Newsletter

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Better Managing New Zealand's Earthquake Risks

This speech was given by Hon Dr Nick Smith, Minister for Building and Construction, Minister for the Environment, on 25 January 2017. Dr Smith's experience as a civil engineer is manifested in this lucid analysis of policy issues related to earthquake risk in New Zealand.

"A big worry in this Trump era of modern politics is that complex issues are dumbed down to 140 character tweets. The beauty of this annual opportunity you give me as Nelson's MP is to give a far more considered and thorough account of a topical issue. The focus of this 22nd Rotary address is the steps we are taking to improve New Zealand's management of earthquake risks.

We were dubbed the Shaky Isles 170 years ago and at two minutes past midnight on November 14 we got another harsh reminder of why. That Kaikoura quake was the largest in New Zealand since 1855. We are one of the most seismically active countries in the world and we need to be at the leading edge of protecting people, infrastructure and the economy from earthquakes.

The challenge in government is that there are all sorts of risks to manage – financial, terrorism, biological, trade, climate change, fire, and cyber-security, as well as the natural risks of floods, volcanic eruptions and cyclones, as well as earthquakes. We cannot pretend that government can eliminate these risks and we will always be limited in the resources we have to reduce them. My long term ambition as a Minister and as a rare engineer in Parliament is to try to ensure as a country we manage these risks and allocate resources based on science-based risk assessment. Politics and rational science are not close relatives, but tonight is an attempt to bring them closer together.

It is worth recalling our history of seismic events. We have had eight fatal earthquakes post-1840, or about one every 20 years. While it is true that two majors inside six years is unusual, we should treat the 40-year lull between Inangahua and Christchurch as unusually long.

There is no evidence the frequency of earthquakes in New Zealand has changed. GNS measures about 15,000 a year, of which 150, or one every three days, is felt. What has been unlucky is that we have had major quakes close to major population centres where the effects are so much greater.

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It is useful to compare the risks to life from earthquakes to other risks. Our history points to an average loss of three lives a year from earthquakes, as compared to 300 a year from road accidents, 120 a year from drowning and 30 a year from house fires. You can see in these numbers why I placed huge importance in getting a new law through Parliament last year requiring smoke alarms in rental properties, when the costs are so small in comparison to earthquake strengthening and the number of lives saved so much greater. These stats are not to discount the risks from quakes, but to keep the relative risk in perspective.

Average expected fatalities are just one factor to take into account in determining priorities. Earthquakes will cost New Zealand close to $50 billion in both public and private sector costs this decade, of which the Government's share is about $20 billion - $18 billion for Christchurch and $2 billion for Kaikoura.

The loss of life from earthquakes in New Zealand pales by comparison internationally. The 185 deaths in Christchurch compares to 230,000 in the 2004 Boxing Day quake and tsunami in Indonesia, the 160,000 killed in Haiti in 2010, the 16,000 killed in the Tohoku quake in Japan of 2011 and the 70,000 killed in Sichuan quake in China in 2008.

It is of note that the last decade has been the deadliest on record for earthquakes globally and that fatalities have been on the rise over the past half century.

The big killers are building failures and tsunamis. The reason for the significant rise is not any increase in seismicity but many more people living in the cities and in coastal areas. Improved building seismic resilience and better managing tsunami risks are the issues we should focus on to reduce future fatalities.

New Zealand's comparatively low level of fatalities despite being one of the most seismically active areas of the world is due to both our relatively low population density and the huge improvements in building standards over the past century.

The Christchurch and Napier earthquakes were similarly sized quakes but whereas one in 100 died in Napier, in Christchurch one in 2000 died. This 95 percent reduction in fatalities can largely be attributed to the huge improvements in buildings' seismic resistance. To put it another way, there would have been about 4000 fatalities in Christchurch were building standards left as they were in 1931. The key issue for my Building Minister's role is how we further improve our engineering and building standards into the future.

It is not my intention to spend too much time on the seismic and engineering sciences, but there are a few core facts needed to explain the Government's priorities and direction of policy. The first is to communicate the scale of energy release in a seismic event that makes designing and constructing earthquake resistant buildings so challenging. The Richter scale used to report earthquakes is logarithmic. An increase from a 5 to a 6 magnitude quake actually represents a 32-fold increase in the energy being released.

