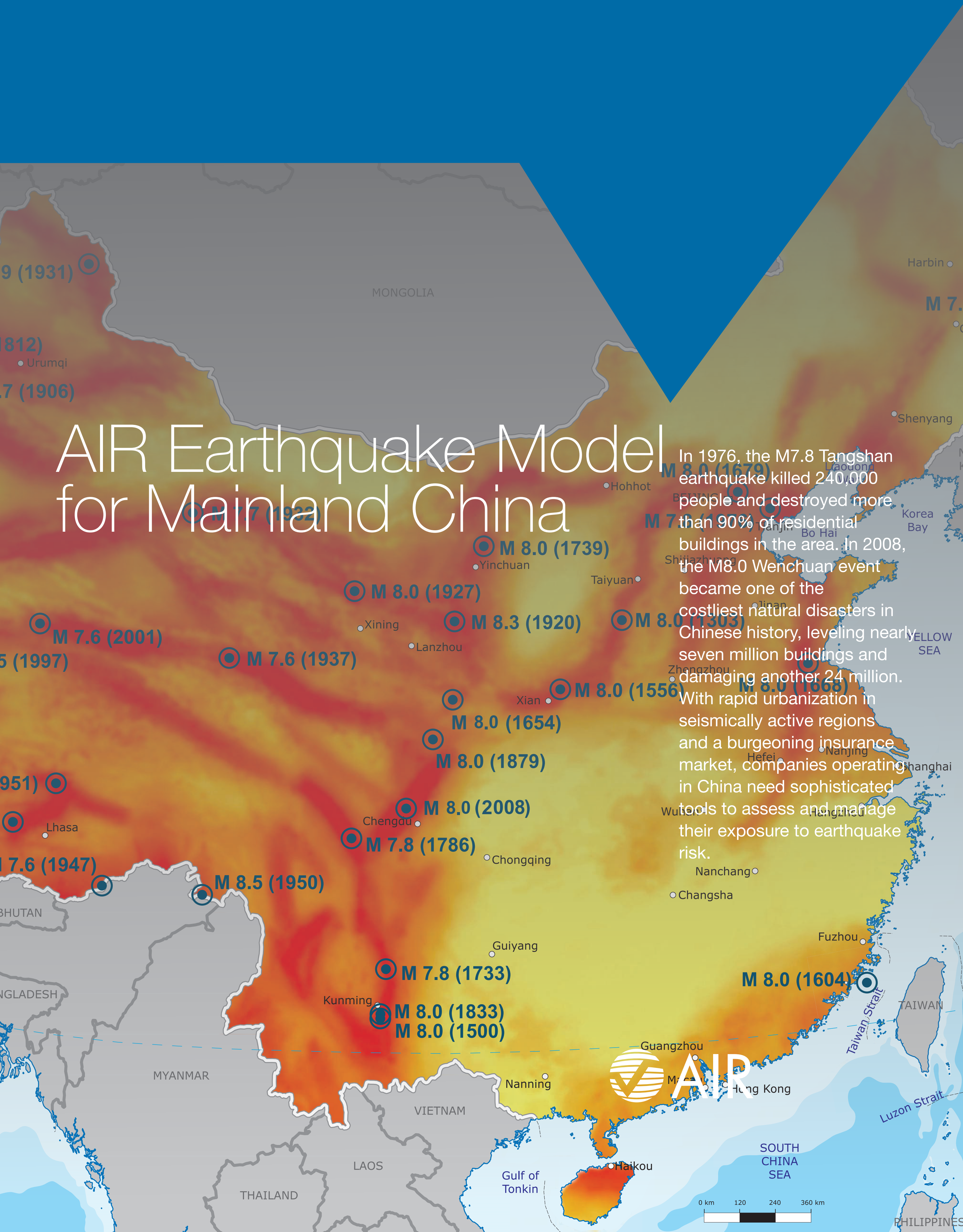
AIR Earthquake Model for Mainland China

In 1976, the M7.8 Tangshan earthquake killed 240,000 people and destroyed more than 90% of residential buildings in the area. In 2008, the M8.0 Wenchuan event became one of the costliest natural disasters in Chinese history, leveling nearly seven million buildings and damaging another 24 million. With rapid urbanization in seismically active regions and a burgeoning insurance market, companies operating in China need sophisticated tools to assess and manage their exposure to earthquake risk.



