AEES NEWSLETTER

June 2009

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President's Report

Welcome to the second AEES Newsletter of 2009. We were saddened to learn of fatalities and many injuries in collapsed buildings in April during the L'Aquila earthquake, some 100 km east of Rome in central Italy (see article p12). This is an all too familiar scenario that we would like to think couldn't happen in a country which has made such important contributions to seismology and earthquake engineering for so long. Former AEES president professor Mike Griffith was out of harms way in northern Italy at the time of the earthquake, too far away in fact to feel the shaking. Mike was invited to join an official post-disaster inspection of the damaged region and will present a report for a later Newsletter or AEES2009 in Newcastle.

It has been a busy year for the committee, an expanded committee, with Gerhard Horoschun joining to lend a hand from the ranks of the Australian Defence Force Academy (University of NSW, Civil Engineering Department) in Canberra. Gerhard has been a familiar figure for many years in earthquake engineering and latterly blast engineering circles in Australia. He has served on the Standards Australia earthquake loading committee since AS2121 -1979 was published and we welcome his participation and expertise.

The three members of the then committee Paul Somerville, Mark Edwards and I attended a GEM1 meeting at Geoscience Australia in Canberra in March. GEM1 is a one year program to develop GEM, a global earthquake model **www.globalquakemodel.org**.

Many of the energetic drivers of GSHAP are also responsible for GEM which is a public/private consortium aimed at developing global models of earthquake hazard, risk and socio-economic impact. A noble cause which has garnered substantial support from the insurance industry and some governments. We will hear more about this ambitious project no doubt.

The organising committee for AEES2009 met on 30 March in Newcastle and Bill Jordan, the convenor, organised my attendance. Arrangements are looking good with an attractive venue by the waterfront and very topical keynote speakers – hope to see you there. Details are on the AEES website and we need your abstracts now (see the flyer enclosed).

In early April I participated in the New Zealand Society for Earthquake Engineering annual conference in Christchurch and had very productive discussions with members of their committee including President Graeme Beattie. We canvassed the possibility of having a joint meeting or PCEE in New Zealand in April/May 2011 in lieu of our normal meeting in November/December 2011 and not long after the Perth WA AEES2010 meeting. This will be up for discussion in Newcastle at the AGM. We also briefly discussed putting together a joint loading code for SW Pacific countries based on our latest Australian and New Zealand codes, the link being the hazard map. Hopefully we can develop this proposal over the coming year.

At AEES2008 in Ballarat, members agreed that:

- Schools and hospitals throughout Australia should be earthquake resistant, new and existing buildings. AEES would prepare a submission to governments that would recommend all schools and hospitals be inspected and, if necessary, brought up to current loading code standard. A draft submission has been prepared and will shortly be presented to the ACT government jointly with the local division of Engineers Australia.
- AEES should publish a book on the history of seismology and earthquake engineering in Australia. A small editorial group has agreed on a basic framework for the book and any member with an interest and willing to contribute should contact me or former president Bill Boyce.

We have included a theme section in this newsletter for a change and hope to do another for the August edition. This one is a seismology theme, the August theme will be an engineering issue. John Wilson has agreed to solicit articles so please don't be shy to have your say.

Kevin McCue
President AEES

Global Earthquake Model (GEM)

GEM seeks to build an authoritative standard for calculating and communicating earthquake hazard and risk. GEM will be the first global, open source model for seismic risk assessment at a national and regional scale, and aims at achieving broad scientific participation and independence. GEM aims to achieve its goals by developing state-of-the-art open source software and global databases necessary for reliably mapping earthquake risk. To this end, GEM has posted these requests for proposals, due 15 July 2009, with these target budgets and durations:

• Global Active Fault and Seismic Source Database, 450,000€, 24 months. Seismic hazard assessments should incorporate an inventory of active faults. GEM seeks to build a uniform global active fault and seismic source database with a common set of strategies, standards and formats. It should include both observational (active faults and folds) and interpretative (inferred seismic sources) elements.

• Global Instrumental Seismic Catalog, 450,000€, 24 months. As basis for its global reference hazard model, GEM seeks the stable quantification of seismicity for as long a time period as possible and in all regions, as the primary tool to be used to characterize the spatial distribution of seismicity, the magnitude-frequency relation and the maximum magnitude.

• Global Historical Earthquake Catalog and Database, 400,000€, 24 months. The record of past earthquakes is among the most important means to evaluate earthquake hazard, and the distribution of damage associated with past earthquakes is a key to assessment of seismic risk. Extending the record of large damaging earthquakes by several hundred of years longer than the instrumental record is thus extremely valuable.

• Global Ground Motion Prediction Equations, 400,000€, 24 months. With the goal of compiling a global reference hazard assessment model, GEM seeks to develop a harmonized suite of ground motion prediction equations (GMPE), built on the most recent advances in the field.

• Global Geodetic Strain Rate Model, 250,000€, 18 months. The geodetically measured secular strain rate provides an independent benchmark for crustal deformation and thus the recurrence of large earthquakes that can be compared with the seismic catalogue and active faults.

We anticipate that proposal will be prepared and submitted by international consortia. Proposals will be subject to peer review, and will be selected by the GEM Scientific Board, with awards expected in mid-September 2009. To learn more about GEM and to download the requests and guidelines for the preparation of the proposals, visit the website www.globalquakemodel.org.

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Visitor from the UK

Professor Julian Bommer, Department of Civil and Environmental Engineering, Imperial College London, made a brief visit to Australia in March and managed a short diversion to Canberra for a get-together to discuss items of mutual interest to our UK and Australian Earthquake Engineering Societies.

We haven't managed to get him out here for our annual conference but live in hope.

The next opportunity for a meeting will probably be in Lisbon at the next World Conference on Earthquake Engineering.

Active Faults in an Australian Context

Kevin McCue

Faults and Earthquakes

Most seismologists believe that earthquakes occur on pre-existing faults but also that earthquakes cause faults. A chicken or egg dilemma, which came first? There are faults everywhere at some scale, some are active, the majority are probably not. Many of them have not been mapped, especially their sub-surface geometry. So what is an active fault? Why are some faults no longer active? What do engineers need to know to determine which is which? Can seismologists provide that advice? The question I posed to some of my seismologist colleagues was whether we had any active faults in Australia far from the nearest plate boundary, after all we do have earthquakes, some of them large ones. I did not expect a definitive answer to a difficult question but I wanted to begin a more public discussion of decisions made in private consultancies and government.

The question is not just of academic interest, a hospital planned for southern Adelaide was relocated in the 1970s so that it did not straddle the surface trace of the Eden Burnside fault, not an inexpensive decision. Earthquake hazard assessment for critical facilities such as the Lucas Heights nuclear reactor, Geelong Animal Health Laboratory and large dams can be totally dominated by postulated activity on nearby faults. These are structures for which the *acceptable risk* is low, much lower than for homes or normal structures.

