AUSTRALIAN EARTHQUAKE ENGINEERING: ACHIEVEMENTS, CHALLENGES AND OBSTACLES

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ABSTRACT:

The Australian Earthquake Engineering Society was established in 1990 with the objectives of promotion and advancement of the practice of earthquake engineering and engineering seismology in Australia. In the decade or so since its establishment the Society has had some successes as well as some disappointments. In this paper, the author will highlight these along with research and other important professional developments during this period. The perceived obstacles to getting a better take-up of earthquake engineering amongst Australian practitioners and the role of the Society in furthering the cause of earthquake engineering in Australia will then be discussed. The paper will conclude with an outline of possible strategies for overcoming these obstacles.

1. INTRODUCTION

The Australian Earthquake Engineering Society (AEES) was established in 1990 following the December 1989 Newcastle Earthquake. The move to establish the Society came out of a perceived need for an official national forum for professionals to discuss earthquake engineering and seismology issues. The New Zealand National Society for Earthquake Engineering was identified as a model for our own organisation.

It is of historical interest to note that the Australian Earthquake Loading Code was under development at the time of the Newcastle earthquake. To clarify, the first committee meeting was held in Adelaide in November 1989, 1 month before the Newcastle earthquake occurred. It must be stated that the general tone of discussion at the initial meeting was that the committee should not put too much effort into it – perhaps simply requiring all structures to be designed for 0.1g horizontal acceleration would suffice. Needless to say, the tone of the second and subsequent meetings was more urgent, reflecting a desire to develop a standard in the mould of a "loading" standard but also including domestic construction within its scope and some guidance on detailing. The resulting standard, published in 1993 (SA) and subsequently called up by the Building Code of Australia in 1995 (BCA), was perceived to be a reasonably "user friendly" document that practitioners previously unfamiliar with earthquake design could cope with.

That said, the original aim of the AEES, as approved upon its inception, is the promotion and advancement of the practice of earthquake engineering and engineering seismology in Australia. With this background, the following sections of this paper consider how well, or in some cases how poorly, the Society has succeeded in achieving its aims. The paper concludes with some suggestions for how the Society might better achieve its original aims and, indeed, if perhaps the aims should be revised to better meet the needs of its membership and the community that the AEES seeks to serve.

2. SUCCESSES

The Society has been successful in establishing a national forum for the discussion of issues important to the earthquake engineering community. Its membership of 247 members is drawn from all states and is comprised of a healthy mix of predominately engineers and seismologists but also has representatives of government agencies, public utilities and the insurance industry. Perhaps the Society's greatest success has been the improved interaction and mutual understanding of earthquake seismologists and engineers.

While the Society was not officially involved or responsible for the new Australian Earthquake Loading Standard, AS1170.4, the committee that produced it was largely comprised of Society members. Certainly, to the extent that its use has impacted on the wider engineering profession and the community it is discussed here in terms of how earthquake engineering has been embraced across Australia. In my view, two of the major successes (of AS1170.4) are that earthquake loads are now considered in all parts of Australia and that domestic construction is included in its scope. Given the likelihood that much of the damage and potential loss of life in a future earthquake would occur in domestic construction, it was very important that this was done. The response of the profession to the 1993 standard was generally favourable. A remarkable result given the fact that prior to its release few engineers had ever performed a seismic design check/analysis! Its ease-of-use was judged to be a "success" and helped it gain quick approval by the profession. This was in stark contrast to the difficult path travelled by the revised steel code at about the same time.

It is of interest to note here the reaction of some sectors of the construction/building industry to the "new" earthquake loading standard. In particular, those involved predominately with the design and construction of small commercial and domestic construction, including two and three-storey apartment buildings, developed "deemed-to-comply" construction details. In a very practical way, this sector has avoided the need to design every house, apartment and small commercial building individually for earthquake loading while still attaining an improved minimum level of seismic resistance. From a pragmatic viewpoint, I believe this is a substantial success.

Another major success in the area of earthquake engineering in Australia must be said to be the "Cities" project and the joint urban monitoring programme. For those who are not familiar with these projects, the "Cities" project involves the development of GIS earthquake risk assessment methods for the major cities in Australia and has already produced a number of microzonation maps. The joint urban monitoring programme saw two seismographs, one on rock and one located on sediment, installed in each of the capital cities plus other major cities of Australia. This programme has greatly increased the number of strong ground motion recorders in Australia and in the event of a large earthquake near one of the major populated regions of Australia, will provide important data on the earthquake ground motion in a region where widespread structural damage is likely to occur. Earthquake engineers will be able to use this data for back calibrating their structural models typically used in structural analysis and design. Seismologists will be able to use this data too in developing improved ground motion models for intraplate earthquake regions such as Australia. Of course, this can only happen if somebody (organisation) continues to maintain and operate them. This is a very real problem for us since "monitoring" is not regarded as research so that universities no longer fund this work. Strong ground motion recorders also do not fall into the "core business" category for state mines departments. At present, they are largely only saved by government water bodies through a "duty of care".

Finally, since 1990 there has been some very important earthquake-related research of international significance undertaken in Australia. While the amount of money put towards earthquake engineering and seismology research in Australia pales in significance to that spent in other more earthquake prone regions of the world such as the US, it has been reasonably well targeted towards areas of local relevance. For example, excellent research has been undertaken on wide band beam construction, unreinforced masonry construction, and intra-plate earthquakes to mention but a few of the many topics. A quick survey of the major research grants funded by the Australian Research Council (ARC) since 1990 indicates that 14 engineering-related projects have been supported. A greater number have been funded in the area of seismology, however, many of these are focussed towards minerals and petroleum exploration and not especially relevant to earthquake engineering applications. Figure 1 indicates the level of research funding for earthquake engineering projects since 1990. As can be seen, the amounts are not large, peaking around the $200,000 mark in 2000 and dropping off rather steeply the past two years. One might naturally have expected that with increasing time since the Newcastle earthquake, the inclination to fund earthquake related research might have decreased! However, there are a growing number of research academics taking an interest in earthquake engineering issues that is most likely responsible for overall upward trend. With this in mind, the recent drop is worrying. It remains to be seen what the sustained level of funding will be over longer term.