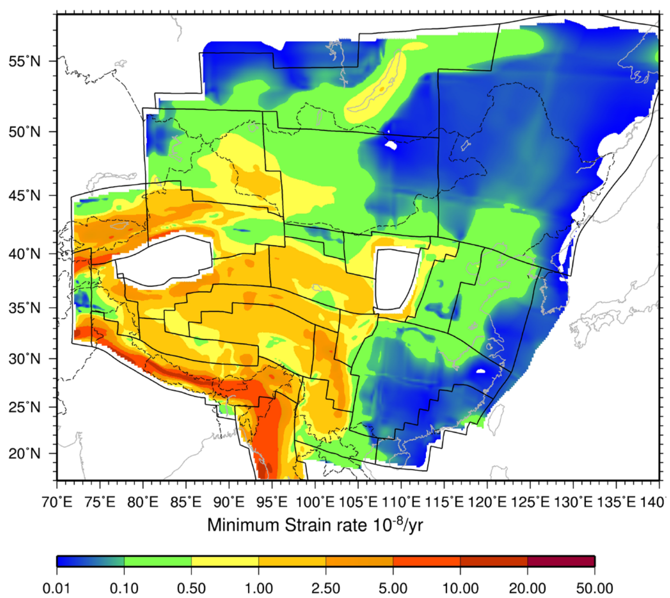
AIR

Collaborating with Chinese Scientists to Produce the Most Realistic Estimate of Hazard

The AIR Earthquake Model for Mainland China draws on the country's long historical catalog, which includes written records of earthquakes dating back to 780 B.C. Even so, historical data alone are not sufficient to provide an accurate representation of the long-term seismic hazard in China, particularly since some high-risk areas have not experienced significant earthquakes in recent history.

Before the 2008 Wenchuan earthquake occurred, for example, the Longmen Shan fault zone that produced the temblor had not generated an earthquake exceeding M7.0 during the last 500 years. Because of this relative absence of activity, some scientists had argued that this fault was no longer active.

Through close collaboration with seismologists at the China Earthquake Administration's Institute of Geology (IGCEA), AIR scientists increased their understanding of the complete seismic cycle of all active and potentially hazardous faults in the region.



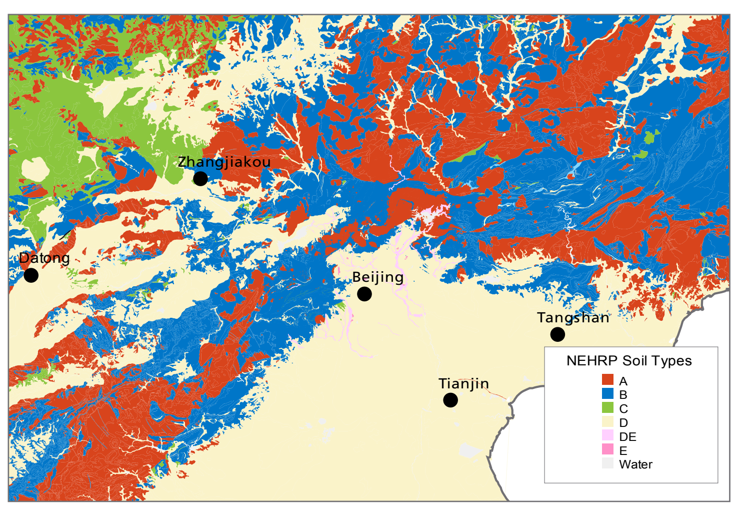
The AIR model divides China into 26 seismic regions and more than 300 source zones; GPS data are used to determine regional strain rates.

The AIR model incorporates the results of paleoseismological research, in combination with historical seismicity, fault slip rates, and data from China's extensive GPS network, to determine a regional strain rate field that provides information not only on the rates and patterns of deformation, but also on the style of faulting. Using this data, AIR seismologists implemented a probabilistic approach to modeling earthquake risk, in which the Longmen Shan fault figured prominently—before the 2008 earthquake occurred.

Twenty-six seismic regions are defined to capture seismic activity across China. These regions, along with more than 300 source zones enclosing known active faults and gridded background seismicity, form the basis of the model's comprehensive catalog of simulated events—which contains over 580,000 events to provide seamless and comprehensive coverage for managing earthquake risk across mainland China.

