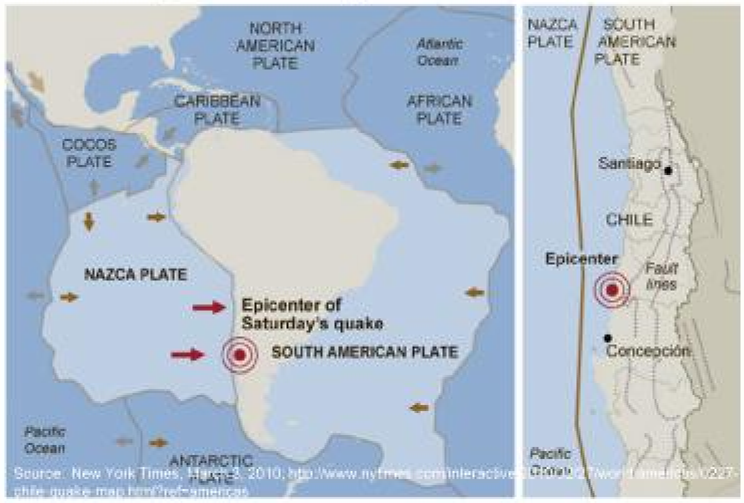
I was part of a post-disaster investigation in March, about 2 weeks after the main shock. The team that I was with had a geology emphasis.

This briefing draws upon the work of the geologic and tsunami investigations performed by my fellow members of the Geoengineering Extreme Event Reconnaissance team which went to Chile in early March 2010. Our work is now published on the GEER website – geerassociation.org. It also draws upon the material developed by members of the Learning from Earthquakes program of the Earthquake Engineering Research Institute, also sponsored by the National Science Foundation, the Pacific Earthquake Engineering research center, and the U.S. Geological Survey. A team of lifeline experts went to Chile later in March and their insights are also posted at the EERI clearinghouse, www.eeri.org, as the TCLEE report .

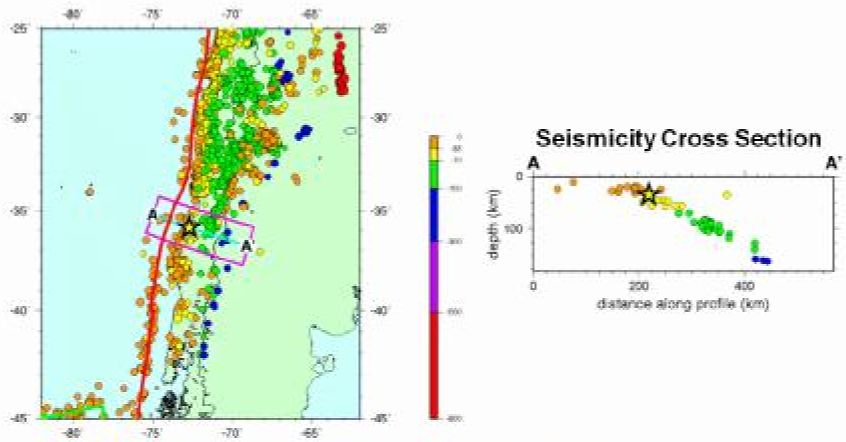
M_w8.8 earthquake struck at 3:34 am, Saturday, February 27



Laurie Johnson PhD AICP

The Mw8.8 earthquake struck off the coast of central Chile at 3:34 am on the morning of Saturday, February 27, 2010. The epicenter was about 205 miles (330 kilometers) southwest of the nation's capital, Santiago. This was a great earthquake - the 5th largest earthquake ever recorded. It occurred on a tectonic plate boundary, where the Nazca Plate is being subducted underneath the South American plate. This subduction is the source of energy creating the Andes mountain range that divides Chile and Argentina.

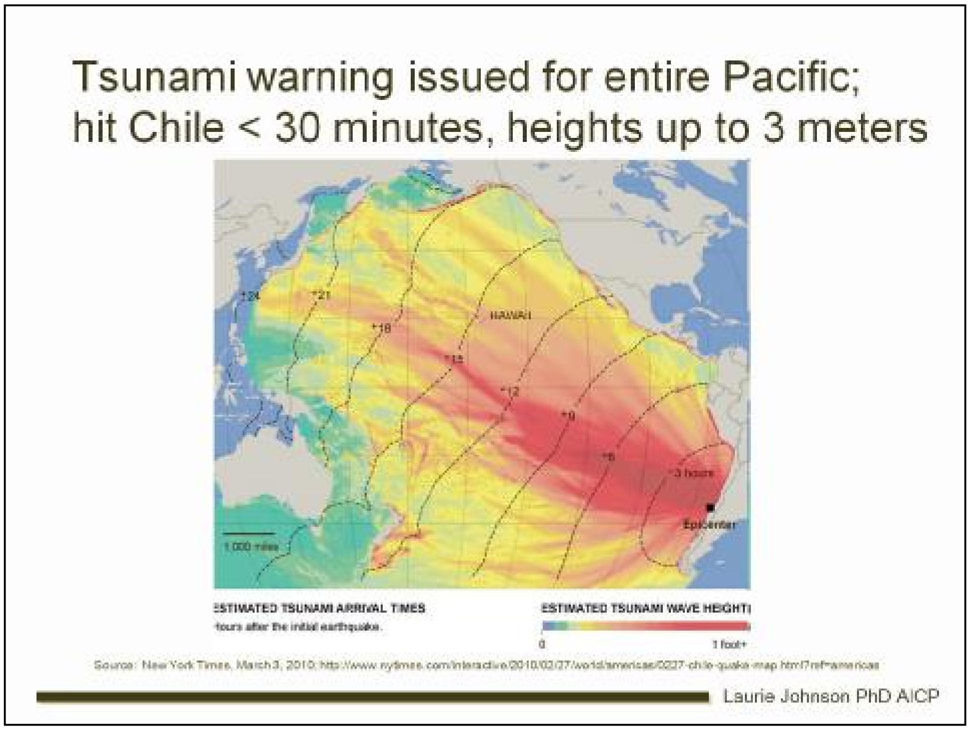
Over 458 Aftershocks (as of March 29), including several over M_w6.5



Source: http://neic.usgs.gov/neis/eq_depot/2010/eq_100227_tfan/neic_tfan_c.html)

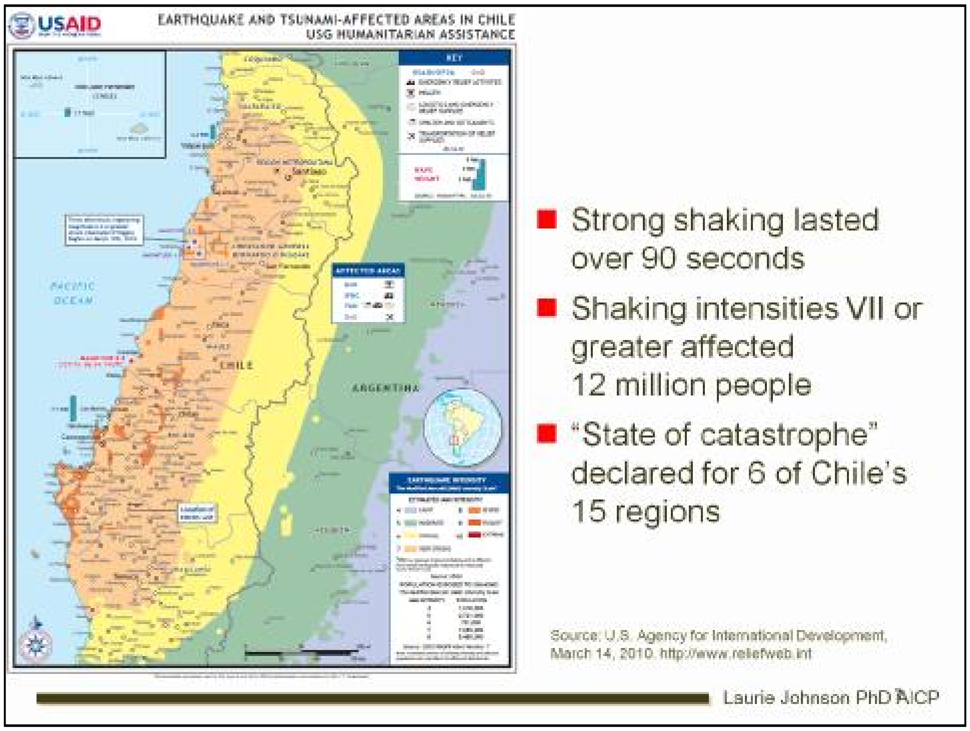
Laurie Johnson PhD AICP

Hundreds of aftershocks have hit the region since the main earthquake, including a M5.9 on Friday, April 23. The most powerful was a Mw6.9. Just within an hour on the morning of March 11, Chile had the equivalent of the Loma Prieta and Northridge earthquakes. The aftershocks are so large that they create their own aftershock patterns. This cross section shows how the earthquakes extend inland and at increasing depths (shown in colors ranging from orange to blue) along that subduction zone boundary.

