

THE GEONET BUILDING INSTRUMENTATION PROGRAMME

S.R. Uma¹, Andrew King¹, Jim Cousins¹ and Ken Gledhill¹

SUMMARY

In New Zealand, the performance of instrumented structures has rarely been tested by earthquake events with design-level motions to enable verification of the code design recommendations and related design assumptions. In the Darfield event, Rutherford building at the University of Canterbury was the only instrumented building that recorded its earthquake response. Lessons from overseas earthquakes, in particular the 1994 Northridge event, have demonstrated the invaluable use of information from instrumented buildings. In order to derive similar benefits from any future New Zealand events, steps were initiated to install modern digital accelerographs in structures. The new building instrumentation programme aims to install earthquake strong-motion instruments within up to 30 structures (mainly buildings and bridges) across New Zealand so as to measure their responses to future earthquake-induced ground motions. This article describes the objective of the instrumentation programme, highlighting the expected benefits to various end-users, the progress made so far and the future scope of the ongoing programme.

INTRODUCTION

Instrumentation of structures with seismic sensors is recognised to be a rational approach that, following an earthquake, can provide valuable information on the behaviour of the structures during the event. In the last two decades, the performance-based earthquake engineering (PBEE) approach has been recognised as a promising step on the way to building 'safer' structures that can perform satisfactorily to match the expectation of owners and engineers. The state-of-the-art tasks set by PBEE targets decision makers and aims to describe the performance of structures in terms of socio-economic variables. In other words, the performance is expressed in terms of dollar-loss associated with the cost of repair to damaged structures, and deaths and down-time of the facilities. However, the current PBEE tools lack reliable estimates of the various parameters influencing the socio-economic variables, including the structural response parameters (for example, floor accelerations and inter-storey drifts) and the extent of damage related to them. At this juncture, seismic instrumentation of facilities is the best way to obtain actual information on the structural responses needed for PBEE to be followed in New Zealand [1].

Monitoring and data collection of various hazards using instrumentation is recognized to be the fundamental step to strengthen the underlying assumptions of scientific and engineering research by increasing their quality, applicability and confidence limits. In New Zealand, 'GeoNet' was conceived to provide national coverage for hazard detection, emergency response and data collection. It is funded by the Earthquake Commission (EQC) and is operated by GNS Science.

The mission of GeoNet is to establish and manage a real-time monitoring and data collection system for the study and response to the geological hazards that affect New Zealand. These hazards include earthquakes, volcanoes, landslides and tsunamis. The impact of these hazards on the community is reflected by the response of the built environment. Therefore the monitoring and recording of the responses of the

built/engineered environment has been integrated with the geological hazards monitoring programme. The objective of the programme is to instrument selected structures, located in various zones of significant earthquake impact, so that the response data will help to improve the understanding of the seismic behaviour of built structures.

EXISTING STRONG-MOTION NETWORK

Most of the seismically active countries in the world have established some network to study ground motion characteristics. Different types of strong-motion accelerographs with varying specifications have been used for this purpose. In New Zealand, several components of the GeoNet system contribute to the collection and utilisation of strong ground motion data. These include both national scale and regional scale networks, and a structural monitoring programme. The national scale network comprises a National Strong-Motion Network and a National Seismograph Network, giving a total of over 220 recording locations. There are also regional strong-motion and seismograph networks contributing to the characterisation of the earthquake activity in New Zealand. However, only the Canterbury region has a dedicated strong-motion network. The other regional networks use weak-motion sensors which overload during strong shaking, but these are still useful for monitoring moderate shaking and for accurate earthquake location. When complete, the regional networks will consist of more than 60 regional strong-motion stations, mainly in Canterbury, and more than 120 weak-motion sites in the volcanic regions and along the east coast of the North Island above the Hikurangi subduction zone.

National Strong-Motion Network

The New Zealand National Strong Ground Motion Network consists of 180 stand-alone high dynamic range accelerographs situated in locations where New Zealanders live and work, and also 46 strong-motion sensors at the National Seismograph Network sites (Figure 1). The prime purpose of the strong-motion network is to record ground motion data in New Zealand towns and cities, including data

¹ GNS Science, PO Box 30 368, Lower Hutt (member)



Figure 1: New Zealand strong-motion recording sites: National Strong-Motion Network sites(solid squares); National Seismograph Network sites(circles); and Canterbury Network sites(light squares) as in Figure 2.

for near-fault ground motions, regional attenuation and microzone effects, as well as providing ground truth shaking data for emergency response. The design philosophy of the network is described in the GNS Science report by Cousins and McVerry [2].

National Seismograph Network

The six-component (3D broadband and 3D strong-motion) recording sites of the New Zealand National Seismograph Network are located throughout the country (at about 100 km

spacing) to provide a uniform location and data collection capability for the study of New Zealand and international tectonic problems. The strong-motion sensors extend the National Strong Ground Motion Network for regional attenuation studies and extend the dynamic range capability of the sites. The National Seismograph Network is also used, along with the regional seismograph stations and the National Strong Ground Motion Network, to provide rapid earthquake locations for public information and responding agencies.