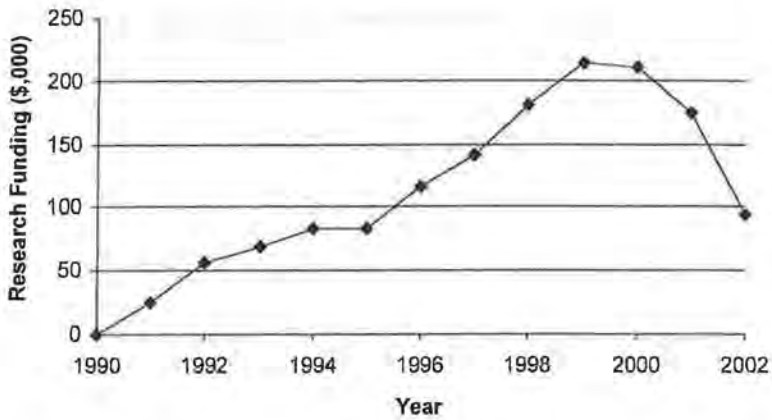

Figure 1. ARC earthquake engineering research funding from 1990 – present.

3. FAILURES

In spite of the best efforts of AEES members and the wider earthquake engineering and seismology community, the engineering profession has been slow/reluctant to adopt many of the modern earthquake engineering design principles. Furthermore, the ongoing maintenance of existing seismic monitoring networks is being threatened through lack of financial support. The reasons for this are somewhat confused but appear to first and foremost the perception that the earthquake hazard in Australia is insignificant and that Newcastle was a "one-off" event. It is difficult to counter this "argument" without some hard data. However, it has always been my position to weigh this against the potential impact of a similar or even larger seismic event in Sydney or Melbourne. The concentration of Australia's population (and economic production) into these two major metropolitan areas means that from a Total Disaster Management perspective, the economic impact of a major earthquake occurring in Sydney or Melbourne would be severe for the entire country.

Other reasons (excuses) for the lack of a "full-blooded" adoption of the most rigorous earthquake design practices in Australia are that the cost/benefit ratio does not justify it. Of course, calculating this ratio is problematic. While it is comparatively easy to calculate the differential cost of design and construction to a more stringent standard, it is extremely difficult to calculate the corresponding benefit. Indeed, often there is little if any financial benefit to a building owner to have their building meet or exceed the minimum standards if "they" are covered by insurance in the event of disaster. One might conclude, in fact, that earthquake insurance is counter-productive in terms of minimising structural damage. Only by taking a "big picture" perspective to calculate benefit, and even then it is challenging to attribute dollar amounts to the benefits, is it likely that a cost/benefit ratio less than one will result. Of course, it is my view that this is just the perspective we should be taking as a Society and indeed the charter of the Institution of Engineers states that as a profession, we are to "serve the needs of the community first", before even our client.

Other related and complicating issues such as a lack of understanding of structural dynamics/seismic engineering fundamentals by the broad structural engineering profession and the current environment of a largely "de-engineered" public sector that we are now operating in make it difficult to convince government bodies, the profession and the community that modern earthquake engineering design procedures warrant being taken up in earnest.

Last but not least, it appears that we have failed (to-date) in getting sound earthquake engineering knowledge integrated into the various state-based disaster management planning processes. The reason for this seems to be a misunderstanding by the AEES of how state disaster management planning operates and perhaps also a lack of understanding, and certainly experience, in how local earthquake engineering expertise can be better (more fully) utilised by disaster management planners.

4. THE WAY FORWARD?

In order to improve the up-take of modern earthquake engineering design principles by the engineering profession and to increase the quality and quantity of earthquake engineering input into the total disaster management process in this country, it is proposed that the society consider a three-pronged attack covering the following three areas: (1) Education, (2) Advocacy, and (3) Coordination.

4.1 Education

Within the domain of education, it is recognised that this will require some long-term effort at the grass roots level in parallel with short-term effort at the professional level. This could take the form of:

- Undergraduate training. This means that we must get earthquake engineering into the under-graduate civil engineering curriculum across the country. This might also require some training of academics since not all civil engineering departments in Australia have the necessary expertise to offer such a course.
- Professional training – the AEES could coordinate and sponsor workshops to raise the understanding of fundamental earthquake engineering principles and design issues amongst practising engineers. This might consist of "refresher" courses (half-day) for those with previous experience and more substantial (3-4 day) courses for "first-timers".

4.2 Advocacy

Within the domain of advocacy, the society should work to raise the awareness amongst the wider community of the benefits of improved seismic resistance in all construction (new and existing) but especially to major building owners/managers. This could take the form of:

- AEES to promote seminar/workshops for building owners and insurers to make them aware of key issues.
- AEES to promote the concept of earthquake rating for buildings. This would aim to encourage building owners and insurers to embrace the concept of earthquake design for new construction and seismic rehabilitation of existing structures.
- AEES to communicate need for strong ground motion data to the federal and state authorities – perhaps even encourage legislation to have large building projects incorporate strong ground motion recorders and their maintenance into the project.

4.3 Coordination

Finally, within the domain of coordination, the society should work to establish effective engagement of the membership with key disaster management organisations at both the national and state levels and to increase the efficiency in the way the very limited national research funding is spent on earthquake-related research. This could take the form of:

- AEES membership to become actively involved in the Total Disaster Management process at national, state and local levels.
- AEES body to workshop all parties involved in the design, construction, and management of the built infrastructure to identify and prioritise research needs. The Society should then communicate this information to the research community, industry and importantly, the funding bodies.

