Christchurch Earthquakes Workshop: Response and Recovery Lessons from the 2010-2011 Earthquake Sequence in Canterbury, New Zealand

Summary Report – February 12, 2013, Seattle, Washington

The impacts and opportunities that result when low-probability moderate earthquakes strike an urban area similar to many throughout the US were vividly conveyed in a one-day workshop in which social and Earth scientists, public officials, engineers, and an emergency manager shared their experiences of the earthquake sequence that struck the city of Christchurch and surrounding Canterbury region of New Zealand in 2010-2011. Without question the earthquake sequence has had unprecedented impacts in all spheres of New Zealand society, locally to nationally – 10% of the country's population was directly impacted and losses total 8-10% of their GDP. The following paragraphs present a few lessons from Christchurch.

The Canterbury sequence began in September 2010 with the M7.1 Darfield earthquake in the Canterbury plains, just west of the city of Christchurch. In the immediate aftermath the citizens of New Zealand felt some satisfaction about their apparent resilience, having experienced no fatalities, only 2 serious injuries, damage to older brick and unreinforced masonry buildings (URMs), and a large but not shocking, direct cost of $4-5 billion. This sentiment was shattered in February 2011 when a M6.3 aftershock ruptured beneath Christchurch, causing 185 fatalities, scores of injured, complete closure of the central business district (CBD), loss of 80% of the historic districts and thousands of residential homes, and a cost in excess of $20 billion. Since then, the region has experienced 58 M≥5.0 aftershocks.

> None of the earthquakes during the sequence occurred on previously known faults.

The Canterbury earthquake sequence had many geologically remarkable characteristics, with ramifications for all other aspects of life. A shallow depth, updip rupture propagation that focused energy toward the Christchurch city center, and possibly large stress drops led to extraordinarily large accelerations during the February 2011 M6.3 aftershock. The widespread and repeating episodes of liquefaction were exceptional features of the sequence, and changed conditions affecting other hazards. Some places experienced significant liquefaction 7 times, causing subsidence of several meters and thus increasing flooding hazards.

> The long-lived aftershock sequence crated challenges for insurance claim processing and building inspections, the

> latter taxing the pool of qualified inspectors needed for continual re-inspection.

Speakers noted a number of demographic lessons. In Christchurch, all buildings in the CBD and 7000 residential homes were abandoned and most will be demolished, particularly in the poorer neighborhoods.

> The siting of residential neighborhoods on known liquefiable terrain highlights the need for better land-use planning.

Many of the displaced residents quickly found temporary accommodation because of effective existing social networks, but a shortage of rental homes now exists and rental prices have risen substantially.

> Knowing that retention of residents and businesses is key to a city's recovery, government officials quickly provided temporary utilities where broken, and subsidies to stalled small- and medium-sized businesses allowing them to retain employees for 6 weeks.

While workshop speakers acknowledged that more should have been done to facilitate business continuity, by early 2012 Christchurch's population had returned to 95% of its pre-sequence size. New Zealanders seem to ascribe to the notion that positive attitudes promote progress. The loss of neighborhoods and the CBD is presented as an opportunity, having created new employment opportunities related to rebuilding and for urban revitalization, particularly in the CBD that had been deemed in need of such revitalization even prior to the earthquakes.
On the health front, the multiple benefits of preparing for natural hazards generally were demonstrated by the lack of illnesses that often result from failed water systems, which were abundant due the extraordinary liquefaction.

> The lack illness was attributed to hygiene measures instituted prior to the earthquakes in response to concerns about an H1N1 virus outbreak.

New insights that may change the messages targeted at public audiences preparing for future disasters resulted from a quantitative analysis of when and why injuries occurred after the February earthquake, made possible because hospital records were made available to social scientists. Analyses of these records showed that the vast majority of injuries were due to actions taken by citizens just after the earthquake, rather than due to and during the event itself.

