The next megadisaster: Are You Prepared?

Earthquake in Colombia–Are You Prepared?

EVENT:	Magnitude 6.8 earthquake
MODEL:	AIR Earthquake Model for Colombia
STOCHASTIC EVENT ID:	710115902
LOCATION:	74.06°W, 4.44°N; approximately 21 kilometers (13 miles) south of Bogotá
EPICENTER DEPTH:	13 kilometers (8 miles)
ESTIMATED INSURED LOSS:	COP 41.20 trillion (USD 22.7 billion)
ANNUAL EXCEEDANCE PROBABILITY:	~1% (100-year return period)

EVENT OVERVIEW

A strong magnitude 6.8 earthquake strikes central Colombia, its epicenter located only 21 km (13 miles) south of Bogotá, the capital. The rupture takes place along the Algeciras-Altamira fault system at the relatively shallow depth of just 13 km (8 miles), striking Bogotá and its environs with violent ground shaking.

Damage is widespread, and many structures built before modern building codes were introduced collapse. Power and water lines, roads, bridges, and other infrastructure are widely disrupted throughout the crowded suburbs, working class towns, and industrial zones that spread out from the capital along the high Andean plateau. Across this greater Bogotá region, homes and local businesses, most constructed of adobe and unreinforced brick, suffer severe damage.

Each edition of this quarterly feature in AIR Currents presents a megadisaster scenario taken from an AIR model's stochastic catalog. Each scenario's loss has an annual exceedance probability of ~0.1% (a return period of ~100 years). The physical characteristics of the hypothetical event are described, exposures are identified, and the AIR model's estimate of insured losses are discussed.

By regularly presenting and discussing the potential impacts of such entirely plausible high-impact events, these scenarios can help risk managers assess the possible impact to their portfolios and prepare for the unexpected.

More than eight million people live in the Bogotá area. Altogether, thousands of buildings are damaged or destroyed and many people are seriously injured or killed. AIR estimates that if such an event were to happen today, insured losses would amount to about COP 41.2 trillion (USD 22.7 billion); insurable losses would come to about COP 105.9 trillion (USD 58.2 billion).[1]

Figure 1 shows the pattern of peak ground acceleration (PGA) emanating from the earthquake's epicenter in this AIR scenario.

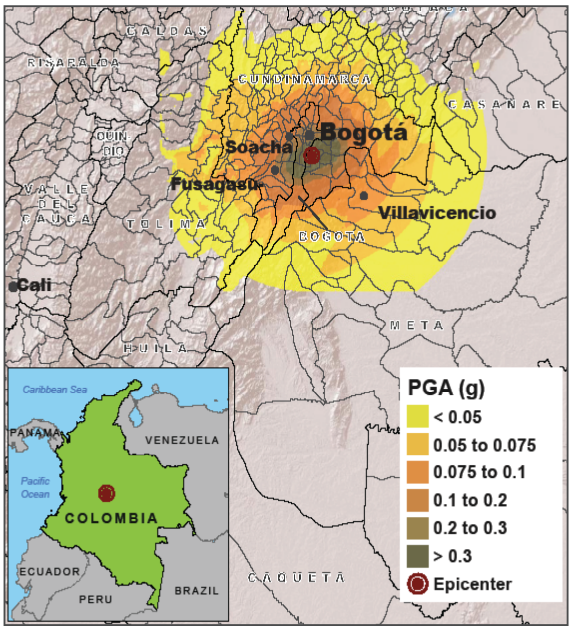

Figure 1. Epicenter and peak ground acceleration (PGA) for Bogotá earthquake: AIR Colombia Earthquake Scenario ID 710115902, resulting in a 0.1% exceedance probability (100-year return period) loss. (Source: AIR)

COLOMBIA'S TECTONIC SETTING AND EARTHQUAKE HISTORY

Colombia was formed by the interaction of the South American, Caribbean, and Nazca tectonic plates. The movement of these plates also built up the northern Andes Mountains and active volcanoes in the region. The mountains, which extend all the way to Tierra del Fuego at the southern tip of the continent, originate in northeastern Colombia as the Eastern, Central, and Western "Cordillera" (or ranges), and merge into a single range in the south of Colombia's western region. About 50 faults have been identified as being associated with the Cordilleras, and they account for much of Colombia's crustal seismicity.

