CATASTROPHE MODELING AND CALIFORNIA EARTHQUAKE RISK: A 20-YEAR PERSPECTIVE

RMS Special Report

EXECUTIVE SUMMARY

The year 2009 marks the 20th anniversary of the release of Risk Management Solution's first catastrophe model, which estimated losses from major earthquakes in California. Since 1989, the RMS® U.S. Earthquake Model has set the standard for analyzing earthquake risk in the United States. The year 2009 also marks the 20th anniversary of the last major earthquake to strike the San Francisco Bay Area, the historic Loma Prieta Earthquake, which occurred on October 17, 1989. In commemoration of these anniversaries, this report explores the first generation of catastrophe models, as well as the advances in the art and science of catastrophe modeling since the industry's inception. The report concludes with an examination of the current earthquake risk in the San Francisco Bay Area and considers the role of the California Earthquake Authority (CEA) in the recovery from a major event, as well as the implications of default rates in the California residential real estate market on overall impacts from a major event.

THE EVOLUTION OF EARTHQUAKE RISK MODELING

The first generation of catastrophe models built exclusively for the insurance industry emerged in the late 1980s. These models represent the decades-long culmination of research on the science of natural hazards, the response of structures to ground motion, and the quantitative measurement of risk—in essence, the synthesis of multidisciplinary efforts from scientific researchers, structural engineers, actuaries, and other financial statisticians.[1] For earthquake hazard, much of this research was centered on earthquake risk in the United States, although researchers across the globe contributed to the birth of the catastrophe modeling industry.

Early 20th Century Developments

A key ingredient in catastrophe modeling is the use of a standard set of metrics that measure the size of a natural hazard—an earthquake's magnitude or a hurricane's intensity, for example. Only with these quantitative measurements of hazard can the risk be assessed and managed. And in the first part of the 20th century, scientific measures of natural hazards advanced rapidly with the occurrence of damaging earthquakes—the 1906 San Francisco Earthquake, the 1908 Messina Earthquake, and the 1923 Great Kanto Earthquake—to name a few.

The 1906 San Francisco Earthquake marked a new era in the awareness of California earthquake risk with the establishment of the State Earthquake Investigation Commission. The commission, led by Professor Andrew C. Lawson of the University of California, Berkeley, published a report in 1908 (commonly referred to as the Lawson Report) which was the first reconnaissance report of a U.S. earthquake (Lawson, 1908). The report—with photographs, detailed maps, and survey data—summarized over 20 scientists' investigations into the earthquake's damage (Figure 1), and provided new insight into the geology of Northern California and the movement of the San Andreas Fault. It served as a benchmark for later reports written following other California earthquakes over the years.

Figure 1: Damage at Stanford University following the 1906 San Francisco Earthquake (Source: Lawson, 1908)

Another early 20th century development critical to the development of earthquake risk models was the John R. Freeman publication on earthquake damage and earthquake insurance (Freeman, 1932), which is acknowledged as being a groundbreaking volume, containing all available knowledge on earthquakes at the time. In this publication, Freeman, an insurance executive concerned about earthquake preparedness, outlined the concepts of risk allocation, risk concentration, and average annual loss (AAL).

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[1] For more information on the evolution of earthquake risk modeling, see Grossi et al., 2008.

The Formative Years: 1968 through 1988

While concepts of earthquake insurance risk were developed in the early 1930s, insurance risk models were not introduced until the 1960s. In 1968, C. Allin Cornell, who is acknowledged as the father of modern seismic risk analysis, published his definitive work on probabilistic seismic hazard analysis (PSHA) in the Bulletin of the Seismological Society of America (Cornell, 1968). The basic structure of his PSHA approach is utilized in modern-day catastrophe models.

Through the 1970s and early 1980s, studies theorizing on the source and frequency of catastrophic events were published, along with approaches to gathering loss information following a disaster (Algermissen et al., 1978), as well as examples of the impacts of historical events on existing property exposure at risk (e.g., Friedman, 1972). These developments led U.S. researchers to compile hazard and loss studies, estimating the impact of earthquakes and other natural disasters. One notable compilation on earthquake-related losses was Karl V. Steinbrugge's anthology of losses from earthquakes, volcanoes, and tsunamis (Steinbrugge, 1982). Within this volume, damage ratios as a function of Modified Mercalli Intensity (MMI) are presented, along with the concept of probable maximum loss (PML) and a zoning map of California for earthquake underwriting purposes.

Finally, in the mid to late 1980s, new methods for alternative risk transfer were explored and insurance claims data was used to develop damage curves (e.g., Friedman, 1987). In addition, the Applied Technology Council (ATC) published the Earthquake Damage Evaluation Data for California report (ATC-13, 1985), in which over 70 earthquake engineering experts were asked to indicate their low, best, and high estimates of damage ratios for close to 80 types of structures subject to earthquakes with MMI levels of VI through XII. Catastrophe model developers used these estimates in their earliest versions of earthquake loss software.

An Innovative Assessment of Risk

Although an actuarial approach to managing risk can be used for pricing some types of insurance, such as automobile or health insurance, such an approach cannot be accurately applied to low probability, high consequence events like earthquakes. A modeling approach is needed. In 1989, RMS released its first generation catastrophe model for earthquake risk, the Insurance and Investment Risk Assessment System (IRAS). Prior to IRAS, research relating to insured catastrophe loss had been fragmented among different disciplines. The new earthquake model represented an innovative step forward in insurance risk assessment, weaving together earthquake science, structural engineering, and actuarial science into a comprehensive system that linked these individual disciplines into an integrated framework. Through IRAS, the translation of property damage to dollar loss was accomplished, filling a need of the insurance industry.

Since the release of IRAS, catastrophe modeling has evolved, not only keeping pace with technological advances, but taking strides forward based on the events experienced over the past 20 years. With each natural disaster, lessons are learned and observations are made that allow modelers to advance to the next generation in catastrophe modeling. For example, in August of 1992—with the modeling industry in its infancy—Hurricane Andrew came ashore and set records for storm surge levels for the southeast Florida peninsula. With an estimated $23 billion in damage at the time (of which $15.5 billion was insured), it was then the most expensive natural disaster in U.S. history.

Over 65% of homeowners in Florida filed claims following Hurricane Andrew. Insurance rates in South Florida increased by 300%, while the rest of the state saw rates increase by 100%. Following Hurricane Andrew, over $4 billion in capital was invested in 12 new reinsurers, and by January of 1994, when the Northridge Earthquake struck Southern California, the industry witnessed the emergence of a new generation of technical reinsurers founded on the concept of catastrophe modeling. In essence, Hurricane Andrew illustrated that the actuarial approach to managing catastrophe risk was insufficient; a more sophisticated modeling approach was needed. Moreover, it highlighted the importance of high resolution data in accurately estimating catastrophic losses.