The public and private sectors had many questions about and sometimes wavering confidence in hazard assessments issued prior to and during the sequence. The extraordinary ground motions in the February M6.3 earthquake, and rupturing of previously hidden faults led to questions about whether the hazard had been underestimated. When asked if the knowledge of these faults would have changed hazard assessments prior to the sequence speakers responded with an unhesitating "no". New data show that the sequence's causative faults have extremely low slip rates, such that even if known previously, inclusion in hazard assessments would have had negligible effect. In other words, the ground motions generated by the February M6.3 aftershock were already included in existing hazard assessments, as those low probability but large motions. What Christchurch experienced was expected probabilistically, including the levels of shaking-induced damage. Speakers emphasized that they learned that information was needed not about hazards alone, but about their impacts or risk.

> The public's nervousness was not adequately addressed by forecasts or aftershock probabilities, because forecasts were not accompanied by scenarios that painted pictures of the range of their possible impacts.

Scenarios and probabilities need to be presented in colloquial language (*e.g.*, not discussions of "design level" earthquakes). The need for evolving hazard assessments became apparent early in the sequence, demanded by the general public seeking reassurance that the future had some element of predictability, by engineers wanting to ensure the safety of inspectors, and all sectors involved in rebuilding. Current estimates show that the hazard for next 5 years will remain elevated above the 50-year average used in the building code.

Demands for public information generally taxed those responsible for overseeing response and recovery. Social media played an unexpectedly significant role in the response and recovery, and mostly facilitated positive activities (*e.g.*, formation and engagement a 10,000 student volunteer army). Greater readiness would have made social media an even more effective tool, and its use sometimes led to the rapid spread of rumors.

Lessons were learned about the benefits of preparedness measures, and challenges that arose when lacking.

> Awareness does not imply preparedness. Polling of the New Zealand public prior to September 2010 revealed that 75% of population had a high level of awareness about earthquake risks, but only 28% had taken preparedness measures at home and 10% at home and work.

Although a national disaster and managed starting at federal level, those at the top emphasized that a strongly top down approach no longer was effective. Moreover, they

learned that all decisions and actions needed to consider the view of the situation and consequences through the eyes of the impacted. The need to develop strong relationships between levels of government prior to any disaster was emphasized.

> Exercises testing coordination between local to national entities had not been conducted and would have led to more effective response and recovery.

Some established regional and local groups were caught without recovery plans when the mainshock struck, and struggled to develop them while also needing to implement them.

We conclude with a few questions and actions specific to urban areas in the US and particularly, Seattle (location of the workshop). The certainty in the financing of the Canterbury recovery contrasts markedly with that in the US. One speaker described Christchurch today as "an enormous urban renewal project paid for by insurance", because 80% of the losses will be covered by insurance. In contrast, insurance for earthquake damage would cover less than 20% in Seattle and California as a whole.

> The pattern of building failures in New Zealand demonstrated the extreme vulnerability of buildings built before modern codes, particularly unreinforced masonry structures (URMs).

This lesson has provided renewed momentum by the City of Seattle to address the vulnerabilities posed by its 1,000 plus URM buildings by crafting a retrofit ordinance to be presented to the City Council within the next year. Lessons about the benefits of having recovery plans in place prior to a disaster have motivated the City of Seattle to develop such plans, which now must be followed by training about and exercising them.

By sharing their experiences with the rest of the world, those in New Zealand responsible for the response and recovery from this remarkable earthquake sequence double the benefits of their work. We particularly thank the workshop speakers, who included David Johnston, Social Scientist at the GNS and Director of the Joint Centre for Disaster Research, Massey University; Kelvin Berryman, Natural Hazards Research Platform Manager and Earth scientist at the GNS; Tom Rasmussen, Seattle City Councilman; structural engineers Mark Pierepiekarz from MRP Engineering in Seattle and John Hare from Holmes Consulting in New Zealand; and John Hamilton, Director of the New Zealand Civil Defense Ministry.