5. CLOSING REMARKS

In closing, from an earthquake engineering perspective it appears that as a nation we have seen some substantial accomplishments over the last decade. However, there is much we could improve on with (perhaps arguably) little additional expenditure.

A 3-pronged approach has been outlined in this paper to encourage the widespread up-take of modern earthquake resistant design principles in Australia. Advocacy and Education are intended to create an environment where the market place understands the benefits of seismic resistance and the engineering community can properly service the communities needs. To me, the Australian Earthquake Engineering Society seems to be the logical group to coordinate these activities as well as serving as a conduit for providing technical expertise to national and state-based disaster management groups.

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SITE RESPONSE ANALYSIS IN NEWCASTLE AND LAKE MACQUARIE.

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ABSTRACT:

Variations in the amount and type of regolith present in a region can cause dramatic variations in the localised earthquake hazard. Consequently, as part of its probabilistic earthquake risk assessment of Newcastle and Lake Macquarie, Geoscience Australia has conducted a detailed site response analysis of the region's regolith.

Six site classes were used to represent variations in regolith materials across the region. Five of these classes contained varying amounts of sands, silts and clays with shear wave velocities between 200 and 400 ms^{-1} overlying weathered rock with a shear wave velocity of 900 ms^{-1}. The sixth site class consisted entirely of weathered rock. Equivalent-linear modelling demonstrated that all of the site classes containing sands, silts and clays amplified response spectral acceleration by a factor of at least 2.3. The class consisting of weathered rock had amplification factors between one and two. The amplification factors are typically greater than those presented in the Australian Standard for Earthquake Loading A map of probabilistic earthquake hazard on regolith demonstrated that variations in the thickness and nature of the regolith caused significant variations in the local earthquake hazard.

1 INTRODUCTION

In September 2002, Geoscience Australia (GA) launched a new product detailing the risk posed by earthquakes to the Newcastle and Lake Macquarie region of Australia (Dhu and Jones, 2002). This product presents the most comprehensive earthquake risk assessment published for any Australian community to date.

A key part of any earthquake risk assessment involves modelling how local regolith (i.e. soils, geological sediments and weathered rock) will affect the ground shaking experienced during an earthquake. Geoscience Australia has developed site response models for the regolith in Newcastle and Lake Macquarie using detailed geotechnical data combined with equivalent-linear modelling techniques. This work is a significant improvement over GA's previous site response models for the region (Dhu et al., 2001) as it incorporates the variability which is inherent in any natural process.

2 GEOTECHNICAL SITE CLASS MODELS

The regolith in Newcastle and Lake Macquarie consists of regions of sediment (deposited over the last 20 thousand years) overlying the weathered and unweathered sedimentary rocks of the Sydney Basin including the coal horizons of the Newcastle Coal Measures (laid down over 200 million years ago). The Quaternary sediments consist mostly of estuarine muds and tidal delta sands.

In order to identify localised changes in earthquake hazard due to variations in the regolith, the Newcastle and Lake Macquarie region was divided into six regolith site classes (Figure 1). These classes represent regions that are considered to have a similar response to earthquake ground shaking, and are summarised below:

Class C. Weathered rock (maximum thickness 15 m).
Class D. Silt and clay (maximum thickness 16.5 m).
Class E. Sand overlying silt and clay (maximum thickness 30 m).
Class F. Sand with interbedded silt and clay (maximum thickness 39 m).
Class G. Silt and clay with interbedded sand (maximum thickness 30 m).
Class H. Barrier sand (maximum thickness 30 m).

The regolith in the classes containing sands, silts and/or clays includes up to 15 m of weathered rock.

The development of these site classes is described in detail in Dhu and Jones (2002). However, it is important to note that all of the site classes containing sands, silts and/or clays were developed from sesimic cone penetrometer tests (SCPTs) undertaken primarily in the Newcastle municipality and the barrier sands to the east of Lake Macquarie (Figure 1). These site classes were then extrapolated to the remainder of the study region based on limited CPT data, microtremor data and inferences regarding the depositional processes in the region.

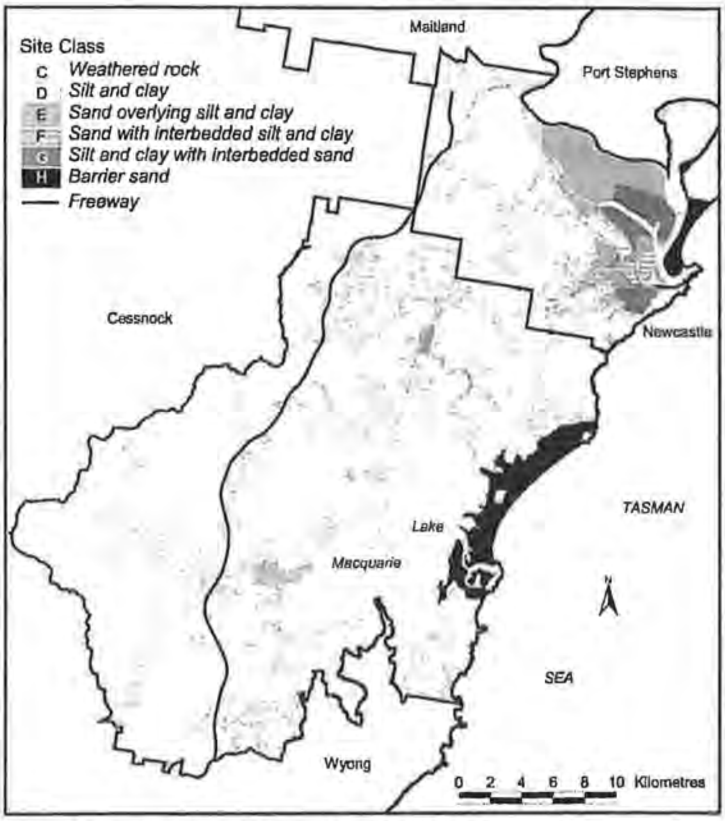

Figure 1: Classification of the regolith in Newcastle and Lake Macquarie

Once the regolith in Newcastle and Lake Macquarie had been classified, representative geotechnical models were developed for each site class. These models incorporated the regolith's thickness, density, shear wave velocity and strain dependent material properties. Idealised profiles for each of these site classes are presented in bold in Figure 2. The detail behind these models is described in Dhu and Jones (2002), however it should be noted that the thicknesses and shear wave velocities were obtained directly from SCPTs, whereas the densities were derived from published generic values.

