CoreLogic®

CATASTROPHE RISK MANAGEMENT

U.S. Earthquake Catastrophic Risk Model

Offering the latest understanding of seismic science and engineering for the U.S.

A Comprehensive Analytic View of Risk

Earthquakes, by nature, have the potential to cause major loss and disruption to society. Damage caused by earthquakes can be catastrophic and can have both a human and financial impact. Earthquakes cause ground motion and displacement of the earth's surface, resulting in damage to the built environment, including buildings and their contents. This damage—and the time it takes to repair it—results in financial losses to earthquake risk managers. The U.S. Earthquake Model from CoreLogic® offers a solution to aid in managing the financial consequences of earthquake risk.

Earthquake losses can be very large and uncertain. Based on the latest scientific consensus of earthquake hazard, engineering, and building practices, the U.S. Earthquake Model helps set rational expectations of risk. This robust model offers a comprehensive analytical view to quantify the risk to a specific building or portfolio resulting in the allocation of appropriate pricing and capital reserves.

Comprehensive Earthquake Methodology

CoreLogic uses a bottom-up, physics-based approach to model earthquake losses, based on established principles of seismology, geology, geophysics, structural engineering, statistics and other related fields. The model first mathematically simulates the earthquake events, then, for each simulated earthquake, it calculates damage to each property, and finally it applies policy structures to estimate losses. These calculations are separated into the three general modules of hazard, vulnerability, and loss.

Seismotectonic Hazard Model

In July 2014, the U.S. Geological Survey (USGS) released the latest iteration of the National Seismic Hazard Mapping Project (NSHMP) hazard model[1] for the continental U.S. In parallel, the Working Group on California Earthquake Probabilities (WGCEP) released the Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3)[2]. These two datasets form the basis of the comprehensive seismic source model of the U.S. Earthquake Model.

For the seismotectonic model, each seismic source and its associated events are defined by:

- Location / depth / fault mechanism
- Geometry / fault area
- Magnitude-frequency relationship
- Minimum and maximum magnitudes

Key Benefits:

- One of the first models in the market to implement the 2014 USGS and UCERF3 hazard data
- Two recurrence frequency models: Time-Dependent and Time-Independent
- Explicitly models damage due to liquefaction and earthquake-induced landslide
- Includes sophisticated modeling of deep sedimentary basins in California and Washington
- Offers a competitive advantage with a current, accurate, relevant model
- Enables confidence in risk management based decisions
- Validated with a plethora of claims data from historical events

Two Frequency Models: Time-Dependent and Time-Independent

Modeled losses for earthquakes are significantly influenced by recurrence frequencies associated with large earthquakes in the stochastic event set. As a leader in the market, CoreLogic has implemented time-dependent recurrence frequencies when available since 1997, as they reflect the scientifically-accepted physical mechanism of stress build-up on faults caused by tectonic plate forces.

In regions such as California and the Pacific Northwest where large earthquakes are more frequent, time dependence represents not only the definitive scientific consensus, it also portrays risk within the foreseeable future, not just the theoretical long term. While time-dependent recurrence rates are the recommended view, CoreLogic also offers an alternate frequency model with a time-independent view.

Ground Motion Modeling

Ground motion intensity defines the hazard to a building, and this intensity changes as seismic waves travel outward from an earthquake rupture area. The U.S. Earthquake Model utilizes spectral acceleration as the hazard parameter to define ground motion intensity. An event footprint is calculated using ground motion prediction equations (GMPEs) and adjusted to local site conditions using site amplification and sedimentary basin response factors; and a site deformation model, which calculates the probability of deformation of the earth's surface due to liquefaction and earthquake-induced landslide.

As based on the 2014 NSHMP hazard model, multiple GMPEs are used to capture epistemic uncertainty with firm-rock as a reference site condition. Multiple, weighted GMPEs are implemented for each of the following tectonic domains:

- California and Western U.S.: Active Shallow Crust
- Cascadia Subduction Zone: Subduction Interface
- Pacific Northwest: Subduction Intraslab
- Central and Eastern U.S.: Stable Continental Crust

SEDIMENTARY BASIN RESPONSE

As ground motion modeling has evolved, several GMPEs have included a sedimentary basin response term. This term is in addition to the standard shallow site factors that have typically been used to incorporate site effects and is used to capture additional three-dimensional wave-propagation effects. With the maturity of the available basin-depth models, the U.S. Earthquake Model incorporates basin response in its ground motion model for California and western Washington to account for their unique wave propagation effects.

LIQUEFACTION AND LANDSLIDE HAZARD

The catastrophic sequence of earthquakes in the Canterbury region of New Zealand in 2010-2011 demonstrated the potential major impact of soil liquefaction in an earthquake. Although regions that are subject to major liquefaction potential are relatively rare, they can inordinately contribute to earthquake losses. Earthquake-triggered landslides can also have a large impact on losses if they occur in a heavily urbanized area. Based on the potential impact in the U.S., the U.S. Earthquake Model includes both liquefaction and landslide hazard in the calculation of earthquake losses.