Beneath Colombia, the Nazca Plate is subducting (moving under) the South American Plate at about 6 cm per year while the Caribbean Plate is moving past the South American Plate at about 1–2 cm per year. Most of the seismicity Colombia experiences is the product of these tectonic interactions. These phenomena all take place along the southeastern portion of the "circum-Pacific seismic zone," which accounts for nearly three-fourths of all the seismic energy released globally every year.

Many strong earthquakes have affected Colombia, and one of the most destructive in recent history was a magnitude 6.2 earthquake in 1999 that struck the city of Armenia. Poor construction and aging buildings led to devastation throughout much of the city. Churches, homes, hotels, historic towers, and other structures toppled in 35 cities during the initial rupture and 99 detected aftershocks, killing about 900 people and injuring 4,000. Table 1 shows AIR modeled losses for this event and four other significant loss-causing historical earthquakes in the model's historical event set.

TABLE 1. MODELED INSURED AND INSURABLE LOSSES FOR HISTORICAL EARTHQUAKES (COP MILLIONS)

EVENT	INSURED LOSS	INSURABLE LOSS
1999 Armenia	3,903,525	7,482,407
1979 Narino	1,185,034	1,909,712
1979 West Central	745,946	1,262,604
1983 Popayan	305,000	618,649
1995 Pereira	70,258	92,846

AFFECTED EXPOSURE

Colombia is one of only a handful of countries to have maintained positive economic growth throughout the period of worldwide economic recession that began in September 2007 and continued through 2010. Colombia has the fourth-largest insurance market in Latin America. During the five-year period from 2007 through 2011, total non-life premium income increased by 67%, according to AXCO Insurance Market Reports.

Most exposures in Colombia are in the country's major metropolitan areas. Bogotá is Colombia's largest and most populous city—and its capital city. Thus, the earthquake in this scenario impacts not only a sizable portion of the most concentrated exposures in the country but also strikes the country's political and economic center (the site of the country's stock exchange and supporting financial institutions, for example). The monetary cost of this scenario is great, but the cost to Colombia's basic institutions and its ability to respond effectively to such a catastrophe would be at least equally significant.

The predominant construction types in Colombia are adobe, unreinforced brick (or masonry), and reinforced concrete. Adobe's strength as a construction material is intrinsically low, and it is unable to support significant lateral loads. Brick did not begin to come into common use in Colombia until the 1940s, and its performance during earthquakes that have occurred since has shown that the buildings generally were built with poor quality mortar and under nonprofessional construction practices. These poor-performing construction types are common in large parts of Bogotá.

Reinforced concrete was introduced only in the 1960s, but since then it has become common. However, its resistance to strong ground shaking has been poor, also largely the result of a range of inadequate construction practices, including the use of poor quality concrete, absence of transverse reinforcements and/or too-wide spacing between supports, overly short columns, irregular or inconsistent vertical and horizontal measurements, and lack of shear walls or bracing.

The overall distribution of residential and commercial buildings in Colombia by construction type is shown in Figure 2. For residential buildings, shown on the left, adobe and masonry make up more than 90% of all structures. ("Masonry" includes confined masonry and reinforced masonry, both of which are better able to withstand ground motion than unreinforced masonry but are subject to the same kinds of often poor local construction practices as outlined above.) Sixty percent of commercial buildings are also made of adobe and masonry, while another almost 17% use concrete construction; thus, more than three-fourths of commercial structures in Colombia also remain highly vulnerable to damage from strong ground shaking.