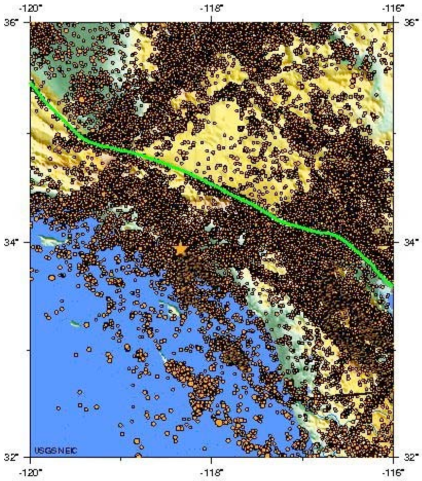
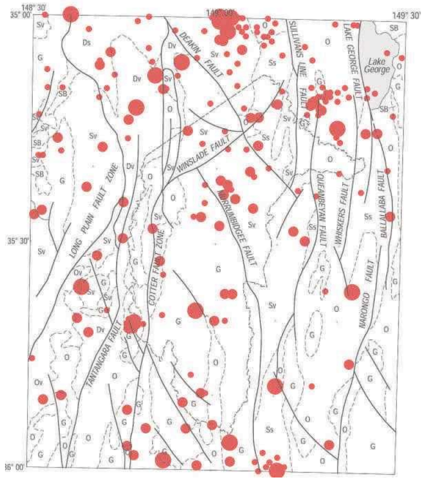


Figure 1
A recent earthquake in California near Los Angeles (from USGS).

Assigning an earthquake to a particular fault can be very difficult even in California bisected by a plate boundary, where the geology has been comprehensively mapped for mineral and petroleum exploration. In figure 1 is an epicentre map (~400x400 km^2) for post-1970 earthquakes in the vicinity of Los Angeles (near the star). The San Andreas Fault, a vertical strike-slip fault, is shown by the green line. The San Andreas fault is not clearly delineated by the recent earthquake epicentres on this scale. There must be many active faults in the vicinity for each epicentre (brown dot) to be on one, in which case does it matter? Could we establish the hazard using real sources?

Figure 2
Earthquakes in the ACT since 1960.



The second figure shows the ACT and some of the surrounding NSW (~100x100 km^2) with computed epicentres (red dots) since 1960 and mapped faults (grey lines). Are such maps sufficient for anyone to determine which fault accounts for which earthquake, if any do? What are the active faults in the ACT where earthquake locations are reasonably good thanks to monitoring by GA, the ANU and independent operators for more than three decades? Rivers flow along faults and some of these are dammed (4 soon to be 5 referrable dams servicing the ACT). People live downstream of some of the dams with obvious safety implications so this is a non-trivial question for the dam owners, let alone those mapping earthquake hazard.

I would like to thank seismologists Dan Clarke, David Love and Mike Turnbull for their opinion pieces to further this discussion, despite their heavy workloads. Next Newsletter we will feature an engineering topic, led by Professor John Wilson.

What is an "active" fault in the Australian intraplate context? A discussion with examples from eastern Australia

Dan Clark, Georisk Project, Geoscience Australia, GPO Box 378, Canberra ACT 2601

A *neotectonic* fault is defined as one that has hosted measurable displacement in the current crustal stress regime (i.e. within the last 5-10 Ma (Sandiford *et al.* 2004)), and is therefore suitably oriented to host (or is *capable* of hosting) future displacement (Machette 2000). Evidence for palaeo-seismicity on a suspected neotectonic fault, potentially identified many thousands of years after the last large earthquake, can be used to confirm such a classification. Large earthquake behaviour on intraplate neotectonic faults, such as those in Australia, is highly non-Poissonian. The time between large ruptures varies considerably with time and is often highly episodic (Crone *et al.*

2003; Clark *et al.* 2007). Stress transfer can promote nearby faults towards failure leading to temporal patterns in rupture (e.g. Caskey & Wesnousky 1997). Consideration of neotectonic faults as *active* or quiescent in probabilistic hazard assessments is hence problematic.

The relevance of earthquake events on a given *neotectonic* fault is dependant upon the large earthquake recurrence interval on the fault and the return period being considered for hazard purposes. This in turn depends on the infrastructure being assessed. A static definition of an active fault, such as that used in interplate California, where a fault is defined as being active if it is associated with a *surface rupture* in the last 10,000 years, is clearly not useful to seismic hazard assessment in an intraplate setting like Australia. This is so because recurrence intervals for surface rupture on neotectonic faults in Australia are measured in the tens of thousands to hundreds of thousands of years or more (Clark & McCue 2003; Crone *et al.* 2003; Clark *et al.* 2007; Clark *et al.* 2008a). Depending upon location and an understanding of patterns in episodic rupture, a fault or fault segment having experienced a surface rupture in the last ten thousand years is likely to have expended a significant portion of its accumulated stress. Consequently it is unlikely to host a damaging event for many thousands of years into the future. Stress re-adjustments following a main shock may induce a temporally extended tail of smaller magnitude earthquakes that justifies consideration of the fault as active *sensu stricto*, but damaging aftershocks more than a year or two after the main shock are extremely unlikely, so the fault might defensibly be termed *quiescent* for seismic hazard purposes. Examples are to be found in the Tennant Creek and Meckering areas, which continue to experience micro-seismicity 21 and 41 years after the respective surface ruptures, but have not generated damaging earthquakes (M>5.5) beyond a couple of years after the main shocks.

More rigorously, the contribution to a hazard determination from a given neotectonic fault source, or combination of neotectonic fault sources, will determine whether the fault(s) should be considered active (Somerville *et al.* 2008). Activity on a fault should be defined on a local basis from neotectonic data, depending upon the recurrence of the local faults and the return period of interest. For example, in a recent study of three faults in the Flinders Ranges (Somerville *et al.* 2008), it was found that for a 10,000 year return period, the faults contributed approximately 40% of the hazard to nearby infrastructure, but only 25% of the hazard for a 2,500 year return period. This contribution reduced to <10% for a 500 year return period, where smoothed instrumental seismicity dominated the hazard. It might be concluded from this study that the three faults, in combination, could be considered to be active for the purposes of assessing critical infrastructure, but