In addition to the geotechnical information presented in Figure 2, the other important feature of the regolith models is the choice of shear modulus and damping curves used to describe the how these properties vary with strain (Table 1). These curves were selected as they were felt to be the most appropriate choices for the maerials in Newcastle and Lake Macquarie

Table 1: Strain dependent curves used in amplification modelling

Material	Curve
Sand	Depth Dependant Sand Curves (EPRI, 1993)
Silt and Clay	Clay Curve - PI 30 (Vucetic and Dobry, 1991)
Weathered and Unweathered Rock	Constant Linear

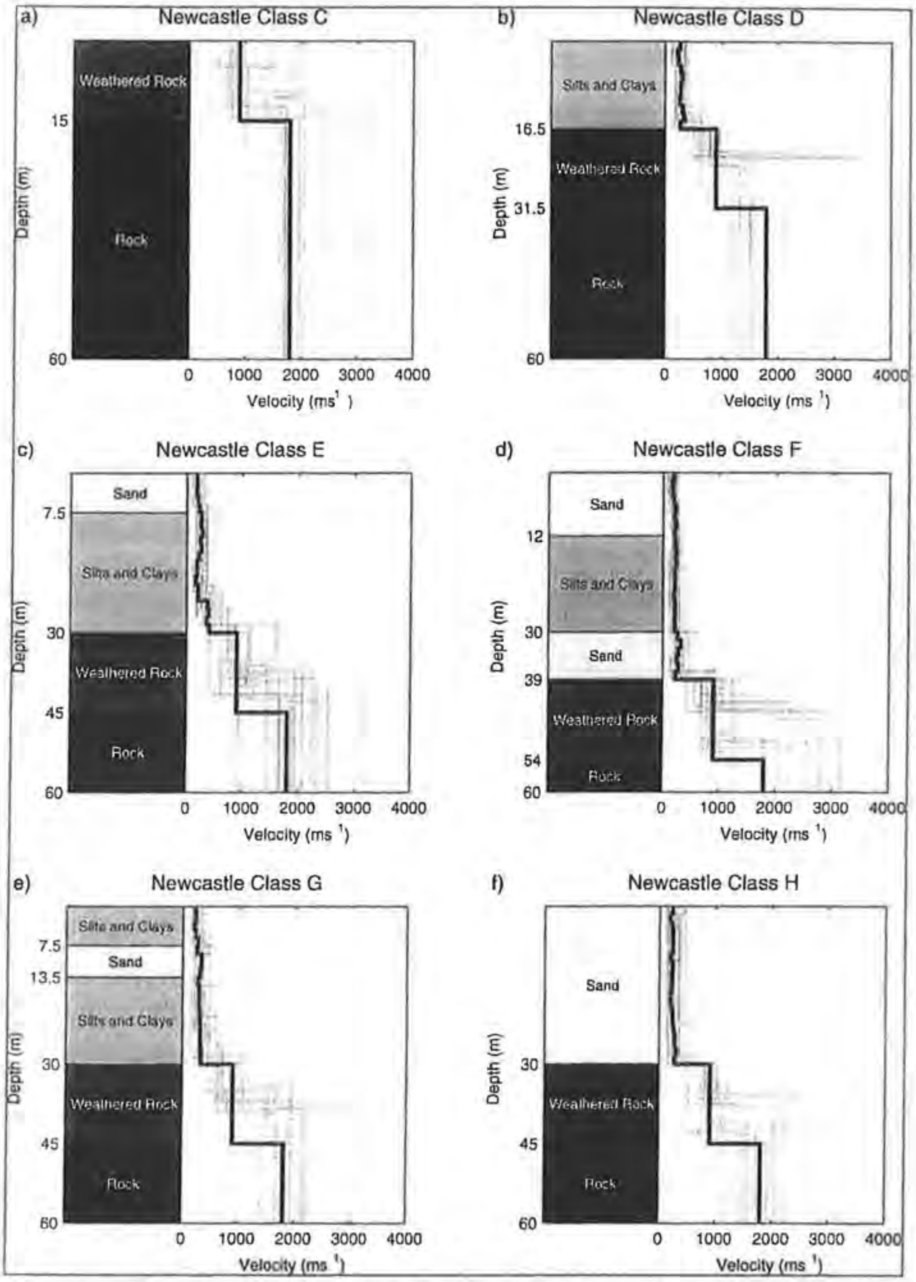

Figure 2: Geotechnical models for the regolith site classes in Newcastle and Lake Macquarie. The dark velocity profiles are the mean velocity for each class, and the light velocity profiles are examples of the randomly generated velocity profiles used in the RASCALS modelling

3 REGOLITH SITE RESPONSE

In this study, the response of regolith to ground shaking was calculated using RASCALS software provided by Dr Walt Silva of Pacific Engineering and Analysis (California, U.S.A.). This software uses the equivalent-linear approach to site response analysis first proposed by Seed and Idriss (1970). Whist a detailed description of equivalent-linear modelling techniques is beyond the scope of this paper, it should be noted that the approach we have adopted has two key assumptions, specifically that:

- the earthquake ground shaking consists primarily of vertically propagating shear waves, and;
- the strain experienced by each layer of the regolith can be approximated by a constant *equivalent strain* set to be 65% of the peak strain experienced in that layer.

