briefing note
333
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The Mw 7.8 November 14, 2016 Kaikoura Earthquake, Briefing 4.

Paul Somerville Risk Frontiers 2 December 2016

Inspections and Occupancy of Government Buildings in Wellington

Speaking to Parliament's government administration committee on November 28, State Services Commissioner Peter Hughes said that the State Services Commission had made it clear from the start that properly qualified structural engineers had to carry out building assessments, while Hughes had worked with chief executives on how to ensure the checks were up to standard. He had asked government agencies to make early contact with unions and keep them informed of checks and repairs, while he met the Public Service Association last week to review what had been done so far.

Hughes said that of the approximately 32,000 state servants in Wellington, about 5000 had been displaced from their normal offices due to the earthquakes. Government agencies had been quite successful in getting most workers back into their buildings, while business continuity plans had kicked in to ensure services were maintained.

About 620 staff from Statistics NZ and the Ministry of Transport who worked in Statistics House were being relocated across two different buildings, with almost all staff expected to be back in an office by Christmas. About 300 staff at Environment House, which was expected to be cleared for re-entry in about four to six weeks, were now based at the Terrace, while about 1100 Ministry of Defence and NZ Defence Force staff were based at the Freyberg Building or at the Trentham military facility while damage to Defence House was assessed.

Hughes said most buildings in the government portfolio had performed well, with the exception of Statistics House, although even there the building performance met the code goal of avoiding deaths and injuries. While the chief executives of individual agencies were responsible for their own buildings, Hughes said they were meeting as a group weekly, with property managers working together as a single team. Asked what lessons government agencies had learned after previous earthquakes, such as in 2013, Hughes said many had outsourced their data storage to specialist providers in secure locations to avoid "downtime" after a significant shake.

Why midrise buildings in Wellington were the most badly damaged

A building is like a tuning fork with its own natural period of vibration (the time it takes for one complete back and forth sway). The natural period of a building can be approximately estimated by dividing its number of stories by ten. (The actual natural period also depends on the materials, structural system, etc., but this is a rough guide). So buildings of 1, 5, 10 and 20 stories have natural periods of about 0.1, 0.5, 1 and 2 seconds respectively. Buildings respond mainly to the ground motions having their own natural period because of resonance. The response spectrum shows the strength of the ground motion as a function of the natural period of the building.

The ground motion response spectra recorded in Wellington (Figure 1) shed light on why most of the damage in Wellington was to mid-rise buildings, as reported in Briefing Note 2. Figure 1 shows response spectral accelerations approaching 500 year code level at periods between 1 and 2 seconds, with exceedances of the 500 year code occurring at about 1.5 to 1.7 seconds on site class D sites.

The 500 year code spectrum is constant in acceleration between about 0.1 and 0.6 seconds period, and then decreases. This is comfortable for a building with a natural period of 0.6 seconds because the natural period of the building becomes progressively longer as it is damaged by the shaking, and the code ground motions are then lower at that longer period than they were at the start of the shaking when the building had a period of 0.6 sec.

However, the recorded response spectra on Class D sites in Wellington do not have that comfortable behavior of the code spectrum. They become larger as the period of the building increases beyond 0.6 seconds, so the ground motion that the building is sensitive to gets progressively stronger and more damaging as the shaking proceeds and the period of the building grows above 0.6 seconds, causing a positive feedback loop. The same would be true of buildings having a natural period anywhere between 0.6 and 1.4 seconds, potentially all midrise buildings on site class D in Wellington. The recorded spectra thus explain the concentration of damage in midrise buildings on Class D sites in Wellington. For low rise buildings (periods of 0.1 o 0.2 seconds), the response spectra are at about one-fifth the 500 year code level in Figure 1, but they reach or exceed code level at 1 to 2 seconds period, corresponding to midrise and high rise buildings.