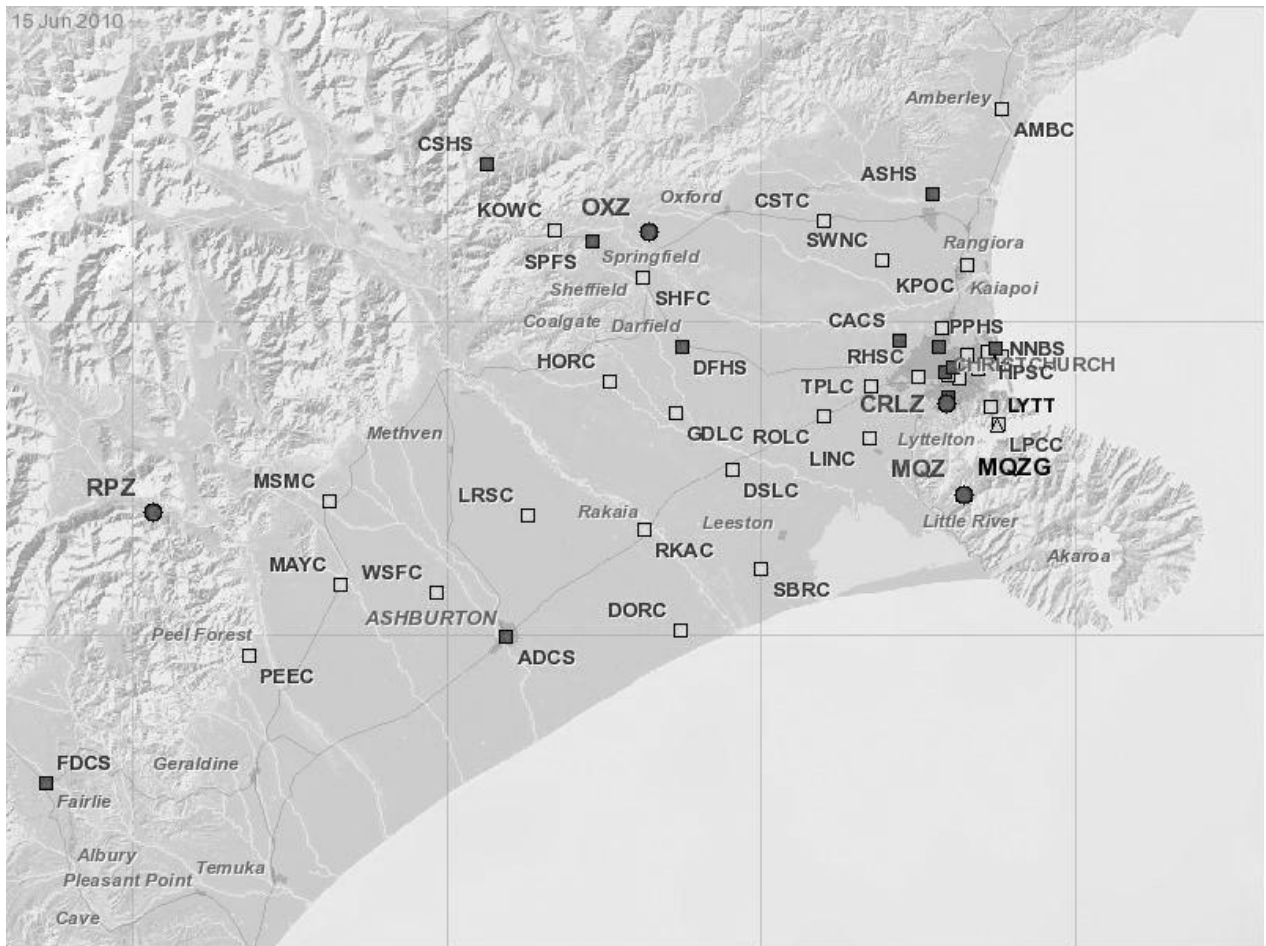


Figure 2: The Canterbury Strong Ground Motion Network (enlarged view).

Canterbury Regional Strong-Motion Network

The Canterbury strong ground motion network (CanNet; see Figure 2) is a regional accelerograph network being installed in the central South Island in anticipation of a magnitude 8+ rupture on the Alpine Fault. This fault stretches along much of the length of the South Island of New Zealand and forms the boundary between the Australian and Pacific plates in the region. It last ruptured in 1717 [3]. In the recent Darfield earthquake in September 2010, the dense array of CanNet comprising 40 accelerographs spread across the South Island, as well as 20 instruments distributed over the city of Christchurch with its highly variable ground conditions provided excellent sets of recorded data. This network employs the New Zealand-manufactured CUSP accelerograph, which is an “internet appliance” style of instrument using a tri-axial MEM silicon sensor, a single-board Linux computer and standard Internet Protocol (IP) communications. The existing network has been extended with additional strong motion instruments along the fault trace towards better understanding of fault rupture mechanism.

The development of the CUSP instrument was carried out during the doctoral study period of Avery [4]. In designing the accelerograph, there were three main design objectives: the first was to keep the initial cost of the instrument low; the second, to minimise maintenance costs; and the third was to protect against component obsolescence. Of the first two, the latter is more important in the overall cost of running a network. Experience has shown that the main cost in operating a network is in the routine maintenance of the instruments, with most of that cost being in travel to the dispersed sites. Thus, in designing the CUSP instrument, much effort was given to minimising the need for site visits by providing

remote access to event data, instrument status and instrument configuration via standard IP networks. The construction cost was kept down by the use of micro-machined accelerometers (MEMs), originally developed for the automotive industry to trigger car air bags, but subsequently made available with characteristics suitable for seismology. Much of the design effort went into extracting better performance from these mass-produced devices by extensive calibration and data processing. Because strong-motion accelerographs have a long working life, a further design objective was to minimise vulnerability to obsolescence. Early sites were instrumented with a 13-bit CUSP-3B model, which is now being replaced with the 17-bit CUSP-3C version.

STRUCTURAL INSTRUMENTATION

Besides studying the nature of earth movement, the structural engineering community is interested in the instrumentation of built structures to record their response during earthquake events. For example, during the 1994 Northridge earthquake, buildings that had instruments provided very useful information for understanding building response caused by damaging earthquakes. As a follow-up action after the above event, the Uniform Building Code, UBC 1997 required owners to provide a minimum of 3 sensors (a) in all buildings of 6 or more storeys with aggregate floor areas of 60,000 square feet (5,574 m²) or more, and (b) in all buildings of 10 storeys and above irrespective of the floor area [5].