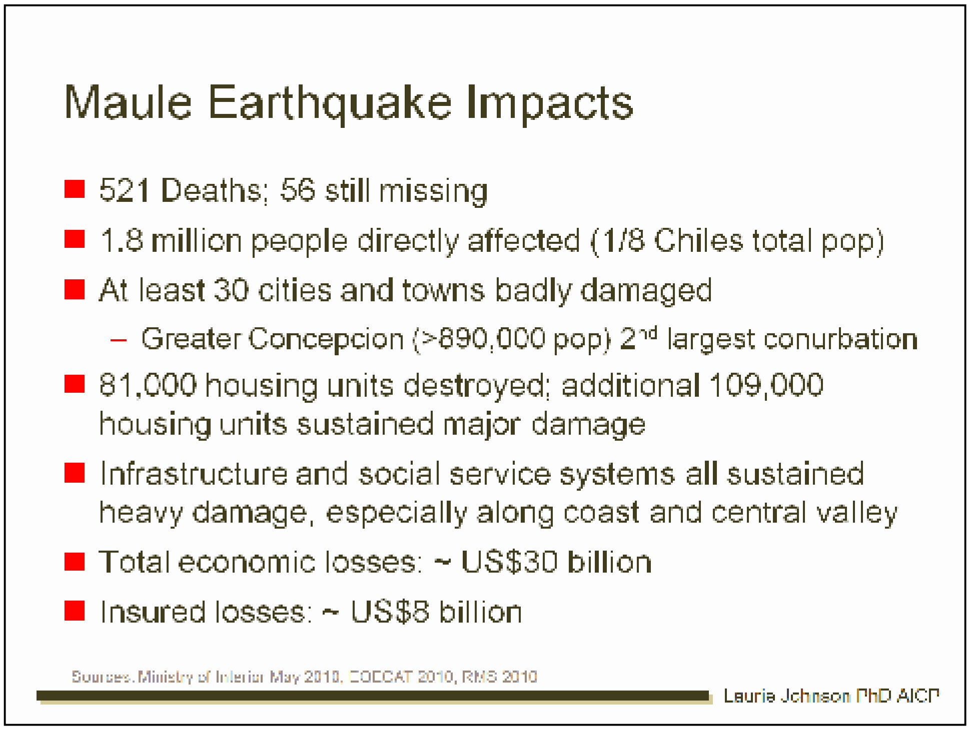


As the earth ruptured during that initial shock, it displaced a large volume of water that took the form of a tsunami that propagated across the entire Pacific Ocean. This graph shows the expected travel time and wave heights; luckily damage was minimal outside Chile and a few other places. However, near the epicenter along Chile’s coast, the tsunami made landfall in less than 30 minutes after the mainshock - at heights of 3 meters or about 10 feet.

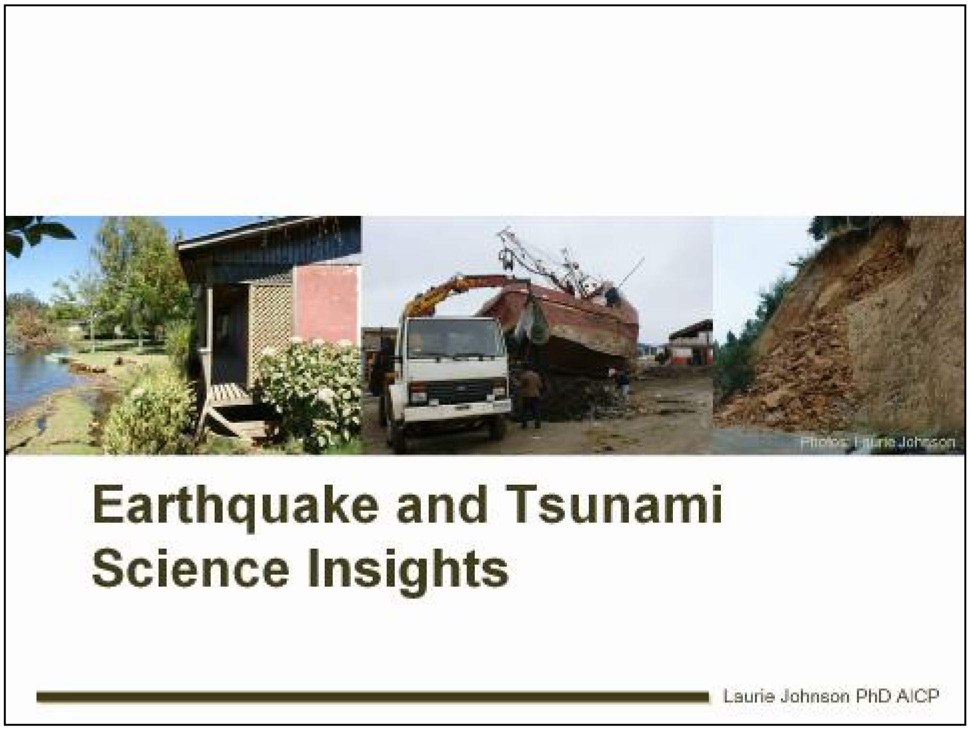
A few comments about Chile. It is a democratic nation, with a population of about 17 million. Its economy is strong, comparable with other strong performing nations in central and south America, like Costa Rica and Argentina, or central European nations like Poland and the Czech Republic. It is a strong international exporter with major industries of fishing, shipping, mining (particularly copper), refining, forestry, winemaking, and agriculture.



The earthquake struck the most industrialized, modern, densely developed parts of the country that includes the nation's capital city, Santiago, the central valley corridor, and major port areas around Valparaiso and Vina del Mar to the north and Concepcion and Talcahuano to the south. Strong shaking lasted over 90 seconds in some places, and affected a vast area and over 2/3 of its population. A state of catastrophe was declared for 6 of Chile's 15 regions (which operate somewhat like states). The earthquake was named after the Maule region, where the epicenter was located.



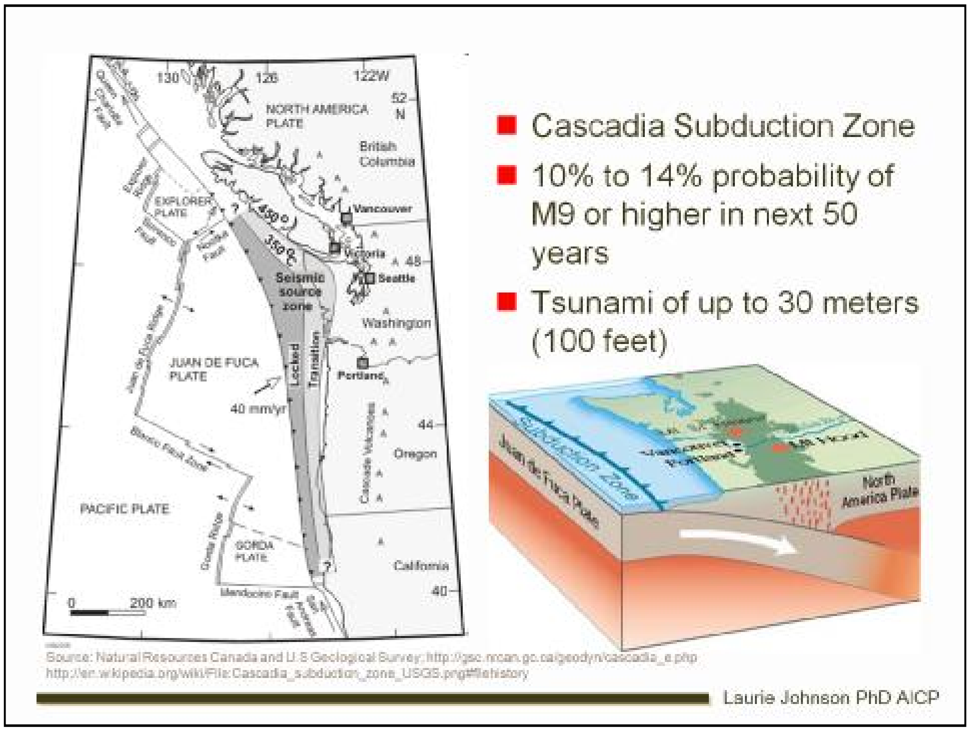
At least 30 cities and towns were badly damaged, nearly 400,000 housing units severely damaged or destroyed, and most infrastructure and social service systems were initially disrupted and sustained heavy damage, especially along the coast and in the central valley towns. Total economic loss estimates range from 15 to 30 billion U.S. dollars (which is about 10 to 20% of Chile's annual gross domestic product). Yet, given the enormous size and massive amount of energy released by this event, the life loss was very, very low.



I've structured the rest of the presentation to provide some highlights of the key early lessons we are learning from this earthquake, first with respect to the science, followed by engineering, and socioeconomic insights.