The RASCALS software operates entirely in the frequency domain, and consequently uses synthetic amplitude spectra for input rock motions, rather than using recorded time histories. For this work, the rock spectra were produced using the source and path parameters described in Toro et al. (1997). Given an input rock motion, the RASCALS software is used to calculate the ground motion experienced at the surface of the regolith. The response of a given regolith model is described by period dependant amplification factors defined by the ratio of the response spectral acceleration* (RSA) of the rock motion to the RSA of the regolith motion.

Natural processes are inherently variable, and consequently it is not realistic to assume that a single geotechnical model will accurately represent the entire region classified as a single site class. Therefore, calculating the site response of a single representative velocity profile will not adequately capture the response of an entire site class. Consequently, a series of 50 velocity profiles was statistically generated for each site class. The velocity profiles presented in Figure 2 were used as median profiles for each class and 50 velocity-depth profiles were then generated from lognormal distributions based on variability observed in North America. Examples of the randomised velocity profiles are displayed in Figure 2. The total regolith thickness and strain dependent material properties were also randomised for each of the velocity profiles. For each input rock motion, amplification factors were calculated for all 50 of the randomised profiles within each site class. The 50 amplification factors for a given site class are then assumed to be lognormally distributed and a mean amplification factor is calculated for this distribution. In addition to calculating a mean, the standard deviation of this lognormal distribution is also calculated.

The amplification factors derived using a rock motion from an earthquake with moment magnitude 5.5 and a rock PGA of 0.25 g are compared against the appropriate amplification factors from the current Australian Earthquake Loading Standard in Figure 3. This figure demonstrates that all of the site classes in the region have the potential for significant amplification of RSA. Figure 3 (a) suggests that the amplification factors from site class C are generally very similar to the factors for the weak rock class from the standard. However, the amplification factors for site class C are greater than those for weak rock at periods less than 0.3 s. Figure 3 (b) compares the amplification factors for site classes D, E, F and G with the factors from the Australian earthquake loading standard for soils containing 6-12 m of silt. The amplification factors from the loading standard do not accurately match the calculated amplification factors for any of the site classes displayed here. For periods less than 0.6 s, the factors from the standard are smaller than the amplification factors calculated for any of the Newcastle and Lake Macquarie site classes. Figure 3 (c) compares site class H with the soil class from the Australian earthquake loading standard containing greater than 12 m of silt. The factors from the standard are generally less than those calculated for site

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* Note that in this paper all RSA's have been calculated using 5% damped single degree of freedom systems.

class H. This difference is greatest near a period 0.9 s which is where site class H has its maximum amplification.

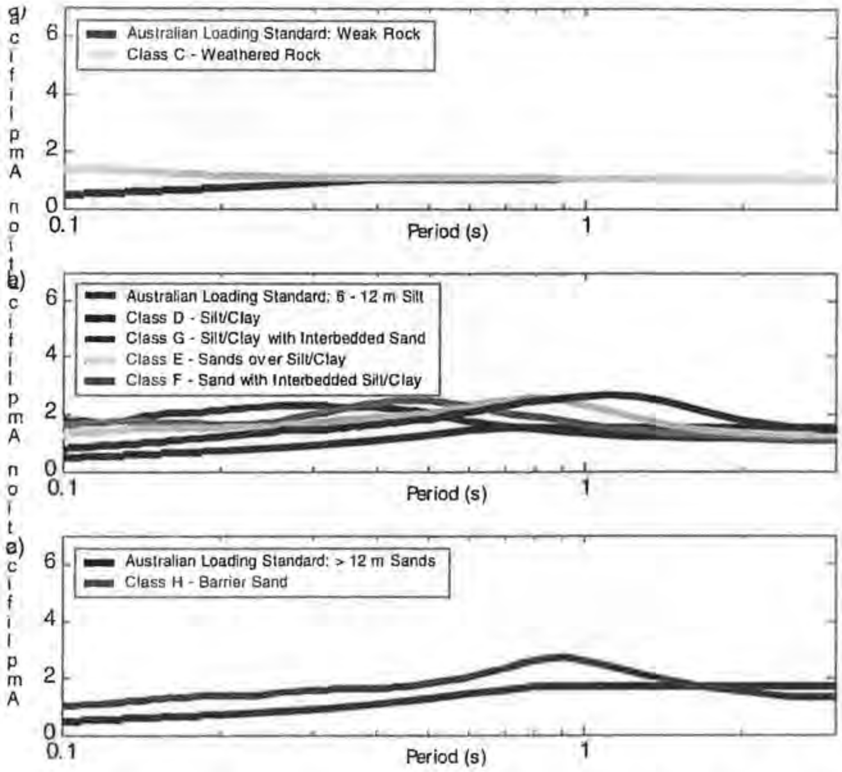

Figure 3: Comparison of amplification factors calculated for Newcastle and Lake Macquarie regolith classes and the appropriate factors from the current Australia Standard for Earthquake Loading (AS1170-4, 1993)

4 EARTHQUAKE HAZARD

The amplification factors described here were combined with the source and attenuation models described in Robinson et al. (2002) to create a map of earthquake hazard on regolith for Newcastle and Lake Macquarie (Figure 4). Figure 4 demonstrates that variations in regolith strongly affect the earthquake hazard in the region, with the soils and sediments deposited in rivers, streams, wetlands and coastal systems having distinctly higher hazard than the weathered rock material that covers the majority of the study region.

5 CONCLUSIONS

The regolith in Newcastle and Lake Macquarie has the potential to amplify earthquake ground shaking. These amplification factors form one of the key inputs into GA's risk assessment of Newcastle and Lake Macquarie (Fulford et al., 2002). The inclusion of variability in the geotechnical models has allowed for natural variabilities to be incorporated into this risk assessment, and have consequently helped provide realistic estimates of earthquake risk in the region.