In recent years structures in New Zealand have not been tested by large earthquakes. One of the main objectives of the instrumentation of structures (mainly buildings and bridges are currently considered) is to mitigate the seismic risk by

building 'safer' structures. This can be achieved by understanding the dynamic behaviour of existing and new structures and thereby verifying the assumptions in the design standards of different vintages under earthquake events. The building instrumentation programme considers the distribution of seismic hazard and the structures in the country to identify typical and representative samples to instrument and monitor.

Seismic Hazard in New Zealand

New Zealand can expect to experience an earthquake of magnitude 7 or greater about once every 10 years. Figure 3 shows known active fault lines in the country, and cities where facilities have been identified for instrumentation. In the North Island, the region around Wellington city has the combination of high seismic hazard (with the Wellington and nearby faults capable of magnitude 7.5 or more, as well as the subduction zone beneath) and high inventory exposure (being the capital of New Zealand) resulting in by far the highest seismic risk in New Zealand. The next highest levels of risk are in the south-eastern part of the North Island (Napier to Palmerston North) and around Christchurch city, which has about one-tenth the risk of Wellington city [2, 6]. Recent earthquakes in the Gisborne area justify the instrumentation of buildings in that city. Auckland can be designated as a low-seismic area; however bridge structures there could be considered for monitoring because of their economic significance.

In the South Island, the Alpine fault is the major earthquake source of interest, but other active faults close to important cities run through the northern part of the island. In Christchurch some buildings and bridges have been identified

for instrumentation to record their response from possible events from Alpine fault or any other unknown fault. Two bridges in particular, Fitzgerald and Ferrymead, have been extensively modelled by students of Canterbury University. The Otira viaduct is a major structure in one of the highest seismic hazard zones in New Zealand. For Greymouth and Westport, a combination of seismic history and poor site conditions warrant instrumentation of a few buildings, and while Blenheim is a small city it has a history of seismic events and is close to the active Wairau Fault. Table 1 summarises the cities identified and their seismic background. We propose to instrument a number of typical buildings (up to 30) and a few bridges, concentrating on national-scale coverage in terms of variety of seismicity and the exposure of buildings to seismic risk.

Existing Structural Instrumentation

For many years, GNS Science has monitored the responses of structures to earthquakes (both publicly and privately owned), but on a very small scale. In 2001, thirty-four structures were being monitored with minimal arrays including 13 conventional buildings, 3 base-isolated buildings, 3 bridges, 7 hydro-electric dams, 1 water reservoir and 4 power-generating structures [7]. The number of recorders varied from 1 to 5. All of the recorders were 3-component accelerometers. The buildings had film recorders of type MO2, which were obsolete by then and now are mostly non-operative for various reasons. The instruments in base-isolated buildings were either film or digital recorders with minimal specifications.

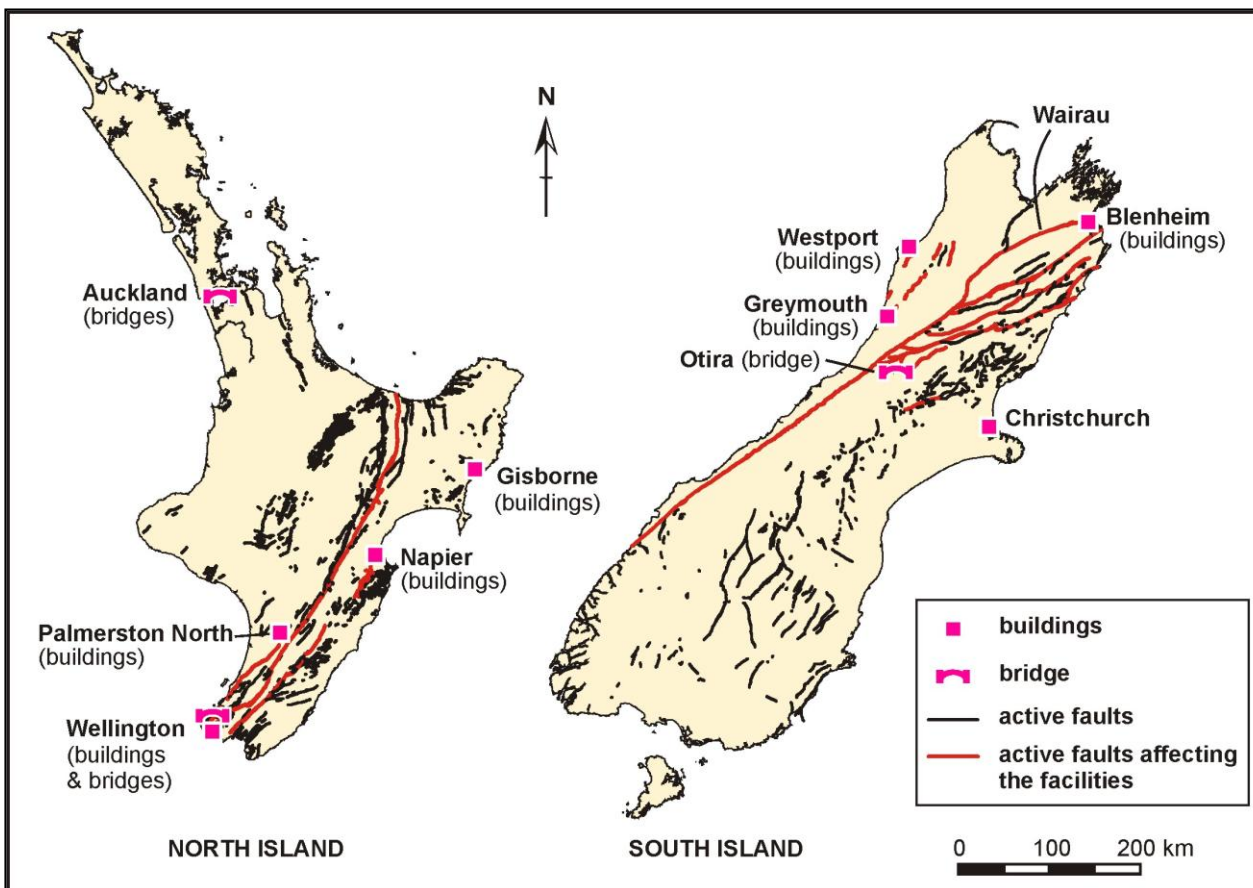


Figure 3: Active faults in the country and proposed locations and facilities for seismic instrumentation.

