To address some of these issues, as well as to provide guidance to building officials, the Los Angeles Tall Buildings Seismic Design Council published a consensus document: "An Alternative Procedure for Seismic Analysis and Design of Tall Buildings Located in the Los Angeles Region" and a task group of the Structural Engineers Association of Northern California developed "Recommended Administrative Bulletin on the Seismic Design and Review of Tall Buildings Using Non-Prescriptive Procedures" for the City of San Francisco. However, a number of issues require more detailed study, and the PEER Center established the Tall Buildings Initiative to address many of these concerns. Given the heightened level of interest, there are challenging some of interdisciplinary research problems, such as the definition of ground motions used for nonlinear response history analysis that incorporate directivity and account for the common features associated with tall buildings (e.g., mat foundation, subterranean levels). Another promising research area involves the use of robust seismic monitoring systems to expand our understanding of the complex behavior of tall buildings, including modeling complex system interactions. An overview of typical structural systems used for tall buildings, issues associated with ground motions and modeling, and opportunities associated with robust monitoring will be presented.

Lithosphere along the Pacific-North America plate boundary – insights from south of the border

Joann Stock (Caltech)

September 10th, 16:00 – Horizon Ballroom

The tectonic evolution of the Pacific-North America plate boundary zone south of the Mexican border provides important constraints on the kinematics and lithospheric evolution of the plate boundary region in Southern California. Because the boundary changes azimuth southwards and becomes an obliquely rifted extensional margin, a detailed kinematic history is preserved in submarine and subaerial basins in individual plate boundary rift segments (bounded by NW-striking strike-slip faults or accommodation zones). I summarize results from studies that have been done in the region of the northern Gulf basins over the past 10 years. The net slip in the northern Gulf of California since 6.3 Ma is well constrained at ca. 300 km from geological tie points. This total amount of opening must feed northward into the Salton Trough region. In addition to causing continental extension, this plate boundary displacement produced a 255 km width of new transitional (non-oceanic) crust in the Upper Delfin Basin. This did not occur by typical midocean ridge spreading processes; an MCS and wide-angle seismic reflection line (Gonzalez-Fernandez et al., JGR 2005) shows lower seismic velocities and lower density, and deeper Moho (at or below 14 km), than seen in typical oceanic crust. Industry seismic lines in the N. Gulf (Aragon-Arreola and Martin-Barajas, 2007 Geology) and Altar Basin of Sonora (Pacheco et al., 2006) show that in most rift segments of the plate boundary in this region, the locus of extension has jumped NW with time, stranding older, now inactive basins to the SE of the actively extending basins. This caused the SE ends of some

NW-striking right-lateral fault segments to be abandoned. This happened at ca. 3 -2.5 Ma for the Lower Delfin Basin segment; the timing of relocation of the extension in the other plate boundary segments is not well known. The distance of these jumps differed from segment to segment along the plate boundary, producing (in map view) an irregular juxtaposition of unextended continental crust, extended continental crust, and lithosphere capped by new transitional crust. This pattern is further complicated by differing amounts of volcanism and magmatic intrusion in different rift segments. A similar pattern is expected along the plate boundary in southern California but it is less well constrained. In particular, some new lithospheric area must have been created within plate boundary segments in the Salton Trough, but the nature and areal extent of the corresponding new crust is still controversial.

The San Andreas fault in the Carrizo Plain: Locked and Loaded?

Lisa Grant Ludwig (UC Irvine)
September 11th, 08:00 – Horizon Ballroom

As the 150 year anniversary of the great Fort Tejon earthquake has passed, it is timely to evaluate the possibility of a similar earthquake involving rupture of the Carrizo section of the San Andreas fault. The Carrizo section of the San Andreas fault has been proposed to rupture relatively infrequently, with centuries long recurrence, and only during the largest earthquakes, thereby controlling the occurrence of great quakes on the southern San Andreas fault. Is the historically quiescent Carrizo section “locked” and unlikely to rupture in the next few decades as previous Working Groups have estimated? Or is it “loaded” and ready to fail? New paleoseismic data reveal 4 -5 ruptures in the time period 1445 – 1857 A.D. and warrant serious consideration of the latter scenario. In this talk, I will review models and data from one of the best characterized sections of the southern San Andreas fault and discuss their implications.

Accounting for Thermal and Poroelastic Processes in Rupture Dynamics

Eric M. Dunham (Harvard)
September 11th, 08:30 – Horizon Ballroom

Studies of fault zones suggest that slip localizes to a narrow shear zone, less than a few hundred microns in width that is embedded within a low permeability ultracataclastic fault core. This is surrounded by a damage zone that can be several orders of magnitude more permeable than the fault core. Given this structure, and the fact that fault zones are fluid-saturated at seismogenic depths, what are the relevant physical processes that influence the evolution of fault strength during earthquakes?

We first consider poroelastic effects in the absence of thermal processes. In-plane slip compresses one side of the fault and extends the other, generating a gradient in fluid pressure that drives flow across the fault. Any asymmetry across the fault, either in elastic properties measured over the scale of the rupture or in poroelastic properties measured over the hydraulic diffusion length (as would occur if slip localizes at the boundary between the fault core and damage zone), leads to effective normal stress changes on the fault [Rudnicki and Rice, 2006]. The sign of the effective normal stress change reverses if the rupture propagates in the opposite direction, in a manner similar to the well-known bimaterial effect of normal stress changes during slip between dissimilar elastic solids. The sign of the effective normal stress change cannot always be predicted solely from the contrast in elastic properties across the fault. In numerical models with opposing elastic and poroelastic effects, we observe, as the rupture accelerates, a reversal in the sign of effective normal stress change from that predicted by the poroelastic mismatch to that predicted by the elastic mismatch, provided that the wave-speed contrast exceeds about 5-10% (the precise value depends on the poroelastic contrast and Skempton's coefficient). For faults separating more elastically similar materials, there exists a minimum poroelastic contrast above which the poroelastic effect always determines the sign of the effective normal stress change, no matter the rupture speed.