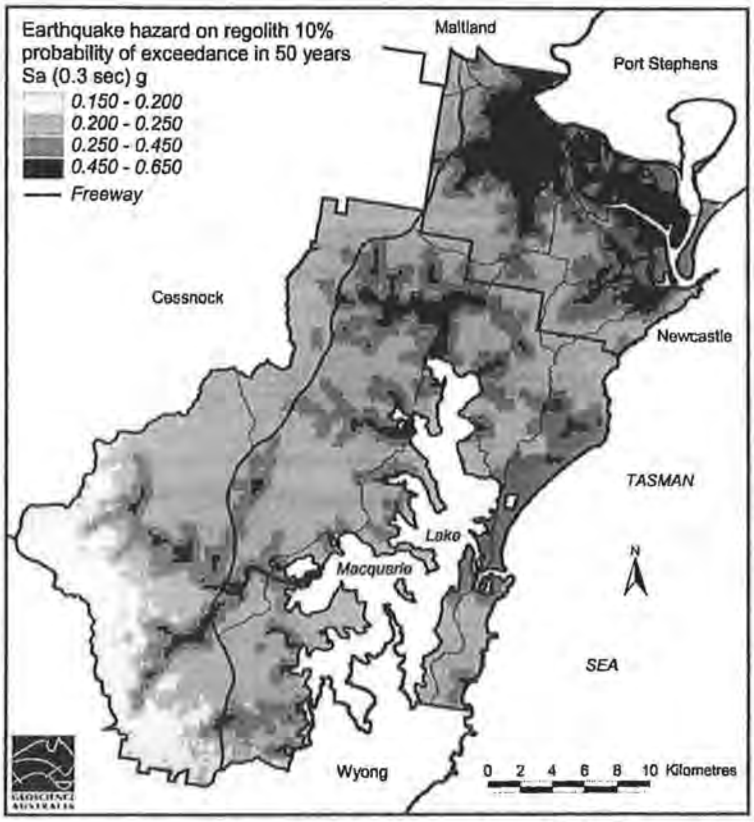

Figure 4: Map of earthquake hazard on regolith for Newcastle and Lake Macquarie. Hazard is defined in terms of RSA at 0.3 s, with a 10% probability of exceedance in 50 years.

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THE SUTTON EARTHQUAKE SWARM 2001/2002: AN AFTERSHOCK DEPLOYMENT CASE STUDY.

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ABSTRACT:

A swarm of around 90 small earthquakes occurred between December 2001 and April 2002 near Sutton, north east of the ACT and only 9 km from Canberra. This is the first known swarm so close to the ACT. The largest event of the swarm had an ML of 2.5. Geoscience Australia monitored the sequence using permanent seismic stations as well as a temporary aftershock array. It is suggested that the earthquake swarm is associated with a single shallow source zone.

INTRODUCTION

Between December 2001 and April 2002, a swarm of around 90 small earthquakes occurred near Sutton, north east of the ACT and only 9 km from Canberra. This is the first known swarm so close to the ACT. The largest event of the swarm had an ML of 2.5. At this magnitude the earthquakes are not potentially damaging and the swarm is likely to abate. However, there is the potential for a larger earthquake to follow the swarm as happened at Burakin, WA last September, especially considering the proximity of the 1949 magnitude 5.5 Dalton-Gunning earthquake. The recent seismic activity has led to widespread community concern.

Seismologically, swarms are poorly understood phenomena and despite being relatively common in Australia have not been well studied. Swarms occur on average every 3-6 years in eastern Australia (Leonard & Boldra, 2001). This paper analyses the recent earthquake swarm in Sutton and discusses the repercussions on the area.

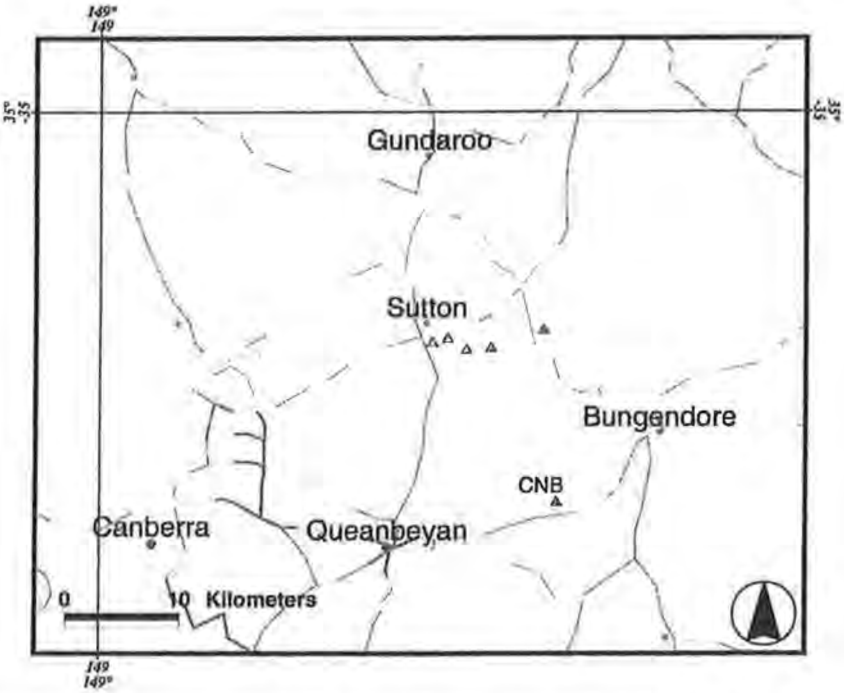

Figure 1: Location map of seismic stations in and around Sutton. The CNB station at Kowen Forest is shown to the southeast.

