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CAT 360

Catastrophe Risk from Every Perspective

The CAT 360 is a quarterly newsletter that features articles developed by our Research and Development Team and covers topics that relate to Catastrophe Modeling, Natural Perils and Information Technology on a global basis. Please feel free to contact the editors if you have any questions or comments regarding any of our publications.

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Issue 10 - 3rd Quarter 2010: Katrina - A Five Year Retrospective

Issue 9 - 2nd Quarter 2010: Volcanoes: Nature's Fury

Issue 8 - 1st Quarter 2010: Making Sense of Earthquake Clusters

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Feature Stories

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Haiti and Chile: Polar Opposites

With only one month of the year remaining, there is little doubt the year 2010 will long be remembered for three major earthquakes. The earthquakes in Haiti, Chile and New Zealand were each of catastrophic strength, but the impact in the separate countries was drastically different, reflecting differing levels of wealth and preparedness - as well as variations in the physical properties of the quakes themselves.

Put simply, Haiti was a much greater human disaster than the Chile or New Zealand events, despite being a lower intensity earthquake. It is a poor nation with no earthquake building codes and over 150 years between major events, whereas Chile is the wealthiest nation in South America, has frequent experience of major quakes and very strict building standards. This article will discuss the vastly different experience between the events in Haiti and Chile, which occurred just one month apart on 12 January and 27 February respectively. It will contrast the physical event properties, methods of construction and sociological and economic conditions.

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The Events

The earthquake in Haiti had a magnitude of 7.0 Mw, while Chile's event had a strength of 8.8 Mw, translating to 500 to 900 times more energy released than the earthquake in Haiti. The Haiti Earthquake had a depth of 8.1 miles and its epicenter was just ten miles west of Port-au-Prince (which has a population of two million) and lasted between 30-40 seconds.

By contrast, the Chilean earthquake had a depth of 22 miles and struck off the coast of the Maule Region, about 200 miles southwest of Santiago (with a population of 5.3 million), lasting 120 seconds. Seismologists confirmed it was the seventh largest earthquake in recorded history. Despite its intense strength, the death toll estimates in Chile are less than 1,000 while in Haiti the number of deaths is said to be as high as 230,000, although the real numbers may never be known.

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Historical Past

The seismicity in the region around Haiti was well documented, even though it was absent from living memory. Just two years before the earthquake struck, a research paper was published discussing the earthquake potential, not only to Haiti but to other islands in the region as well. However, the last earthquake of this strength to occur in the Port-au-Prince area of Haiti was in 1770 and before January, the peril did not feature on the country's disaster radar.

Haiti's focus had been primarily on the peril of hurricanes. There is plenty of evidence that the basic hurricane building codes in place were not adhered to. Even where they were, the basic heavy masonry construction that provides resistance to hurricanes is a disastrous method of building to withstand earthquakes. The effects of ground shaking had not been considered when the majority of buildings in Port-au-Prince were constructed. In the case of this hazard, "out of sight, out of mind" led to a tragedy of epic proportions.

By contrast, Chile's seismic past has been very well studied, with large earthquakes occurring annually in the region. Since 1900, there have been 22 earthquakes greater than 6.3 Mw in magnitude and of those, 14 were greater than 7.5Mw. As a result, Chile's expertise on its earthquake hazard is considered world class. However, this expertise has been gained as a result of some deadly lessons. In 1906, an 8.6 Mw quake near Valparaiso killed 20,000 people; in 1939 a 7.8 Mw quake near Chillán killed 28,000 and the record-shattering 1960 9.5 Mw quake near Valdivia resulted in a death toll of 5,000.

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Common Building Practices in Haiti

The building practices common in Haiti have been described as "archaic". Most structures are built without engineers, building code standards or inspectors. Post earthquake surveys uncovered building flaws that proliferated across the country: weak or missing reinforcement, structures on steep slopes with unstable foundations, inadequate or nonexistent inspections, poor designs, materials and techniques. It was a disaster waiting to happen.

Ahead of the earthquake in January, building collapses had happened even without any ground shaking to weaken them. They were purely a result of badly-made structures. In November 2008, a three-story cinder block school suddenly collapsed due to poor construction, killing 91 and injuring 162 others. The same building suffered a partial collapse in 2000, but was rebuilt. Only five days after the Pétionville school disaster, portions of Grace Divine School in Port-au-Prince also collapsed.

Most Caribbean countries (including Haiti) have building laws based on the Caribbean Uniform Building Code. But in Haiti (as well as others) these rules only exist on paper. Few people in Haiti build structures to resist the major hurricanes that routinely ravage the island. Before this year, the idea of building structures that were even remotely resistant to earthquakes would not have occurred. In fact, it has been published that the island only has one earthquake engineer, suggesting the country was largely devoid of engineering expertise. In summary, some of the issues that made Haiti so vulnerable to earthquake hazard include:

- A lack of building standards;
- No government oversight or expertise;
- Non-existent engineering; and
- Substandard materials utilized on buildings.

The economic conditions in Haiti caused these issues to exist as the basic needs of clothing and shelter were placed well above earthquake resistant housing.

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Unreinforced Masonry Construction in Haiti

The most prevalent building type in Haiti consists of low-rise, non-engineered concrete block masonry structures used for single-family dwellings and small businesses. These low-rise buildings are typically one to two stories tall, although three-story buildings are not uncommon. They are constructed with unreinforced concrete masonry units, framed by lightly reinforced concrete columns. Floors and roofs are reinforced concrete slabs. Foundations are typically one meter deep and assembled with stone or rock rubble and lightly cemented mortar. When built on sloped land, foundations can be as tall as two meters above ground. Buildings are built quickly and cheaply, but as we now know, at a great risk of collapse.