A complementary study explores coupled thermal and poroelastic effects while neglecting the undrained pore pressure changes from stresses within the fault zone (which formed the basis of the previously considered bimaterial effect). Shear heating of fluids within the shear zone locally increases pore pressure. If diffusion of heat and fluid cannot occur sufficiently rapidly, then the effective normal stress is reduced. We combine this model for thermal pressurization with a rate-and-state friction law that includes strong velocity weakening at coseismic slip rates arising from flash heating of asperity contacts. Numerical modeling reveals both crack-like and pulse-like rupture modes. The rupture mode is determined by the background stress level on the fault; below a critical level, no crack-like solutions can exist. The critical stress level is a function of both the velocity-weakening characteristics of the friction law and a "hydrothermal diffusivity factor" that quantifies the efficiency of thermal pressurization; low diffusivities favor crack-like ruptures. The width of the shear zone, even if less than a few hundred microns, also influences the rupture mode; wide shear zones favor pulse-like ruptures.

Quantifying strain within the Salton Trough – Transients and 3D deformation fields

Rowena Lohman (Cornell)
September 11th, 14:00 – Horizon Ballroom

The state of strain within the Salton Trough / Imperial Valley region of Southern California and Northern Baja California, where the North American-Pacific plate boundary transitions between the divergent margin in the Gulf of California to the predominantly strike-slip San Andreas system, can be assessed through the use of a variety of observation types with differing temporal and spatial scales and sensitivities. High heat flow, volcanic/hydrothermal activity, seismic swarms, and transient fault creep episodes mark the region. The Superstition Hills fault, in particular, is known to creep at shallow depths both in the immediate aftermath of large earthquakes, and with transient episodes of high creep monitored by local stainmeter networks.

Interferometric Synthetic Aperture Radar studies in Southern California have been able to identify areas of anthropogenic deformation (which may bias studies using nearby GPS sites), isolate the deformation fields from large earthquakes, and place constraints on interseismic and transient creep episodes. The arid climate of Southern California results in a favorable environment for producing coherent interferograms over time intervals of up to several years in many areas. However, the Imperial Valley sustains a large amount of agricultural activity, resulting in widespread interferometric decorrelation over time intervals of even less than a month. Efforts using point target analysis methods that ingest large numbers of interferograms can isolate stable "phase corridors" along the major E-W highways and cement culverts crossing the valley and framing the agricultural fields. Analysis of the phase behavior along these corridors can help us track the ground deformation associated with inter-valley features such as the Imperial fault. Here, I review the existing catalogs of geodetic and seismic data and identify the likely areas where current and future SAR data will be able to advance our understanding of Salton Trough tectonics.

Cascadia Episodic Tremor and Slip events observed on GPS, seismic and borehole strainmeter arrays

Timothy Melbourne (CWU)
September 11th, 14:30 – Horizon Ballroom

Several rapidly expanding GPS networks along the greater Cascadia forearc have enabled identification of 36 isolated Episodic Tremor and Slip (ETS) events since 1997, including two in 2007. ETS events are observed throughout the forearc, from northern California to southwestern British Columbia, with station density generally increasing towards the north. Events located in well-instrumented regions can be tracked as they migrate laterally north-south along the plate boundary, but increasing station density has resolved many smaller transients that could not previously be confidently identified. At the specific latitude of the northern Washington State and southwestern British Columbia, the 14-month average recurrence interval still holds true, 5 events after first recognition. Elsewhere, this periodicity is not observed. Along central Vancouver Island, a host of smaller events distinct from the 14-month recurrence occur with an aperiodic fashion. Sporadic smaller events also appear throughout the subduction zone to the south, including within the region known for the 14-month periodicity. In southern Washington State, some of the largest transient displacements are observed, but lack any obvious periodicity in their recurrence. Along central Oregon, an 18-month recurrence is evident, while in northern California (Yreka) the 11-month periodicity previously documented still holds true.

We invert estimated GPS offsets for the largest 14 events using non-negative thrust faulting along a plate interface divided into roughly 500 subfaults. Those events have equivalent moment magnitudes ranging from 6.3 (smallest resolvable with GPS) to 6.8, and typically 2-3 cm of slip. The largest spatial extent of the events resolved to date is just under 500 km along strike, and maximum duration is seven weeks, which lies in marked contrast to other subduction zones. Averaged over many ETS events, the upper limit of transient slip in the vicinity of Seattle, WA lies just west of the heavily urbanized Puget Sound region, suggesting that the lower limit of megathrust seismic rupture may extend much closer to this area than previously thought.

During the time window of 2005-2007.2, a systematic quantification of seismic tremor observed both during and outside of ETS events has demonstrated a very linear relationship between tremor duration and inverted GPS equivalent moment. Moreover, no GPS transients during this time period are observed in the absence of tremor. This suggests that the GPS-measured transient deformation may be the integrated near-field offsets resulting from many small, discrete seismic slip events (meaning aseismic, transient creep is not needed to explain the GPS signal). This hypothesis is supported from inferences about tremor source characteristics drawn from borehole seismic spectral features and tremor locations determined from surface arrays: the observed quantity, timing and location of tremor largely explains the ETS signal as observed on surface and borehole strain- and tiltmeter arrays. Together, these data suggest that Cascadia, and presumably other subduction zone ETS events, are comprised largely of form of microseismic clustering unique to subduction zones and in fact have little aseismic creep associated with them.