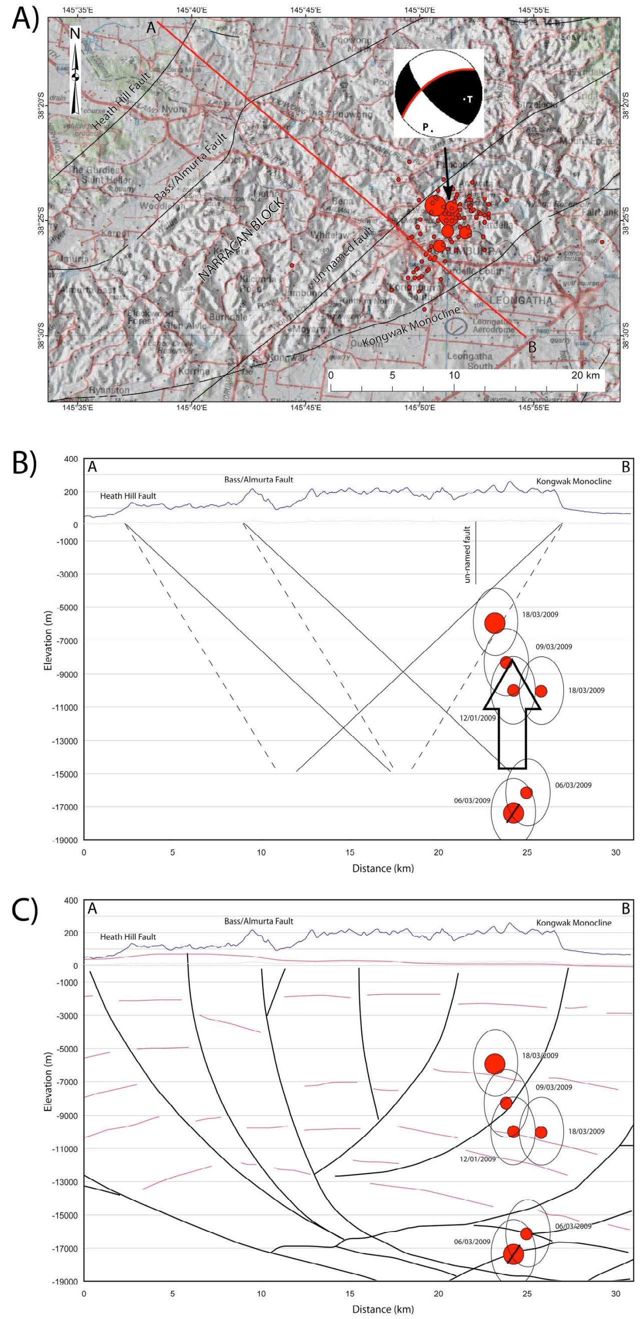


***Figure 1** – **a)** Plot of the epicentres of the largest of the March 2009 Korumburra earthquakes (courtesy of Wayne Peck at ES&S, 24/04/2009) overlaid onto 3 second SRTM DEM data with major fault traces marked. Focal mechanism courtesy of Kevin McCue (preferred nodal plane marked). **b)** Cross section A-B showing plausible subsurface envelopes of the major faults (45° and 60° dip) and hypocentre locations projected onto the section plane. Rupture width of the 06/03/2009 M4.6 event is shown oriented with the preferred nodal plane of the focal mechanism. Subsequent locations suggest that the 06/03/2009 events occurred at ~6 km depth (black arrow), **c)** Line drawing of BMR seismic line 90/15 from the eastern Gippsland Basin (Williamson et al. 1991) superimposed on the topography above the Korumburra earthquakes. Post Strzelecki Group sediments from the Gippsland Basin have been stripped from the line and the base of Latrobe Group used as a proxy for the ground surface near Korumburra. The master fault (and hence the asymmetry) is assumed to be the Bass/Almurta by analogy with the along-strike Yarragon fault. In b) and c) relief above sea level is exaggerated ten times. Relief at actual scale is shown by the grey line.*

perhaps not for the purposes of typical residential and commercial construction. This approach is not without its complexities, potentially leading to a situation where a single fault in isolation is not considered active, but when viewed amongst a group of proximal contributing faults may be considered active. In addition, Somerville *et al.* used a slip rate averaged over the last 100,000 years (three seismic cycles). It is not clear how this slip rate relates to the longer term slip rate on the faults.

Those concerned with short-term seismic hazard often consider a fault to be *active* if it is associated with historic seismicity, which in the Australian context is restricted to the last ~100 years (Leonard 2008). However, in most intraplate areas worldwide, in the absence of surface rupture, historic seismicity does not have a clear and demonstrable relation to neotectonic faults. This is especially the case where instrumental earthquakes are small and the subsurface geology is incompletely known. Take for example the recent Korumburra sequence of events in the Gippsland region of eastern Victoria. These events, culminating in two magnitude 4.6 earthquakes on the 6th and 18th of March 2009, occurred at ~7-9 km depth (Gary Gibson, ES&S, personal communication, 2009) below an uplifted block between the Bass-Almurta Fault and the Kongwak Monocline (the Narracan Block, **Figure 1a**). Both faults are considered to be *neotectonic* as there is significant geologically recent topography associated with them (>100 m), but it would be bold to place the events on either fault on the basis of a spatial association with the surface trace alone. Assuming a square rupture, the rupture planes of the largest two events are unlikely to be larger than ~1.5 km on a side. The horizontal errors associated with the hypocentres are in the order of kilometres, and the vertical uncertainties of a similar order or greater. Furthermore, the subsurface geometry of neither fault is known. Convergent dips of between 45-60° in the upper five kilometres of crust are geologically reasonable (**Figure 1b**). By analogue with faults of the eastern Gippsland Basin, into which these faults link, dips might be expected to shallow markedly below 5 km depth (i.e. a listric geometry). A plausible fault geometry is depicted in **Figure 1c**, which superposes the structural geometry imaged by seismic reflection line BMR line 90/15 in the eastern Gippsland Basin (Williamson *et al.* 1991) onto the topography of the Narracan Block. Depending upon the preferred structural geometry, and the level of confidence placed in the hypocentral depths, one could develop a scenario where slip/creep on the Bass/Almurta Fault in the ductile lower crust stressed the hanging-wall block and triggered events on the fault underlying the Kongwak Monocline. Without high-precision seismic reflection data and accurate estimates of hypocentral locations this scenario remains speculative. For this reason it is not usually possible to confidently associate small to moderate earthquakes with particular structures, and hence assign an "active fault" label.

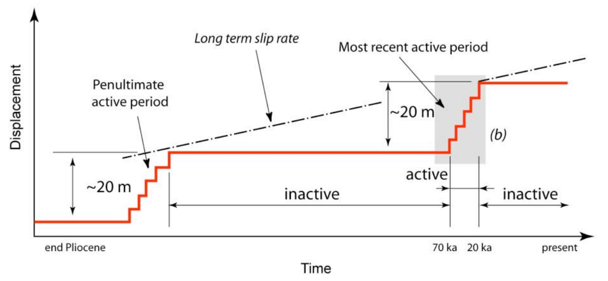


Figure 2 – Schematic diagram depicting clustered surface rupture behaviour modelled on the Cadell Fault. In an active period, the fault might host surface ruptures with a recurrence of <10,000 years. In intervening periods of quiescence the fault might be considered to be quiescent, depending upon the return period of interest.