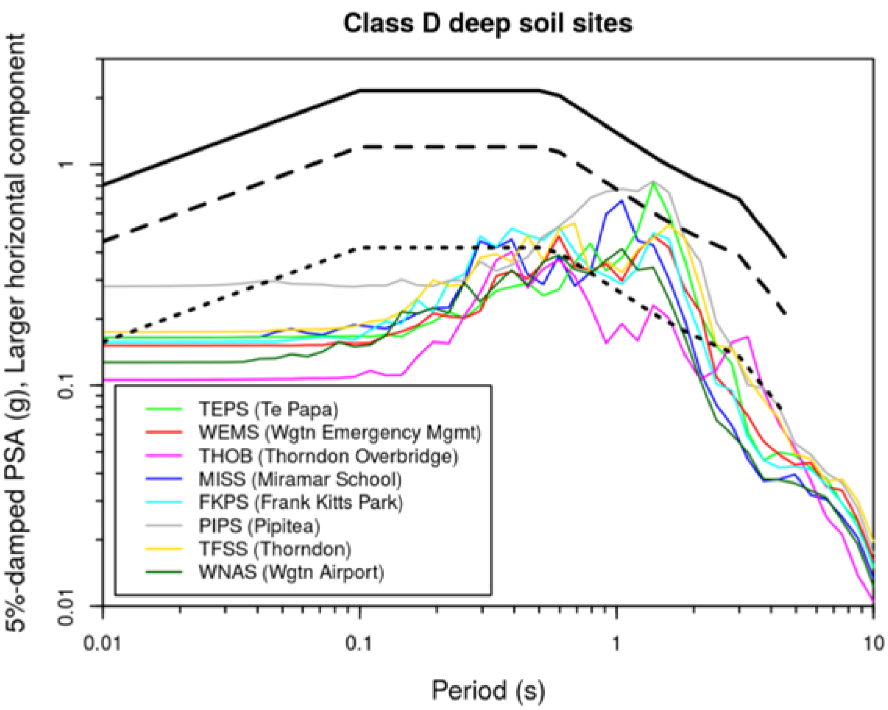

Figure 1. Response spectra recorded in Wellington compared with the code design spectra for site class D for annual probabilities of exceedance of 1/50, 1/500, and 1/2500 (short dash, long dash, and solid lines respectively). Source: GNS Science.

Slow Earthquakes on the Hikurangi Subduction Zone

The GPS stations of Geonet have detected slow earthquakes on the Hikurangi subduction zone (Figures 2 and 3). Slow earthquakes involve very gradual slip that occurs over a period of weeks or months without releasing any seismic energy, and indicate gradual movement on the plate interface. As stated on the Geonet website**,** *"The ongoing slow-slip event off the North Island's east coast has moved some GPS stations up to 2-3 centimetres. This movement is similar to what has been observed in previous East Coast slow-slip events over the last 15 years, so is not necessarily abnormal. We see events in this area usually every 1-2 years. We have also observed other slow-slip events happening in response to large earthquakes. The last slow-slip event offshore of Gisborne followed the Te Araroa earthquake in September 2016. A slow-slip event also occurred following the 2007 M6.7 Gisborne earthquake. (The current) slow-slip event is particularly interesting as it appears to involve slip along the plate boundary from Hawke's Bay up to East Cape at the same time. Normally we see slow-slip events in these regions but they are separated in time or happen one after the other, as was the case after the Te Araroa Earthquake. It is possible that passing seismic waves from the M7.8 earthquake caused stress changes that triggered the slow slip event." "The Kapiti-Manawatu slow-slip event has involved movement across the Hikurangi subduction zone plate boundary of between 5-7cm, equivalent to a magnitude 6.8 earthquake in the last two weeks. The Gisborne-Hawke's Bay event has involved slip across the plate boundary up to about 15cm, equivalent to a magnitude 7.2 earthquake."*

The bottom left corner of Figure 2 indicates that there has been slow slip of about 10 cm on the Hikurangi plate interface in Cook Strait between Seddon and Wellington (see Figure 2 of Briefing Note 3 for a map and cross section of the Hikurangi subduction zone). The USGS estimates that about 1 metre of slip occurred on the Hikurangi plate interface in Cook Strait during the Kaikoura earthquake (see Figure 1 of Briefing Note 3). Slow earthquakes release the stress on the plate interface, which is good, but indicate that movement is occurring on the plate interface, which could be bad if it accelerates and becomes a potentially large earthquake on the Hikurangi trough beneath Wellington.