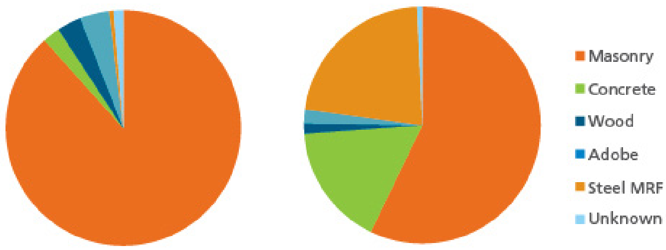

Figure 2. Construction types for residential structures (left) and commercial/industrial structures (right)

Indeed, it was nearly 30 years ago, in 1984, that official building codes were instituted in Colombia—relatively late compared to other countries in South America. These codes were based on ATC-3-06 of 1978 (a benchmark set of recommended codes developed by the Applied Technology Council, an internationally recognized professional engineering organization) and consisted largely of regulations to address masonry construction deficiencies shown to be endemic in the country by two then-recent large earthquakes—especially the Popayan earthquake the year before, 1983.

The magnitude of the Popayan earthquake was only 5.6, but it ruptured near the surface—at a depth of just 10 km (6.2 miles)—and destroyed the 200-year old center of the culturally important city, killing nearly 300 people. Twenty-three percent of the homes in the city (population 265,000 according to the 2010 census) were completely or partially destroyed, while more than 70% of all housing was severely impacted.

ESTIMATING THE IMPACT

Figure 3 provides a comparison between the pattern of ground shaking intensity shown in Figure 1 and the pattern of potential losses (by Municipios) for this scenario taken from the AIR model's stochastic catalog. Seismic waves move outward from an earthquake's epicenter in roughly concentric circles—except as they are influenced by other factors such as different soil types, rock formations, and other crustal features along the waves' path of propagation.

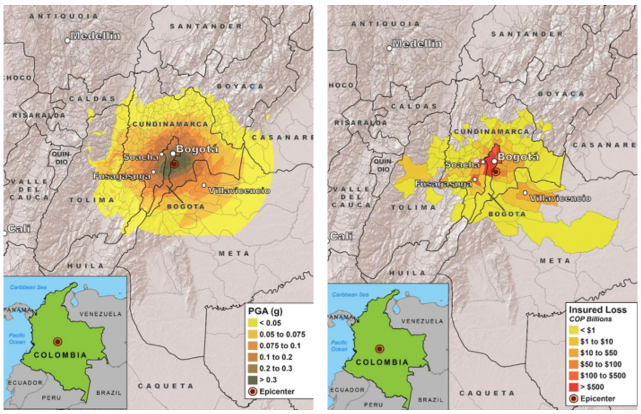

Figure 3. Gridded Ground shaking (left) and insured loss by Municipio (right) (Source: AIR)

The ground shaking intensity map in Figure 3 shows an irregular extension of greater seismic intensity to the southeast of Bogotá—which is mirrored on the losses map by higher losses than normally would be expected in the Municipio where the city of Villavicencio (population 385,000; 2005) is situated more than 60 km (40 miles) away from Bogotá and the earthquake epicenter.

Bogotá is situated, however, at the highest altitude in the world for a city with its population: at 2,620 meters (8,596 feet). Villavicencio is at an elevation of just 467 meters (1,532 feet); it lies below Bogotá at the foot of the Cordillera Oriental mountains where the geometry of the rising mountains both channels and amplifies the seismic waves spreading out from the earthquake. In addition, Villavicencio is built on relatively soft soil and mountain basin material, where ground shaking has greater effect. It is known as "The Gateway to the Llanos," the vast Colombia-Venezuelan plain that stretches for hundreds of kilometers.

In this scenario, Insured losses for Villavicencio are estimated at COP 40.2 billion (USD 22 million). One utility of this Megadisaster exercise is that it can help alert risk managers to potential portfolio locations—like Villavicencio—that might otherwise might not be thought to be at heightened risk. Just this type of phenomenon—stronger than anticipated shaking because of local soil and geological conditions—has happened several times in Colombia, most recently with the Armenia earthquake in 1999 noted earlier.

The total estimated insured losses for this stochastic scenario, as stated earlier, come to COP 41.2 trillion (USD 22.7 billion). The overwhelming majority of losses (roughly COP 39.7 trillion) occur within the greater Bogotá CRESTA Zone. Only three Municipios from other zones stand out—Villavicencio, just discussed, with COP 40.2 billion in losses; and the cities of Soacha, with COP 1.0 trillion in losses, and Fusagasuga, with COP 156.8 billion in losses. Both Soacha and Fusagasuga, like Bogotá, are within 30 km of the earthquake epicenter.

