

CHANGED PERCEPTIONS OF EARTHQUAKE HAZARD IN AUSTRALIA - POST NEWCASTLE 1989

by
Kevin McCue

Australian Geological Survey Organisation, Canberra ACT 2601 Australia

Kevin McCue is a seismologist with AGSO where his primary responsibility is the delivery of AGSO's earthquake outputs under the Earthquake and Nuclear Monitoring Project. Kevin has worked in seismology for 30 years now with a primary focus on engineering seismology including earthquake hazard assessment and analysis and interpretation of strong motion data.

SUMMARY:

The 1989 earthquake near Newcastle has changed the Australian psyche regarding earthquakes in continental Australia. Engineers and the media now accept that earthquakes are a threat to the safety of the community who are now prepared to use the current loading code for design and construction and to pay for improved monitoring. The risk to major urban areas remains however the stock of old, poorly maintained URM pre-code buildings.

INTRODUCTION :

To appreciate the changed perception of earthquake hazard in Australia since the Newcastle earthquake we have to recall the situation that existed at the time of the earthquake:

- Newcastle was rated zone zero in the Seismic Zone Map that was part of AS2121-1979 (Figure 3.1, p13). However even for buildings in the non-zero rated areas of the map, no earthquake resistant design was mandatory because the State of NSW had not called up the code. The code commentary notes that zone zero did not imply that the risk was zero – just that the mandatory requirements were zero because the implied threat was low.
- The nearest seismograph and accelerograph to Newcastle were in Sydney at Lane Cove and south of Sydney at Lucas Heights respectively, more than 100 km away.
- Neither seismology nor earthquake engineering were taught at the University of Newcastle so there was no earthquake culture amongst the engineering profession.
- There was no earthquake engineering society in Australia to promote knowledge of the principles of earthquake engineering nor to provide post-disaster response advice.
- The previous earthquake history of Newcastle was not recognized by Newcastle City Council and population as a whole.
- There was no record of the ground shaking caused by a magnitude 5 or greater earthquake within 50 km of an epicentre in Australia, no data on the intensity, duration or frequency content of the shaking, nor on how the ground shaking changes with foundation type, rock or soil.

THE LESSON LEARNED

It is my contention that the lessons of Newcastle have not only not been forgotten in the last decade but have substantially contributed to our safety. It is more important that they not be forgotten in the future. As a result of the 1989 Newcastle earthquake much has changed for the better:

- The new Loading Code AS1170.4 has been called up into the Building Code of Australia and an estimate of the 10% in 50 year *pga* ground motion is mapped throughout the continent.
- The Hunter region is now monitored both with seismographs and accelerographs.
- The AEES is a thriving society with a register of professionals able and willing to participate in post disaster response functions.
- An excellent book on the earthquake history of the Newcastle region was published¹ so that no one can now be excused for not knowing the history and potential hazard.

The promise made by the then mayor of Newcastle to facilitate establishment of a chair of Earthquake Engineering at Newcastle University has not eventuated but it was probably always outside the Council's scope to influence the university curriculum.

On the negative side, the old and most vulnerable buildings in 1989 are now older and more vulnerable and the code does not address the issue of their safety unless they are substantially modified. These old buildings contribute most to the risk of failure in earthquakes, another lesson of Newcastle 1989 and of Adelaide 1954 before it.

THE NEWCASTLE EARTHQUAKE ALERT

Video footage of an interview in Newcastle at the time of the earthquake demonstrates that the ground shook strongly for just a second or two, more like an explosion, and that it was not immediately recognised by the interviewee and camera crew as an earthquake. At the ASC in Canberra 300 km away there were only two officers on duty, it being Christmas holiday time, but we felt the slight vibration and ran to the analogue drum recorders in the foyer of the building to investigate. The pen on the Canberra recorder was banging from side to side and as we watched the first P seismic waves arrived at Toolangi near Melbourne, then Moorlands in Tasmania and finally Woomera in South Australia. Digital data was telemetered into the ASC at the time from Alice Springs and Warramunga in the Northern Territory and Mawson in Antarctica.

The paper records had to be changed and the arrival times read and typed into the computer program. With such a sparse network it was difficult to determine an accurate epicentre quickly and, because most of the analogue stations were clipped no reliable magnitude could be determined for some hours. An aftershock monitoring team could not leave Canberra until 6 hours after the earthquake because of the lack of a readily available aftershock kit.

Compare that with the situation today; data from more than 30 stations of the National Seismographic Network throughout Australia are telemetered into AGSO in near real time. Many of the stations have triaxial broad-band seismometers as opposed to the vertical short period stations of 1989. An earthquake alert system interrogates this telemetered data and pages seismologists 24 hours per day when an earthquake is detected so that a rapid earthquake alert and tsunami warning can be provided to the Emergency Management Agency, governments and media. This system is backed up by an independent pager system operating on a separate seismograph network in SE Australia and alternative communications carrier by the Seismology Research Centre. Earthquakes can normally be located and advice provided in a 30 to 40 minute time frame.