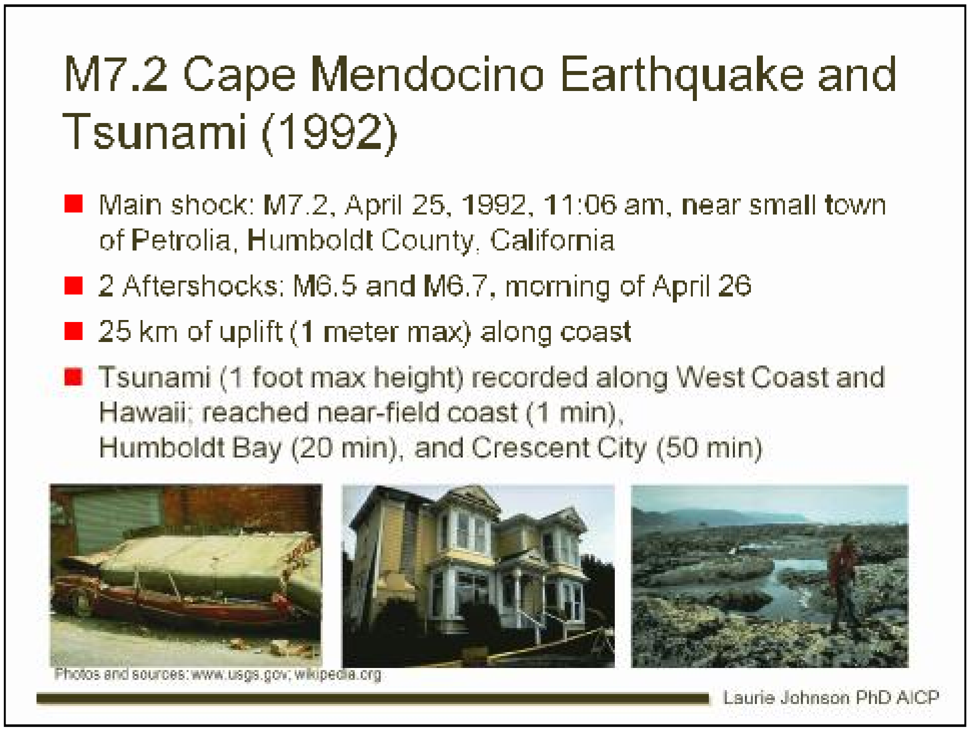
If you have ever been to or plan to go to Chile, one of the most remarkable things that you are likely to see is just how similar Chile's coast is to the U.S. West Coast. The geography, topography, and vegetation are all similar to parts of Oregon, and northern and southern California. As I mentioned, the February 27 earthquake impacted a vast area with a north-south distance of about 600 km (370 miles), which is roughly the same distance between LA and San Francisco, or from the northern California border up to Seattle.

Chile's subduction zone is one of the most active in the world (with plates colliding at a rate of 80 mm per year) and it is capable of generating very large earthquakes. Since 1973, Chile has had 13 earthquakes of M7 or greater, and the M9.5 earthquake of 1960 was the largest ever recorded in the world.

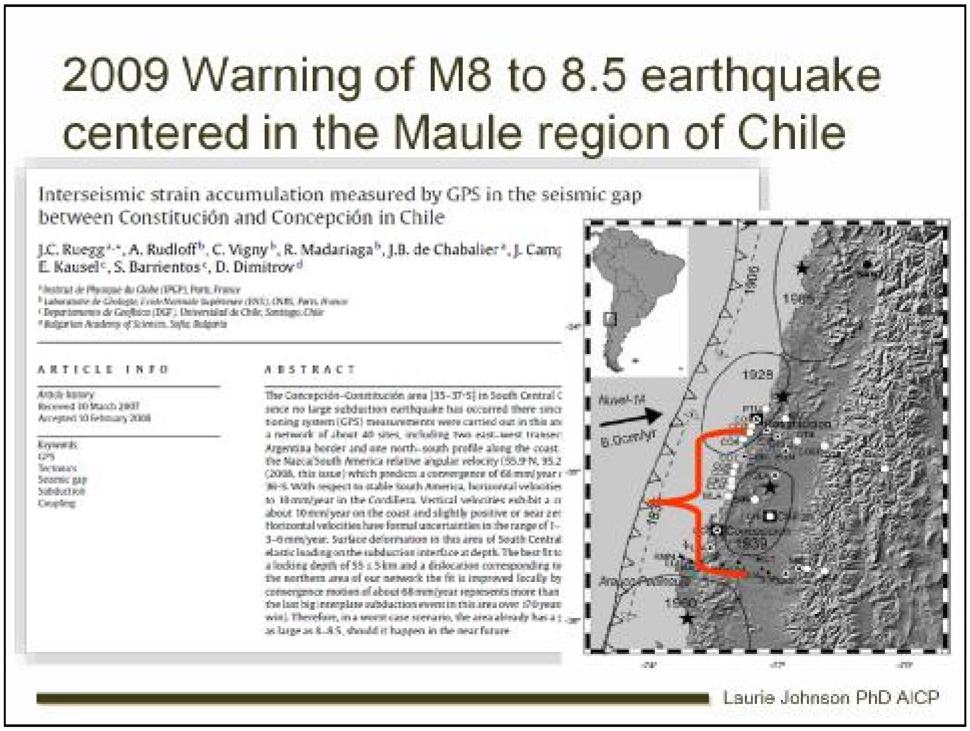


The geology of Chile's coast is also very similar to the U.S. West Coast. The Cascadia subduction zone starts in far northern California and all the way up the coast into British Columbia. Here, the Juan de Fuca plate is colliding with the North American plate at a rate of 40 mm per year, or about half the rate of Chile's. But, the Cascadia subduction zone doesn't rupture as frequently as Chile, and geologic evidence indicates that great earthquakes have occurred at least 7 times in the last 3,500 years, suggesting a return time of 300 to 600 years. The last known great earthquake was in January of 1700, which set off a great tsunami that struck Japan. Recent studies have concluded that the Cascadia subduction zone is much more hazardous than previously thought. Estimates are that there is a 10 to 14% probability of a M9 or greater earthquake occurring in the next 50 years. Such an earthquake would also set off a tsunami capable of reaching heights of 30 meters (100 feet). An earthquake of this magnitude would cause widespread destruction throughout the Pacific Northwest.

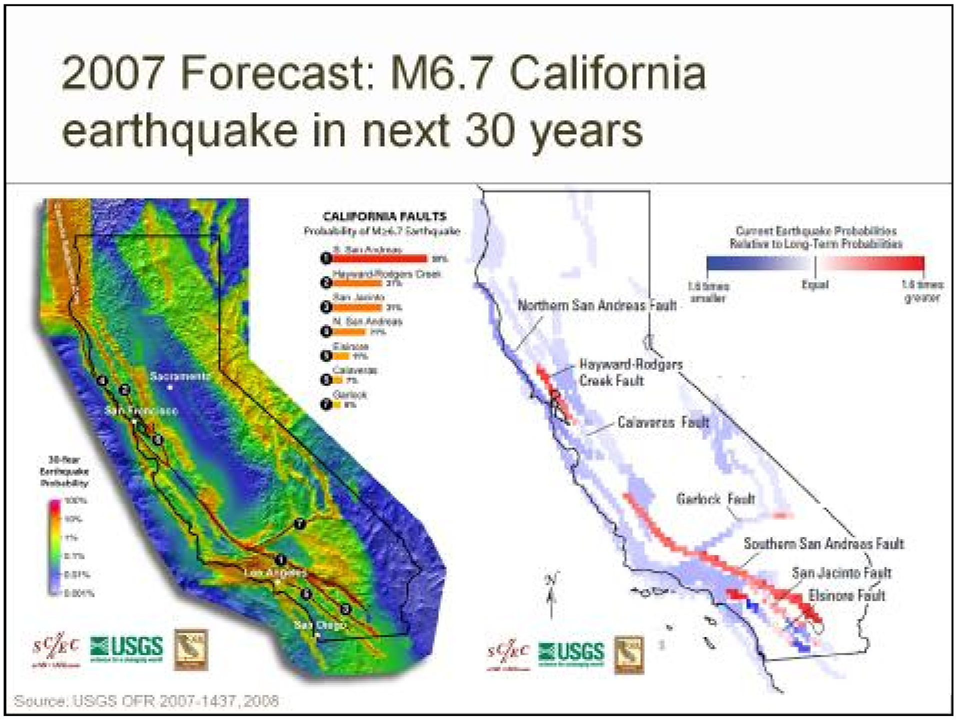
Other similar subduction zones in the world usually have such earthquakes every 100–200 years; the longer interval here may indicate unusually large stress buildup and subsequent unusually large earthquake slip.