The 1994 Northridge Earthquake definitively marked the end of the loss experience approach to assessing earthquake risk in California. The quake occurred beneath the highly populated San Fernando Valley along a blind thrust fault that showed no visible surface traces. According to Property Claim Services (PCS), the event generated $12.5 billion in insured loss at the time. If the volume of collected earthquake premiums to insurance loss payments in California from 1970 through 1994 is compared, the loss ratio (i.e., ratio of premiums to loss) is approximately 25% excluding the Northridge Earthquake. When the Northridge Earthquake losses are included, the overall ratio increases to over 200%. Up until this point, the standard method to managing earthquake risk was to employ a probable maximum loss (PML) approach that focused on the accumulation of insured exposure across the whole Los Angeles basin. Within the accumulation zone, risk was assumed to be 80% commercial structures. However, 60% of the insured loss was to the residential line of business.

This event additionally highlighted issues of incomplete or inaccurate exposure data, an issue with which the industry is still struggling many years later. Appurtenant structures were found to be twice the value and twice as vulnerable to shaking damage. There were also widespread welding failures at the beam-column connections of 2,000 steel moment-resisting frame structures across the region. The total losses were 28 times the collected 1993 premiums and took many months to accumulate. A huge amount of claims data became available for catastrophe modelers to calibrate damage curves, as well as develop new functions for additional sources of damage (e.g., earthquake sprinkler leakage).

Catastrophe Modeling in 2009

In March of 1994, an estimated 10–12% of property insurers used catastrophe models; in 2009, over 90% of insurers utilize models. Insurers take a more comprehensive approach to understanding and managing risk in today's marketplace. For example, the importance of accurate input data into models is appreciated, as it is imperative to the underwriting process. The "garbage in, garbage out" principle holds irrespective of how advanced or state-of-the-art a model may be. Partial information on a structure's characteristics can result in an inaccurate measure of risk. For example, is a residential structure coded as masonry when in fact it is wood frame? Is a commercial structure in fact a petrochemical refinery when it is coded as a chemicals processing plant? Are the structures' and contents values underestimated? This type of misinformation in the underwriting process results in inaccurate measures of risk.

There is also a growing appreciation for the limitations of models. The science and impact of natural hazards are not completely understood and models are an approximation of a very complex suite of physical phenomenon. By recognizing the uncertainty associated with loss estimates, insurers can take steps to protect themselves against rare tail events. Moreover, the scope of modeled losses, which most often includes structural damage, contents damage, and other time-based impacts from a disaster, such as business interruption, is recognized. Following Hurricane Katrina in 2005, the scope of initial loss estimates included the impacts of direct wind damage and direct storm surge damage, but not mold infestation due to the levee failures in New Orleans. As insurers and reinsurers become more sophisticated in their use of models, there will be continued pressure on the developers of models to provide more complete solutions that calculate all possible direct and indirect losses from a disaster.

Advances in Earthquake Science since the 1989 Loma Prieta Earthquake

In the two decades since the Loma Prieta Earthquake struck the San Francisco Bay Area on October 17, 1989, tremendous advancements in the scientific understanding of earthquake occurrence and earthquake effects have taken place. These advances are, in part, the result of high precision data and analysis made possible by technological innovations in both instrumentation and computation; in addition, other advances have resulted from a focused effort on field data collection.

GPS technology, in its infancy at the time of the Loma Prieta Earthquake, now enables direct measurement—at high precision and in a timeframe of weeks—of the deformation on the Earth's surface created by the buildup of pressure on faults at depth. This provides a critical constraint on earthquake occurrence, because the energy that enters the system through this increase in pressure (know as strain accumulation) must equal the energy released in subsequent earthquakes (i.e., the concept of an earthquake cycle, one of the major scientific advances that came from the study of the 1906 earthquake). Another key advance in quantifying earthquake occurrence comes from the paleoseismological study of active faults, which provides information on the recurrence time between past major earthquakes on the faults. By digging trenches across active faults and measuring and dating the displacement between disrupted soil layers on either side of the fault line, a history of the timing of past earthquakes on the fault can be constructed. LIDAR (Light Imaging and Detection Radar), allowing extremely high precision topographic imaging of surface fault features, such as offset stream channels, provides the third key component needed to quantify earthquake occurrence—the slip rate, or the average long-term rate at which two sides of a fault move past each other. By integrating this information, seismic deformation in a region can be partitioned on to individual faults. The likelihood of future earthquakes on a fault system can thus be related to the slip (or magnitude) of past events, the average repeat time, and the elapsed time since the last event.

The transition to digital, broadband seismic recording technology coupled with real-time data acquisition and transmission allows seismologists now to produce maps of shaking intensity within 5 to 10 minutes of the occurrence of a significant earthquake throughout much of the U.S. and within 30 minutes of significant global events. The USGS releases these ShakeMaps on the web (http://earthquake.usgs.gov/eqcenter/shakemap/) and relays them directly to emergency responders to provide a complete image of the spatial distribution and intensity of strong shaking immediately following an event and to aid in focusing response where it is most needed. Dense arrays of the new digital seismic recorders in Japan, Taiwan, and parts of California are providing unprecedented portrayals of the complex patterns of damaging strong ground motion in large earthquakes. These data sets are being used to calibrate computationally intensive ground motion simulations that attempt to recreate actual seismograms (time histories) beginning from the movement or slip on the earthquake fault and propagation of the seismic waves through the Earth, including complex regions such as basins and near surface soils as they radiate out from the earthquake source. The ground motion simulations allow a much more detailed view of the likely shaking and damage patterns in future earthquakes.

BAY AREA EARTHQUAKE RISK

In commemoration of the 20th anniversary of the RMS® U.S. Earthquake Model and the Loma Prieta Earthquake, this section discusses the current landscape of earthquake risk in the San Francisco Bay Area. The innovative management of risk, now achievable due to the latest generation of catastrophe models and other scientific, technological, and engineering advances, is explored, including the role insurance has in recovering from a significant Bay Area earthquake and the impacts of the current economy on the ability of homeowners to pay for earthquake damage.

