Understanding of Earthquake Risk Improving Dramatically in US

Major Advances Made In Quake Probabilities, Ground Motion

By Dr. Ken Campbell and Bill Keogh

The understanding of California earthquake risk by the scientific community, catastrophe modelers and the property and casualty insurance industry has improved dramatically since 2002, especially regarding earthquake probabilities and ground motion.

Although California receives the most attention regarding earthquake risk in the United States, seismic potential stretches across the continental US, from coast to coast and border to border. Beyond California, earthquakes are also a particular concern in the Pacific Northwest, where very large earthquakes on the Cascadia Subduction Zone threaten the cities of Portland and Seattle; and the Midwest, where large earthquakes in the New Madrid Seismic Zone threaten large commercial centers, including Cincinnati, Indianapolis, Little Rock, Memphis, Nashville and St. Louis.

As a catastrophe risk modeling firm for the global insurance and reinsurance industry, EQECAT incorporates the latest information on earthquake hazards into its models, to improve the understanding of potential earthquake loss of those in the earthquake risk markets.

Scientific Research Fostering Improved Hazard Data

Part of that information is the Uniform California Earthquake Rupture Forecast (UCERF) 2.0 model. This model is a joint research effort of the US Geological Survey (USGS), the California Geological Survey (CGS) and the Southern California Earthquake Center (SCEC) under the umbrella of the 2007 Working Group on Earthquake Probabilities, as explained by E.H. Field and others in the "*Bulletin of the Seismological Society of America*", published in August 2009 by the Seismological Society of America. The UCERF model specifies the locations of faults, the magnitude o the potential rupture and recurrence rates and the short-term, or time-dependent, probabilities that a large earthquake will occur on these faults.

Another key component of the current understanding of earthquakes is The Next Generation Attenuation of Ground Motions (NGA) Project, a study which began in 2003. It is a "multidisciplinary research program coordinated by the Lifelines Program of the Pacific Earthquake Engineering Research Center (PEER), in partnership with the U.S. Geological Survey and the Southern California Earthquake Center," as explained by Jonathan P. Stewart, Ralph J. Archuleta, and Maurice S. Power in "Earthquake Spectra", published in February 2008 by the Earthquake Engineering Research Institute.

The NGA models specify the amplitude of ground shaking at a given location based upon the magnitude of the earthquake, the distance from the fault, the local site conditions and other physical properties of the earthquake.

EQECAT model damage-estimates also include extensive field studies to understand how buildings and contents may be affected by various levels of ground motion intensity.

For the insurance industry, incorporating this data provides a better understanding of earthquakes and their potential impact on structures. This is critical to having a clear and current understanding of loss potential, which can be enormous.

For example, based upon the current EQECAT US Earthquake Model, an earthquake with a magnitude of 7.9 in the San Francisco area, similar to the 1906 quake, could result in total economic damage of more than $400 billion, with insured losses in excess of $50 billion. A hypothetical earthquake on the Puente Hills Blind Thrust fault beneath Los Angeles could be even more costly, exceeding $600 billion in total economic damage and more than $120 billion in insured losses.

Three Official Revisions Encapsulate Understanding of Earthquakes in California

There are three official updates that encapsulate the latest understanding of earthquake hazards:

- The 2008 USGS US earthquake hazard model which includes corrections and additions through 2009. It supersedes the model published in 2002.
- The UCERF 2.9 earthquake source model, published in 2009, which was a complete update of the time-independent and time-dependent earthquake probabilities in the UCERF 1.0 model. When issued, UCERF 1.0 was the first state-wide model for the application of time-dependent earthquake probabilities in California.
- The NGA model project, published in 2008, which culminated a five-year study of ground motion attenuation in the western US and similar tectonic regions throughout the world.

Each of these updates plays an important role in quantifying and managing US earthquake risk, and is part of a succession of refinements to the collective understanding of exposures. The USGS hazard model is a comprehensive model of earthquake source – magnitude, location, depth, and rupture mechanism – for the US. The UCERF model is California-centric, and, in addition to being the source data for the USGS hazard model, also provides an assessment of the conditional probability that an earthquake will occur on a fault given the time since the last earthquake rupture. These time-dependent short-term conditional probabilities can vary substantially from the time-independent long-term probabilities derived directly from the USGS model.

Finally, NGA relationships provide a better understanding of the potential ground motions occurring from an earthquake rupture. The description of these attenuation relationships has become more sophisticated due to the interaction between the various NGA development teams and the extensive monitoring of actual earthquake ground motions worldwide during the last decade.

EQECAT's US Earthquake Model Uses Soil As Starting Point

EQECAT's US Earthquake Model was released in 2006 and is consistent with the 2002 USGS hazard model, the UCERF 1.0 earthquake source model, and the "soil" versions of the "rock" attenuation relationships that were part of the 2002 USGS model.

While considering the scientific data on the effect of local site conditions on earthquake losses, EQECAT scientists and engineers determined that there is often more insurance exposure to ground motion on soil than on rock. Thus, rather than using rock as a starting point – the typical process for many, including the USGS – and adjusting the ground motions to soil, EQECAT decided to use soil as the starting point and adjust the ground motions to rock.

This significantly reduced the uncertainty of the ground motion estimates on soil and provided estimates that were more consistent with the NGA models. EQECAT incorporated this and other state-of-the-art concepts into its 2006 model so that its US Earthquake Model would be more up-to-date and more accurate.

Serving as a consultant to the California Earthquake Authority (CEA), the largest writer of personal lines earthquake insurance in the country, EQECAT is required to have its model implementation peer reviewed by scientists and engineers represented by organizations such as the USGS, the CGS and PEER.

As a result of this process and in preparing the 2006 model release, EQECAT set out to develop the first consistent state-wide time-dependent earthquake probability model for California. Previous working groups on California Earthquake Probabilities had independently developed such models for southern and northern California, but they had not yet developed a single contemporary state-wide model. EQECAT's time-dependent model was eventually adopted by the USGS and the CGS as a major component of the UCERF 1.0 model in 2007. As a result, EQECAT was the only earthquake catastrophe modeling firm to have the key aspects of UCERF 1.0 incorporated into its model.

In the 2006 release, EQECAT sought to address some of the known biases in the rock attenuation relationships identified in the 2002 USGS model. EQECAAT's chief seismologist, Dr. Ken Campbell, a lead author of one of the 2008 NGA models adopted by the USGS in 2008, was working in parallel to adopt key elements of the NGA technology in its 2006 release.

EQECAT proposed the use of interim ground-motion attenuation models that used a more reliable soil reference site condition. These interim attenuation models, while not precisely the new NGA models, were more representative of the ground motions observed from earthquake events than the models in the 2002 USGS hazard model. This interim approach was evaluated and accepted by the USGS and the CGS prior to adoption into EQECAT's 2006 model.

EQECAT is currently working on the integration into its 2010 model release of the UCERF 2.0 model update, final versions of the NGA attenuation relationships, updated attenuation relationships for the Central and Eastern US and an updated temporal earthquake clustering model for the New Madrid Fault Zone.

Some of these elements were already included in the 2006 EQECAT US Earthquake Model. As a result, EQECAT expects that changes to the hazard and loss from its 2010 release will be more modest than if it had not already implemented some of these components.

Going forward, EQECAT's engineering and scientific teams remain focused on advancing the understanding of earthquakes and keeping clients up-to-date so that they may efficiently and effectively manage their portfolios which may be affected by seismic hazards in the US and abroad.

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