How might episodic rupture activity modify our perception of what might be considered an active fault? The Cadell Fault in southern NSW might be considered to be very active on the basis of having slipped in the order of 25 m in the last 70,000 years (Clark *et al.* 2007). However, detailed palaeoseismological data implies that this displacement occurred in the interval ~70,000-20,000 years ago, with an average recurrence for M>7.0 earthquakes of ≤10,000 years. No large events have occurred for more than 2-3 average seismic cycles since 20,000 years ago. Seismic reflection profiling of the fault suggests that only one other similar period of activity, again involving in the order of 20 m of relief building (25 m of slip), has occurred on this fault in the last two million years (**Figure 2**). If this pattern were to continue, barring a last dying gasp of the recently past period of activity, we might not expect another large event on this fault for several hundreds of thousands of years. Consequently, a significant overestimation of hazard would result if a probabilistic hazard assessment used the average recurrence for this fault over the most recent active period, in the absence of information about the longer term rupture behaviour.

The situation is not often as clear cut as for the Cadell Fault, for the reason that Australia's neotectonic record is highly under-explored. For example, the Lake George Fault, 40 km east of Canberra, has experienced ~120-250 m of displacement in the current stress regime (Singh *et al.* 1981; Abel 1985). This implies a slip rate of ~12-25 m/Ma, and an average recurrence in the order of a hundred thousand years or more for M>7.0 events. With the exception of undeformed strandlines from palaeo-lake high-stands which suggest no rupture in the last 100,000 years (Kathryn Fitzsimmons, ANU, personal communication, 2008), nothing is known of this faults' rupture behaviour. Activity that might impact a seismic hazard assessment cannot be demonstrated with current knowledge. The Lapstone Structural Complex near

Sydney might be assumed to be more active than the Lake George Fault by virtue of its >400 m high escarpment. However, recent work suggests that only ~10% of the relief across the feature formed as the result of neotectonic activity (Clark *et al.* 2008b). The average recurrence of M>7.0 events is in the order of millions of years. Hence, for most seismic hazard purposes this complex of faults must be considered quiescent, stressing the point that estimates of fault activity need to be based upon sound neotectonic data.

In light of the potential for pronounced episodic rupture behaviour on Australian faults (e.g. Crone *et al.* 1997; Crone *et al.* 2003; Clark *et al.* 2007; Clark *et al.* 2008a) (**Figure 2**) it is questionable whether long term slip rates (and the recurrence estimates based upon them) are everywhere (or anywhere) appropriate for probabilistic seismic hazard assessment. In the case of the Cadell Fault, the recurrence for surface rupture between periods of activity is essentially zero, while the recurrence in active periods is <10,000 years. As the duration of an active period can stretch to 100,000 years, it may be appropriate to use this "short-term" recurrence when assessing hazard of a fault in an active period, as Somerville et al. (2008) have done. The model presented in **Figure 2** helps to conceptualise the points critical to understanding the hazard posed by intraplate faults, and hence assess activity: (1) is the SCR fault in question about to enter an active period, in the midst of an active period, or in (or just entered) a quiescent period, and (2) if a fault is in an active period, what is the "average" recurrence interval and what is the variability around this average. This "average" could be incorporated statistically into probabilistic seismic hazard assessments (e.g. Somerville et al., 2008).

It is likely that faults in more neotectonically active areas, such as the Mount Lofty and Flinders Ranges, and the Otway, Bass and Gippsland Basins might individually, or in combination, be considered active for applications down to a 2500 year return period (c.f. Somerville *et al.* 2008). In Western Australia, where recurrence intervals are very large and faults spatially isolated (e.g. Clark *et al.* 2008a), faults might not justifiably be termed active for all except studies relating to the most critical infrastructure.

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How should we define an 'active fault' in Australia

David Love PIRSA

From the historical earthquake data I have seen (principally in South Australia, but also other states), I have not seen data convincing me that any mapped fault is active. One general pattern is that continuing activity occurs in and close to elevated areas, and many flat areas have little activity. Elevated areas are usually folded and faulted. Is the activity due to weakness from folding, faulting or something else? We also have offshore activity, generally poor located, and odd areas like the South West Seismic Zone in Western Australia. More accurately located events, such as from the 2004-06 Flinders Ranges SA seismic survey, show some correlation between geological features and hypocentres, but it is not possible to make a clear connection between mapped faults and hypocentres. It is very difficult to demonstrate the location of a fault at depth (even with good seismic reflection data) in the Flinders Ranges.

I would be interested to know how many plate boundary faults exist that suffer magnitude 6^{+} events, but do not exhibit more regular activity. How much plate boundary movement is also happening without earthquakes?

Where a fault has historical and geological data for movement, I can see a clear case for the two to be included in a hazard analysis. But where a fault has no obvious historical activity, despite a large geological offset, should it be allowed to dominate a hazard analysis? How much uncertainty is there in dating of event times, length of contiguous faulting, certainty that it will break in a single event, and maximum throw estimates. Surely there is some need to demonstrate that it has not been 'healed' or 'de-stressed' before it assumes a major role in a hazard map? The Flinders and Mount Lofty Ranges now have about 130 years of historical earthquake activity, with 45 years of network recording. What is going to give us the best estimate for the next 50 years?

When including a geological fault in a hazard analysis, there are two very different ways to handle its inclusion. One is to subtract the expected fault activity from the zone and apply it to the fault. The other is to add the expected fault activity to the existing hazard. The former method does have a problem if the expected geological movement is more than the historical source zone data suggests. I have a conceptual problem with the latter when the Gutenberg-Richter relation (if we follow McCue and Sinadinovski) seems to roll off at about M5.5. Historical data needs to be carefully reviewed to demonstrate more clearly if this roll-over is true. If it is, then I feel the latter method should not be used unless there is very strong evidence.

Would we be closer to producing a hazard map if we investigated stress?

How Serious are we about Active Earthquake Fault Identification?

Mike Turnbull (Central Queensland University, Central Queensland Seismology Research Group)
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Consider the region of central Queensland bounded by Maryborough in the south, Gladstone in the North, and west to Monto, Eidsvold and Gayndah. Although this area only contains about 12% of the Queensland residential population (about 500,000 people[1]) the Gladstone region alone currently generates some 27.4% of Queensland's and 7.6% of Australia's annual international exports by tonnage carried by sea in 2004-2005. Current Gladstone port trade is valued at greater than \$5 thousand million per year[2] and industry projects valued at up to \$30 thousand million are planned over the next few years. It is probably accurate to say that if the Central Queensland industrial revenue was disrupted for 6 months the Queensland government would be bankrupt.