To get some sense of scale, the Christchurch 2011 quake at a 6.3 involved a release of energy equivalent to four Hiroshima atomic bombs. The Kaikoura earthquake at 7.8 was 180 times more powerful and the equivalent of 800 Hiroshima bombs. But the magnitude 9, mega thrust Tohuku earthquake that struck Japan in 2011 was 80 times stronger again and the equivalent of 60,000 Hiroshima bombs. So my first point is that earthquakes involve the release of phenomenal energy and that we cannot make our buildings totally safe.

The Christchurch earthquake was comparatively small and made deadly not by its size but by its location. We need to be prepared for the worse scenario of a Kaikoura or Tohoku scale quake close to a major city.

The analogy I would make to improved building design is the improvements made in vehicle standards.

Cars today are not 100 per cent safe in a crash but the risk of fatality has been made an order of magnitude better by smart design.

The challenge with buildings is more difficult because cars generally last 15 years, whereas buildings last 100, buildings are generally one off designed whereas cars are massed produced and accidents occur far more frequently than earthquakes, enabling design lessons to occur far more frequently. The common feature is that while we can make buildings a lot safer, a big enough crash or quake will still result in fatalities. My greatest concern is about the thousands of vintage buildings still in use that pose the most risk.

The second important scientific fact relates to the cause and probability of earthquakes. We heard all sorts of phantom theories about earthquakes being triggered by the phase of the moon, by oil exploration activity and from Destiny's Brian Tamaki that sexual sinning was the cause. Earthquakes are caused by the sudden movement along faults of the earth's tectonic plates and the timing cannot currently be predicted beyond probability estimates.

I was particularly offended by the moon-man, who caused widespread alarm in 2011 when he publically predicted a major shake at the Sign of the Kiwi on Christchurch's Port Hill's at a particular date and time. I was part of Skeptics New Zealand's protest on site to highlight the nonsense of such pseudo-science. Extensive studies have shown no correlation between phases of the moon and earthquakes.

The science does, however, tell us two things about the probability of earthquakes. There are no surprises that the risk of earthquakes varies significantly with geography, i.e. that Wellington is much more prone than Auckland but the scale of difference needs highlighting. We would expect a significant earthquake of intensity MM8 in Wellington about once every 120 years, in Christchurch or Nelson every 720 years, in Dunedin every 1700 years and in Auckland once every 7400 years. For the record, the most high risk earthquake locations are Arthurs Pass, Hanmer Springs, Hokitika, Masterton and Kaikoura. The importance of this is that we need to focus our policies on the areas of greatest risk and avoid imposing excessive costs in areas like Auckland and Dunedin, where the seismic activity is low.

The second factor about the timing of earthquakes that we know is that they are much more likely after a significant quake. One of the worst psychological impacts of earthquakes is the long tail of aftershocks that can last several years. There is nothing more soul destroying than fixing the sewer pipe or removing the liquefied silt only to have it re-break and re-appear time and time again.

The last technical issue I want to cover is an explanation of why some buildings failed and others did not in the Kaikoura earthquake. People have been both mystified and unnerved by the fact that many older buildings labelled as earthquake prone had minimal, if any, damage in Wellington, while other new modern buildings had life-threatening partial failures. The explanation for this lies in the way the frequency of shaking interacts with the natural frequency of a building.

Every building has a natural frequency. If you give it a strong enough shove, it will naturally rock back and forward with a particular frequency. A short building may have a period of 0.2 seconds, but a tall building may be at over 2 seconds per sway. If the frequency of the earthquake's shaking coincides with the building's own frequency, it will experience much more extensive damage.

An earthquake will typically release a whole lot of shaking frequencies, but the short sharp shaking abates in close proximity to the quake. So the Kaikoura earthquake in Wellington had strong frequency shakes in the range of 0.8-1.2 seconds that lasted for an unusually long time. That affected buildings in the five to ten storey range. For these buildings, the earthquake was stronger and longer than the design standards required. But these same buildings would not be the most vulnerable in a major quake close to the city. The one and two storey, unreinforced masonry buildings that were untouched by the Kaikoura quake would be more likely to be hugely damaged and cause significant loss of life in a closer quake.