High-Resolution Ground Motion Modeling Captures Site-to-Site Variation

To determine the intensity of ground shaking, the AIR Earthquake Model for Mainland China employs ground motion prediction equations that are appropriate to China's varied regional characteristics. The modeled ground motion is then modified to reflect local soils, which can dramatically alter the intensity and frequency content of ground shaking at a site. AIR employs detailed geological and soil maps published by the Geological Survey of China and provincial Bureaus of Geology and Mineral Resources, with resolutions as fine as 0.5 km for select major metropolitan areas.



High-resolution soil maps are essential for reliable earthquake hazard assessment. The AIR model employs the most detailed soil data available, with resolutions of up to 0.5 km in key urban areas.

Unique Damage Functions for Buildings Under Construction

China continues to grow at a rapid pace, leading to a construction boom across the country. As a result, the construction all risks/erection all risks (CAR/EAR) line of business comprises a higher portion of insurance business in China than in many other regions. Drawing on China-specific construction data, equipment costs, building code requirements, and project timelines, AIR engineers have developed damage functions that incorporate the variability over time in both the vulnerability and the replacement cost of buildings under construction, including five separate construction phases from project inception to project completion.

The AIR model considers both building and contents damage of various construction types under construction to estimate potential losses over the course of a project. Clients can use Touchstone®, to assess catastrophe risk for buildings under construction, whether for individual buildings, policies comprising multiple locations, or whole portfolios of properties.

The AIR model captures the time-dependence of replacement costs and vulnerability of buildings under construction.

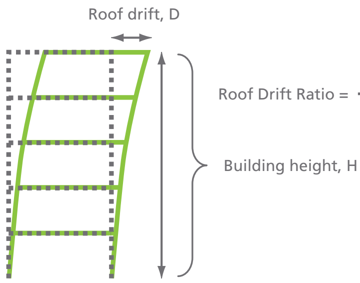
An Objective, Engineering-Based Approach to Assessing Building Vulnerability in China

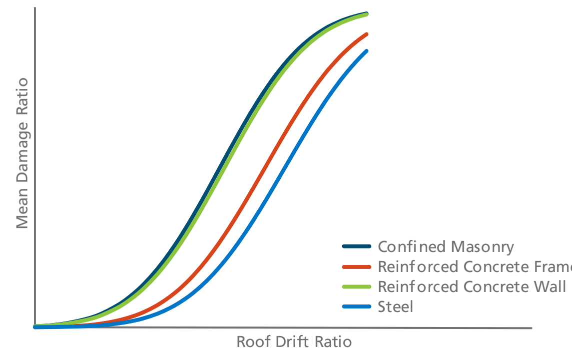
The scope and complexity of building damage is influenced by a building's dynamic response to ground motion, which varies depending on the ground motion characteristics, the local site conditions, and the building's attributes. The highly variable performance of buildings was demonstrated during the 2008 Wenchuan earthquake when some buildings—on similar soils and equal distance from the rupture—remained virtually intact, while others were heavily damaged. The AIR Earthquake Model for Mainland China captures this variability—or uncertainty—in damage.

China's insured building stock in urban areas is dominated by mid-rise confined masonry and mid- to high-rise reinforced concrete buildings, which, if constructed in compliance with the building code, are expected to perform adequately for moderate earthquakes. However, in many small towns across China, the majority of the building stock is made up of older unreinforced masonry (URM) structures, which are highly vulnerable to ground motion.

Leveraging the results of detailed engineering analysis of region-specific construction practices and building design, published research, and damage observation data from the China Earthquake Administration (CEA), AIR engineers have developed more than 200 separate damage functions for a wide variety of construction types, structural systems, and occupancy classes.

Roof drift ratio, which describes overall building deformation, is used as the measure of building damage and is calculated using the capacity spectrum method for different construction types and ground motions.