HISTORY

The seismic history of the Sutton area is difficult to ascertain. Regular firing on the Majura firing range and blasting at local quarries compound this. Felt reports describe the recent tremors as 'bangs' or 'explosions', which were for a time confused with the anthropogenic noises described above. The Geoscience Australia (GA, formerly BMR/AGSO) database policy, until recently, largely excluded events less than magnitude 3, so the catalogue for small events is incomplete. This has meant poor representation of Sutton region earthquake data where the largest recent event was 2.5. This has been rectified in all states except Victoria, NSW and the ACT; and work is underway to complete the ACT and Snowy Mountains area dataset.

The Sutton area is thought to have become seismically active in mid-December 2001, and earthquakes have been recorded since early January 2002. GA has been closely monitoring the area since January 16, 2002. The events peaked shortly after this with a maximum of 8 events (including the largest of the sequence at ML 2.5) on January 24. In hindsight, the 1999 ML 2.3 earthquake in Gungahlin has marked similarities, with residents describing the event as "an explosion" rather than shaking (McKue, 2001). The location on the associated isoseismal map is rather subjective, and could potentially be relocated to the Sutton area.

The Sutton area remains seismically active (at 15th August, 2002), though event magnitudes and frequency have abated considerably.

ANALYSIS

GA operates a national seismic network for earthquake and nuclear monitoring, which provides a reasonable azimuthal coverage for monitoring the ACT. Between January 24 and April 23 approximately 90 Sutton earthquakes were recorded on this network. During this period up to 4 temporary stations were deployed in 6 locations around the source zone.

A first pass analysis was conducted when a concerned Sutton resident contacted GA with a felt report. While on the phone, she experienced another event. Comparison with data from stations at Canberra (CNB) and Young (YNG) showed the event ML to be 0.7. This suggests that the events were occurring in close proximity to the resident's home (within 1 km). From this it is inferred that the Sutton events are at shallow depth. This is confirmed by observation of the Rg phase on most readings. The waveforms of most of these events are very similar suggesting a common source zone.

Events were read from local permanent stations with YNG and CNB recording the most events. Some were also recorded on Dalton (DAL) and Mila (MILA). Magnitudes were calculated for events recorded at YNG, DAL and MILA. However, most events were too small to be reliably picked from the permanent stations. They are only observed in quiet periods with filters applied.

These events were then crosschecked with continuous and triggered recordings from the Sutton array. Minimal filtering was required as the events were well recorded on the temporary stations. Some smaller events were processed using a high pass filter to clear background long period noise.

The 90 events are graphed in Figure 2 and show the swarm starting at a peak in mid January. The most seismically active day was January 23 when 8 earthquakes were recorded including 2 greater than ML 2.5. The activity gradually abated over the following 3 months, with several smaller peaks in activity.

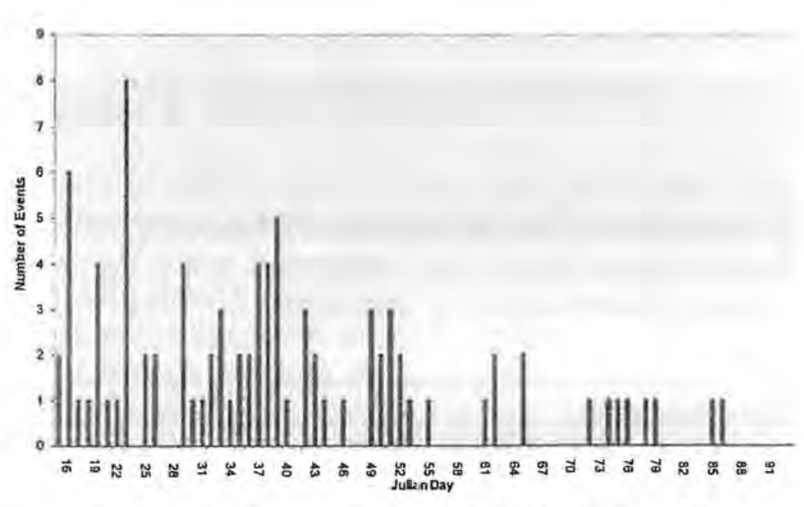

Figure 2: Earthquake frequency per day of the Sutton swarm.

The best-located (of 35 located events) are plotted in Figure 3 along with their associated error ellipses. These are considered well located as their EW and NS errors are less than 30 km (Leonard & Boldra, 2001). Error ellipses of well-located events lie within the (larger) error ellipses of poorly located events. As location accuracy increases, event locations converge on a given point to the southeast. A small number of well-constrained events show a pronounced ellipticity on the NS axis. This is due to CNB dropping out while the events occurred, thereby providing poor NS constraint. Overall though, well-located error ellipses plot within less well located ellipses and contain most event locations. This supports the suggestion that most if not all, the earthquakes share the same source zone.

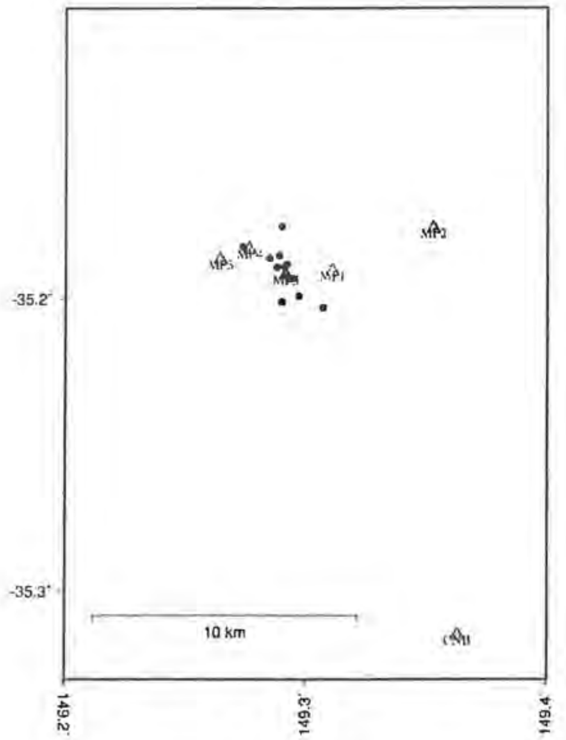

Figure 3: Error ellipses plotted for the 15 best located events.