The 1989 Loma Prieta Earthquake

On October 17, 1989 at 5:04 p.m. local time, the Loma Prieta Earthquake occurred in the Santa Cruz Mountains, south of San Francisco, measuring M6.9 on the moment magnitude scale. The ground motion was felt across the San Francisco Bay Area and resulted in 63 casualties, over $6 billion in property damages, and $960 million in insured loss at the time of the event. The damage from the event, including a collapsed section of the San Francisco-Oakland Bay Bridge (Figure 2), spurred many organizations across the region to retrofit for future earthquake events, including the East Bay Municipal Water District (EBMUD), and Pacific Gas & Electric (PG&E), among others (for more information, see RMS, 2008). While it is generally agreed that improvements across the infrastructure of the Bay Area will mitigate impacts from future earthquakes, there is arguably more concern over other property exposure at risk, including soft story buildings.

Based on the latest understanding of earthquake risk in California, RMS estimates that a recurrence of the Loma Prieta Earthquake in 2009 would result in an estimated $38 billion in economic loss and $3.6 billion in insured loss to the residential and commercial lines of business. This loss, though in excess of the largest property damage in recent California history, is neither the result of the most probable event nor the most potentially damaging event. Future earthquakes are likely to be larger and closer to the core exposure of the Bay Area, with the highest probability ruptures expected on the Hayward or San Andreas faults and causing even greater damage to the high concentrations of exposure around San Francisco Bay.

Figure 2: Damage to the San Francisco-Oakland Bay Bridge, spanning the San Francisco Bay, as a result of the 1989 Loma Prieta Earthquake; a seismic retrofit of the bridge is ongoing in 2009

Earthquake Scenario for the Bay Area

In order to fully explore the earthquake risk management issues in the San Francisco region, an appropriate scenario event must be chosen. The scenario selected for this analysis represents a rupture of the Peninsula segment of the San Andreas Fault as defined by the Working Group on California Earthquake Probabilities, convened in 2002 and 2007 (WGCEP, 2003; WGCEP, 2008). The rupture extends 88 km northwest from just north of the Loma Prieta rupture in the Santa Cruz Mountains to just offshore from Golden Gate Park in San Francisco, where the fault makes a change in geometry. This segment ruptured in the 1906 San Francisco Earthquake, offsetting roads and fence posts along the rupture with between 2 m to 3.5 m of slip. Historical accounts suggest that this same segment of the San Andreas Fault may have also ruptured in 1838, producing an estimated magnitude 7.0 to 7.4 earthquake. The occurrence of the 1838 earthquake is often cited as the reason for the relatively low slip on the Peninsula segment of the fault in the 1906 earthquake, as the stretch of the San Andreas Fault north of San Francisco slipped between 4 m to 8 m (and averaging about 6 m) in 1906.

Although there is abundant low-level seismicity on the San Francisco Peninsula, careful study has shown that the earthquakes are not occurring on the fault itself, but in the regions adjacent to it. This observation is consistent with the notion that the San Andreas Fault is locked, re-accumulating strain for release in the next major earthquake. Data from high-precision permanent GPS stations distributed throughout the region demonstrate that such strain is accumulating along the Peninsula segment of the San Andreas Fault at a rate of 17 to 20 mm/yr. Thus, 1.75 to 2.05 m of slip has accumulated on this segment in the 103 years since 1906, sufficient to produce a M7.2 earthquake. Hence, this event can be considered a likely earthquake. The worst case scenario for the Bay Area would be a repeat of the 1906 event, a full, 500-km long rupture of the San Andreas Fault in northern California, an event with an estimated recurrence interval of more than two hundred years.

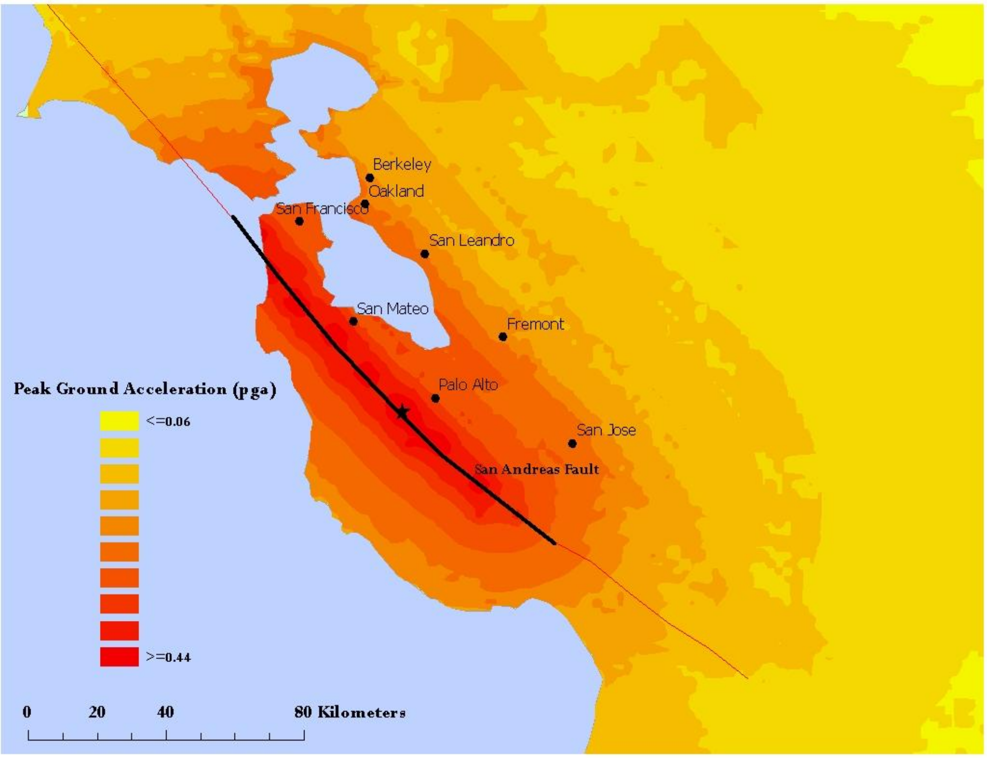

Figure 3: Ground motion, as measured by peak ground acceleration (pga) for the M7.2 scenario event on the Peninsula segment of the San Andreas Fault (Source: USGS ShakeMap)

A recent report by the San Francisco Planning and Urban Research Association (SPUR), on creating a resilient city, identified this M7.2 scenario rupture of the Peninsula segment of the San Andreas Fault as an “expected” earthquake for the city (SPUR, 2008). SPUR defines an expected earthquake as one that can be expected—conservatively but reasonably—to occur once during the useful life of a structure or system, and more frequently if the structure is renovated periodically (as most San Francisco buildings are) to serve more than one or two generations. San Francisco’s Community Action Plan for Seismic Safety (CAPSS) program has also adopted this M7.2 scenario as one of the four scenarios to assess the vulnerability of existing structures in San Francisco neighborhoods.