The framing of an Earthquake / Hurricane Resistant Wood Frame Home

Earth Sack Construction - Earthquake and Hurricane Resistant Housing

An Artist Rendition of Shipping Container Homes

Fortunately, not all buildings in Haiti are built in this fashion. The city centers of Port-au-Prince and Pétionville have a small number of engineered steel-framed concrete-clad and reinforced concrete high-rise apartments. The tallest commercial is 12 stories and built to the ACI 318 standard. Older warehouses and newer industrial factories, used by the garment industry, are lightweight steel frame and truss systems with non-structural concrete block infill. These structures are far more resistant to all perils (not just earthquakes) and while significant damage did occur to these structures, they did not collapse.

While it is unlikely that the economic conditions in Haiti will significantly improve in the foreseeable future, there are techniques in developing structures that are resistant to both earthquakes and hurricanes, yet remain economically viable. These include modern wood frame structures, geodesic domes, earth sack construction and recycled steel shipping containers. Additionally, expertise in building using one of these techniques can be transferred locally, so that Haitian communities can become self-sufficient in their construction activities in the near future.

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Common Building Practices in Chile

In contrast to Haiti, the overall building performance in Chile was remarkable. There was significant building damage (up to $8bn in insurance losses), but the relatively few deaths from such a strong event is attributed to the building codes and practices in place. These exemplary practices include the following:

- Code - Building codes are strict and enforced;
- Inspection - An inspection process is required for every structure built in Chile;
- Materials - Modern materials of specific quality are a key ingredient in the building process;
- Technique - Ability to execute and adhere to building codes during the construction phase; and
- Expertise - Well trained engineers and architects are able to design building resistant to earthquake hazards.

Chile has conducted detailed research to find weak points in the soil under major cities and has one of the most modern building codes in the world. The damage surveys, building code and enforcement are necessary protections in a country that is situated on the Pacific's volatile Ring of Fire and is therefore, accustomed to experiencing major earthquakes.

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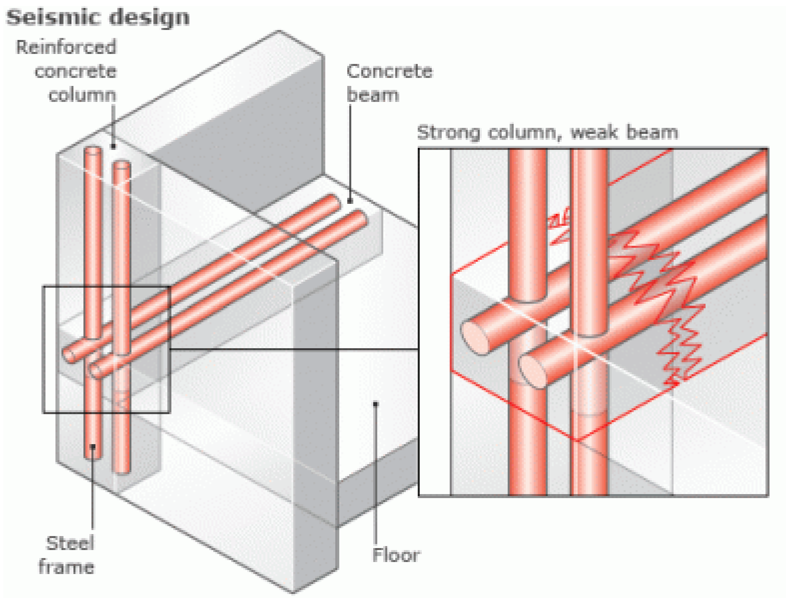
Seismic Resistance

Like in California, the earthquake code is designed to save lives as its primary objective. This means that buildings are able to withstand the shock of an earthquake, and remain standing. Structural damage can occur, but the occupants of such buildings should be able to walk out with minimal injuries. One of the techniques used in Chile has been described as "Strong Columns - Weak Beams".

The idea with this system is that buildings are held up by reinforced concrete columns, which are strengthened by a steel frame. Reinforced concrete beams are joined onto the columns to make floors and the roof. If there is an earthquake, the idea is that the concrete on the beams should break near the end, which dissipates a lot of the energy of the earthquake, but that the steel reinforcement should survive and the columns should stay standing. This means the building will stay upright, protecting the occupants inside.



Strong Column - Weak Beam Construction

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Exceptions to the Rule

While the vast majority of buildings in Chile performed very well during the Maule event, there were catastrophic failures. One example was the Alto Río, a 15-story apartment building in Concepción. This building failed in the event, collapsing on its side and resulted in eight casualties. The failure was attributed to a flaw in the foundation design, possibly due to unanticipated liquefaction. However, even though the building did fall over, the structure did not collapse and maintained its overall shape, indicating that the structural strength was very good. The building has since been demolished.

Other notable exceptions include the Torre O'Higgins building and an industrial park on the outskirts of Santiago. It is thought extensive damage at La Ciudad Empresarial could have been exacerbated by the soft soils it had been built on. Where structures did fail, investigations are underway to establish whether the codes were followed.

The Alto Rio Apartment Failure

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Moving Forward

The recovery process in Haiti will be far longer than it will be for Chile. Most of the displaced population are still living in temporary tents and for some, the recovery is nowhere in sight. However, part of the international aid being sent to Haiti is not just in the form of goods and materials, but knowledge and expertise as well.

In conclusion, there really is no comparison between this year's earthquakes in Haiti and Chile. The political and economic conditions in the two countries are poles apart. Therefore, it would be unrealistic to expect the standards in Chile to be implemented in Haiti. However, lessons learned in the Chile earthquake could be transferred to Haiti, only on a simpler basis. Schools in Haiti could be built using the strong column, weak beam approach for example. This would provide a strong and safe environment for generations to come in Haiti. It is a vision that can become a reality with just a bit of help from communities around the world.

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