Applying Region-Specific Policy Conditions for the Most Accurate Risk Estimates

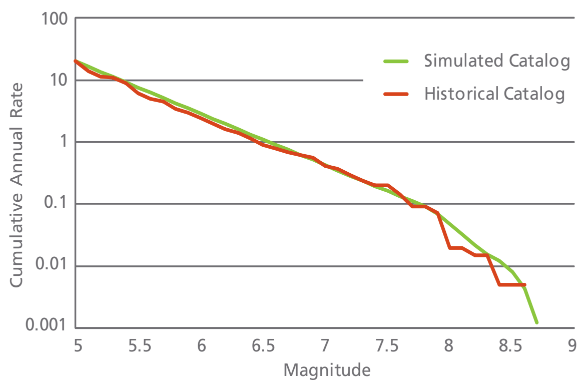
China's property insurance industry is one of the fastest growing in the world. The AIR model enables insurers and reinsurers to estimate losses for policies that contain complex terms and conditions. Users have the ability to set limits by coverage for location limits and deductibles, policy limits and deductibles, and facultative (assumed and ceded) and treaty reinsurances. In addition, policies that use the maximum of the site deductible or the percent-of-loss deductible, a common commercial policy condition used in the Chinese insurance market, are explicitly modeled in Touchstone. The AIR Earthquake Model for China is also available in AIR's CATRADER®, the industry standard for analyzing reinsurance contracts and insurance-linked securities.

A Comprehensive Approach to Model Validation

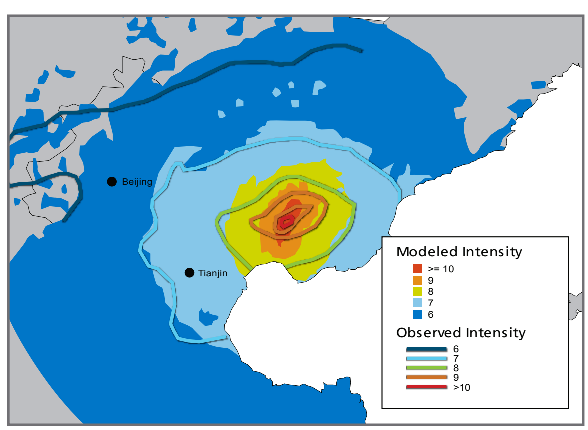
Model validation extends far beyond a simple comparison between modeled losses and reported losses. Each model component is validated against actual data from historical events. For example, the model's stochastic catalog is validated against historical frequency–magnitude distributions. AIR validates the model's hazard component by comparing modeled ground motion with actual instrumental recordings made during earthquakes.

Modeled damage footprints are validated against actual observations either from published reports or from AIR post-disaster surveys, including the extensive survey undertaken after the 2008 Wenchuan earthquake.

Losses from the AIR Earthquake Model for Mainland China have been validated through extensive analysis of both detailed claims data for recent earthquakes and aggregated data as reported by the insurance industry for several historical earthquakes, including the 1976 Tangshan earthquake and the 1996 Lijiang and Neimeng earthquakes.



AIR validates every component of the model. Here, modeled ground motion for the 1976 Tangshan earthquake matches well with the observed.

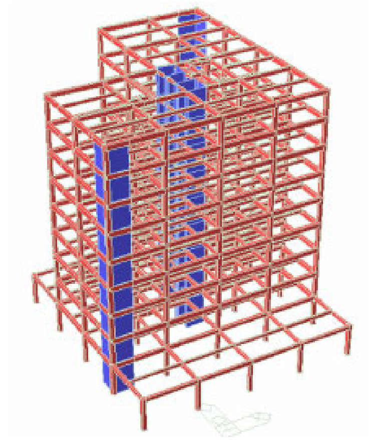


Validation of modeled intensities for the 1976 Tangshan Earthquake

Collaborating with the Leading Authority on Design and Construction Practices in China

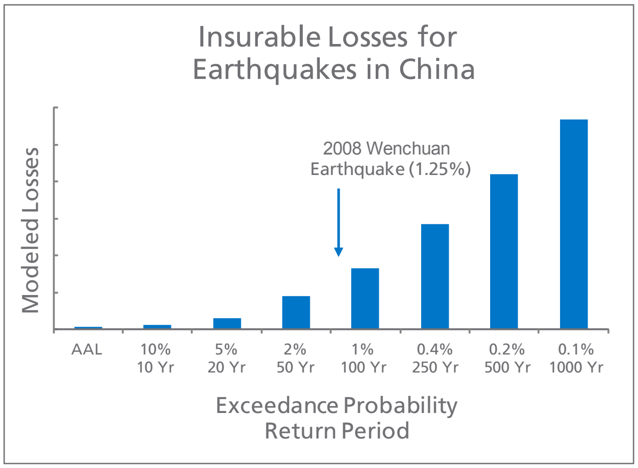
AIR has forged a partnership with the Beijing Institute of Architectural Design (BIAD), the premier architectural design and consulting institute in China. To enhance the understanding of regional variations in building design and construction practice and their impact on building vulnerability, the BIAD undertook a series of seismic performance studies on behalf of AIR.