IMPACTS OF A SAN ANDREAS EARTHQUAKE IN 2009

In order to determine the potential property loss from a M7.2 event along the Peninsula segment of the San Andreas Fault in 2009, the ground motion footprint provided by the USGS ShakeMap program was transformed into an RMS footprint file and run against the 2009 RMS® Industry Exposure Database (IED) in the latest version of the RMS® U.S. Earthquake Model. The technological advances achieved through the ShakeMap program allow the seamless inclusion of ground motion parameters as input into the RMS modeling software. Peak ground acceleration (PGA), as shown in Figure 3, as well as Modified Mercalli Intensity (MMI), peak ground velocity (PGV), and spectral acceleration (Sa) at 0.3, 1.0, and 3.0 seconds, are utilized for analysis purposes.[2] The value of residential property and commercial property at risk from this scenario earthquake totals $1.8 trillion. This estimate includes the ten Bay Area counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma, and estimates the value of both structures and their contents, with residential property comprising 60% of the exposure at risk.

RMS estimates that this event would result in close to $119 billion in economic loss to the residential and commercial lines of business, with insurance covering approximately $19 billion of this loss (Figure 4). This insured loss estimate assumes the latest understanding of take-up rates for residential and commercial earthquake coverage in California, as well as the impacts of loss amplification on these insurance coverages, including economic demand surge and the expansion of coverage (i.e., policy leakage). As one can see, the percentage of total economic loss covered by insurance is small; on average, insurance will cover approximately 15% of the total economic damage, with commercial insurance penetration higher than the residential penetration rate.

This result is not surprising, as on a global basis, insurance is more widely available for wind perils (hurricanes, typhoons, windstorms) than for earthquake risks. For example, the 1995 Great Hanshin Earthquake in Japan caused total economic losses estimated at over $100 billion, but insured losses only covered 3% of the loss due to limited payout rates from Japan's residential insurance at that time. By contrast, insurance claims for windstorms Lothar and Martin in Western Europe in 1999 are estimated to have paid for more than 50% of the total economic losses.

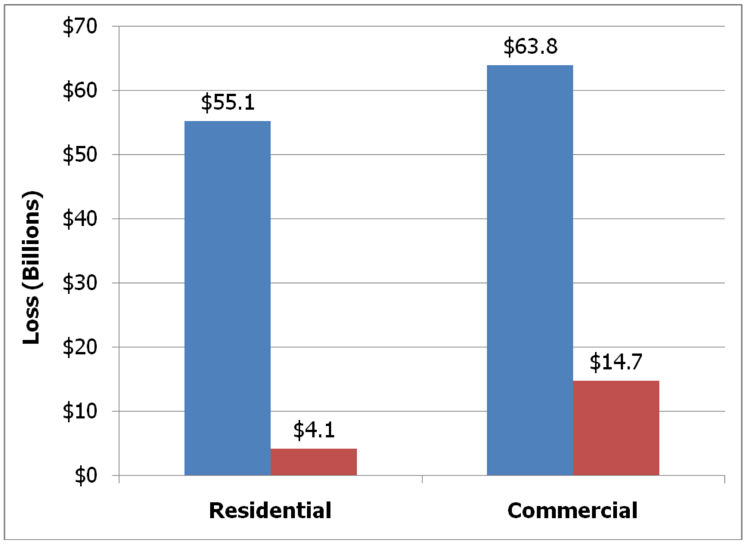

Figure 4: Total economic damage (blue) and insured loss (red) to the residential and commercial lines of business as a result of a M7.2 earthquake on the Peninsula segment of the San Andreas Fault in 2009

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[2] For more information about the use of ground motion estimates and the vulnerability of property at risk, see *The 1868 Hayward Earthquake: 140-Year Retrospective*. Risk Management Solutions Retrospective Reports. http://www.rms.com/Publications/.

Residential Earthquake Insurance in California

In the above earthquake scenario, insurance would pay for only approximately 7.5% of the total residential loss, illustrating the low take-up rate of coverage in California's residential earthquake insurance market. However, if the insurance take-up rate was the same level as it was in 1996, insurance could cover approximately 25% of the total residential loss for this scenario event. Therefore, it is worth exploring the history and current issues of residential earthquake coverage in the state of California.

Historically, there was little earthquake insurance purchased by consumers in California until the 1971 San Fernando Earthquake, after which there was significant growth. In 1985, the state passed the "mandatory offer law" that compelled insurers who offered homeowners coverage in California to offer earthquake coverage as well. In 1995, Assembly Bill (AB) 1366 narrowed the scope of the mandatory offer law with the creation of the "mini-policy", allowing a deductible up to 15% for earthquake building damage and allowing the coverage for personal property and loss of use to be limited to $5,000 and $1,500, respectively. While this coverage was the statutory minimum coverage, a variety of coverage was offered in the marketplace. The typical policy before the 1994 Northridge Earthquake carried a 10% deductible and generally provided the same limits on dwelling and personal property as the underlying homeowners policy.

By the mid-1990s, approximately one-third of insured homeowners also had earthquake coverage. When the magnitude of the insured losses in the 1994 Northridge Earthquake prompted insurers to restrict sales of homeowners coverage, the legislature decided not to repeal the 1985 mandatory offer law but instead establish the California Earthquake Authority (CEA), a publicly-managed, privately-financed entity (http://www.earthquakeauthority.com/). On December 1, 1996, the CEA opened its doors for business and residential insurers had the choice to opt into the CEA. Roughly 70% of the California homeowners insurance market joined the CEA, and this aggregate share has changed little over time; it is approximately 75% in 2009, with the CEA writing approximately 800,000 policies. These policies represent a 9% take-up rate of residential earthquake coverage across the state.

Following the Northridge Earthquake but before AB 1366 took effect, the take-up rate for residential coverage reached 36% across all insurers, with CEA participating insurers covering approximately 22% of this total (Figure 5). This was primarily a function of the CEA participating insurers rolling in policies they had acquired before the CEA's inception. As customers began receiving an offer of a relatively high cost CEA policy, or a mini-policy from non-CEA companies, earthquake penetration quickly dropped.