A similar but smaller earthquake of M7.2 struck on April 25, 1992, at 11:06 am, at the boundary between the Cascadia and San Andreas systems in the Cape Mendocino area of northern California. Two additional shocks of magnitudes 6.5 and 6.7 occurred the next morning. The main shock generated uplift of up to 1 meter along a 25 km section of the coast and caused a tsunami that reached the mouth of Humboldt Bay in about 20 minutes after the shaking with wave heights of about 1 foot. It reached communities closer to the Cape in even less time. The tsunami arrived at Crescent City in 50 minutes and was detected in Oregon, the San Francisco Bay Area, Santa Barbara, and Hawaii. Although not destructive, the earthquake is a good indication of the kinds of effects we would likely see, but at a much more destructive scale, in a M9 Cascadia event.

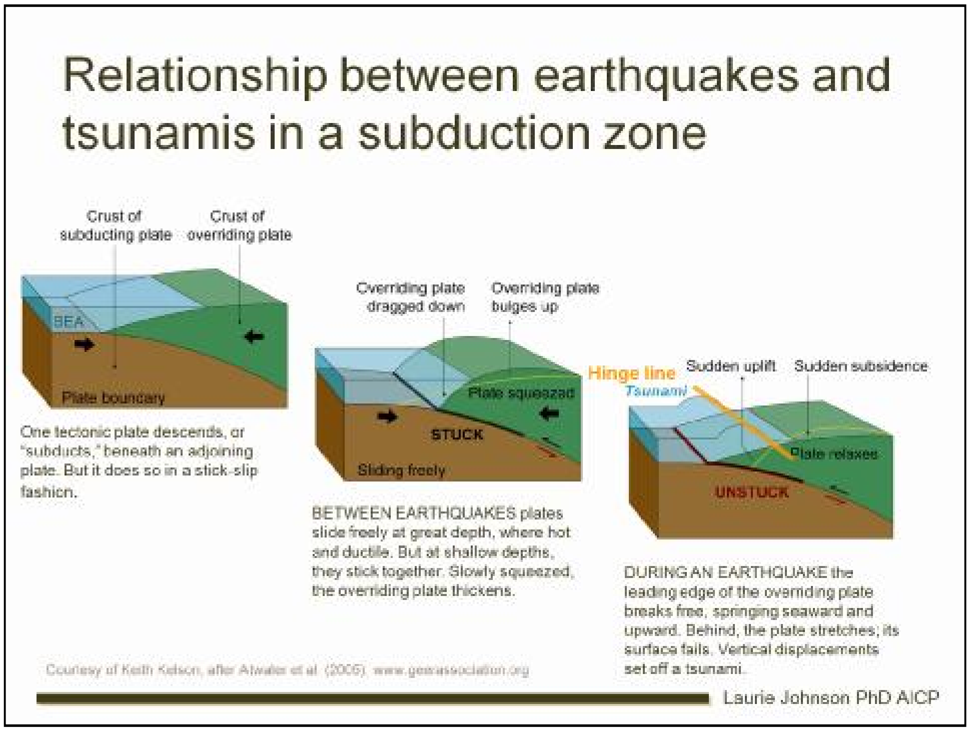


Similar to the Haiti earthquake in January, a scientific study was published one year before the Chile earthquake, reporting that strain accumulation were excessive in an area the fault system that had not experienced a major earthquake since 1835. The authors warned that a rupture in this "seismic gap" north of the city of Concepcion could generate a M 8 to 8.5 earthquake. As much as we would like for there to be more precise predictions, these recent multi-decadal forecasts based on advanced methods are proving to be extremely accurate.



A similar forecast was made in 2007, by the Working Group on California Earthquake Probabilities, which warned of a nearly 100% likelihood of having a M6.7 earthquake in California in the next 30 years. Their forecast, source by source, ranks the southern San Andreas as the most likely generator (60%), followed by the Bay Area's Hayward-Rodgers Creek fault and So Cal's San Jacinto fault (both with a 30% likelihood). It is based on similar geological methods that consider recurrence intervals and strain accumulations. A 100 mile section of the southernmost section of the San Andreas fault (running from San Bernardino south to the Mexican border) had its last major earthquake in 1690. The section to the north of San Bernardino last ruptured in 1857 in the Fort Tejon earthquake. Strain accumulations across these two sections suggest that we are now at, or passing, their mean recurrence intervals of 300 and 140 years, respectively.

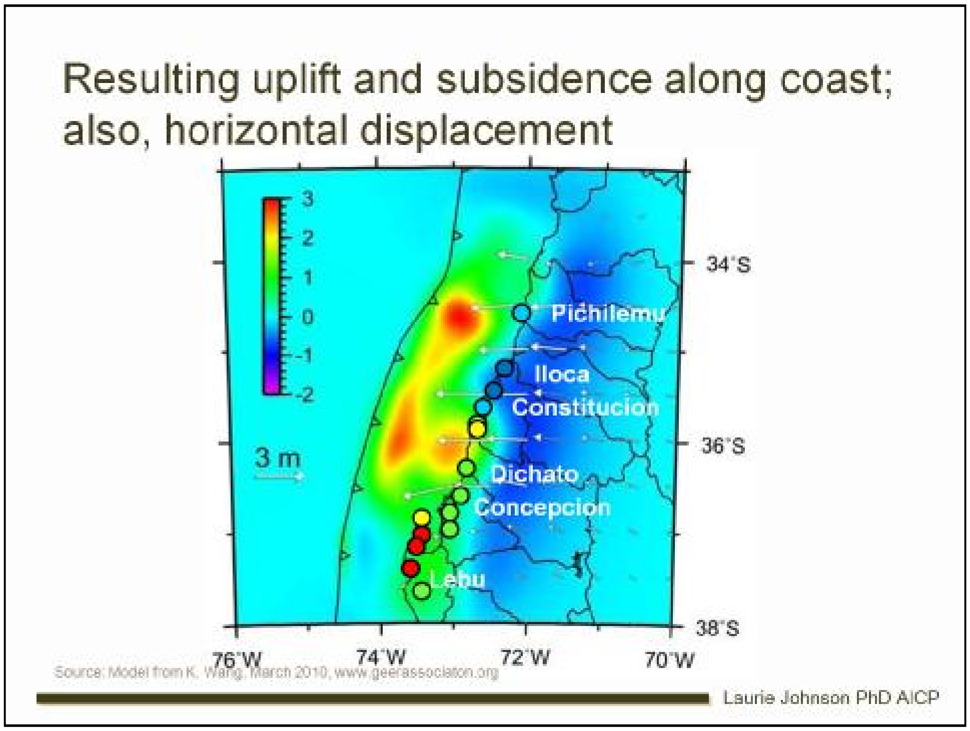
The section of the plate boundary system just to the south was the source for the recent M7.2 earthquake that struck on Easter Sunday. This photo is of the rupture along the Borrego fault – the main source – which has exhibited about 3 meters of both horizontal (right lateral) and vertical slip. The rupture set off a major aftershock sequence that has extended north onto the San Andreas system, and rattled southern California for the past couple of weeks.



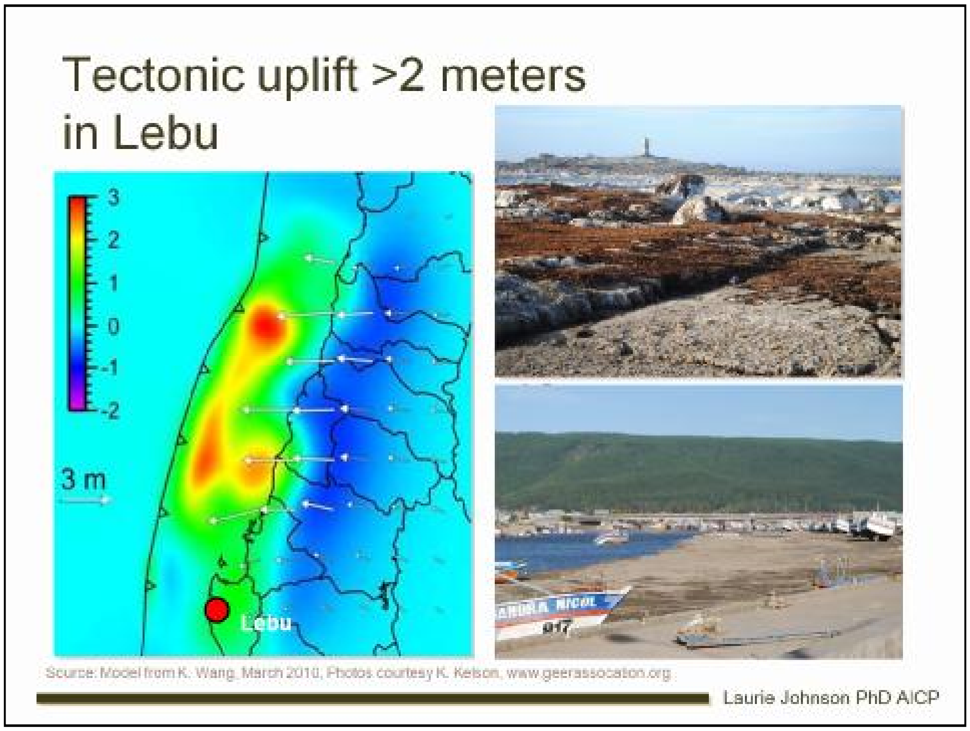
A important question that has been asked since the February 27 earthquake is why the resulting tsunami was so much smaller and did not have the far field effects of the 2004 Sumatra earthquake. I hope this set of diagrams will help illustrate what happened. Here we see a model looking from north to south of the Chilean (or this could be the Cascadia) subduction zone, with the seaward plate descending underneath the continent.