Vulnerability Informed by Engineering

The U.S. Earthquake Model incorporates vulnerability curves that are well-honed from thousands of seismic studies conducted by CoreLogic and its affiliated engineers over the past 40 years, and are additionally founded on first-hand observations from more than 90 earthquakes worldwide. Vulnerability is also calibrated to tens of thousands of claims and exposure data points from the Northridge (1994) and Loma Prieta (1989) events.

Multiple-Parameter Wood-Frame Residential Vulnerability

For residential structures, CoreLogic represents vulnerability using a three-dimensional surface to capture the phenomenon of damage acceleration—the more damage that occurs during a given earthquake, the more damageable a building becomes. By estimating damage from multiple input parameters rather than a spectral acceleration at a single structural period, the model more accurately reflects the reality evidenced by data from thousands of claims.

Informed Defaults for Foundations

For wood-framed houses, the most significant susceptibility driving earthquake damage is the foundation type, and particularly its connection to the structure above. For California, where the majority of U.S. earthquake risk is located, CoreLogic incorporates ZIP Code-level default values for foundation type, based on data made available in aggregate form by the California Earthquake Authority (CEA), for whom the U.S. Earthquake Model from CoreLogic is the selected model.

Comprehensive Vulnerability Modeling

CoreLogic uses an engineering approach, claims data, and expert opinion to develop the vulnerability functions within the model. Damage from earthquake ground shaking is calculated using a series of vulnerability functions specific to construction type and occupancy. Vulnerability functions are created to calculate damage impacts for different building heights (low, mid, and high-rise), and are based on historically observed damage, experimental research, and structural calculations performed by CoreLogic engineers.

Full Suite of Structure Types and Occupancies

With a full suite of representative structure types and occupancy categories for each line of business, the model differentiates risk across hundreds of combinations, and allows only realistic pairings of occupancy and construction. A common set of structure types and occupancies is available worldwide and aligned with that of the U.S. Inland Flood Model.

Perils Covered

In addition to calculating losses from ground shaking (including damage due to liquefaction and earthquake-induced landslide), the U.S. Earthquake model covers associated perils, which can either be included or excluded from analysis. Results for each peril are reported separately.

- **Fire Following Earthquake:** Conflagration—widespread, uncontrollable fire that is initiated by an earthquake—can be the primary agent of damage. The model incorporates a ground-up methodology to model the physical mechanism of conflagration, ignition, spread, and suppression.
- **Sprinkler Leakage:** Water damage to contents from sprinkler leakage can exceed shaking contents damage. The model accounts specifically for the resulting sprinkler leakage losses.
- **Workers Compensation:** The six sub-perils for Workers' Compensation can be specified. These include Death, Major (Injury), Medical Only, Minor (Injury), Permanent Total (Disability) and Temporary (Disability). Losses are calculated based on claims data by state by sub-peril split between medical and indemnity components.

Global Catastrophe Modeling Platform

Available through a suite of catastrophic risk management products from CoreLogic, the U.S. Earthquake Model is included in the global multi-peril catastrophe modeling platform, Risk Quantification & Engineering (RQE®). RQE is a statistically robust simulation platform delivering high confidence outputs. As one of the most comprehensive full simulation Catastrophe Modeling solutions in the market, CoreLogic offers a wide range of analytics outputs allowing for the accurate assessment of catastrophe exposure, both gross and net of reinsurance contracts that can used to inform underwriting decisions, pricing, diversification, portfolio accumulations and capital requirements.

Why Consider CoreLogic?

Increasing catastrophic events are challenging the P&C insurance industry to revisit existing catastrophic risk management and loss adjustment strategies by improving the overall understanding of all natural hazards. CoreLogic is dedicated to the science of understanding natural hazard risk and focused on delivering decision support data and products to the insurance industry. With a staff of Ph.D.-level scientists and engineers, we have taken risk assessment a step further by developing a proprietary methodology that enables a more granular level of risk management control and reporting. Catastrophe Risk Management from CoreLogic offers a comprehensive look at risk by evaluating probable events, and verifying current and post event impacts.

1 Field, E. H., G. P. Biasi, P. Bird, T. E. Dawson, K. R. Felzer, D. D. Jackson, K. M. Johnson, T. H. Jordan, C. Madden, A. J. Michael, K. R. Milner, M. T. Page, T. Parsons, P. M. Powers, B. E. Shaw, W. R. Thatcher, R. J. Weldon II, and Y. Zeng (Working Group on California Earthquake Probabilities) (2013). Uniform California earthquake rupture forecast, version 3 (UCERF3)—The time-independent model, *U.S. Geological Survey Open-File Report 2013–1165, California Geological Survey Special Report 228, and Southern California Earthquake Center Publication 1792*.

2 Petersen, M. D., M. P. Moschetti, P. M. Powers, C. S. Mueller, K. M. Haller, A. D. Frankel, Y. Zeng, S. Rezaeian, S. C. Harmsen, O. S. Boyd, E. F. Field, R. Chen, K. S. Rukstales, N. Luco, R. L. Wheeler, R. A. Williams, and A. H. Olsen (2014). Documentation for the 2014 update of the United States national seismic hazard maps, *U.S. Geological Survey Open-File Report 2014-1091*.

FOR MORE INFORMATION, PLEASE CALL 866-774-3282
OR EMAIL US AT hazardrisk@corelogic.com

1-USECRM-0516-01

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