The total insured loss breaks down by line of business[2] to:

RESIDENTIAL:	COP 6,270,052,146,460	(USD 3,448,528,680)
COMMERCIAL:	COP 34,646,723,857,915	(USD 19,055,698.122)
AUTO:	COP 284,925,114,920	(USD 156,708,813)

ARE YOU PREPARED?

If COP 41.2 trillion (USD 22.7 billion) seems like a high level of loss, it is important to remember that the scenario described here is just one of many entirely plausible high loss earthquake scenarios in Colombia. The loss associated with this event has an annual exceedance probability of 1%; thus it should not be considered an extreme tail scenario. Far greater losses are possible.

To ensure that your organization is employing responsible risk management practices—and owning the risk associated with insured properties in Colombia—it is important to prepare for a wide range of scenarios in order to respond effectively when disaster strikes. AIR's models capture the full range of possible earthquake experience to enable a probabilistic view of risk to your portfolio. Scenario modeling, as described in this exercise, can also be useful to elucidate the potential impact of low probability but extremely high impact events.

To develop confidence that the model is producing the most realistic loss estimates, it is important to follow a few modeling best practices:

- Whenever possible, collect and input detailed data when you define your exposures. This means accurately capturing all the primary building characteristics of the exposures: construction type, occupancy, building age, height—and most importantly, a true replacement value. These attributes play a crucial role in estimating a particular structure's vulnerability in response to seismic ground motion.
- Capture accurate, detailed location information for the properties that make up your portfolio. While AIR models can accept CRESTA-level or Municipio-level information, relying solely on low resolution address data can lead to significant over- or under-estimations of risk. The different responses a building can exhibit to earthquake-induced ground motion are highly dependent on both the building's precise location relative to the earthquake's epicenter and the soil on which it rests.
- Be aware of non-modeled sources of insured loss. Not discussed in this scenario, for example, are possible losses attributable to liquefaction, fires following the earthquake, or to the impact of a tsunami (although not relevant to this scenario)—phenomena not currently included in the AIR model. Recent large-loss earthquakes around the world, however, have highlighted the need to account for such hazards. The 2013 update to the AIR Earthquake Model for Japan will explicitly model these subperils, and AIR is re-examining all of our earthquake models around the world with the end to make them more comprehensive.
- Finally, it is important to examine not only your losses, but also to determine your overall loss ratio for properties in the impacted CRESTA zones. That is, how do your estimated losses compare to the "Total Insured Value" (TIV) of the entire area in which they were incurred (i.e., Loss/TIV)? While your overall losses might at first appear to be distressingly high, you should be aware that such losses typically represent a loss ratio of less than 30%.

CLOSING COMMENTS

WHAT WILL BE THE NEXT MEGADISASTER?

It is impossible for any model to predict what the next megadisaster will be, which makes it all the more important for companies to use catastrophe models to prepare for such events. AIR's models are robust, capturing the effective behavior of physical phenomena and their impact on the built environment. They have been thoroughly validated using data from a wide variety of trusted sources. And the full range of scenarios the models provide—encompassing so many perils and places—allows a unique and important global perspective on a firm's overall risk. The diligent analysis of model results can help risk managers prepare for many contingencies, ensuring that the scenario presented here—and many others—are not entirely unexpected.

[1] All USD amounts are based on an exchange rate of COP 1 = USD 0.00055, current in mid-May of 2013

[2] These losses reflect the assumption that residential take-up rates are low but are much higher for commercial properties. However, it should be noted that there is considerable uncertainty with respect to actual take-up rates in Colombia.

ABOUT AIR WORLDWIDE

AIR Worldwide (AIR) is the scientific leader and most respected provider of risk modeling software and consulting services. AIR founded the catastrophe modeling industry in 1987 and today models the risk from natural catastrophes and terrorism in more than 90 countries. More than 400 insurance, reinsurance, financial, corporate, and government clients rely on AIR software and services for catastrophe risk management, insurance-linked securities, detailed site-specific wind and seismic engineering analyses, and agricultural risk management. AIR is a member of the Verisk Insurance Solutions group at Verisk Analytics (Nasdaq:VRSK) and 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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