Between earthquakes, stress builds up as the plates get stuck which results in a bulging, or uplift, of the continental plate.

When the earthquake occurs, the plates un-stick and the overriding plate springs seaward and upward. That upward motion displaces a volume of water that becomes the tsunami. Onshore, the surface bulge relaxes. The point at which the surface of the earth is either relaxing or springing up is called the hinge line. (shown here in orange).



In the February 27 earthquake, that hinge line meandered on an offshore as the model illustrates, with areas in shades of green to red being uplifted and areas of blue to purple subsiding. Although the rupture length was long, some of it was also very near to, or onshore, therefore substantially reducing the volume of water displaced. The earthquake rupture also occurred at a much greater depth of 40 km (compared to 20 km for the 2004 earthquake). Both of these factors, helped significantly reduce the size of the tsunami in this earthquake, compared with the 2004 earthquake. But, this rupture also caused major uplift and subsidence of the coastline, and the land around Concepcion moved an estimated 3 meters westward.



Part of my research focused on understanding the permanent deformation that is likely to result to the land, as well as impacts to buildings and infrastructure, as a result of these movements. One of the most dramatic illustrations of the permanent effects was in Lebu, on the south end of the rupture zone which saw uplift greater than 2 meters. Lebu's harbor has been severely impacted as illustrated in these photos – with the former lighthouse island becoming a peninsula and boats being stranded. The impacts to subsurface systems were also significant and still being evaluated by other experts.

View of Concepcion from across Bio Bio River. Photos: Laurie Johnson

Engineering and Lifeline Insights

Laurie Johnson PhD AICP

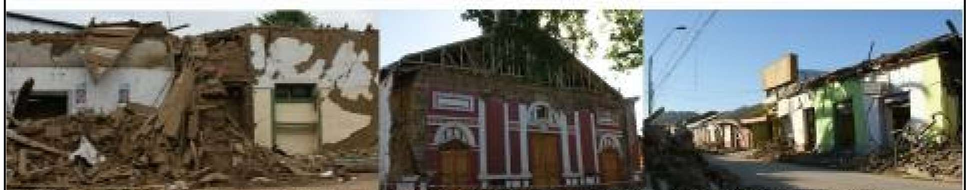
Now to focus more on the built environment. Chile has had seismic design provisions in its building codes since 1935, and the standards are comparable with the U.S., Japan, and Turkey. Generally, seismic codes get stricter with time and most of Chile's recent construction follows the 1996 and 2003 updates of their building code. This collage of photos taken of Concepcion from across the Bio Bio river shows the modern skyline, with older single story buildings and one of 4 major bridges collapsed in the foreground.

Much of the Chilean earthquake-affected region is zoned (in the building code) to require buildings to handle up to 0.4 g (force of gravity) in peak ground accelerations. Some ground motion records exceeded 0.4 g, and thus even some modern structures were not designed to withstand such levels of ground motions. The earthquake also generated strong, long duration ground motions. Structures that are most vulnerable to these long-duration waves are long bridges and tall buildings. Some modern high-rise, reinforced concrete, apartment buildings sustaining significant structure damage which may be a result of code inefficiencies and/or construction practices.

Poor performance of adobe, masonry, and non-engineered buildings

- 62% of destroyed dwellings were adobe construction

	Housing Units Destroyed	Housing Units Significantly Damaged	Housing Units with Minor Damage	Total Housing Units
Coast	7,931	8,607	15,384	31,922
Urban Adobe	26,038	28,153	14,869	69,060
Rural Adobe	24,538	19,783	22,052	66,373
Multi-unit Public Housing	5,489	15,015	50,955	71,459
Multi-unit Private Housing	17,449	37,356	76,433	131,238
Total	81,444	108,914	179,693	370,051



Adobe damage in Parral and Constitución. Photos: Laurie Johnson; Source: Housing damage, Government of Chile, March 29, 2010

In general, newly built structures performed fairly well while older buildings sustained heavier rates of damaged. And, as these governments statistics show, over 60% of the dwelling units that were totally destroyed, were of the oldest and most vulnerable of construction types in Chile – adobe buildings. In Chile, about 25% of the country's building stock is older without any seismic design provisions. And for comparison, in California, estimates are that more than 80% buildings were constructed before 1970 (and before the major code changes that followed the 1971 San Fernando, 1989 Loma Prieta and 1994 Northridge earthquakes). Thus, while California has only a few adobe structures from the colonial days, it does have many buildings that are vulnerable to serious damage or collapse.

Seismic provisions in Chile's building codes saved lives and met performance objectives

Structures built between 1985 and 2009

Buildings that Collapsed	4 (approx)
Buildings to be Demolished	50 (estimate)
Number of 3+ story buildings	9,974
Failures of 3+ story buildings	0.5%
Number of 9+ story buildings	1,939
Failures of 9+ story buildings	2.8%

Source: Jack Moehle, www.peer.berkeley.edu; Courtesy of R Lagos, Chile

renelagos engineers

Laurie Johnson PhD AICP

Looking more closely at the modern structures, data obtained from Rene Lagos, a Chilean engineer, reports that there were approximately 11,913 structures built between 1985 and 2009 that were shaken by this earthquake. Of those, four buildings collapsed and about 50 (some other estimates are as higher as 150) will need to be demolished. Approximately 2.8% of the 1,939 buildings that were 9 or more stories failed, and 0.5% of the 9,974 buildings of 3 or more stories failed. This is an important and remarkable set of statistics that offer many insights. The predominant building type in Chile, especially in taller 9+ story modern structures, is reinforced concrete. It is rare that a high rise isn't reinforced concrete. It is similar to the types of tall buildings being constructed along the west coast.

Still, there were a few spectacular failures

Rio Alto apartment building, Concepcion; Photo courtesy of Jack Moehle, www.peer.berkely.edu

Laurie Johnson PhD AICP

While nearly all of them performed very, very well, even when subjected to the maximum design levels of shaking, a few did not. This building was in the news and the site of a major search and rescue operation for several days. You are looking at a view of the entrance to the building's underground parking garage on the left, and the building has toppled over onto its back with the base shown here in the upright position. A major commission has been appointed to investigate the cause of this buildings collapse,…

Questions of design, construction quality, and enforcement

Apartment building, Concepcion; Photo courtesy of Jack Moehle, www.peer.berkeley.edu

Laurie Johnson PhD AICP

But already national and international engineering experts are raising questions about the design, construction quality, and code enforcement practices, particularly in recent years. Here is another reinforced concrete building that sustained substantial damage to the upper floors.

Another major issue that we also saw in the Nisqually earthquake and in California in Loma Prieta and Northridge are the contribution to damage that soft or poorly compacted soils can make. Engineered structures in deep alluvial basins around Santiago, in the floodplains of towns located along rivers in the central valley, or in areas of higher water tables along the coast and waterways were all impacted by these vulnerable soil types. These images are from a business park in northeast Santiago; several well built buildings suffered extensive damage that was likely caused by the amplified ground motions that happened at this site.

Significant nonstructural losses even when buildings undamaged

- Nonstructural systems very comparable to U.S. – nonstructural walls, ceiling tiles, M/E/P equipment and distribution systems
- Code-specified nonstructural protection not enforced

Laurie Johnson PhD AICP

While there are many, many more engineering lessons, I want to focus briefly on the issue of non-structural losses which were quite significant even in structurally sound buildings. Nonstructural systems in Chile are quite comparable to the U.S. – in fact they call the ceiling tile systems, California ceilings,. These images are from two hospitals that were closed because of non-structural damage. Damage to ceilings, nonstructural walls, mechanical, electrical and plumbing equipment and distributions systems were all quite significant and are leading to major delays in business resumption. Even those Chile has code-specifics for nonstructural protection, it is not well enforced – also a problem we have in many places in the U.S.

