using the Federal Emergency Management Agency and National Institute of Building Safety sponsored code, HAZUS, developed to provide a national standard for earthquake loss estimation. We have incorporated a recently developed soils map for the state of California, a preliminary map of liquefaction susceptibility and hazard curves for each of 5858 census tract centroids. Seven soil conditions are tied to the 1997 Uniform Building Code soils classification scheme, that is based on shear-wave velocity in the upper 30 meters. Liquefaction susceptibility is based on previous Division of Mines and Geology earthquake planning scenarios. Building inventory and fragility related to an installed in HAZUS. Preliminary results suggest about $5 billion (1990 dollars, 1990 inventory) in total loss annually statewide. Of that, about 3 billion is direct structural and non-structural damage to structures, $1.5 billion to low-rise wood frame structures. The remaining $2 billion is contents losses and direct economic losses. The $5 billion represents an effective annual tax of about $200 per year for each and every Californian. Los Angeles County is subject to the greatest expected total annual loss of over $1.5 billion, fully 30% of the statewide total. This is the consequence of the great exposure to seismic shaking in metropolitan Los Angeles County. Alameda County is a distant second, with $424 million annual losses. Loss estimates have a high uncertainty in the earthquake hazard model, structure fragility and structure inventory. We estimate an uncertainty of at least a factor of 4 at 2 standard deviations.

**SISPRO: A Scientific Program to Quantify Seismic Effects on a Subsurface Nuclear Waste Installation**

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In 1991, the french Government decided to fund a 15 years research program in order to establish a long term program for nuclear waste disposal. More recently, in the framework of this program, it has been asked to study viability of an interim storage in a subsurface installation, at a depth of typically few 10 meters. For this concept, seismic aspects have to be carefully taken into account, to show for instance how the seismic exposure is modified when the installation is builded in the subsurface domain. More generally, 3 axis of research are inspected to circumvent and predict seismic effects : analysis of in situ seismic records in depth, centrifugal experiments and numerical modeling. Subsurface seismic displacements will be recorded in a well known area, in the south of France. This is the Netherlands National Program for Engineered Barriers, in the Netherlands. Their synthetic results will be validated with records. They are the basis for the methodology which will be builded in order to be applicable to any site of interest. This is a several years program designed to assess methods to tackle seismic hazard for nuclear waste disposal, seen from seismologist point of view. First results from records analysis and numerical simulations will be shown.

**New Scenario Earthquake Hazard Maps for the San Francisco Bay Area**

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We have developed detailed seismic hazard maps for two major earthquake scenarios in the San Francisco Bay area. These maps incorporate the effects of source rupture directivity, crustal wave propagation and near-surface soil response, as well as the associated uncertainty. The maps will be useful to a broad audience of earthquake risk analysts to provide improved estimates of ground motion hazard for input to probable maximum loss analysis, structural designs and building codes, and urban disaster planning.

The maps present estimates of ground motion hazard for: a 474-km long M 7.9 on the four northern segments of the San Andreas (repest of 1906); and an 87-km long M 7.1 on the northern and southern segments of the Hayward fault. To generate rock motions, the approach combines the results of a numerical ground motion simulation model with attenuation relations. In the numerical simulation model, the earthquake rupture and crustal wave propagation are represented using a stochastic finite-fault simulation method with random vibration theory (RVT) to generate suites of response spectra for each scenario.

Four alternative attenuation models were used that are appropriate and commonly used to estimate ground motions in California. To accommodate the effects of near-surface amplification in soil (or soft rock), we developed frequency- and amplitude-dependent amplification factors. These factors take into account depth to bedrock (for alluvial sites), site type (based on near-surface geology), and nonlinear amplification effects at high strains. The amplification factors were applied to rock motions across a dense geographic grid, then averaged across models at several discrete spectral periods. The results were contoured to yield hazard maps for 5% damped response spectra at periods of 0 sec (i.e., PGA), 0.3 sec, and 1 sec, and at the median and 1-sigma levels.

**Incorporating Site Response into Earthquake Hazard Microzoning Maps**

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As part of a USGS-supported program to develop microzonation maps for the Portland, OR, and Salt Lake City, UT, metropolitan areas; the Albuquerque-Santa Fe, NM, corridor; and the Wasatch Front, UT, we have incorporated the site response of unconsolidated sediments and underlying rock to compute surficial ground motions. All four areas are located in alluvial basins and so site response effects are expected to be significant in future large earthquakes. Based on the available geologic data, we define site response categories based on surficial geological conditions and, when data on the available geologic data, we define site response categories based on surficial geological conditions and, when data is available, the total thicknesses of unconsolidated units above a specified reference rock datum. Each category is further subdivided to account for ranges of thicknesses, e.g., 10–50 ft., 50–100 ft., etc. Each site category is characterized by an average shear-wave velocity profile; based on this profile, 30 randomized profiles are computed to account for the horizontal and vertical variability in velocities and category thicknesses using a correlation model developed by G. Toro. Recently developed shear modulus reduction and damping curves (e.g., Silva et al., 1997) are assigned to the various surficial site categories to account for strain-dependent nonlinear soil response and uncertainties in nonlinear properties. Based on the site category profiles and degradation curves, amplification factors are calculated, using the stochastic numerical ground modeling approach coupled with an equivalent-linear methodology. Amplitude factors are for 5%-damped acceleration response spectra for each site category and are developed for expected rock outcrop peak accelerations. The point-source stochastic methodology is used to generate rock spectra for a controlling earthquake, which are then propagated up through the velocity profiles. The event is placed at several distances to produce expected outcropping rock peak accelerations of 0.05 to 1.25 g. In the Portland metropolitan area, unconsolidated units consisted of alluvial and flood deposits up to 500 ft. thick atop Columbia River basalt. Amplification factors ranged from 0.5 to 1.4 g for peak horizontal acceleration, and 0.6 to 2.2 g for 1.0 second spectral acceleration relative to Columbia River basalt. At high ground motions (> 0.5 g), nonlinear site response is significant.

**A Comparison of Methodologies to Achieve a Site-specific PSHA**

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The objective in developing site specific soil motions for engineering design is to produce seismic demands that reflect a desired hazard level or degree of conservatism that is uniform across structural frequency. An essential aspect of this process is the accommodation of appropriate degrees of uncertainty and variability in these assessment. The usual approach to developing site-specific soil motions involves defining regionally generic rock (or very firm conditions) outcrop motions and then performing site response analyses to accommodate the effects of local soils. In this approach the hazard level is usually set at the base of the soil column (in defining the control motions) and the actual hazard level of the resulting soil motions is generally poorly known. To provide conservatism, that is to ensure that the resulting soil motions are not likely to reflect a lower hazard level than the control motions at some frequencies, parametric site response analyses are performed to incorporate both uncertainty and variability in dynamic material properties as well as site response model deficiencies. The resulting suite of soil motions is then either smoothly enveloped or mean values estimated. Since the effects of site variability have been counted twice, once in developing the control (rock outcrop) motions and again in the parametric site response analyses, the resulting soil motions can reflect significantly higher hazard levels than desired as well as hazard levels that vary with