Table 1. Locations and seismic criteria considered for building instrumentation programme

City	Structures and seismicity
Auckland	Mega-city, bridges
Wellington	Major city, Wellington fault, above Hikurangi subduction zone, buildings
Napier, Gisborne	Seismic history, above Hikurangi subduction zone, buildings
Palmerston North	Wellington fault, buildings
Christchurch	Major city, Alpine fault (long period effect), buildings and bridges
Otira	Alpine fault, Otira Viaduct
Greymouth, Westport and Blenheim	Seismic history, buildings

New Structural Instrumentation Programme

Within the new and improved funding environment provided by GeoNet, the structural instrumentation programme has taken the initiative to improve the objectives and the outcomes by considering the following aspects: (i) to instrument buildings in places of highest seismic hazard (i.e. where data are most likely to be obtained) so that the lessons learned there can be applied in places of highest seismic risk and (ii) to instrument a range of building types in places of highest seismic risk with the aim of verifying the performance in weak to moderate levels of shaking so that proper preparation can be made for the rare, severe events. In this process, based on the quality of records available from the older types of instruments and the cost of maintenance, efforts are underway to replace the older instruments with new ones with enhanced array capabilities and to alter the priority of the structures to remain instrumented. The extent of instrumentation is expected to provide an optimum balance between the cost and technical utility of the data from the sensors. Currently, tri-axial accelerometers are supplied by Canterbury Seismic Instruments Ltd (CSI) for instrumentation. A structural engineering advisory panel has been formed with members from both design consultancy firms and academia to advise on the instrumentation programme and monitor progress. The scope of the project includes the evaluation of monitoring equipment, liaison with property owners and civic authorities, the installation of monitoring and communications equipment, the establishment of robust and fail-safe computer infrastructure, the development of data processing and analysis systems, rapid information delivery, and the promotion of education and outreach activities.

SEISMIC INSTRUMENTATION NETWORK

Figure 4 shows a typical schematic representation of the components of the seismic instrumentation deployed within a building. The CUSP-M sensors are distributed at various levels of the building and connected through ethernet cables to the CUSP-M central recording unit. The GPS receiver provides accurate timing (to less than 1 ms). Often one of the sensors is mounted in an enclosure a short distance from the building so as to record “free-field” motions.

mStages Involved in the Instrumentation Project

The whole building instrumentation project involves the following stages, with each stage requiring different amounts of time depending on the building under consideration. These stages are:

1. Selecting the structure to instrument based on the criteria discussed above and advice from the advisory panel;
2. Obtaining a licence agreement with the property owners;
3. Acquiring plans and building details of the property;
4. Identifying and finalising appropriate locations for sensors: this involves visits to the site and discussions with architects;
5. Obtaining quotes for the cabling of the structure and arranging the purchase of instruments. Signing of the cabling contract and cabling the structure;
6. Designing and arranging the purchase of data communications equipment for the transfer of the data to the GeoNet Data Centre;
7. Arranging for the supply of sensors from the manufacturers (various sources for seismic accelerometers, displacement transducers, wind sensors);
8. Entering information on the instrument array in the GeoNet site and instrument database (DELTA);
9. Installing the sensors and commencing data recording (this involves co-ordination of sensor suppliers and GeoNet staff to verify the transfer of data);

Experience has shown that obtaining the licence agreement between the building owner and GNS Science is the most time consuming stage. In the few cases where engineering professionals were actively involved these resulted in quicker agreements because they were able to effectively convince the building owners.

The success of the project is based on the cooperation between various people and organisations, such as property owners, design engineers and funding agencies, together with the end-users who would potentially make use of the recorded data. The possible benefits that can be harnessed by these groups are discussed below.

Benefits to Building Owners

There are a number of benefits to the owners of instrumented buildings:

- **Markedly reduced disruption and downtime following an earthquake:** Because the building behaviour can be determined from the instrumentation, buildings that are ‘safe for continued occupancy’ will avoid unnecessary access restrictions. Zones within the building where local stresses have resulted in damage will be identified. Counter-measures needed for the building to be ‘made safe’ can be developed based on the understanding of the building response during the event, and remedies will be quickly identified and suitable measures developed to address the specific damage experienced.
- **Assurances relating to tenancies demanding building safety will be demonstrable:** Often rental holidays are expected by tenants (or termination of tenancy agreements) because of a perception that the building is unsafe. The building ‘safety’ state can be demonstrated by reference to the instrumented results.