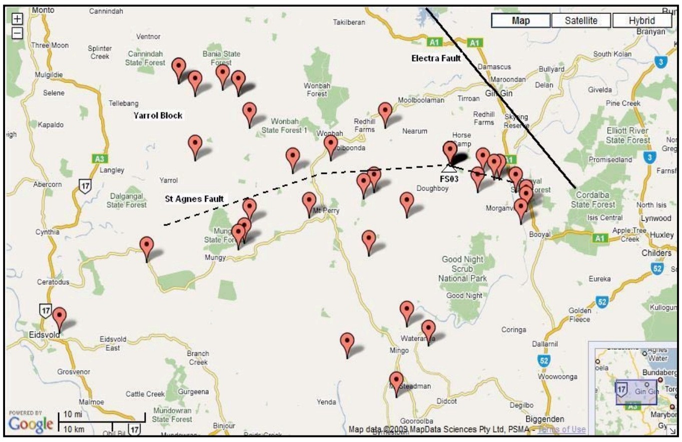

Figure 1: Earthquakes that provide evidence of the St Agnes fault being active

This region is known to have a major complex of geological fault zones that have generated the two largest earthquakes to have occurred on the east coast of mainland Australia. The 1918 "Great Queensland Earthquake" has often been listed in literature as a magnitude 6.2 (it is now listed in the EMA Database[3], and the Geoscience Australia Catalogue as a magnitude 6.0[4], but as recently as 2006 the University of Queensland literature listed its magnitude as 6.3[5]). The 1918 Gayndah Earthquake has often been listed in the literature as a magnitude 6.0 (it is now listed in the Geoscience Australia Catalogue as a magnitude 5.5[4], but as recently as 2006 the University of Queensland literature listed it as a magnitude 6.1[5]) event. The recent experience of the central Italian magnitude 6.3 earthquake, with over 180 people killed and tens of thousand homeless and dislocated, not to mention the economic cost to lives, infrastructure and industry, gives us some idea of the similar effect such an event could have on south-eastern Queensland – save that the low CQ population density mitigates the human vulnerability.

Seismic monitoring carried out by the author using data obtained from station FS03 from 2004 to 2008[6] has provided more than 100 earthquake locations (ranging in magnitude from 0.5 up to 4.4) that are evidence of active faulting west of Bundaberg.

Figure 1 indicates the location of FS03 and 42 of those events in the immediate vicinity of one particular fault line designated the St Agnes fault by the author. This fault is indicated on the Bundaberg Geological Sheet as an unnamed lineage. The surface expression of the fault is particularly evident on satellite image maps such as GoogleEarth. Seismic station FS03 is located on the down throw of its 40 m scarp, along the bottom of which flows the St Agnes Creek (hence the name of the fault). The western extension of the St Agnes fault intersects the Yarrol Block fault zone that gave us the 1935 Gayndah event. The eastern end intersects the Electra Fault. It is interesting that the Burnett River features at both extremities of the St Agnes Fault.

Research carried out by the author[7][8] and with Weatherley[9] indicates that the broader Central Queensland region can (and has) generate at least one magnitude 6.0 earthquake in any given 120 year period. The St Agnes fault is just one of probably hundreds of active faults in the region.

Despite the economic importance of the region, and the demonstrated disastrous seismic potential of it, there is no funding available to identify and locate the active faults in this area in detail. It would be of engineering and economic interest to identify those faults with the potential to adversely affect the large urban and industrial centres.

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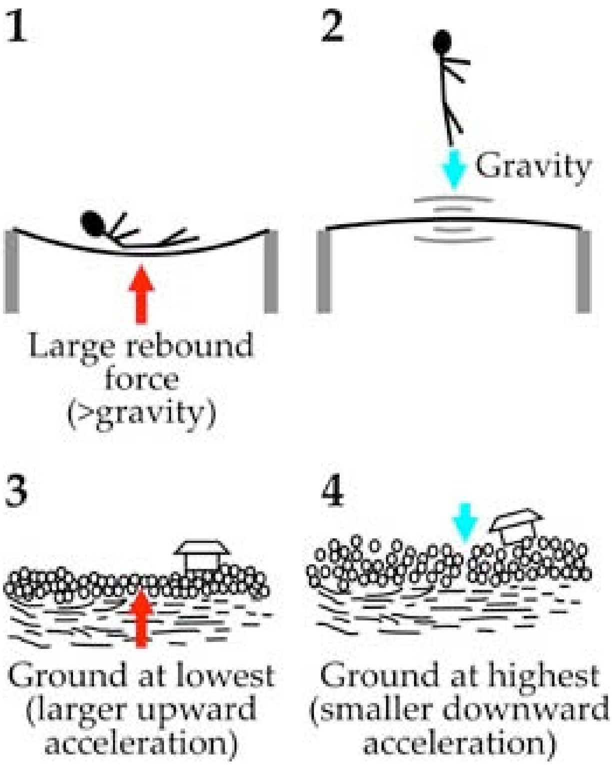
Trampoline model of Vertical Earthquake Ground Motion

(from Physics Today October 30, 2008)



Seismic sensors at the surface of a borehole near the epicenter of a magnitude-6.9 earthquake this year in Japan revealed unpredicted asymmetry in the vertical wave amplitudes at the soil surface: The largest upward acceleration was more than twice that of the largest downward acceleration. The data also showed that the soil surface layer was tossed upward at nearly four times the gravitational acceleration— more than twice the peak horizontal acceleration. These findings run contrary to current structural engineering models, which presume that seismic waves from earthquakes shake the ground horizontally more than vertically. Shin Aoi and colleagues at Japan's National Research Institute for Earth Science and Disaster Prevention propose what they call a trampoline model to explain the observed nonlinear bouncing behavior. In their model, the soil undergoes compression in the upward direction and behaves as a rigid mass with no intrinsic limit on acceleration, much like an acrobat rebounding from a trampoline (figures 1 and 3). In the downward direction, though, dilatational strains break up the soil and the loose particles fall freely at or below gravitational acceleration (figures 2 and 4). The observed seismographic data were simulated by combining the theoretical waveform from the trampoline model with selected borehole data that resembled elastic deformation of a deformable mass. The researchers say that other events need to be analyzed to learn how material conditions t vertical ground response during large earthquakes. (S. Aoi et al., Science 322, 727, 2008.) — Jeremy N.A. Matthews

Related links:
Kik-Net: Japanese network of strong-motion seismographs
United States Geological Survey Shake Maps
Stanford University Quake Catcher Network

2009 L'Aquila Earthquake

The **2009 L'Aquila earthquake** occurred in the central Italian region of Abruzzo on 6 April 2009, its magnitude 6.3. The majority of the damage occurred in the medieval city of L'Aquila (capital city of the Abruzzo region) and the surrounding villages. At least 294 people died, 20 of them children. Several buildings collapsed and the earthquake caused damage to between 3000 and 11000 buildings in L'Aquila. Schools remained closed in the Abruzzo region. In the city centre of L'Aquila, many streets were impassable due to fallen masonry. The hospital at L'Aquila, where many of the victims were brought, suffered damage in the M4.8 aftershock an hour after the main earthquake. While most of l'Aquila's medieval structures suffered damage, many of its modern buildings suffered the greatest damage, for instance, a dormitory at the university of l'Aquila collapsed. Even some buildings that were believed to be "earthquake-proof" were damaged. L'Aquila Hospital's new wing, which opened in 2000 and was thought capable of resisting almost any earthquake suffered extensive damage and had to be closed.