Distinguishing cause of loss:
Shaking or tsunami? Similar to wind vs. surge

Laurie Johnson PhD AICP

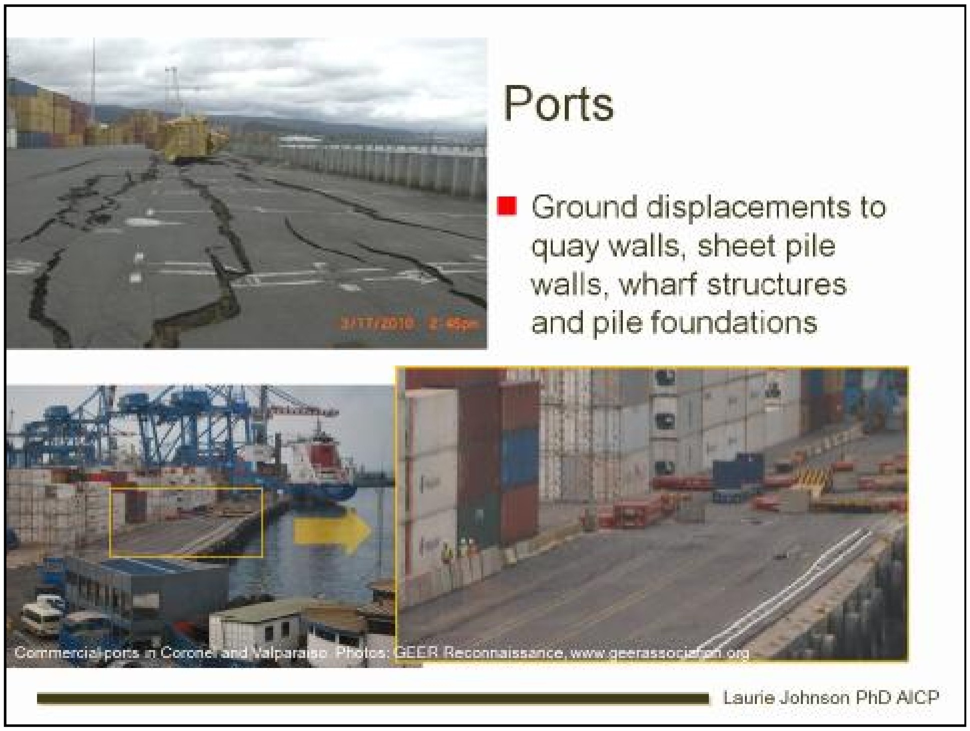
Another major issue that we need to think about is distinguishing the cause of loss. These images of modern buildings that were both shaken and then impacted by the tsunami, look eerily familiar to buildings impacted by both wind and surge. It is difficult to know how much of the damage was actually shaking related when the structure has been washed away.

Refineries: Aconcagua (west of Santiago) and Bio-Bio (near Concepcion)

- Both refineries initially shut down (e.g. loss of power, check critical elements, appraise possible damage); only minor, non-critical structural damage
- Aconcagua (98,000 bpd capacity) had only minor damage and restarted in 10 days
- Bio-Bio (130,000 bpd capacity) sustained relatively minor damage but with more substantial effects
- Damage from fallen heater refractory
- Ground failures damaged floating roof tank and steel crude oil pipeline
- Gasoline and diesel is being imported into the service area
- 3 to 7 months estimated to restore operating capacity

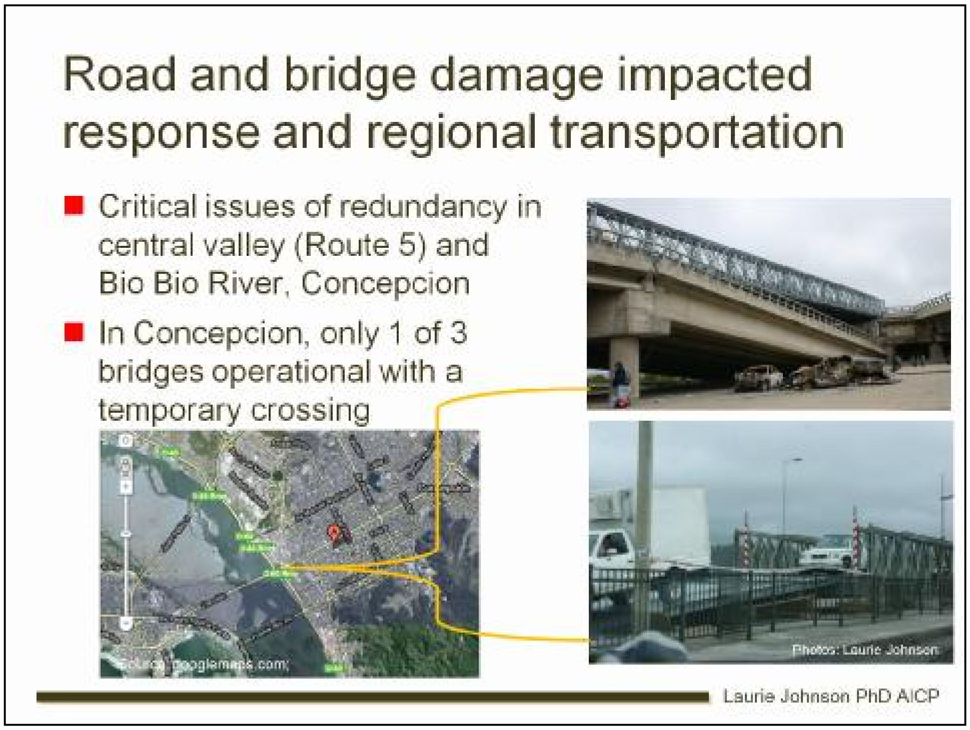
Source: Modified ASCE TCLEE Chile web report, May 2010, www.eeri.org; Photo: Laurie Johnson

Laurie Johnson PhD AICP

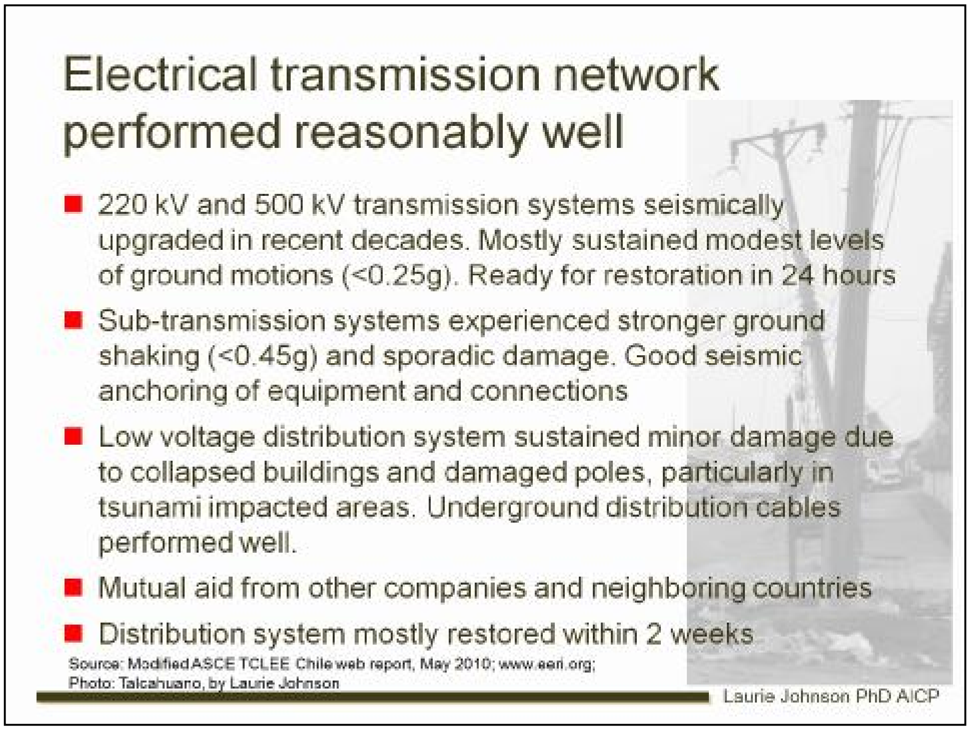


Ports, which are a critical lifeline in Chile’s export economy, also experienced significant damage from ground deformation. Damage was observed in the foundations and walls of several major wharfs at ports in Valparaiso (bottom images) and Coronel (top image). Coronel, which is south of Concepcion, suffered lateral spreading and liquefaction, causing displacements of over 1 meter. Containers feel, sinkholes erupted, but there has not been a significant amount of damage to cranes or other major equipment.

Chile has 35 operational ports (10 state owned, 25 privately owned). 2 are military ports. 95% of exports & 90% of imports are conducted through ports. Valparaiso Port. Significant movements and backfill settlements of up to 50cm and 20cm, respectively were observed at the concrete-block gravity wall (public dock). Significant movements were observed at commercial dock. These involve quay wall displacements and backfill settlements exceeding 1m and 0.3m, respectively. No surface expression of liquefaction was observed.



As I mentioned at the start, all the lifeline systems suffered damage and much of it was already being repaired when we were there 2 weeks after the earthquake. Certainly subsurface damage will take much longer to find and fix, and more detailed studies will be coming out in the next few months. I'd like to address one issue briefly and that is damage to roads and highway bridges. Damage to these systems impacted the country's response efforts and is still having a major impact on the region's recovery as trucks have to navigate the reroutings on the country's major artery through the central valley – route 5 – and over the mountain highways to the coastal ports. In Concepcion, only 1 of the 3 highway bridges over the Bio Bio was operational. I showed a previous image of one of the most heavily damaged and collapsed Bio Bio bridge. The John Paul the 2nd at the far north was also destroyed. In mid-March only the middle bridge – the Llacolen – was in operation. While the bridge itself was in good shape, all the approach ramps had been damaged. Temporary steel structures were being installed. Traffic delays was quite substantial.