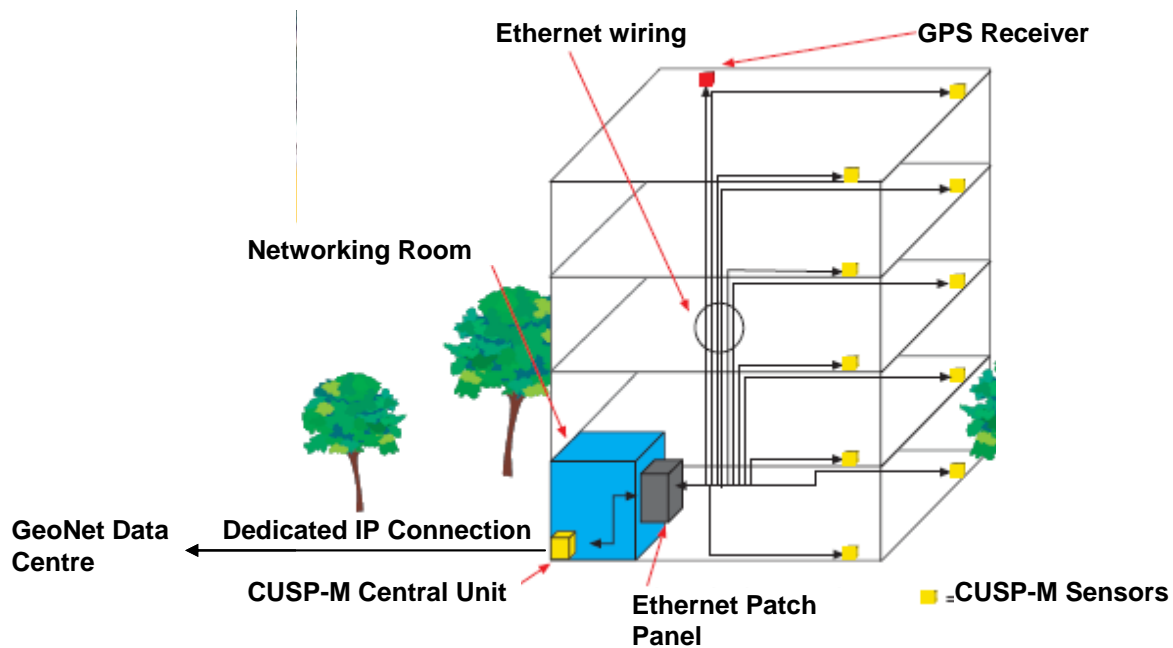


Figure 4: Schematic representation of the deployment of instrumentation components within a building (Courtesy CSI Ltd).

Broader potential tenancy base: The presence of instruments within a building is a clear indicator to tenants that earthquake performance is an aspect of concern to the owner and that ‘safe performance’ is a likely consequence. In some cases, such buildings may be suitable for occupancy by essential post-disaster service providers with the responsibility of ensuring reliable public access to those services following a damaging earthquake.

- **‘Good Citizenship’ accolades can be awarded:** Acknowledgement of the public-good benefit from instrumentation (as mentioned elsewhere) can be shared by owners willing to have instrumentation installed in their buildings. The presence of instrumentation enables the post-earthquake repair to be limited to those components where repair is necessary. It avoids demolition or replacement of components (or buildings) where such extreme actions are unjustified. The ‘smart structures’ may be advertised by the building owner or developer as providing a public service by contributing to a safer community.

Benefits to Society

The data acquired from instruments during moderate or extreme motions generated either by earthquakes or severe wind will form the basis of engineering and scientific studies into the response of buildings and their contents. Such response is complex, with a combination of random lateral sway and twisting movements. The evaluation of instrument readings will therefore require a high level of technical expertise not present within the general public. As extreme events are rare, a major effort is needed to record how buildings respond to confirm existing engineering design assumptions. The resulting knowledge will move the design and construction of buildings forward for future generations, and regulations can be more appropriately aligned to the anticipated public performance expectations.

Benefits to Engineering Community

Structures built conforming to design standards are expected to perform well, provided the design assumptions that have gone into those standards are realistic. The aftermath from earthquake events provide the engineering community with a very good opportunity to verify the design assumptions and to improve them if necessary. In this regard, it is paramount to monitor and record the building response during such events. Large intensity events are useful to test the structures in their inelastic range and to correlate the response data with the structural damage incurred during the event. The building response during moderate intensities is also important because of the likelihood of non-structural damage affecting the ‘operational continuity’ of a building resulting in losses due to ‘downtime’. In PBEE, the performance measures are generally in terms of interstorey drift and displacements for structural frames and peak floor acceleration for contents and acceleration-sensitive components in the building. A combination of sensors measuring displacements (such as displacement transducers and GPS units) and accelerations (using tri-axial accelerometers) are proposed for the GeoNet-instrumented buildings at this stage. A set of instruments spread through the building can reveal the history of non-linearity in the structure (as schematically represented in Figure 4) and hence the history of damage. Instruments placed at ground level and a nearby ‘free-field’ instrument will help to quantify the soil/ structure interaction effects. Also, these records can be used to determine the ground-motion parameters that correlate building response and damage. The knowledge gained enables the engineering community to develop improved design and recommendations and to provide some bounds of acceptable assumptions relating to the structural models used for design [1]. A good array of sensors mounted in a building can provide a wealth of information on load history against the actual damage that incurred. The seismic instruments can be integrated into the existing network so that the records can be processed for rapid assessment and screening of earthquake damage. Monitoring buildings with special devices to dissipate energy (such as base-isolators, dampers, etc.) would help to improve the design of devices and also to understand the damage mechanisms of those buildings.

UPDATE ON STATUS OF THE PROGRAMME

The new instrumentation programme commenced during 2006, with the first building instrumented being the Physics building at Canterbury University. This was used as a pilot for CSI and the GeoNet team to trial the technology, and has only recently been fully commissioned. The GNS Science Avalon building was first to be fully commissioned and successfully recorded the Gisborne earthquake in December 2007. A

description of the instrumentation of this building is given in a later section. By the end of May 2010, five buildings had been completed and data can be retrieved from the GeoNet Data Centre. Eight other structural arrays (buildings and bridges) are at various stages of construction. The details are given in Tables 2 and 3.

