CATASTROPHE
RISK
MANAGEMENT

Japan Earthquake and Tsunami Model

Region specific innovations in both hazard and vulnerability

The Japan Earthquake and Tsunami model from CoreLogic® embodies state-of-the-art earthquake and tsunami risk modeling in Japan. Incorporated into the CoreLogic Catastrophe Risk Management suite—the global multi-peril platform RQE® (Risk Quantification & Engineering)—the Japan Earthquake and Tsunami model comprises a post-Tōhoku-oki view of hazard and engineering research from Japanese government agencies, lessons learned from the 2011 Great East Japan (Tōhoku-oki) Earthquake, and also introduces a new tsunami model to fully capture the unique and complex seismic risk in Japan.

Earthquake and Tsunami Risk in Japan

Historically, Japan has experienced some of the largest earthquake and tsunami events ever recorded, including the 2011 M9 Tōhoku-oki event. The Tōhoku-oki earthquake was the fourth-largest and most costly earthquake event ever recorded, with estimated economic losses of $210 billion (2011 USD)[1]. Although Japan's population has a high degree of awareness and preparedness for earthquake risk, large earthquakes and their resulting perils represent a grave risk to life, economy, insurers and insureds.

Key Features

REGION-SPECIFIC HAZARD DEFINITION

CoreLogic® honors the long tradition of Japanese earthquake science by adhering to customary region-specific use of hazard parameters. The CoreLogic model adopts a view of hazard based on the December 2013 report released by the Earthquake Research Committee—Headquarters for Earthquake Research and Promotion (ERC-HERP) as implemented by the National Research Institute for Earth Science and Disaster Prevention (NIED) in the Japanese National Seismic Hazard Maps. New views of hazard including new seismic source zonation with earthquake ruptures cascading over multiple segments, updated maximum upper-bound magnitudes, and revised ground motion attenuation relationships with an improved nonlinear soil amplification model with a countrywide resolution of 250 meters.

TIME-DEPENDENT RECURRENCE RATES

Time-dependent probabilities used for main inland fault sources and subduction zone sources of potential earthquake rupture scenarios represent definitive scientific consensus while portraying risk in the foreseeable future, not just the theoretical "long-term." CoreLogic has used time-dependent recurrence frequencies since 1997, as they reflect the scientifically-accepted physical mechanism of frictional stress build-up and release at the tectonic plate or geologic fault interface. Deep within the earth, where rock is ductile, fault surfaces are aseismic and glide smoothly relative to one another, but at the surface, rocks are solid and in frictional contact across a fault surface, thus "locking" the fault. An earthquake occurs when strain from continuous plate motion at depth overcomes frictional resistance of the interlocked surface. An earthquake is more likely to occur on a fault that is late in its seismic cycle, relative to the average time between large earthquakes, and is less likely to occur on a fault where an earthquake has occurred in more recent time.

[1] The World Bank: The Great East Japan Earthquake: Learning from Megadisasters, 2014.

VULNERABILITY FUNCTIONS BASED ON THE LATEST DATA AND INSIGHTS

The Japan Earthquake and Tsunami model utilizes a full suite of vulnerability functions characterized in terms of peak ground velocity (PGV), including those developed uniquely for structures with seismic protection systems and region-specific construction practices such as the use of steel columns embedded in concrete, known as Steel Reinforced Concrete (SRC). The CoreLogic model offers updates to performance based effects of deep foundations and seismic base isolation, informed by damage and loss data from the Tōhoku-oki earthquake. Vulnerability insight is well-honed from hundreds of seismic studies conductedover the last 30 years, as well as first-hand observations of 90 earthquakes worldwide, including nine in Japan. Vulnerability is also calibrated to claims from the Tōhoku-oki (2011), Kobe (1995), Tottori (2000), and Geiyo (2001) events.