The Government has been severely tested by the challenges of the Christchurch and Kaikoura earthquakes and, while some mistakes have been made, I think history will judge our Government well. I particularly give tribute to Gerry Brownlee who, through the Canterbury and Kaikoura earthquakes, has done the lion's share of the work.

We have poured in billions of dollars, passed special pragmatic laws to facilitate the rebuild, bailed out failed insurers to protect householders and acted decisively on getting infrastructure quickly fixed.

The responsibility is not just to rebuild but to learn every possible lesson so as to improve our resilience as a country to future earthquakes.

Tonight I want to outline a dozen initiatives we are taking to achieve this.

1. New Earthquake Prone Building Act
2. Adding Natural Hazards To The Resource Management Act
3. Post-Quake Building Act Reform
4. Improving Consistency Of Building Assessments
5. Standards And Training Of Engineers
6. Powers For Addressing Newly Identified Risks
7. Tackling High Risk Parapets And Facades Post Kaikoura
8. Supporting Heritage Buildings Upgrades
9. Improving Tsunami Warning Systems
10. Supporting Innovative Design
11. Investing In Seismic Research
12. National Policy On Natural Hazards"

The full text of these twelve initiatives can be found at:
https://riskfrontiers.com/better-managing-new-zealands-earthquake-risks/

Storm Direction Controls Coastal Erosion Risk in New South Wales

By Thomas Mortlock

Between 3 and 7 June 2016, an East Coast Low (ECL) storm caused widespread flooding, wind damage and coastal erosion along the eastern seaboard of Australia. Wave heights measured offshore of Sydney were not exceptional, but beachfront properties experienced some of the worst erosion losses in 40 years. Recent research suggests the major cause of erosion was the unusual north-easterly wave direction, which may have significant implications for future coastal management along the east coast [1].

Wave direction controls probability estimates

The peak storm wave height measured offshore is a key design parameter for coastal engineers and is commonly used as an indicator of coastal erosion potential. For example, most seawalls are built to prevent overtopping up to a 1 in 100-year storm wave event and erosion hazard planning uses similar design conditions. However, annual return intervals (ARI) of extreme ocean wave heights can change dramatically according to wave direction.

For example, the peak storm wave height measured at the Sydney buoy on 5 June 2016 was approximately 6.5 m which - based on 35 years of observations - is exceeded, on average, once every two years. Coastal wave conditions were clearly less

Figure 1 Waves at South Narrabeen on Monday 6th June 2016. These conditions don't occur every other year! Images reproduced with permission from Mark Onorati.

frequent than this (Figure 1), and beach monitoring showed more sand was eroded from Sydney beaches during this storm than the benchmark ‘1 in 100-year’ event, the ‘Sygnia Storm’, of 1974 [2]. Evidently, the peak-wave-height method can grossly under-estimate erosion risk if wave direction is ignored.

When extreme values are recalculated to include wave direction, the June 2016 storm becomes a 1 in 30-year event. While this is a more realistic estimate, it still does not explain why the erosion response in 2016 was larger than other ECL events over (at least) the past 40 years.

Wave power retained across the shelf

There have been many more powerful ECL storms than the 2016 event, but few have produced waves from north of southeast (only 8% over the past three decades at Sydney). Large storms such as those in 1974, 1997 (the ‘Mothers Day Storm’), 2001 and 2008 (the ‘Pasha Bulker Storm’) all produced waves from the south of southeast because of the cyclonic rotation of the low-pressure systems.

While rarer, easterly and north-easterly storm waves retain a higher portion of their offshore wave power by the time they arrive at the NSW coast. This is because they approach normal to the coastline, meaning shorter travel distances across the continental shelf and thus dissipate less energy via friction with the seabed, than do waves approaching from oblique angles.