Table 2. Completed buildings with data availability

Duration	Building	Location	Progress
2007-2008	GNS Avalon	Wellington	Completed, data available
2008-2010	Wellington Hospital (new building)	Wellington	Completed, data available
2008-2010	BNZ CentrePort	Wellington	Completed, data available
2008-2010	Victoria University student accommodation building	Wellington	Completed, data available
2008-2010	Canterbury University Physics building	Christchurch	Completed, data available (excellent data records from Darfield event)
2009-2010	Te Horo House (Timber building)	Levin	Completed, data available

Table 3 Ongoing projects initiated after 2009

Date*	Building	Location	Progress
May 2010	Te Horo House	Levin	Licence Agreement signed Jan 2010, cabling being installed
June 2010	Hawke's Bay Regional Council	Napier	Licence Agreement signed Aug 2009, cabinet and cabling installed, sensors have just arrived from CSI
Sep 2010	Majestic Centre	Wellington	Licence Agreement signed Mar 2010, getting cabling quote updated
Nov 2010	Thorndon Overbridge	Wellington	Licence Agreement signed by NZTA Mar 2010, liaising with CentrePort for access cabling quote being updated
Dec 2010	Massey University Vet Tower	Palmerston North	Licence Agreement in final stages, sensor locations identified
Dec 2010	West Quay	Napier	Body Corp have approved, Licence Agreement with their lawyer
Jan 2011	Nelson Marlborough Institute of Technology	Nelson	Licence Agreement signed March 2010, cabling completed sensors installed

* These are expected completion dates only.

ACCESS AND USE OF RECORDED DATA

The following are the key aspects of use and access of earthquake response data from buildings within the GeoNet building instrumentation programme.

1. The data will not be available directly to the public from the GeoNet web site.
2. The data will be made available to scientific and engineering users on application with the following conditions:
 - a. They may not re-distribute the data.
 - b. They may not charge for the acquisition of the data.
 - c. Authors of papers, articles or other documents that use these data shall, when the specific building is able to be identified, agree to submit their work for comment

from the building owner before releasing such work for publication.

3. GNS Science will not unreasonably withhold the data.
4. GNS Science will advise the building owner that such an application has been received.
5. GNS Science will not charge for the data.
6. The data will be in the raw format downloaded from the instrumentation. On request from a building owner, GNS Science will supply a list of users who have been given data collected from their building.

The user's IP address will be required so that access through the firewall can be enabled. The Java client software for this repository will permit access to continuously-recorded data or to event-based data (using the earthquake reference number).

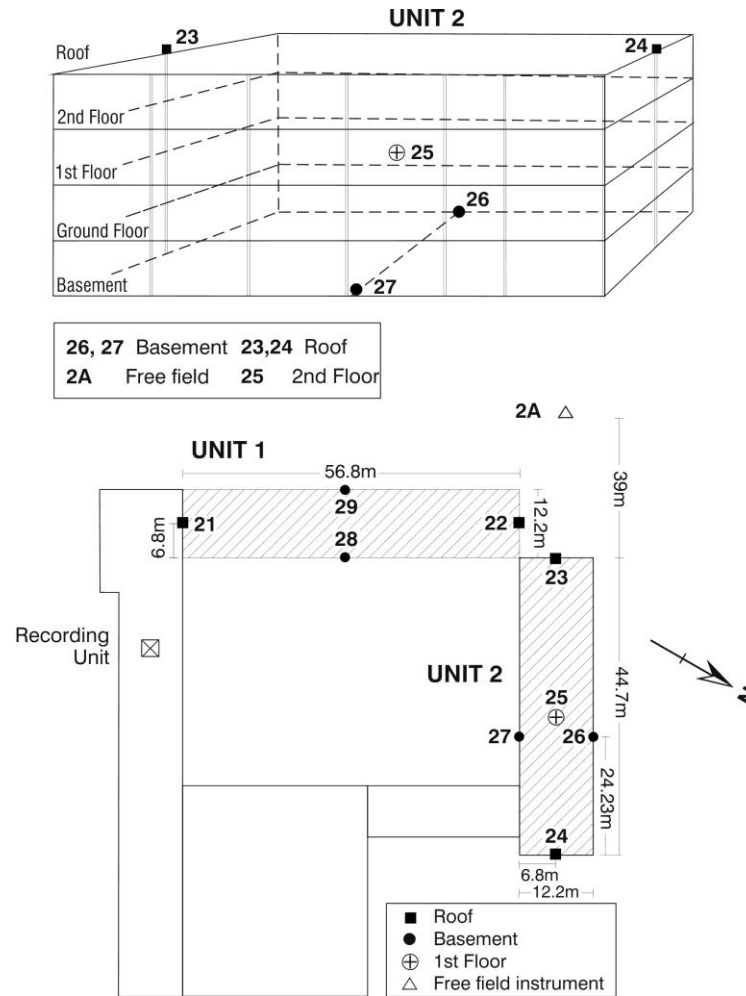


Figure 5: Units instrumented at the GNS Science office.

INSTRUMENTATION OF GNS SCIENCE BUILDINGS

Two buildings at the GNS Science complex at Avalon (Units 1 and 2 in Figure 5) were selected for instrumentation to represent low-rise, reinforced concrete, two-way, moment-resisting frame buildings constructed prior to 1976. The buildings are about 500 m from the Wellington Fault, are located on deep soils (river gravels) and are exceptionally well detailed. Moreover, the central recording/processing unit for all instrumented facilities (present and future) is located within the complex and hence it was convenient to test the instrumentation programme there. The two instrumented buildings, which are three storeys plus basement, are separated from each other and neighbouring buildings by seismic gaps.

Orientation of Sensors and Interpretation of Data

The standard sensor is a tri-axial accelerometer that records accelerations in 3 orthogonal directions. Although a sensor can be mounted either upright on the floor, upside down on the ceiling or vertically on a wall, the data are always provided to the user as a right-handed set, X, Y and Z, where X is the first

horizontal axis, Y is the second horizontal axis, oriented 90 degrees anticlockwise from X, and Z is the vertical axis, with positive acceleration upwards (Figure 6). The X and Y-axes are usually aligned with the main axes of the building. This consistency of output regardless of sensor orientation is achieved by applying a gravity offset.

An angle of importance is the azimuth, which is the angle from True North to the Y-axis, in degrees east of True North. This angle is required because it is not always possible to have all sensors pointing in the same direction, so that rotations about the Z-axis may be required before modelling the structure's response (see Figure 7). The philosophy followed in the GeoNet database is that the data are stored exactly as reported by the sensors, leaving any manipulations needed for modelling the responsibility of the user.