Damage in a modern concrete-framed building with infill walls.

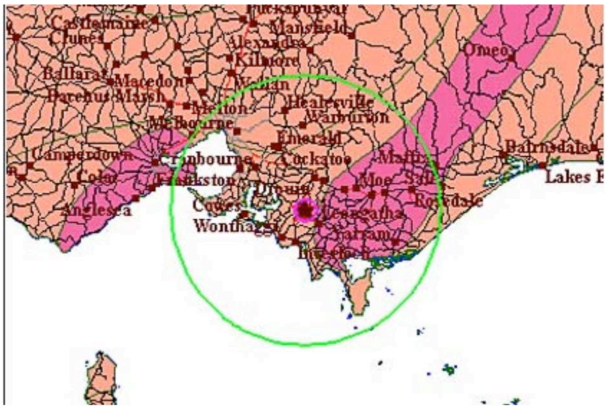
Korumburra Victoria Earthquakes

An earthquake of magnitude 4.6, struck Gippsland Victoria at 7.55pm on 6th March, its epicentre near Korumburra, nearly 100 km SE of Melbourne.

Gippsland residents reported cracked walls, shaking houses, rattling windows and distressed animals after the earthquake.

State Emergency Service spokesman Allan Briggs said the service had received 30 calls for help in areas as far apart as Ascot Vale and Knox.

The calls were for minor structural damage, including cracks in walls, he said.



Map: *Epicentre (star) showing expected felt area in green and possible damage radius in red. Background is part of the earthquake hazard map of Australia (red higher than orange).*

Shaking was felt throughout the Melbourne metropolitan area. It shook the football stadium holding a large crowd at a pre-season game of Australian football.

The Herald Sun hotline was apparently flooded with reports from terrified residents as far away as Leongatha and Warragul, but no-one reported any injuries or damage. A Drouin West resident said she had been sitting in the lounge when her two-storey house shook. "The house just moved, it sounded like a massive bang upstairs and the whole house shook,'' she said. "You're just waiting, this was the worst one I've felt. "My husband was outside milking a few cows and we could hear him carrying on... I knew that it had to be an earth tremor …'' Another Arawata resident said she suspected there had been a tremor when all her neighbours left their houses to see what the disturbance was. "We were inside and just heard this big crash,'' she said. "There was an almighty bang and that was it.''

Another resident reported: "We felt the whole top storey of our house shaking. The birds in the aviary were making a lot of noise for a few minutes before the earth tremor."

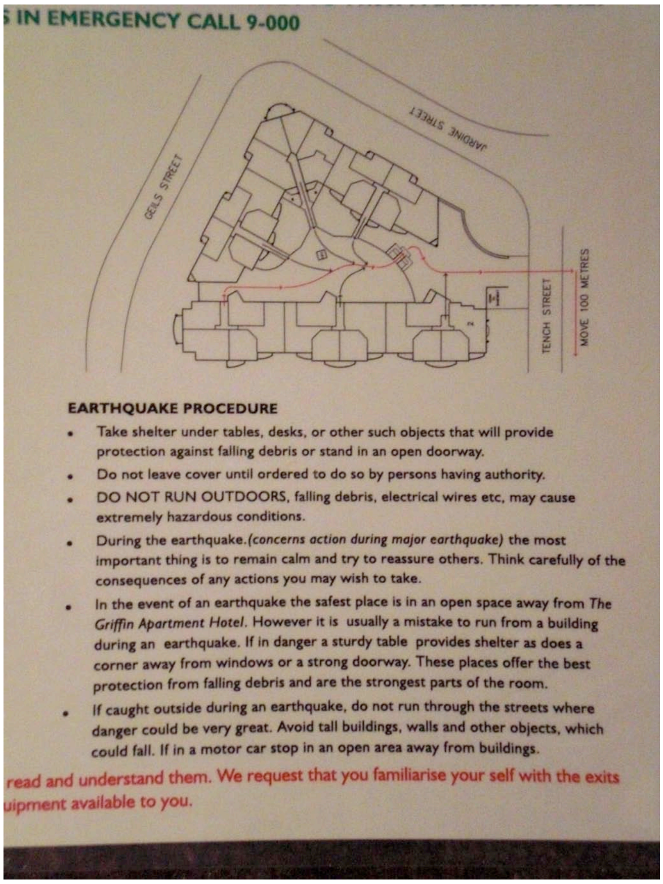
Three of the hundreds of aftershocks exceeded magnitude 3.0, the first of them occurred just 6 hours after the mainshock, at the same time as a magnitude 2 earthquake struck Young NSW. It was Victoria's largest earthquake since 2001, when a magnitude 4.8 earthquake occurred near Swan Hill in northwestern Victoria.

Gary Gibson installed a near-epicentre seismograph on Sunday and GA and ES&S staff installed another five more on Monday, just before the second M4.6 event hit. These recorders were equipped with broad-band and strong motion sensors so a significant dataset has been captured.

Gippsland is no stranger to earthquakes, the map shows the epicenter on the edge of the higher risk area (red) in the current hazard map of Australia in AS1170.4 - 2007.

From John Adams, Canadian seismologist visiting Canberra

John sent the Editor this photo of an un-expected notice in a Canberra hotel:



From our Members (Helen Goldsworthy)

Learning from Earthquakes

Tewkesbury Lecture at the University of Melbourne

Given by Professor Nigel Priestley, 1st April, 2009

Review by Dr. Helen Goldsworthy, University of Melbourne

Many local structural engineers eagerly anticipated Nigel Priestley's March/April 2009 visit to Melbourne. Nigel's insightful and intelligent approach to a-seismic design, in which he debunks what he has previously called "myths and fallacies", is widely appreciated and guaranteed to excite interest.

During his week in Melbourne, postgraduate students, academics and structural consultants benefited from him giving nine hours of seminars that summarized the main thrust of the direct displacement based design method. This is a method he has developed over many years, culminating in a book that he has co-authored with G.M. Calvi and M.J. Kowalsky entitled "Displacement-Based Seismic Design of Structures"

Nigel also met individually with postgraduate students to discuss their projects in more depth.

On the evening of Wednesday the 1st of April Nigel gave the Tewkesbury lecture in one of the large medical theatres at the University of Melbourne, with an audience estimated to be between 150 and 200 people. Many of these were local engineers, and some seismologists. Others may have stumbled in because of the recent earthquakes close to Melbourne. Nevertheless, by the end of Nigel's very convincing presentation, they, like my husband Jeff (Professor of Law at Monash University) would have been strong advocates for displacement-based design!

The focus of the lecture was not on the many known structural imperfections that have been revealed time and again in past earthquakes, although there were certainly some well-chosen slides to illustrate certain points. It was, instead, on the areas where there are still weaknesses: the crudeness of seismicity estimates, the vulnerability of structural concepts and errors in design philosophy. Each of these was discussed in detail.

