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## **Opportunities in Disasters – A perspective from the Christchurch 2010 – 2012 Earthquake Series**

Williams, A.<sup>1</sup> Gibson, M.<sup>1,2</sup>

<sup>1</sup>Beca Ltd, P O Box 6345, Auckland 1141, New Zealand (ann.williams@beca.com)

<sup>2</sup>Stronger Christchurch Infrastructure Rebuild Team (SCIRT) (marcus.gibson@beca.com)

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On 4 September 2010, an earthquake of magnitude 7.1 occurred in Christchurch city, the largest city in the South Island of New Zealand, affecting both Christchurch and the surrounding Canterbury region. It has been followed by two major earthquake events (or groups of events) occurring on 22 February 2011 (M 6.3 and M 5.7) and 13 June 2011 (M 5.6 and 6.3) and significant events on 09 October 2011 (M 5.5), and 23/24 December 2011 (M 5.8, 5.3, 6.0, 5.0, 5.1), all at 5 km to 10 km depth.

The earthquakes have had a significant impact on the people of Christchurch, their physical and psychological well-being, their homes, infrastructure, buildings in the central business district and the economy. The region has been affected by widespread repeated liquefaction and lateral spreading on the plains, and rockfall and slope collapse in the Port Hills and Lyttelton areas. The 22 February earthquake resulted in 181 deaths, most of which occurred in the catastrophic failure of two multi-storey office buildings. A characteristic of the earthquakes has been the very large vertical and horizontal ground accelerations (vertical accelerations of up to 1.6 g and horizontal accelerations of up to 1.9 g from processed data) that have resulted in significant rock falls and slope collapse. Seven deaths resulted from rock falls.

Five years on from the most damaging of the earthquakes, we can see some of the opportunities that have arisen from them. They are many and arise from both technical and economic needs, but also the consideration of future accountability and include such things as:

- Development of a free access geotechnical database for Canterbury; the database includes geological maps, land use maps, crack maps, earthquake settlements and geotechnical borehole logs. The database is now being expanded to include all of New Zealand with investigation data being uploaded to the database in exchange for database access
- The collaboration of consultants and international experts to develop designs and resilience in key components of infrastructure that are difficult to repair or where failure would be catastrophic
- The coming together of the geological, geotechnical and structural engineering communities in joint meetings and forums
- Modification of the New Zealand earthquake design standard; changes have been adjustment of the Hazard Factor from 0.22 to 0.30, and an increase in the Risk Factor  $R_s$  for the serviceability limit state from 0.25 to 0.33. The method of defining design actions for vertical ground motion has also been altered
- The opportunity to observe ground and structure response to the different earthquake events and gather an unprecedented dataset (for example from some 30 seismographs, documentation of repeated liquefaction, careful mapping) to inform new design
- Technical growth through research, investigation, applying design principles and observing how they perform in subsequent earthquake events
- Identification of the need to improve and establish benchmarks in engineering practice; this has facilitated establishment of a register of Professional Engineering Geologists, publication of the practice area of registered engineers and development of guideline documents by regulatory and

technical bodies setting out minimum requirements for design activities and particular activities to be carried out by registered practitioners.