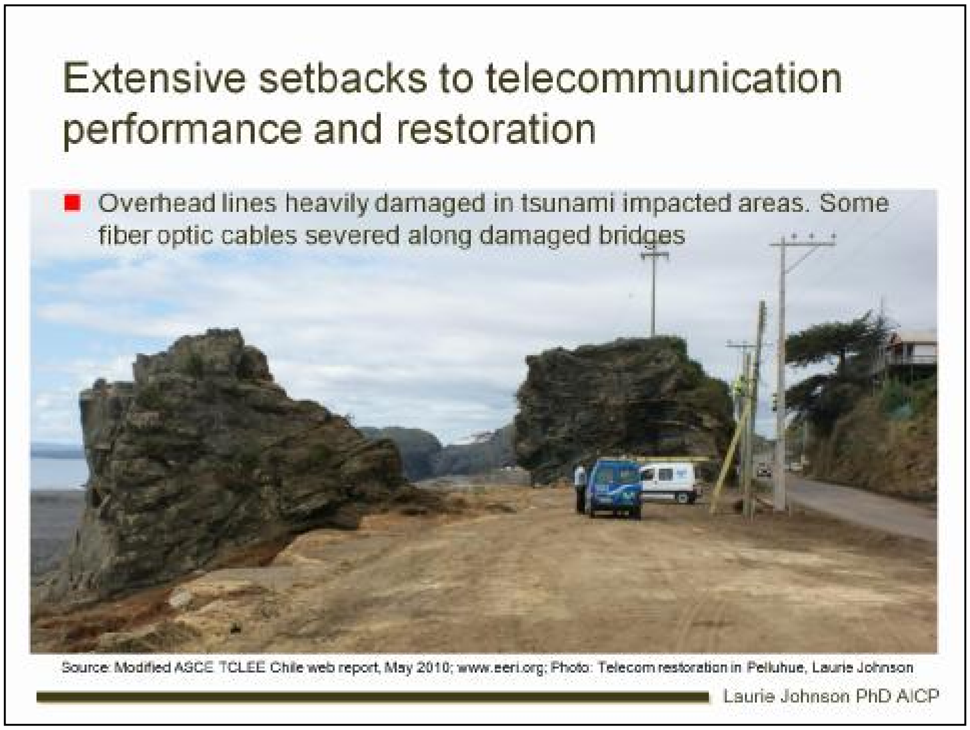


Ground shaking and ground failures impacted all lifelines and damaged to buildings, bridges, highways, railways, ports, and systems involving water, waste water, gas and liquid fuel, electrical, telecommunication, as well as contributing to lifeline interdependency issues.

•The hardest hit regions were Region VII and Region

VIII. We understand that one company had to replace a total of 450 poles and lost 1,500 poles

out of an installed base of 759,000, and 82 transformers out of 50,109.



All service providers, both landline and wireless services, experienced extensive setbacks due to commercial power outages, equipment failures, building failures, and loss of reserve power in most distributed network facilities (base stations, small remote switches, and digital loop carrier (DLC) remote terminals).

Cell site towers are designed based on wind load. Based on our collected information, one operator had issues with antennas in 50 % of their sites. At least two towers collapsed, one was a monopole design on poor soil while the other was mounted on a concrete water tank that collapsed.

Many utilities that relied on wireless service were having difficulties within the first week after the earthquake to dispatch maintenance crews to damaged sites in order to restore service.

Another example of damage is that a backup generator failed due to a transfer switch problem, which was used to power the air conditioner. This caused overheating of electronic components that resulted in equipment malfunction.

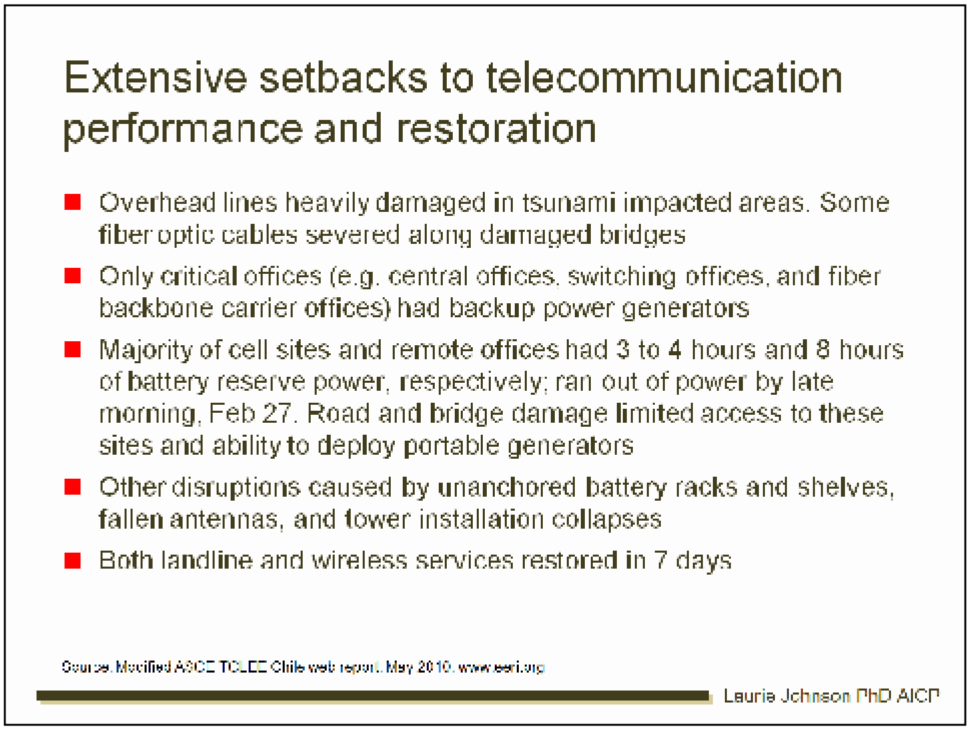
About 70 % to 80 % of the cell sites in regions VII and VIII had problems with either equipment or antenna damage. This rate falls to about 50 % in region V, mostly in sites located in rooftops. Cell sites do not typically anchor equipment. Switches and MTSOs have seismic designed equipment.

Fallen perimeter walls or nearby construction collapse affected operation in a few cell sites.

Although fiber optic cables were severed in many locations mostly due to collocating on bridges and overpasses, alternative links provided by another company allowed to some transmission circuits for inter LATA (local access and transport area) operation.

Close to 200 outside plant DLC or DSLAM remote terminals were affected mostly due to lack of power. Close to 150,000 landline subscribers were affected mostly in small remote offices with less than 5000 subscribers again due to power problem as none of these sites have backup power generators.

There were many logistical problems in order to refuel sites with permanent generators or at sites where portable generators were deployed. It was difficult to buy or rent portable generators. Some of them were provided by affiliated companies outside of Chile. Diesel supply was difficult to ensure. Some network operators had some supply contracts in place before the earthquake. Road conditions and lack of power at diesel supply points affected recovery operations. Lack of personnel and need for maintenance also affected diesel supply. Theft of batteries, generators and diesel was an additional problem not expected.



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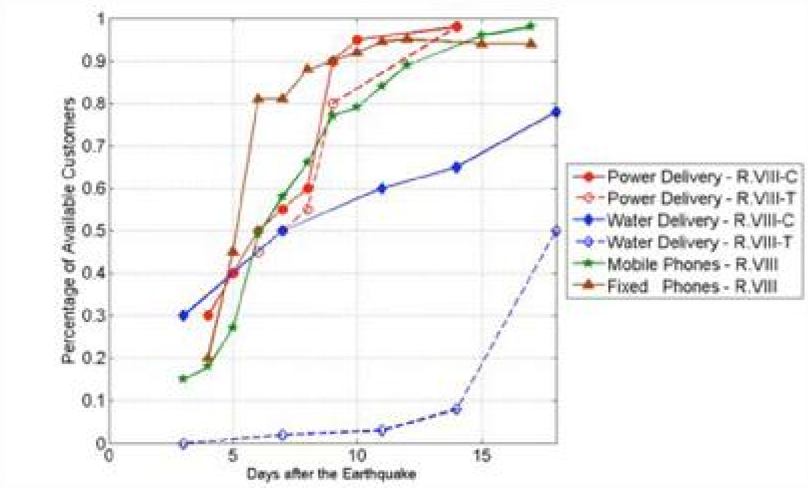
, but disruption impacted emergency response communications and many utility and business restoration efforts