With regard to crudeness of seismicity estimates, Nigel pointed out that the earthquake intensity levels that engineers were required to use in structural design in the vicinity of many recent earthquake events such as Northridge, Kobe, Turkey, Taiwan and Sichuan were woefully inadequate, leading to widespread damage. Some of the reasons for this were explored. It was postulated that a mismatch between the areas of interest (especially the period range) of seismologists and engineers, when examining the effect of earthquakes in a particular region, could be partly to blame. He also was concerned about the way engineers take probabilistic data from seismologists and "are forced to treat it deterministically." A question posed by Nigel that is particularly relevant to regions of low seismicity is as follows: "If the seismicity of a region is dominated by a single, rarely occurring event (say return period of 1000 years, PGA = 0.5g), and the design accepted risk has a return period of 500 years, what should the design PGA be? 0.25g?" His logic was that either the design event was going to happen or it was not, and that to design for the lower level of seismicity would not help matters if the worst-case scenario were realised. Other issues discussed were geographical amplification of ground shaking (eg. on the ridges of steep hills), the non-stationary nature of seismicity in some regions of the world such as Chile, and the concept of "uniform risk".

The first part of the section of his lecture on "Structural Vulnerability: some conceptual issues", was a summary of current seismic design philosophy in which consideration is given to three levels of earthquake called service, design and extreme, with corresponding return period of 50, 500 and 2500 years. The performance levels generally expected under these levels of earthquake were said to be "no damage", "repairable damage", and "no collapse".

The obvious, and crucial, point was made that "Displacements are more important than strength" in determining the level of damage sustained.

Nigel stressed that the following were essential if acceptable seismic performance were to be achieved: suitable structural form, suitable form/material combination, emphasis on deformation, capacity design, detailing for ductility, and the provision of redundancy. It was in this section that some well-chosen slides of excessive damage during recent earthquakes were displayed to illustrate the various points that were being made. Nigel demonstrated that the actual structural performance was sometimes different to what had been anticipated in design, even if the design were nominally code-compliant. For example, poor performance has been observed under diagonal earthquake attack at the corner of a building where a reinforced concrete structural wall acts as the lateral force-resisting system in one direction and the end of the wall is a "column" in the reinforced concrete moment-resisting frame acting in the transverse direction. Large out-of-plane displacements in the corner at the lowest storey of the wall are largely driven by the transverse frame behaviour.

Many of the slides in this section of the lecture emphasised the importance of designing to control inelastic deformations at extreme levels of earthquake. This is sometimes called the capacity design method, in which the structural designer establishes certain strength hierarchies within the structure so that the energy dissipating mechanism at extreme levels of earthquake is a reliable one. The objective is to ensure that the required ductility can be achieved at the chosen weak, ductile regions, and a premature brittle failure is avoided in those and other regions.

The last section of the talk on "Deficiencies in our design approaches" is a reminder to all of us to question the existing design paradigms and the assumptions behind them. Nigel has spent much of his working life not only questioning, but also coming up with some workable answers!

Key assumptions behind the force-based design approach were examined closely and found to be wanting. The reliance on the use of initial elastic stiffness to determine the fundamental period of the structure, and the distribution of forces between elements in the structure, was challenged because of the failure to recognise that stiffness is directly related to strength. The stiffness of structural members is usually estimated by crude approximations (for example using some proportion of the gross cross-sectional properties in the case of reinforced concrete members), and it is not generally recognised that there is a wide range of stiffness associated with a particular size member depending on its strength. The multi-modal method is thought by many to be a refined analysis that gives more accurate results than other methods.

Nigel argued that our lack of knowledge of the stiffness of the members due to the unknown strengths at the start of the design means that the perceived improvement in accuracy is dubious. Further to this, an example was given of a reinforced concrete frame subject to an earthquake ground motion leading to changes of axial force level that are different in different columns at the same storey level, and hence relative changes in strength and thus stiffness of those columns.

The force reduction factors used in current force-based design were shown to differ widely from one code to the next, and the estimates of displacement demand were also shown to vary widely. The desirability of high strength was questioned and it was alleged that the greater cost associated with providing higher strength does not necessarily lead to significant improvements in performance. In a brief summary of the history of seismic design philosophy, Nigel revealed that the importance of displacement capacity, rather than strength, has been recognised internationally in a-seismic design since about 1990. Many researchers have pursued the holy grail of developing a new displacement-based (or performance-based) approach to design.

After convincing us of the need for a change in design philosophy, Nigel succinctly expounded his particular method "Direct displacement-based design (DDBD)". In his method he places limits on strains in key members and also on floor-to floor drifts in order to determine the target displacement. He logically focuses on secant stiffness at the target level of displacement, and neatly avoids the problems associated with the use of initial stiffness. His outline of the DDBD approach showed that it is a rational alternative to force-based design in which force reduction factors are not needed and no iterations are required. It does require knowledge of the relationship between the effective damping and ductility for a given structure, and on simple estimates of the yield displacement. According to Nigel the method leads to a rational distribution of strength between structural elements and to uniform risk structures, and it ensures that near-field response, torsion, irregular structures and P-delta effects are directly and correctly addressed.

The direct displacement based approach developed by Nigel is one that many Australian researchers, including myself, have been familiar with for some time. However, for some in the audience, it was their first exposure to this, and it clearly excited much interest. It should, once again, be emphasised that behind this method is a deep appreciation of the need to establish suitable strength hierarchies within structures, and the importance of proper detailing in the regions chosen to behave in a ductile manner. This is particularly important for the extreme level earthquake, but since Australian designers are not usually forced to consider this level of event, they are less likely to use capacity design principles in their assessment of the completed design. Nigel's discussion of the importance of large events in regions of low seismicity is very relevant here. In fact, in the draft displacement-based code at the back of his latest book, the extreme level event is the one that is assumed to control the design for regions of low seismicity, and the "single requirement is that the building must not collapse, and there should be no loss of life" under this extreme event (defined as one with a 2500 year return period). I, personally, support this approach, although I would advocate a quick check of drift levels (and strain levels in key elements) at the design level earthquake (500 year return period) to reduce the possibility of damage to both structural and non-structural components at this lower level (corresponding to a site further from the large magnitude earthquake than the site with a 2500 return period event). No doubt there will be many interesting debates that will flow on from Nigel Priestley's 2009 visit. It was an action-packed one-week visit and one that was greatly appreciated by all in attendance at the various seminars, public lecture and meetings.

Conferences

International Conference on Performance-Based Design in Earthquake Geotechnical Engineering

Date: 15-17 June, 2009
Venue: Tokyo, Japan
Website: www.comp.tmu.ac.jp/IS-Tokyo/
Email: ytsoil@rs.noda.tus.ac.jp

This conference will cover a range of topics associated with performance-based design in earthquake geotechnical engineering.