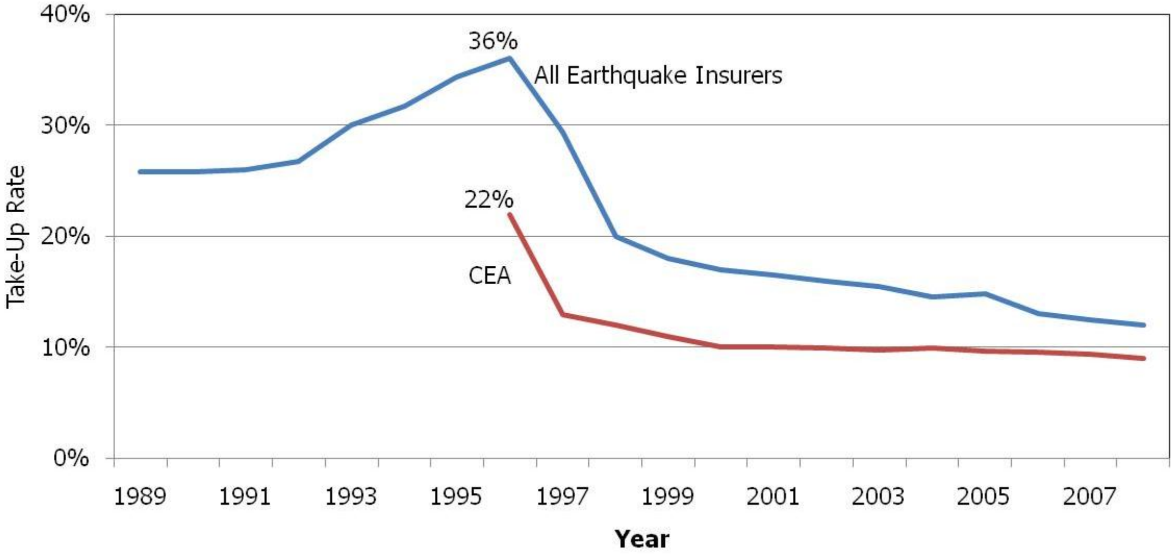

Figure 5: Take-up rates for residential earthquake insurance coverage in California for the California Earthquake Authority and the private market (blue) and the CEA only (red) from 1989 through 2008 (Source: Marshall, 2009)

Increasing Earthquake Insurance Take-up Rates

The mandatory offer law, which compelled insurers to offer earthquake coverage to consumers, was a good step in making coverage available to homeowners. In addition, the same chapter of the Insurance Code that contains the mandatory offer law also contains requirements that prohibit insurers from canceling a homeowners policy due to the acceptable of an earthquake offer and clarifies statements on the scope of homeowners policies, which do not cover earthquake shake damage, but do cover fire following an earthquake, even if the fire is caused by the earthquake. However, this legislation did not mandate that consumers had to purchase the coverage. With actuarially sound rates, many homeowners who live in seismically active areas believe that they cannot afford coverage and the standard coverage for contents and loss of use is too limited. Moreover, as one can infer from Figure 5 (i.e., consistently decreasing take-up rates since 1996), with no recent major earthquake event, homeowners might mistakenly believe that it cannot happen to them and the risk is too small to insure against.

The CEA is currently exploring options to increase the number of Californians protected by earthquake insurance, while maintaining its financial strength. Increasing take-up rates is crucial for the recovery of an area and the reduction in federal aid assistance following a major California earthquake. Two options being explored are the redesign of the CEA's financial structure and policy coverage enhancements. The first option involves the use of a federal debt guarantee, which would be established by new legislation at the federal level. The second option involves offering flexible policy options, and thus, encouraging more homeowners to voluntarily purchase insurance. For example, the Catastrophe Obligation Act (COGA) of 2009, introduced in the U.S. Senate in April 2009 and currently referred to the Senate Committee on Banking, Housing, and Urban Affairs in the fall of 2009[3], would guarantee the debt issued by State catastrophe insurance programs, including the CEA. As a result, the CEA has argued that, with a substantially different structure for claims-paying capacity, significant reductions in premiums for earthquake insurance would be achievable.

Given this ongoing political process, the exploration of take-up rates and policy coverage enhancements are explored in the next two sections.

Losses in 2009 with 1996 Take-Up Rates

Revisiting the potential insured property loss from a M7.2 along the Peninsula segment of the San Andreas Fault in 2009, the approximately $4 billion in loss to the residential line of business will be paid out by the CEA and the private market (Figure 4). However, the payout could potentially be much higher—on both an absolute and relative basis—with higher take-up rates. Based on an RMS analysis, considering the highest take-up rates seen in the past twenty years (as shown in Figure 5)[4], the residential insured loss from this scenario event would increase from $4 billion to approximately $14 billion. Moreover, of this $14 billion, the CEA would sustain a loss of $6 billion with the private market covering the remaining $8 billion (Figure 6). This translates to a total payout of approximately 25% of the estimated $55 billion in residential economic damages, a substantial increase over the current expected insured loss. However, as previously discussed, there are barriers to increasing the take-up rates of residential insurance, including homeowner's willingness to pay for coverage and the accumulation of capital by the CEA, and this result should be viewed with consideration of these barriers. The CEA does not believe, given its current financial structure, that it could acquire enough affordable capital (e.g., for its claims paying capacity) to support a 22% take-up rate.

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[3] For more information and full text of the bill, see http://www.govtrack.us/congress/bill.xpd?bill=s111-886.

[4] As stated earlier in the text, the 1996 take-up rate for the CEA represents a large number of acquired policies from participating insurers (i.e., policies offered by insurers before opting into the CEA).

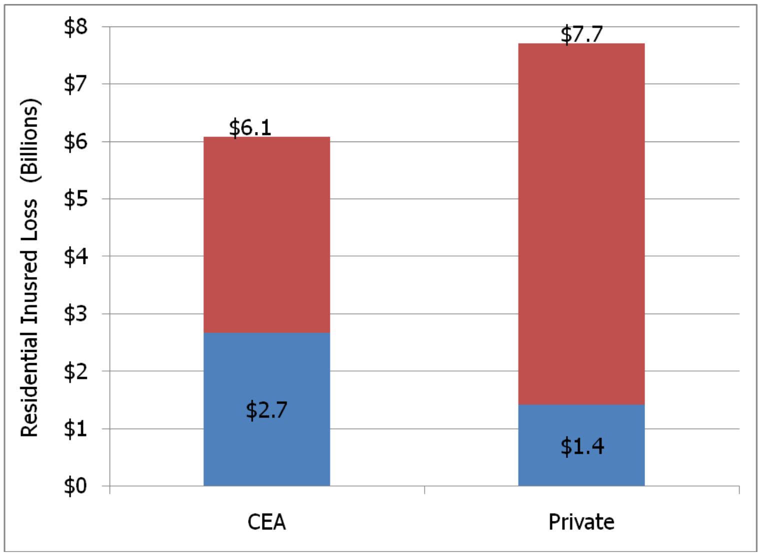

Figure 6: Residential insured loss to the California Earthquake Authority and the private residential insurance market from a M7.2 event on the Peninsula segment of the San Andreas Fault in 2009 with current take-up rates (blue) and in 2009 with 1996 take-up rates (blue + red)