The locations and azimuths for each sensor are available from the GeoNet site and instrument database (DELTA) <http://magma.geonet.org.nz/delta/>.

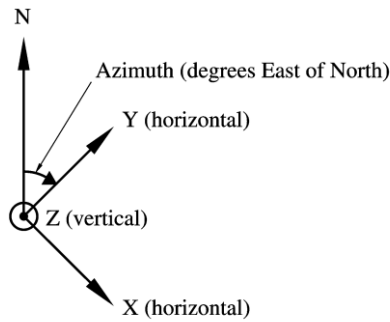


Figure 6: Axis and orientation conventions for reported data.

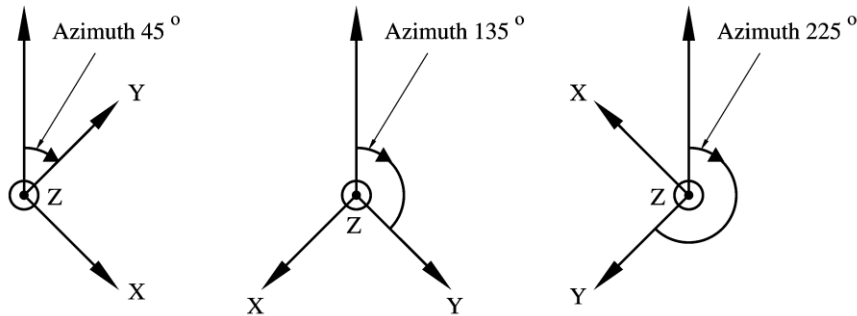


Figure 7: Three examples of possible sensor orientations for sensors parallel to the walls of a rectangular building with walls oriented at 45° and 135° from true North.

DATA FROM THE GISBORNE EARTHQUAKE 2007

The GNS Science Avalon building sensors yielded an excellent set of records from the magnitude 6.6 Gisborne earthquake of December 2007. It is to be noted that the source to site distance is about 400 km. Nevertheless, the recorded data showed potential amplification in floor response. The acceleration histories are processed and are shown in Figure 8. The peak accelerations recorded by all the 10 sensors in 3

directions are listed in Table 4. Note that the site is stepped so that the basement location is effectively at ground-level.

Equivalent data from the former Gisborne Chief Post Office (now River Oaks Mews) are given in Figure 9 and Table 5, recorded on obsolete film strong-motion recorders. Again a considerable degree of amplification occurred, approaching serviceability-level shaking. There was only minor non-structural damage to the building [8]. It is a 6-storey building dating from the early 1970s.

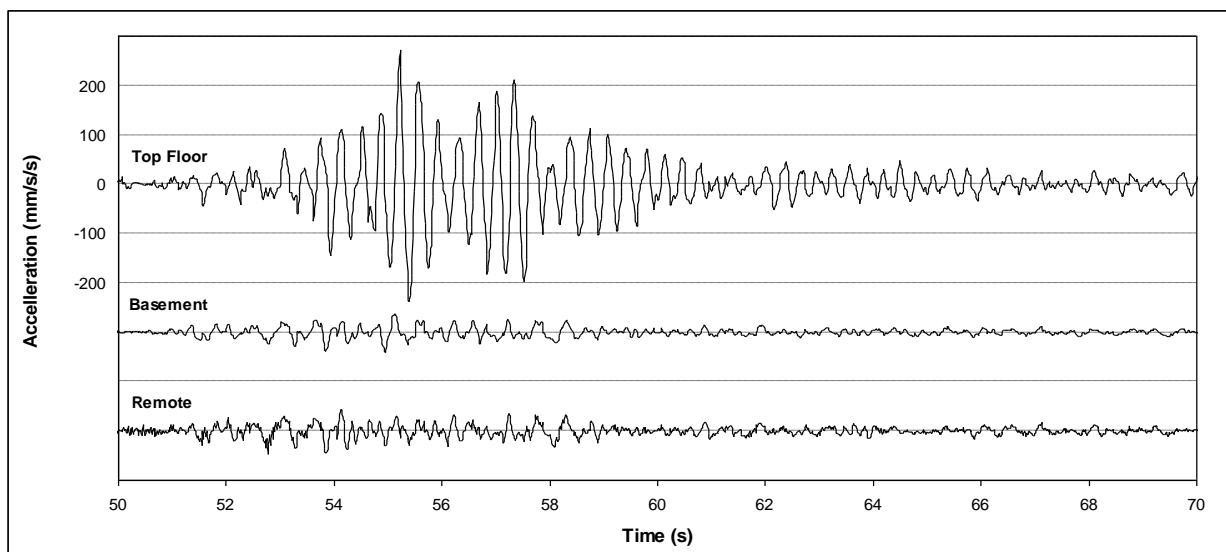


Figure 8: Records from the GNS Science Avalon building sensors for the 2007 Gisborne earthquake: comparison of the central portion of one of the top floor (sensor 21) records with the equivalent parts of records from the basement (sensor 28) and remote sites (2A free field instrument). The basement and remote site records have been offset for clarity.