Earthquakes of magnitude 3.0 or more can be detected in the Hunter region on the National network and smaller earthquakes are recorded on the four local area network stations, one component of the North Lambton station is telemetered into the Newcastle Regional Museum and onto a drum recorder. In addition there are now several digital triaxial accelerographs in Newcastle.

As a result of the Newcastle earthquake AGSO now has a modern accessible six station aftershock kit which has been successfully deployed in Australia and Papua New Guinea.

THE GROUND SHAKING IN NEWCASTLE

In December 1989 there were no instruments in Newcastle capable of recording the ground shaking. Coalmine blast recorders were saturated. Any analysis of the failure of the Workers Club or Junction Motel is dependent on a knowledge of the earthquake input.

Temporary instruments were installed the day after the earthquake in a small network around the city in time to record the single small aftershock which had proven most useful.

Following the Newcastle earthquake, AGSO and State Government representatives met in early 1990 and agreed that all cities of 50,000 people should be instrumented with seismographs and at least two accelerographs, one on rock, the other on soil (the joint urban monitoring program - JUMP). There were not sufficient funds for the seismographs but AGSO purchased the accelerographs and the States installed and maintain them. This strategy has been very successful since most of the stations have recorded earthquakes. In 1994 a magnitude 5.2 earthquake struck Cessnock^{2,3}, its epicentre only 30 km west of the 1989 earthquake and this time good recordings were obtained of the ground motion, not just in Newcastle but also in Sydney and on dams south of Sydney in the distance range 43 to 300 km.

The aftershock data has been used to estimate the *pga* in Newcastle during the 1989 earthquake. Wesson⁴ and Sinadinovski⁵ used independent synthetic methods, phase spectrum and empirical Greens function respectively, to estimate the *pga* of the 1989 Newcastle earthquake resulting in substantially identical results of about 0.2g.

NEWCASTLE'S CONTRIBUTION TO THE NEW LOADING CODE

A number of earthquakes in the magnitude ranges 5.0 to 5.3 and 4.0 to 4.3 have now been recorded in NSW, Victoria, South Australia and Western Australia in recent years on JUMP and other instruments. Suitably scaled, these recorded *pga*'s are being used in a new attenuation equation in the current revision of the Loading Code.

In a separate study⁶ a rock spectrum has been developed for the Loading Code from a carefully selected suite of accelerograms recorded worldwide and scaled to a peak ground velocity of 50mm/s which is typical of the 1 in 500 year peak ground velocity for most southeast Australian cities. Comparison of the synthetic accelerograms of the Newcastle earthquake against this spectrum are very encouraging.

REMAINING PUZZLES

The Newcastle area has been hit by earthquakes of magnitude about 5 in 1837, 1841, 1842, 1868, 1925, 1989 and 1994. The Hunter region network that has been operating since 1990 was expected to record numerous smaller earthquakes but few have been observed, the latest a micro-earthquake on 12 August 1999. Why?

Sydney and Newcastle are only 100 km apart and both are in the Sydney Basin yet their earthquake histories of the last 150 years are dramatically different. Why?

DISCUSSION

The reference list and code progress show the benefits of having a vibrant earthquake engineering society with close interaction between engineers and seismologists in Australia and strong links to the IAEE and NZNSEE.

AEES members have made a strong contribution to the development of the new loading code through membership of the Standards committees and participation in AEES, NZNSEE and PCEE conferences.

Monitoring must be for the long term! Each earthquake teaches seismologists and earthquake engineers vital lessons for improving community safety in a cost effective manner. For the first time we have hazard maps and spectra in the new Loading Code which are relevant to Australian earthquakes. More data will allow us to further optimise the hazard and risk analyses. Some Australian buildings should be instrumented.

REFERENCES

1. Hunter, C., 1991— Earthquake Tremors Felt in the Hunter Valley Since White Settlement. Hunter House Publications, Raymond Terrace, NSW.
2. McCue, K., Dent, V., Jones, T., Gregson, P., & Gibson, G., 1994 — Attenuation of strong shaking in Australia. *in* Proceedings of the Australian Earthquake Engineering Seminar, Canberra 14-15 November 1994.
3. McCue, K., Dent, V. and Jones, T.,— 1995 The Characteristics of Australian Strong Ground Motion . *in* Proceedings of the Pacific Conference on Earthquake Engineering, Melbourne, 20-22 November 1995.
4. Wesson, V., 1996 — Synthetic Ground Motions for the December 1989 Newcastle Earthquake. The Australian Earthquake Loading Standard 3 years on - how is it working and what have we learned? Proceedings of the Australian Earthquake Engineering Seminar, Adelaide, 1996.
5. Sinadinovski, C., McCue, K.F., Somerville, M., Muirhead, K., Muirhead, T., 1996 — Simulation of Intra-Plate earthquakes in Australia using Green's Function Method: Sensitivity Study for Newcastle event. The Australian Earthquake Loading Standard 3 years on - how is it working and what have we learned? Proceedings of the Australian Earthquake Engineering Seminar, Adelaide, 1996.
6. Somerville, M., McCue, K.F., and Sinadinovski, C., 1998 — Response Spectra for Australia. Proceedings of the Australian Earthquake Seminar, Perth WA 1998.