Losses in 2009 with a Range of Coverage Options

Utilizing the same M7.2 scenario earthquake, RMS analyzed the potential loss covered by CEA policies, considering a range of coverage terms for structure, contents, and loss of use. The basic CEA policy covers structural damages to a residential dwelling or mobile home, paying up to $5,000 to repair or replace personal possessions and $1,500 for living expenses while the home is being repaired or rebuilt. For this basic coverage, all claims are subject to a 15% deductible. It should be noted, however, there are enhancements to coverage available, including higher personal property and additional living expense limits of $100,000 and $15,000, respectively, as well as a deductible buy-down to 10%.

The CEA is actively exploring flexible policy options to allow "consumers to choose the coverage that fit their needs" (Marshall, 2009). As shown in Table 1, options for coverage include a 50% limit for structure damage with deductibles ranging from 10% to 20%, as well as significantly higher limits on contents loss and loss of use. The increased contents coverage, ranging from $25,000 to $100,000, would be subject to deductible as well (which is not a current coverage option), but the $10,000 to $15,000 for additional living expenses would not be subject to a deductible (consistent with the current coverage option).

If one considered all permutations of the structure, contents, and loss of use coverage for the CEA policy conditions shown in Table 1, as well as the current basic policy coverage (also shown in last column of Table 1), there are close to 150 combinations to consider. From these potential policy coverage terms, a subset of 36 combinations is utilized to analyze the impacts of the coverage options on the insured loss from the M7.2 event on the Peninsula segment of the San Andreas Fault (See Appendix for full listing).

Table 1. Coverage options for a California Earthquake Authority policy considered in an analysis of the potential payout from a M7.2 scenario event on the Peninsula segment of the San Andreas Fault (Source: Marshall, 2009)

Option	**Type of Coverage**	**Amount of Coverage**	**Deductible**	**Current Basic Policy for Type of Coverage**
Option 1	Structure	50%	10%, 15%, 20%*	100% with 15% deductible
Option 2	Contents	$25,000, $50,000, $75,000 or $100,000	10%, 15%, 20%**	$5,000 with no deductible
Option 3	Loss of Use	$10,000 or $15,000	No deductible	$1,500 with no deductible

*Applied to 50% coverage

** Applied to amount of content coverage

Considering the current take-up rate of CEA policies across the impacted region, the insured loss would average $2.9 billion for these 36 combinations of coverage options, with a minimum loss of $2.5 billion and a maximum loss of $3.4 billion. The minimum loss corresponds to the case of 50% structure coverage with a 20% deductible and limits of $5,000 and $1,500 for contents and loss of use, respectively. The maximum loss is sustained for 50% structure coverage and $100,000 contents coverage, both subject to a 10% deductible, with a $15,000 limit on loss of use. A histogram of these results is illustrated in Figure 7.

In light of these results, which illustrate over a 30% difference in loss (i.e., increase in loss from the minimum to the maximum loss across the coverage options), it is useful to consider other risk metrics associated with these options for coverage. For example, the average annual loss (AAL) associated with the case of 50% structure coverage and $100,000 contents coverage, both subject to a 10% deductible, with a $15,000 limit on loss of use is approximately 25% higher than the AAL for the case of 50% structure coverage with a 20% deductible and limits of $5,000 and $1,500 for contents and loss of use, respectively. Further analyses, considering a range of take-up rates in conjunction with these coverage enhancements, is necessary to determine the overall impacts on the CEA's current risk financing and alternative approaches for claims-paying capacity.

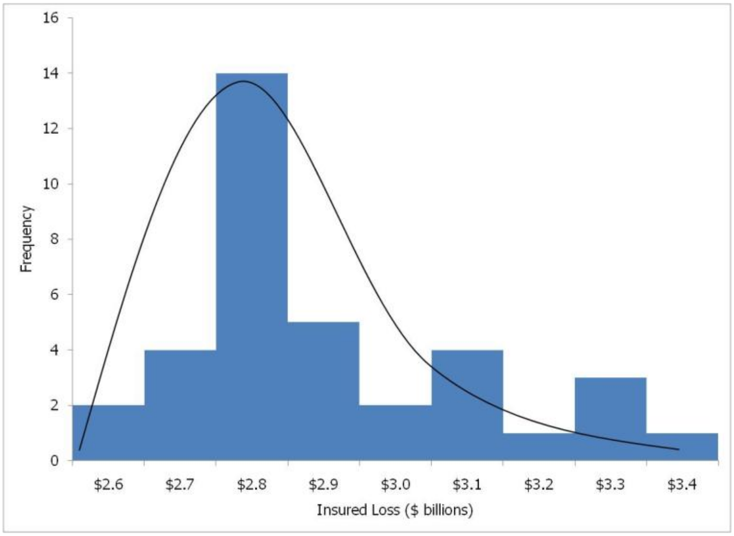

Figure 7: Histogram of insured loss to the California Earthquake Authority, considering 36 combinations of structure, contents, and loss of use coverage, from a M7.2 event on the Peninsula segment of the San Andreas Fault in 2009 with 2009 take-up rates

Residential Mortgage Default Risk

Separate from the insurance industry impacts from a M7.2 earthquake on the Peninsula segment of the San Andreas Fault, the mortgage industry is also at risk from a major Bay Area earthquake. Following the 1994 Northridge Earthquake, it was estimated that the mortgage industry sustained losses up to $400 million due to defaulting, including "foreclosure expenses, property repair costs, lost interest income, write-downs of existing loan balances and other administrative costs" (Aon Benfield, 2009). A significant consequence of the low take-up of residential earthquake insurance coverage in California is the strong likelihood that homeowners might walk away from their homes after a major event, as there are no payments to restore equity in a property to pre-disaster levels (Anderson and Weinrobe, 1986). Moreover, with the current economic conditions, pre-disaster equity levels of Bay Area homes are not necessarily positive and, in fact, could be negative.