PERILS COVERED

In addition to calculating losses from ground shaking, the model covers these associated perils:

- **Tsunami:** Fully probabilistic and scenario tsunami model with 24,000 events directly linked to the earthquake stochastic event set covering all tsunamigenic earthquake sources local to Japan.
- **Fire Following Earthquake:** Conflagration—widespread, uncontrollable fi re that is initiated by an earthquake—can be the primary agent of damage. Each contributor to conflagration (ignition, spread, and suppression) is modeled as a physical mechanism.
- **Sprinkler Leakage:** Water damage to contents from sprinkler leakage can exceed shaking contents damage. The model explicitly accounts for the resulting sprinkler leakage losses. These associated perils can be included or excluded from analyses. Results for each peril are reported separately. Ground failure hazards, when their potential is known, can be modelled using secondary modifiers.

INTRODUCING THE NEW TSUNAMI SUB-PERIL

This new, fully probabilistic and scenario earthquake tsunami flooding model is included as a sub-peril in the Japan Earthquake Model. Tsunami heights are computed using the Cornell University Multi-grid Coupled Tsunami Model (COMCOT), a state-of-the-art numerical model for all subduction interface and offshore crustal events of moment magnitude (Mw) ≥7.0, including Nankai Trough, Sagami Trough, Japan Trench, Chishima / Kuril Trench events, Izu-Bonin Trench events (many of which cause tsunami damage, but not shake damage due to the great distance from shore), Sea of Japan events, and relevant stochastic, historical, and scenario events. The tsunami hazard is computed on a 30-meter digital elevation map and incorporates the impacts of tides and flood defenses.

RATIONAL APPROACH TO UNCERTAINTY

The CoreLogic approach to uncertainty conforms to scientific consensus for time-dependent frequencies of large earthquakes on the Nankai Trough subduction zone. This approach differs from NIED's use of smaller sigma values, and implies lower confidence in estimates of earthquake recurrence intervals and consequent lower probabilities for large subduction earthquakes impacting the Nunki Trough region, the east coast of southern Honshu, than NIED suggests. The maximum magnitude associated with a given seismic source is also highly uncertain, and therefore accounted for using a Gaussian distribution of magnitudes for the largest events in Japan.

Model Specifications

IMPORT RESOLUTION

Exposure data is accepted and geocoded at resolutions of latitude/ longitude, postal code, district or city, and prefecture levels. When input data is provided at aggregate levels, the model adds refinement to loss results by disaggregating exposure to a resolution consistent with the hazard generation. The disaggregation scheme is weighted by population distribution.

HAZARD ANALYSIS RESOLUTION

Ground motion hazard is differentiable at a uniform resolution of 250 meters, representing the level of detail for soil type information. Tsunami hazard is differentiable at a resolution of 30 meters throughout the affected coastal areas.

GEOGRAPHIC COVERAGE

All 47 prefectures of Japan are covered.

LINES OF BUSINESS

Lines of business include residential, commercial, industrial, kyosai, and personal accident.

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.

SECONDARY STRUCTURE MODIFIERS

Risk can be differentiated by detailed structural characteristics, including seismic base isolation, various foundation types, and configurations of walls, roof, and connections, as captured by secondary structure modifiers.

MODEL OUTPUT

Risk metrics include OEP and AEP loss exceedance curves, AAL, TVAR, and simulations of historical and scenario events. In addition, RQE's Year Loss Table (YLT) uniquely features three-dimensional output: simulation year, events, and sample outcomes. Instead of reporting mean losses with standard deviations, each loss in the YLT represents one possible outcome for the associated event. This allows users to retain the full distribution of uncertainty when using model output in dynamic financial analysis and capital modeling. Conventional event loss results and other risk metrics can be derived from the YLT with arithmetic or simple database queries. YLT and event loss results are supported at the portfolio level. Other risk metrics are supported at multiple levels of refinement: from total aggregate portfolio results, to detailed output by policy and site. Hazard metrics are also available at site level.

COVERAGE TYPES

The model calculates damage to structures (building damage), contents, and time element (business interruption and additional living expenses). Separate vulnerability functions are used for building and contents damage. Time-element vulnerability is a function of both structural and contents damage.

FINANCIAL MODELING

Insurance policy structures and reinsurance treaty types are modelled. All payout rules used in the Japanese earthquake insurance market, including a variety of step policy types, are modelled. Payout rules for Zenkyoren type policies are also included in the model.

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

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