

# Christchurch Earthquake - an overview

## THE EARTHQUAKE

GNS Science believe that the earthquake arose from the rupture of an 8 x 8 km fault running east-northeast at a depth of 1-2 km depth beneath the southern edge of the Avon-Heathcote Estuary and dipping southwards at an angle of about 65 degrees from the horizontal beneath the Port Hills. The amount of slip between the two sides of the fault was up to 1.5 m. The Port Hills have risen by about 40 cm, the mouth of the estuary has moved westward by a few tens of cm, and the land just north of the estuary by tens of cm to the east. Land west of the estuary, and the estuary itself, will have sunk by roughly 10 cm as a direct result of the fault rupture. However, there may be additional subsidence on top of this as a result of ground compaction during the strong shaking.

Earthquake records show that some buildings may have experienced shaking more than two times more intense than a new building would be currently designed for, but perhaps for a lesser duration than envisaged by the loadings code (NZS 1170.5). The intensity of shaking appears to have died out rapidly as it travelled westwards from the fault.

## DESIGN OF BUILDINGS FOR EARTHQUAKES

Non-residential buildings designed before 1976 were not explicitly required to have ductility incorporated in them. In the early 1980s, the design standard for reinforced concrete was revised significantly to ensure non-brittle behaviour under design-level earthquake loadings, and the strong-columns/weak beams philosophy was introduced so that life safety could be achieved under design-level earthquake shaking.

During the 1990s, the understanding of the faults and historic earthquakes came together as the NZ Seismicity Model developed by GNS Science, and this is the basis for the current seismic zoning of New Zealand. This is considered internationally as a state-of-the-art model. The September and February earthquakes are thought to be consistent with this model.

Buildings are not designed to be earthquake-proof. Two design levels are considered. A building of ordinary importance is designed for a level of shaking that has a 10 % probability of being exceeded in its design life of 50 years. The design standards are formulated to ensure that life safety is achieved during that shaking, but the building might be an economic write-off because of the damage. It must not collapse at this level. The designer is also required to check that the building does not have damage at a level about 1/6th of this design level. This Serviceability Level is set to correspond with shaking that has a 10% probability of being exceeded in one year. To put it another way, The Life Safety design level can be expected to be exceeded on average (over a very long period of time) once every 500 years, and the Serviceability Level once every 20 years.

Note that no mention has been made of earthquake (Richter) Magnitude, as the building responds the same way to shaking that comes from a small close earthquake or a large distant one.

## OBSERVED PERFORMANCE OF COMMERCIAL BUILDINGS IN THE CBD

The buildings designed to the current standards have, with few exceptions, performed well and as intended, with little damage. Notable exceptions are the failures of stairs in the Forsyth Barr building, and the tilting of a 10-storey building on Oxford Terrace near the river. The two buildings which have catastrophically collapsed (the Pyne Gould Corporation and CTV buildings), while described by the press as modern, are understood to have been constructed in about 1963 and 1986 respectively. Many buildings designed before the early 1980s

may have experienced earthquake loads significantly above that for which they were designed. Nevertheless, many of them have experienced no or minimal structural damage. A number of experienced structural engineers have observed that buildings with well-conceived and simple structural systems with minimal irregularities have exhibited superior performance to those which may have only nominally or theoretically met codified requirements.

In buildings of all ages, ceiling systems, and in-ceiling services such as light fittings and air conditioning/supply systems, have been damaged to various degrees. While significant non-life-threatening damage is acceptable in the levels of shaking probably experienced, it is clear that lessons can be learnt in how to minimise this damage. The relevant Standard has recently been revised so as to address many of these known issues.

## **DAMAGE TO INFRASTRUCTURE AND GROUND**

Most of the infrastructure damage is directly attributable to liquefaction. The likelihood of liquefaction in the wider Christchurch area in this level of earthquake has been known for more than 15 years, and was documented in great detail in studies commissioned and publically disseminated by Environment Canterbury and the Christchurch City Council more than eight years ago. The propensity for buried services to be disrupted and uplifted by the buoyancy of the liquefied material is well-known from the experiences of other earthquakes around the world, but the scale of the damage experienced in Christchurch may be the greatest ever recorded anywhere in a modern city.

## **POST-EARTHQUAKE BUILDING EVALUATION**

Voluntary committees of the NZ Society of Earthquake Engineering have worked for more than 20 years to develop and refine guidelines for the rapid evaluation of building safety after a damaging earthquake. The Society's guidelines have been implemented by the Civil Defence in both the Christchurch earthquakes, and this is likely to be seen as an exemplary model by the international community. Similarly, the rapid development of Urban Search and Rescue teams with internationally-consistent training and methods over the last ten years has been heavily supported by professional engineers, and is attracting huge praise from all those who have observed them in action. IPENZ has planned for the provision of voluntary support from the profession for such a disaster as this earthquake, and has implemented those plans.

Despite the tragic losses of life, professional engineers should be extremely proud of the efforts made over many decades that have minimised the effects of this extreme event.

Prepared with the assistance of Members of the New Zealand Society for Earthquake Engineering · 4 March 2011