Heavy damage to water and wastewater systems in both cities and rural areas

- Essbio water serves 4 million people in urban areas: 7,000 km of transmission and distribution lines (1,200 km in Concepcion)
- Most system damage in Concepcion and Talcahuano. 72 breaks in main (500mm+) lines and 3,000 repairs to smaller lines (as of April 12 2010)
- Leak rate (as of April 12, 2010) at 60%; it was 40% prior to earthquake
- Concepcion water treatment plant also damaged
- Rural water systems (particularly tanks) damaged
- Government water trucks provided relief supplies
- Heavy damage to wastewater systems from ground deformation; untreated sewage discharged into rivers and ocean
- Canals across central valley also sustained damage and impacted agricultural production

Source: Modified ASCE TCLEE Chile web report, May 2010; www.eeri.org; Photo: Water line in Talcahuano by Laurie Johnson

Lifeline interdependencies increased loss of functionality and delayed restoration efforts



Source: Modified ASCE TCLEE Chile web report, May 2010; www.eeri.org

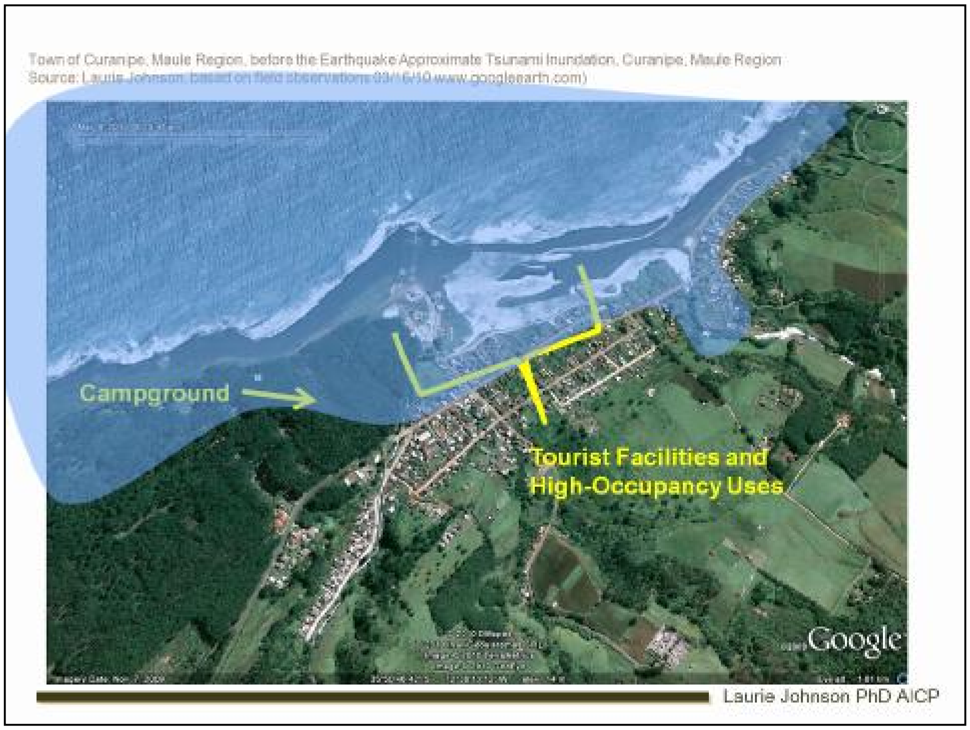
Laurie Johnson PhD AICP

Socio-economic and Governance Insights

Laurie Johnson PhD AICP

Recovery is moving remarkably well in most places in Chile. The country is in good financial shape and there will be considerable government funding for housing repairs and other non-insured losses. Now, to close with a few socioeconomic and governance lessons.

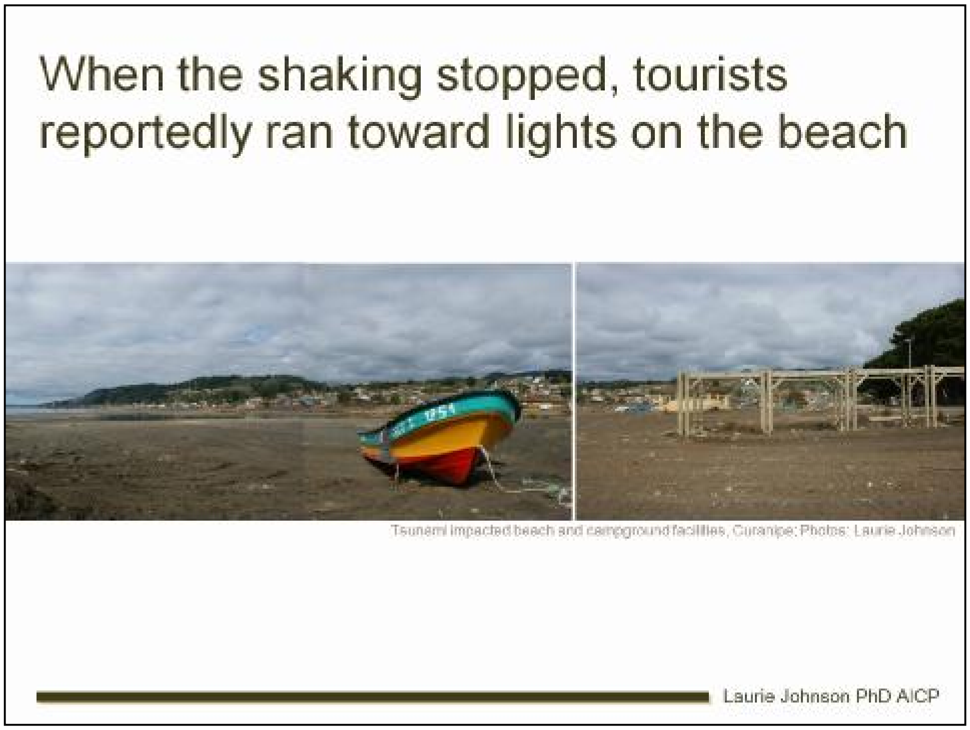
The first has to do with casualties. Although all the forensic data wasn't available to us, media and local reports indicated that most the earthquake related deaths were caused by the tsunami. And many were tourists. It was late summer in Chile and a peak weekend for tourist travel to the coast. This was particularly problematic since the earthquake struck just after 3:30 am, and power was immediately knocked out in many places. Many people we spoke with recalled how bright the moonlight was, how many people were still partying in crowded discos and other tourist facilities at the beaches, how warning systems did not work, how locals knew that a tsunami was likely after an earthquake and ran for higher ground as soon as the shaking stopped, but tourists did not. Now, looking back, there is much blame being laid with local governments who had not used the tsunami inundation maps that had been developed by the Chilean navy in the past few years, how high occupancy, tourist and camping facilities were located in the inundation areas, the national and local warning systems and signage were inadequate, and that there was a major breakdown in emergency communications at all levels of government.



The town of Curanipe is a very popular beach resort just north of the earthquake's epicenter and therefore was struck by the tsunami in less than 30 minutes after the shaking.

A campground, restaurants, hotels, discos, outdoor amphitheatre and other facilities were all located in the low-lying area along the beach.

The approximate inundation area of the tsunami is shown in blue.



Local officials who we spoke with said that many people were down on the beach, sleeping in the campground, or in the discos when the earthquake struck. While residents ran for higher elevation areas, many tourists reportedly were unfamiliar with tsunamis and just ran toward visible lights, which happened to be on the beach. There were at least 40 deaths here.

In U.S., nearly 500 cities and 1 million people vulnerable to tsunami

State	# Cities Susceptible to Tsunamis	Population Endangered by 50-foot Tsunami
Alaska	52	47,000
California	152	589,500
Hawaii	123	131,000
Oregon	60	31,500
Washington	102	96,000
Total	489	895,000

Source: TsuInfo Alert, 2000

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Since 2004, the west coast states have substantially ramped up their tsunami hazard mapping and response planning efforts. A worldwide warning system is now operational. But, there are substantial populations exposed to the risk, many are in the near-field of a Cascadia event that might leave them with little time to escape.

Long-term ripple effects in specific sectors

Fish processing plant closures are impacting the economy both locally and nationally


Port San Vicente, Talcahuano, Photos: Laurie Johnson

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Additional post-disaster losses caused by looting and fires

- Looting and civil unrest erupted throughout the central region, even in areas with relatively little damage
- Recovery has stalled in some places as residents want to stay safely away

Concepcion city center and Talcahuano port area; Photos: Laurie Johnson

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Residents of remote coastal villages reported strangers coming in to loot.

Key Insights

- Can we make better use of rupture forecasts issued in advance (e.g. Haiti, Chile, and the West Coast)?
- There will be lessons that translated into both code changes and cat risk modeling changes
- Many insights for risk management now, particularly in reducing risk of nonstructural and business interruption losses, warning and evacuation planning, and multi-level coordination

State of California

Republic of Chile

JOINT DECLARATION

State of California

Republic of Chile

JOINT DECLARATION BETWEEN
THE STATE OF CALIFORNIA, UNITED STATES OF AMERICA,
AND
THE GOVERNMENT OF THE REPUBLIC OF CHILE
ON COOPERATION IN EMERGENCY AND DISASTERS

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THANK YOU!

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