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GROUND MOTION ANALYSIS OF THE CANTERBURY EARTHQUAKES: RESULTS TO DATE AND ON-GOING RESEARCH

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EXTENDED ABSTRACT

The 2010-2011 Christchurch earthquakes produced severe ground motions, significant ground failure and structural damage in Christchurch city and its surrounding suburbs. A dense array of strong motion instruments over the Canterbury Plains has resulted in a unique strong motion dataset which captures the complexity and spatial distribution of ground motion over the region at the same set of locations in multiple strong earthquakes.

Direct examination of the recorded ground motions illustrates significant directivity effects resulting from the nature of rupture propagation, particularly in the 4 September 2010 Mw7.1 Darfield earthquake. Basin-generated surface waves resulting from the deep fluvial basin of inter-bedded Quaternary sands, silts and gravels are also readily apparent in the amplitude and duration of long period ground motion. The presence of the Banks Peninsula volcanic complex also resulted in important basin-edge effects along the south of the city that are repeatedly evident at the Heathcote Valley instrument; and topographic effects on the hills of the peninsula itself are evident based on recently installed instruments. The severity and spatial extent of liquefaction in native soils was a particularly unique feature of the earthquakes. The occurrence of cyclic mobility and other ground failure phenomena is evident in numerous surface ground motion recordings. The large number of strong motion observations provides abundant empirical data illustrating the significant horizontal and vertical ground motion amplitudes which can be produced by moderate magnitude earthquakes in close proximity to the earthquake sources. Comfortingly, such observations compare well with empirical ground motion prediction models of elastic response spectra for both horizontal and vertical ground motion components.

Examination of the ground motion recorded at the same location over multiple strong shaking events clearly indicate systematic features which are arguably the result of shallow and deep site effects. However, the absence of coupled downhole array instruments means that simple one dimensional site response analyses are complicated by ill-defined 'input' motions. Therefore, the relative importance of different seismic wave propagation phenomena relative to source, path and site effects are not

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obvious, and this limits the insight which can be gained via direct examination of ground motion records and other observations at the surface.

On-going research is providing a comprehensive characterization of the shallow and deep geotechnical and geophysical properties of the Canterbury basin area. To date, over 8000 CPT tests have been performed over the urban area of Christchurch. Furthermore, at 22 locations, passive surface wave testing with circular arrays of broadband seismometers and active surface wave testing with the NEES@UTexas TRex vibroseis has enabled information about the seismic velocity structure of the basin to be developed for depths ranging from 200m to greater than 1km. This information, coupled with available seismic reflection, refraction, and travel time tomography datasets will be used to develop a numerical model for the region that will be used in kinematic broadband simulations with seismic effective stress analyses of surficial soils. Such physically-based simulations will enable further fundamental insight into the mechanics of these observed ground motion phenomena, and enhance our ability to predict such effects in future earthquakes worldwide.

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