In ideal economic circumstances, a property's net equity—the property value less any outstanding mortgage balance—is positive. If the initial purchase of a home included an accurate appraisal and a down payment, there are no other liens on the property (e.g., the homeowner does not take out a second mortgage or a home equity loan), and the value of the property increases over time, it would be expected that the net equity would increase over time as well. Only in the event of a disaster, where significant property damage occurred, would the net equity become negative (Figure 8). Assuming these ideal circumstances, one study on mortgage default risks, conducted following the 1971 San Fernando Earthquake, concluded that the two main drivers behind the decision of homeowners to default on their mortgage loans following a disaster are the absolute amount of negative equity post-disaster and the property value of the home pre-disaster (Anderson and Weinrobe, 1986).

However, the current residential real estate market in the Bay Area does not exhibit these ideal conditions. Property values in certain segments of the market have significantly decreased and alternative mortgage instruments have been widely utilized (e.g., adjustable-rate mortgages, interest-only loans), allowing the purchase of a home with little or no down payment. Moreover, in 2009, the rate of mortgage default notices against California homeowners has reached its highest level in the last 20 years.

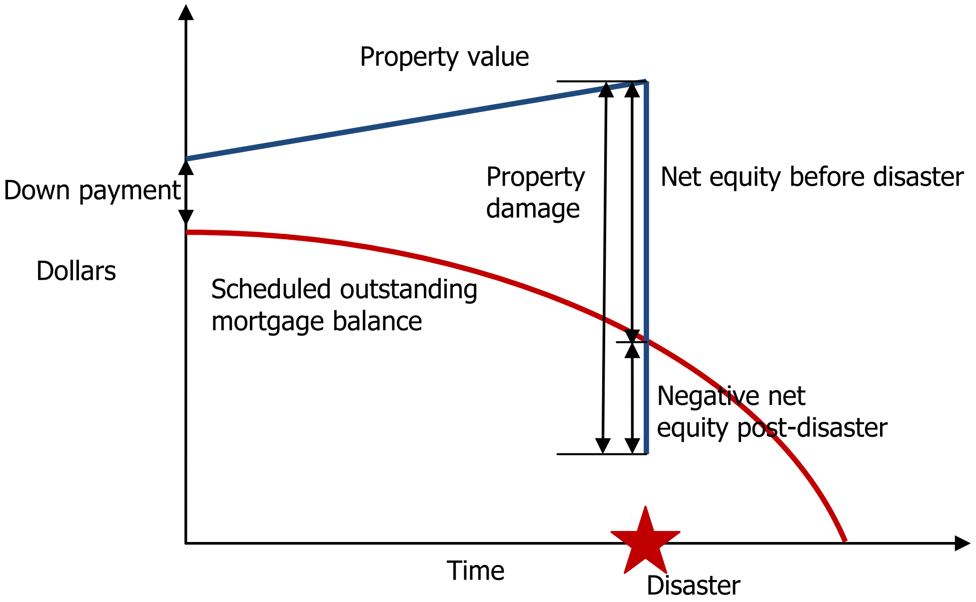

Figure 8: Illustration of net equity in a property over time, given an accurate appraisal, initial down payment, no additional liens on the property, and increase in market value; in these ideal circumstances, if a disaster occurs, net equity can become negative due to property damage (Source: Anderson and Weinrobe, 1986)

Figure 9 illustrates the current earthquake risk and mortgage default risk in the San Francisco Bay Area (on a ZIP Code basis). Earthquake risk is quantified in terms of loss cost, defined as the average annual loss (AAL) per $1,000 exposure of residential property (Figure 9(a)). Mortgage default risk is measured as the notices of default per 1,000 homes in the first three quarters of 2009 (Figure 9(b)). Areas of high loss cost and high notices of default are very well correlated in Alameda and Contra Costa counties in the East Bay along the Hayward Fault, as well as in some San Francisco neighborhoods. These ZIP Codes with both the highest level of earthquake risk and highest rate of mortgage default are areas that are currently least resilient in recovering from a major event. The form of reconstruction and economic renewal in these areas following a major disaster is also more uncertain.

RMS is actively researching mortgage default risk, as it impacts the ability of the region to recover from a major earthquake and can lead to a reduction of money available immediately following an event. For example, given the rate of mortgage default notices in the Bay Area, credit could tighten even further following an event, creating an additional reduction of funding to homeowners that are not defaulting but need loans to perform repairs. There could be less demand on the construction sector and therefore, a reduction in post-disaster demand surge. However, with delays in repairs, damage could increase; homeowners that intend to repair their homes could have additional water damage due to rainfall before repairs can be made.