AIR's collaborative research with the BIAD provides a wealth of information that serves both to increase the industry's understanding of China's earthquake risk and to inform the AIR model.



AIR partners with the Beijing Institute of Architectural Design (BIAD) to study seismic performance in China.

Model Performance in Real-Time



AIR estimates that the exceedance probability of a loss the size of the Wenchuan earthquake is approximately 1.25% (or a 75-year return period).

On May 13, 2008, hours after the devastating Wenchuan earthquake, AIR seismologists were running simulations of the event using the available information on epicentral location, depth, magnitude, and direction of rupture. Within 24 hours, AIR issued estimates of industry losses and was assisting clients in assessing losses to their own portfolios.

Model results generated in real time indicated that total property loss, excluding damage to infrastructure, would be in the range of RMB 109-328 billion (USD 16-48 billion). Several months later, the National Wenchuan Earthquake Expert Committee (NWEEC) reported a comparable ground-up property damage of around RMB 362 billion (USD 53 billion) for Sichuan Province, which is close to AIR's upper estimate. The difference can be attributed to a few factors, most notably the fact that fully a third of the NWECC's RMB 362 billion resulted from secondary, non-modeled hazards, such as landslides.

AIR's loss estimates issued in the immediate aftermath of the event provided much needed information about loss potential in the absence of any substantive information about what was happening on the ground. Weeks after the earthquake, AIR dispatched teams of engineers to Sichuan Province to survey the damage. Observations bore out the model's results.

Model at a Glance

Supported Geographic Resolution	CATRADER: County, Province, CRESTA Touchstone: Province, county, and postcode resolution, plus user-provided latitude and longitude
Stochastic Catalog	Contains 10,000 simulated years with more than 580,000 events
Vulnerability Module	219 unique construction types and occupancy classes, including General Residential, Temporary Lodging, Apartment/Condo, and Construction All Risks/Erection All Risks (CAR/EAR); accounts for the impact of height and year of construction on building vulnerability
Model Validation	Validated using loss experience data for the Tangshan (1976), Xingtai (1966), Lijang (1996), and Neimeng (1996) earthquakes and damage survey data from the Wenchuan (2008) earthquake

Model Highlights

— Informed by AIR's research collaborations with the China Earthquake Administration, the Beijing Institute of Architectural Design, and other leading institutions and scientists in China

— Draws on more than 2,000 years of historical earthquake activity, extensive paleoseismic research, and GPS data to identify regional strain rates

— With a stochastic catalog of more than 580,000 simulated temblors, considers a full range of potential events and their financial costs

— High-resolution soil and geological maps from the China Geological Survey are used to determine the ground motion at each affected site

— Damage functions for the CAR/EAR line of business capture the variability over time in the vulnerability and replacement cost of buildings under construction

— Features a disaggregation tool in Touchstone that enables clients with aggregate (province-level) exposure data to leverage AIR's industry exposure database to disaggregate the exposure data in their own portfolio to a higher resolution

— Incorporates an engineering-based capacity spectrum approach to differentiate the responses of various building classes to different ground motion intensities

ABOUT AIR WORLDWIDE

AIR Worldwide (AIR) provides risk modeling solutions that make individuals, businesses, and society more resilient to extreme events. In 1987, AIR Worldwide founded the catastrophe modeling industry and today models the risk from natural catastrophes, terrorism, pandemics, casualty catastrophes, and cyber attacks, globally. Insurance, reinsurance, financial, corporate, and government clients rely on AIR's advanced science, software, and consulting services for catastrophe risk management, insurance-linked securities, site-specific engineering analyses, and agricultural risk management. AIR Worldwide, a Verisk (Nasdaq:VRSK) business, is headquartered in Boston with additional offices in North America, Europe, and Asia. For more information, please visit www.air-worldwide.com.

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