9th US National & 10th Canadian Conference on Earthquake Engineering: ***Reaching Beyond Borders***

Date: 25-29 July, 2010
Venue: Toronto, Canada
Website: www.2010eqconf.org
Abstracts: Due by 31 March, 2009

This Conference in Toronto, Canada, will provide an opportunity for both researchers and practitioners to share the latest knowledge and techniques for understanding and mitigating the effects of earthquakes. This is the first time that a conference of this scale is being organized jointly by the Earthquake Engineering Research Institute (EERI) and the Canadian Association for Earthquake Engineering (CAEE). The conference will facilitate synergy between U.S. and Canadian colleagues, as well as other participants from around the world. This conference will bring together professionals from a broad range of disciplines, including architecture, structural engineering, seismology, geology, geophysics, geotechnical engineering, business, public policy, social sciences, regional planning, emergency response planning, and regulation.

The 7th International Conference on Tall Buildings

Date: 29-30 October, 2009

Venue: InterContinental Hotel, Grand Stanford, Hong Kong
Website: www.hku.hk/civil/ictb7
Email: ictb7@hkucc.hku.hk
Conference Theme
Sustainable tall buildings – Design, research, construction and building services
Organiser
Department of Civil Engineering, The University of Hong Kong (HKU)
Co-organisers
The Hong Kong Institution of Engineers (HKIE)
The Hong Kong Institute of Architects (HKIA)

Key Dates

15 June 2009 Deadline for abstract submission
30 June 2009 Notification of acceptance of abstract
1 August 2009 Deadline for full paper submission
15 Sept 2009 Notification of acceptance of paper

Abstracts and papers should be submitted to ictb7@hkucc.hku.hk and be written in English, the official language of the conference
Contact for Further Information:
Centre for Asian Tall Buildings and Urban Habitat
Department of Civil Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong
email: ictb7@hkucc.hku.hk

ATC & SEI Conference on Improving the Seismic Performance of Existing Buildings and Other Structures

Date: 9-11 December 2009
Venue: San Francisco, California
Website: www.atc-sei.org

This inaugural conference, organized by the Applied Technology Council and the Structural Engineering Institute of the American Society of Civil Engineers (ASCE), is dedicated solely to improving the seismic performance of existing buildings and other structures. For full details visit the conference website.

CECAR 5 ASEC 2010 – Innovative Community Building

The 5th Civil Engineering Conference in the Asian Region and Australasian Structural Engineering Conference 2010

Date: 8-12 August, 2010
Venue: Sydney Convention & Exhibition Centre, Australia
Website: www.cecar5.com
Abstracts: Now open for submission

continued next page…

9th US National & 10th Canadian Conference on Earthquake Engineering

Date:	2010
Venue:	Westin Harbour Castle Hotel, Toronto, Canada
Abstracts:	Deadline 31 March, 2009 (500 word max)
Website:	www.2010eqconf.org

The 9th U.S. National and 10th Canadian Conference on Earthquake Engineering to be held in Toronto, Canada, in 2010 will provide an opportunity for both researchers and practitioners to share the latest knowledge and techniques for understanding and mitigating the effects of earthquakes. This is the first time that a conference of this scale is being organized jointly by the Earthquake Engineering Research Institute and the Canadian Association for Earthquake Engineering. The conference will provide a unique environment to facilitate synergy between U.S. and Canadian colleagues, as well as other participants from around the world. This conference will bring together professionals from a broad range of disciplines, including architecture, structural engineering, seismology, geology, geophysics, geotechnical engineering, business, public policy, social sciences, regional planning, emergency response planning, and regulation.

Obituary Dr John Lahr

(Col Lynam passed on the following news item. John was well known in the seismological community worldwide, especially through the PSN).

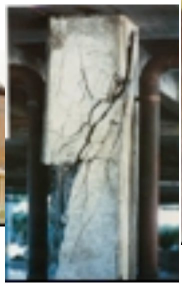
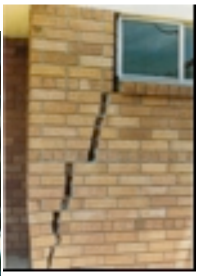
Dr. John Lahr, USGS Emeritus Geophysicist, passed away on March 14, 2009, at the age of 64, from malignant brain cancer.

John was very active in putting seismometers in schools around the country through the Seismographs in Schools Program of the Incorporated Research Institutions for Seismology (IRIS), for which he taught teacher workshops, travelled to schools throughout the US, worked with many more teachers via e-mail and phone, and helped in the development and trouble-shooting of the equipment and software. He was also mentor to, and colleague of, many in the PSN network. We shall miss him greatly.

John's obituary was published in the Corvallis Gazette Times:

www.gazettetimes.com/articles/2009/03/27/news/obituaries/3obi03_lahr0327.tx



AEES 2009 11-13 December, 2009

Newcastle Earthquake - 20 years on

Crowne Plaza
Newcastle, NSW

The 2009 AEES conference will be held in Newcastle, New South Wales to mark the 20th anniversary of the 1989 Newcastle earthquake. The conference will consist of three half-days (Friday afternoon, Saturday and Sunday mornings) and there will be conference dinners on both Friday and Saturday evenings. The AEES AGM will also be held during the conference.

The theme for this year's conference is 'Newcastle Earthquake – 20 Years On'. Authors are invited to submit papers on topics related to any and all aspects of the 1989 Newcastle earthquake as well as other topics relevant to earthquake engineering and engineering seismology and also from related extreme event topics including blast, tsunami, critical infrastructure protection, disaster response, emergency management and insurance.

Amongst the keynote speakers at this year's conference will be Professor Robert Melchers who will discuss the failure mode of the Newcastle Workers Club in the 1989 earthquake.

COMMUNITY FORUM: On the Saturday afternoon, a community forum will be held, on the theme 'Newcastle earthquake, 20 years on'. At this forum a panel of half a dozen experts will field questions from the audience.

The format will be similar to last year's with a blend of keynote speakers, oral presentations and poster presentations. Each poster presenter will be given the opportunity for a short oral presentation to the conference delegates together with a dedicated time in front of their poster for in depth discussion. The full paper will be reviewed and published in the proceedings.

Newcastle is a city that reaches out to the sea. It is bounded by pristine beaches and an active working harbour. A 2 hour drive north of Sydney, Newcastle is accessible via car, rail, air or bus. Newcastle Airport is located 30 minutes from Newcastle city centre and receives direct flights from Melbourne, Brisbane, Sydney, Norfolk Island, the Gold Coast and Canberra. Flights from all other international and national cities arrive into Sydney airport.

Key dates: Abstracts due: 15 June Papers due: 28 August

ABSTRACTS Please submit abstracts, not more than 200 words, of proposed papers to Sharon Anderson at srj@bigpond.net.au by **15 June, 2009**. Authors will receive further instructions on acceptance of their abstract. For other information contact organising committee: Bill Jordan ph: 02 4929 4841