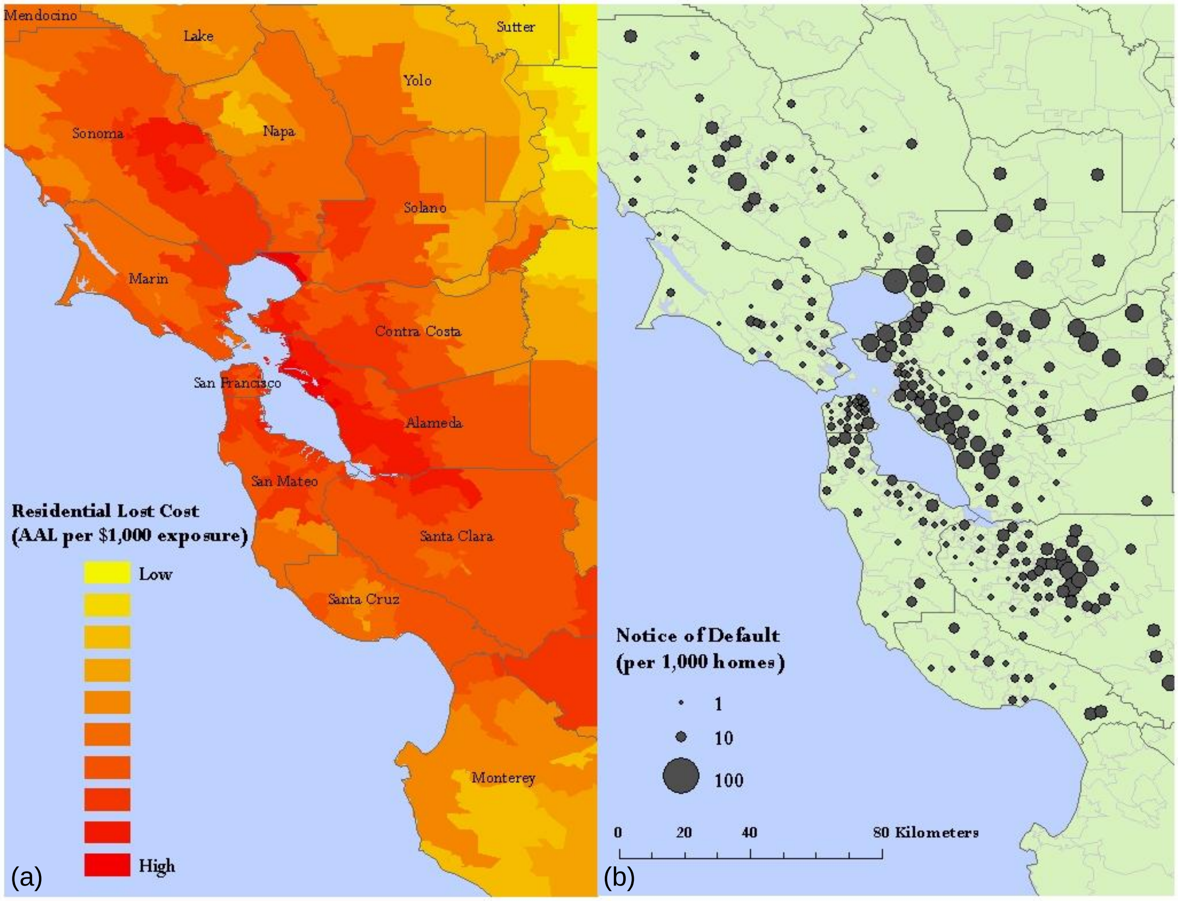

Figure 9: Comparison of earthquake risk to mortgage default risk: (a) residential loss cost, defined as the Average Annual Loss per $1,000 exposure, in the San Francisco Bay Area, as estimated from the RMS® U.S. Earthquake Model; and (b) average notice of default per 1,000 homes in the 10-county region of the San Francisco Bay Area, based on the first three quarters of 2009 (Source: MDA DataQuick Information Systems)

Conclusions

The analyses presented in this report, exploring the issues surrounding San Francisco Bay Area earthquake risk—from insurance take-up rates to insurance coverage options to increased levels of mortgage defaulting—are only achievable through the utilization of the current generation of catastrophe modeling and other scientific advances. Natural hazard catastrophe modeling has evolved considerably from the days when actuarial methods relying on past loss experience were used for risk assessment and management. Catastrophe modeling is now part of the landscape of tools used by the insurance industry for a better understanding and management of risk, as it provides the means for incorporating additional information from a wide array of disciplines as it becomes available. Catastrophe modeling also provides a unified platform for decision makers to quantify the uncertainty associated with risk and incomplete information.

Insured losses from catastrophic events have increased over the past 20 years, in part due to an increase in population and exposure in areas susceptible to catastrophic events. One thing is certain—this trend in losses and the associated global catastrophic risk will continue into the future. Risk Management Solutions remains committed to facing this challenge, aiding in the management of San Francisco Bay Area earthquake risk.

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APPENDIX

🟩 Denotes current basic coverage

Case	Type of Coverage	Amount of Coverage	Deductible	Type of Coverage	Amount of Coverage	Deductible	Type of Coverage	Amount of Coverage	Deductible
1	Structure	50%	10%	Contents	$5,000	None	Loss of Use	$1,500	None
2	Structure	50%	15%	Contents	$5,000	None	Loss of Use	$1,500	None
3	Structure	50%	20%	Contents	$5,000	None	Loss of Use	$1,500	None
4	Structure	50%	10%	Contents	$25,000	20%	Loss of Use	$1,500	None
5	Structure	50%	15%	Contents	$25,000	20%	Loss of Use	$1,500	None
6	Structure	50%	20%	Contents	$25,000	20%	Loss of Use	$1,500	None
7	Structure	50%	10%	Contents	$50,000	15%	Loss of Use	$1,500	None
8	Structure	50%	15%	Contents	$50,000	15%	Loss of Use	$1,500	None
9	Structure	50%	20%	Contents	$50,000	15%	Loss of Use	$1,500	None
10	Structure	50%	10%	Contents	$100,000	10%	Loss of Use	$1,500	None
11	Structure	50%	15%	Contents	$100,000	10%	Loss of Use	$1,500	None
12	Structure	50%	20%	Contents	$100,000	10%	Loss of Use	$1,500	None
13	Structure	50%	10%	Contents	$25,000	20%	Loss of Use	$10,000	None
14	Structure	50%	15%	Contents	$25,000	20%	Loss of Use	$10,000	None
15	Structure	50%	20%	Contents	$25,000	20%	Loss of Use	$10,000	None
16	Structure	50%	10%	Contents	$100,000	10%	Loss of Use	$15,000	None
17	Structure	50%	15%	Contents	$100,000	10%	Loss of Use	$15,000	None
18	Structure	50%	20%	Contents	$100,000	10%	Loss of Use	$15,000	None
19	Structure	100%	15%	Contents	$25,000	10%	Loss of Use	$1,500	None
20	Structure	100%	15%	Contents	$25,000	15%	Loss of Use	$1,500	None
21	Structure	100%	15%	Contents	$25,000	20%	Loss of Use	$1,500	None
22	Structure	100%	15%	Contents	$100,000	10%	Loss of Use	$1,500	None
23	Structure	100%	15%	Contents	$100,000	15%	Loss of Use	$1,500	None
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28	Structure	100%	15%	Contents	$100,000	10%	Loss of Use	$10,000	None
29	Structure	100%	15%	Contents	$100,000	15%	Loss of Use	$10,000	None
30	Structure	100%	15%	Contents	$100,000	20%	Loss of Use	$10,000	None

31	Structure	100%	15%	Contents	$25,000	10%	Loss of Use	$15,000	None
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33	Structure	100%	15%	Contents	$25,000	20%	Loss of Use	$15,000	None
34	Structure	100%	15%	Contents	$100,000	10%	Loss of Use	$15,000	None
35	Structure	100%	15%	Contents	$100,000	15%	Loss of Use	$15,000	None
36	Structure	100%	15%	Contents	$100,000	20%	Loss of Use	$15,000	None

ACKNOWLEDGEMENTS

Authors: Patricia Grossi and Mary Lou Zoback

Contributors: Furkan Ahmad, Munish Arora, Hesaam Aslani, Auguste Boissonnade, Jason Bryngelson, Gilbert Molas, Robert Muir-Wood, Sumeet Nanar, Tuna Onur, Mohsen Rahnama, Pasan Seneviratna, Taronne Tabucchi, Chesley Williams, and Don Windeler

Editor: Shelly Ericksen

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