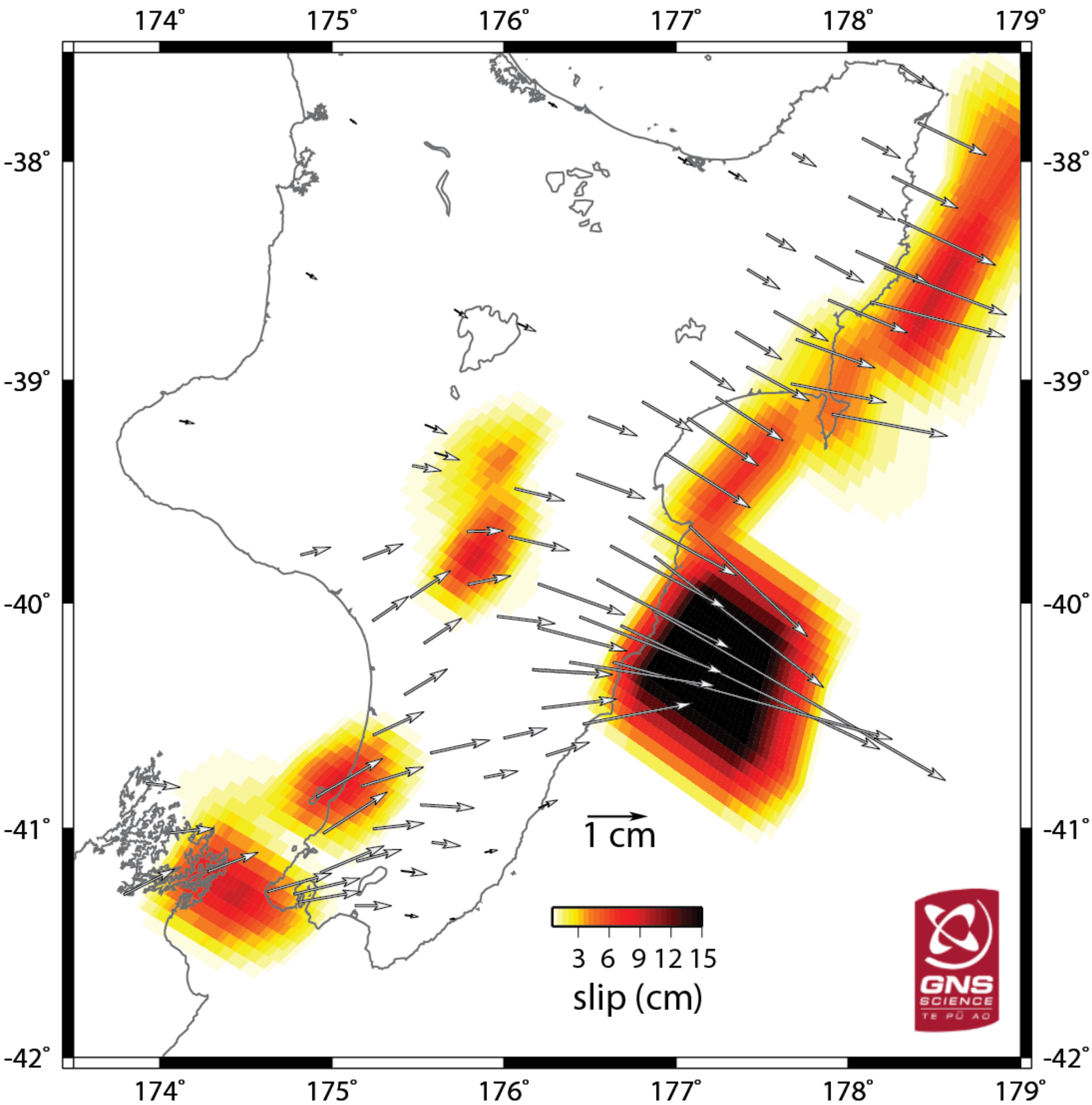

Figure 2. Patches of slip on the Hikurangi subduction plate boundary beneath the North Island. GPS station movements are denoted by the arrows. Source: GNS Science.

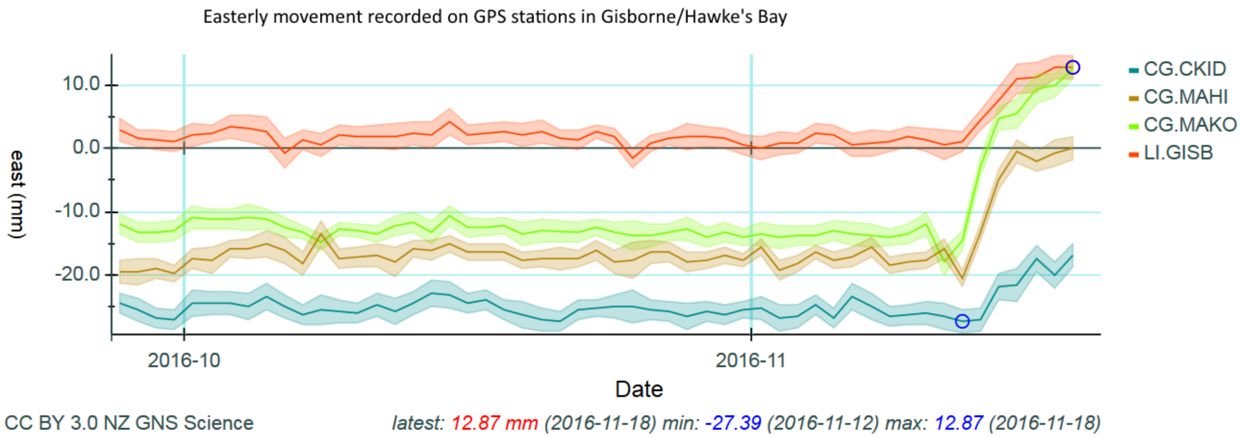

Figure 3. Easterly movement of the ground recorded by GPS stations in Hawke's Bay. Source: GNS Science.