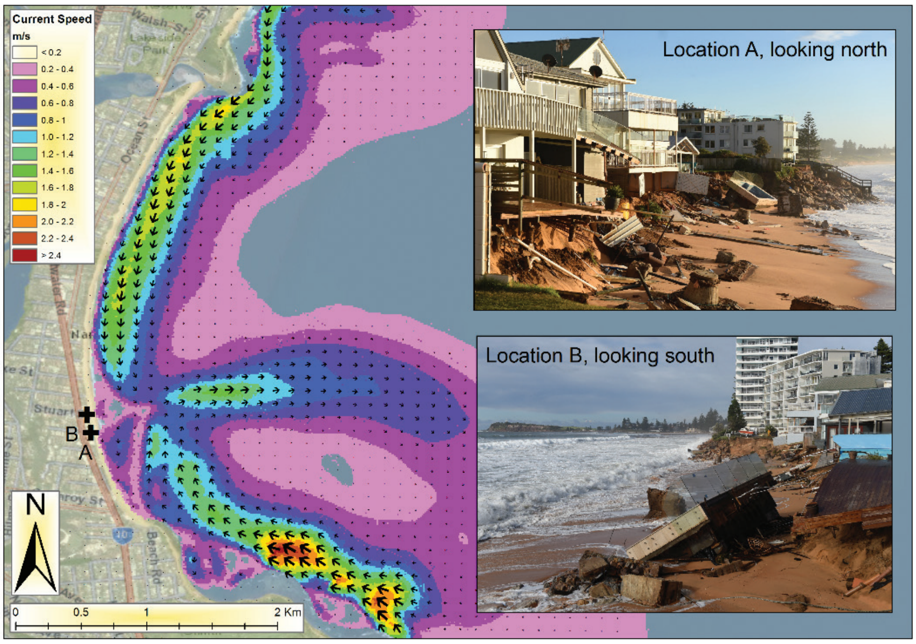

Figure 2 Modelling of water current speed and direction at Collaroy-Narrabeen during the June storm. A mega-rip cell is formed at Collaroy exactly where the most severe erosion damage occurred. Long Reef is located at the far south of the image.

This means smaller storm waves from the east and northeast can produce more powerful coastal wave conditions - and erosion - than do larger storm waves from the south.

Coastline shape amplifies erosion risk

The present-day NSW coastline has evolved over the past 6,000 years during a period of relatively stable sea level and under a predominantly south-easterly wave climate. As a result, the northern sections of beaches up and down the coast are more exposed to wave energy while the southern ends receive much less, and are often protected by rocky headlands. This south-to-north gradient in wave energy at the coast controls the morphology of the beach and dunes – both being lower and narrower towards the southern ends.

For this reason, NSW beaches are particularly vulnerable to storms from the east and northeast because wave energy is focussed on southern beach sections not equilibrated with high wave exposure under the prevailing south-easterly wave climate.

Collaroy particularly vulnerable

Collaroy, a suburb situated at the south end of the Narrabeen-Collaroy embayment on Sydney’s Northern Beaches, was one of the worst affected areas in June 2016. Six properties, including some multi-unit blocks, were declared structurally unsafe and residents were evacuated.

The shorefront at Collaroy is characterised by years of inappropriate development into the active beach zone, contributing to its reputation as one of the State’s erosion ‘hot-spots’. Our modelling now shows that the geometry of the Collaroy embayment, in particular Long Reef headland, amplifies erosion during east and north-easterly storms.

During most wave conditions, Long Reef shadows Collaroy and Fishermans Beach from wave energy, but during east and north-easterly storms it contributes to a mega-rip circulation which instead focusses erosion at Collaroy (Figure 2). The location of rip currents is well known to correspond to areas of beach erosion as they facilitate the offshore transport of sand during a storm. In areas where the beach is severely lowered, waves can attack adjacent dunes and undermine structural foundations of buildings.

Implications for coastal management

The June 2016 ECL highlighted the importance of storm wave direction for coastal erosion risk in NSW. While an unusual event in the context of the past few decades, extreme wave events from this direction are projected to become more common for Southeast Australia in the future with climate change [3,4].

Regulatory requirements for both shoreline recession and beach erosion planning currently ignore potential changes in wave direction under a warming climate. They also do not consider the significant impact less powerful storms from unusual directions can have on coastal risk. There needs to be a fuller examination of the implications of changes to the storm wave climate for the NSW coast to inform sustainable management practice for the coming decades.

The full research paper on which this article is based can be accessed at: http://www.mdpi.com/2073-4441/9/2/121.

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