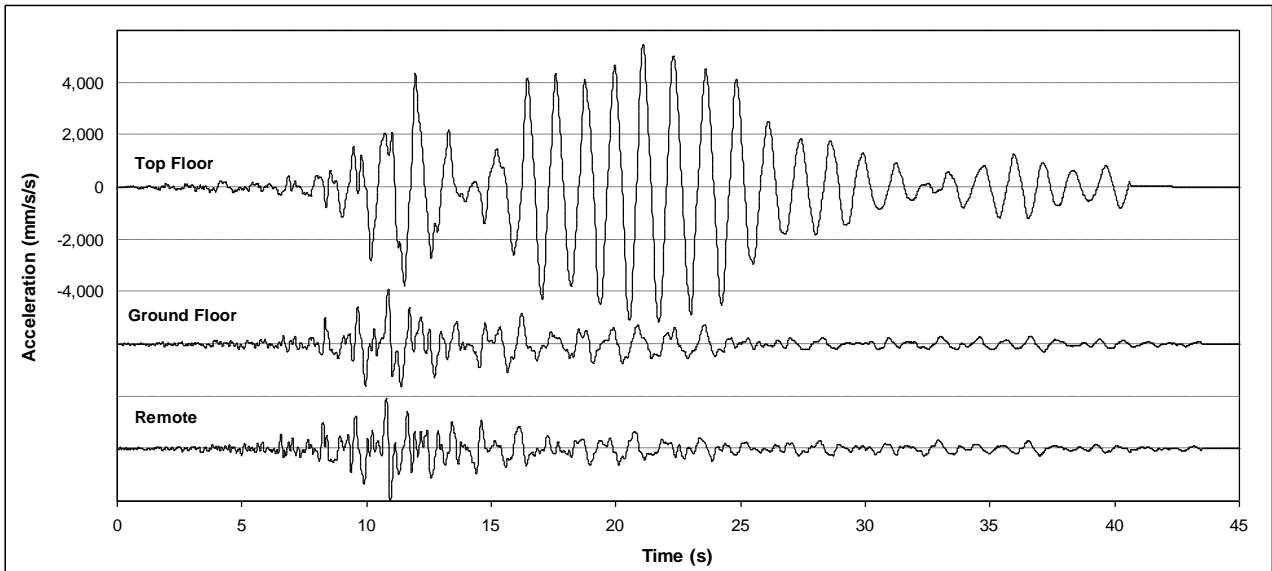


Figure 9: Records from the former Gisborne Post Office for the 2007 Gisborne earthquake: comparison of the top floor record with records from the ground floor and remote sites. The ground and remote site records have been offset for clarity.

Table 4. Peak accelerations from the GNS Science Avalon array in the 2007 Gisborne Earthquake.

Sensor No.	Peak Acceleration (mm/s/s)			Sensor Location	Azimuth (Y)
	X	Y	Z		
21	151	273	24	Unit 1, Top Floor, SE end	60
22	141	217	23	Unit 1, Top Floor, NW end	60
23	165	169	22	Unit 2, Top Floor, SW end	60
24	160	190	25	Unit 2, Top Floor, NE end	60
25	66	76	28	Unit 2, Mid height, Centre	60
26	56	41	15	Unit 2, Basement, NW side	60
27	54	40	16	Unit 2, Basement, SE side	60
28	43	41	20	Unit 1, Basement, NE side	60
29	45	40	24	Unit 1, Basement, SW side	60
2A	57	48	24	Remote Site (Ground surface)	72

Table 5. Peak accelerations from the former Gisborne Post Office array in the 2007 Gisborne Earthquake.

Sensor No.	Peak Acceleration (mm/s/s)			Sensor Location	Azimuth (Y)
	X	Y	Z		
018D	4005	5467	2270	Top Floor	44
018B	1569	2106	687	Ground Floor	44
018A	2159	2164	665	Remote Site (Ground surface)	44

Displacements computed from the recorded accelerations are shown as a polar plot in Figure 10. Although there is not a perfect match of the orientations, the top floor displacements were clearly greater along the transverse (short) building axis than along the longitudinal axis.

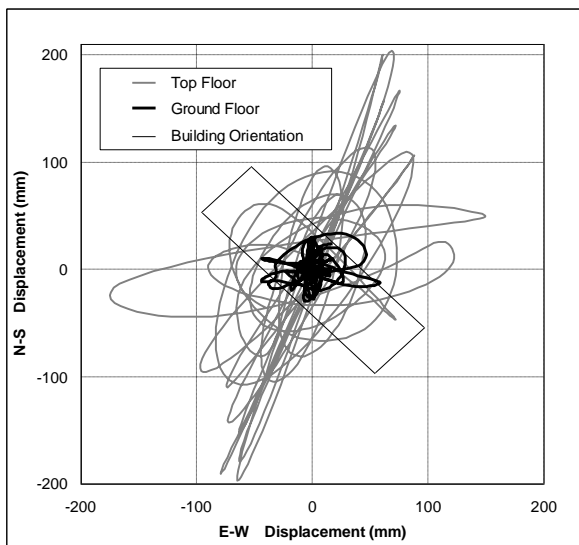


Figure 10: Polar plot of displacements for the former Gisborne Post Office building in the 2007 Gisborne Earthquake.

COSTS

The programme is undertaken as a part of the EQC-funded GeoNet programme that is operated and administered by GNS Science. The cost of supply, installation, data retrieval and maintenance is covered by GeoNet as an integral part of its basic scientific data collection programme. Building owners willing to accommodate the installation of the instruments and associated control gear will be indemnified against damage from any cause during the installation and ongoing operation of the equipment.

Private organisations with particular interests in recorded building motions are welcome to contribute by funding instruments, with the management and data retrieval and archiving being carried out under the GeoNet auspices.

SUMMARY

The ongoing instrumentation programme under the GeoNet project is unquestionably a major step forward in seeking solutions for the immediate and long-term requirements of performance-based earthquake engineering in New Zealand. The recent Darfield event has reinforced the need for installing instruments to record building response; the data can be used for calibration of analytical models and verification of design assumptions. The instruments in University of Canterbury physics building have recorded the building response. Ultimately, it will enable improving community resilience, particularly through the building of 'safer' structures. The proper choice of instruments and the facilities to be instrumented, together with an efficient system for data collection and maintenance, are vital factors in the success of the instrumentation programme.

It is encouraging to note the interest from university students in making use of the recorded data. It is envisaged that a lot more end-users from research organisations will come forward to use the available information for the public good. In conclusion, the strong-motion monitoring programme will help to serve the community by leading to improved technologies for mitigating seismic risk and improving post-earthquake damage assessments.

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