The fault plane solution was carried out using the FOCMEC suite of software developed by Snoke (1984) at Virginia Tech, USA. Focmec takes polarities and amplitude ratios as input and performs a systematic search of the focal sphere and reports acceptable solutions, based on selection criteria for the number of polarity errors and errors in amplitude ratios. Another program in the suite, Focplt, produces focal-sphere plots based on the Focmec summary file (Snoke, 2002).

The high station density close to the event means we have a broad azimuthal spread of arrivals. First arrival polarities were clearly read on these nearby temporary stations. They were more ambiguous on permanent stations due to high background noise. The few readings from the permanent medium distance stations fill out the hemisphere. Allowing for up to 3 polarity errors, and incorporating readings from 8 Sutton events, several focal mechanisms were found to be consistent with the readings. Given the paucity of data and it's composite nature, the focal mechanism is very well constrained.

The analysis suggests a thrust mechanism with a minor strike-slip component. The implied maximum horizontal compression direction is approximately N-S. Work in press by Clark & Leonard (2001) suggests that the area is generally under a WNW/ESE sense of pure compression. The composite focal mechanism for the Sutton swarm is consistent with the principal stress axes and maximum horizontal compression direction they derived from an inversion of multiple focal mechanisms in the Dalton Gunning area.

Figure 4: Sutton composite focal mechanism using readings from 8 well-located events.

CONCLUSION

A swarm of around 90 small earthquakes occurred between December 2001 and April 2002 near Sutton, NSW. The largest event of the sequence had an ML of 2.5. Geoscience Australia monitored the sequence using permanent seismic stations, as well as a temporary aftershock array. Evidence suggests that the swarm is associated with a single shallow source zone. A good focal mechanism was produced using a composite of 8 well-located events. This suggests thrust faulting with approximately NS compression, and is consistent with results for the region.

ACKNOWLEDGEMENTS

I would like to thank the property owners for their patience in allowing us to deploy and check the instruments. I would also like to thank members of the Geohazards group at Geoscience Australia for their kind help. Especially, Jim Whatman, Terry Smith, Andrew Owen and Craig Bugden for help in field operations and Dan Clark for help with the synthesis.

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POSSIBLE EFFECTS OF EARTHQUAKE ON ADELAIDE'S WATER AND SEWERAGE SYSTEMS

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ABSTRACT:

It is on record that within six decades the Central Business District of Adelaide experienced three earthquakes all of which resulted in damage to masonry, albeit of a minor nature. From the perspective of the water industry, of interest are not only hazard parameters Modified Mercalli Intensities, but also issues of vulnerability that include factors such as the age of the water and sewerage infrastructure, dependence upon continuity of electricity supply and demographic factors.

This paper explores some of the issues that could arise from possible earthquake damage to metropolitan Adelaide's water and sewerage systems.

Paper No. 20

INTRODUCTION

Within the span of European settlement in South Australia, one earthquake, the Beachport earthquake of 1897, has resulted in Modified Mercalli Intensities which, some have argued, have reached IX.

It could also be argued that a value approaching IX, although unlikely, might nevertheless not be beyond the realms of plausibility for Adelaide.

The generally accepted consequences of an MM IX event are:

Panic. Masonry D destroyed. Masonry C heavily damaged, sometimes collapsing completely. Masonry B seriously damaged. Damage to foundations. Brick veneers fall and expose frames. Ground cracking occurs. Minor damage to paths and roadways. Underground pipes broken. The potential for serious damage to major water supply reservoirs is low.

The aspect of damage to underground pipes is of interest since it would appear that, some time after the 1989 Newcastle earthquake, increasing seepage betrayed the fact that, although Mercalli Intensities of somewhere around VII to VIII had been experienced, underground pipes had nevertheless sustained fractures.

In common with the Newcastle situation, a significant percentage of Adelaide's underground piping infrastructure was laid in first half of the twentieth century and in some cases it could be argued that it is past its use-by date. It is not difficult to imagine, for example, how vulnerable to tremor damage an aging pipe could be.

Consideration must be given to the relationships of water and sewerage infrastructure when compared to other utilities. The risk to the community from a major gas leak may well be higher than the initial loss of sewerage services.

EXTENT OF METROPOLITAN INFRASTRUCTURE

Dams - 8
Water Treatment Plants - 6
Water mains – 8,600 kilometres
Waste Water Treatment Plants – 5
Sewer mains – 6,800 kilometres

As far as Adelaide is concerned, the extent of damage sustained would depend on what part of the city, North or South, is impacted, and the extent of the area affected.

In the event of earthquake impact in Adelaide, the issues for the Water / Sewerage industry would include the following:

WATER ISSUES

There would be obvious system problems and some areas may be without water. Adelaide's water systems can be configured to "move" water around and it may be decided to supply some water to a larger area rather than better pressure in the mains in a smaller area. The priority would be to provide water for drinking and washing followed by restoration of sewerage systems.

Dam failure(s).

Given the low risk of damage to major reservoirs, perhaps we should turn our attention to those the numerous farm dams scattered in the nearby Adelaide Hills, some of which have large capacity. These may pose threats to public safety, albeit on a smaller scale, should they be breached.

If the Happy Valley or Hope Valley Dam was to be breached then major interruptions to water supply resulting in water restrictions could occur. Would the Torrens Weir still be intact?

Damage to Water Filtration Plant(s)

Although these systems could be by-passed, the water may not be considered potable. There may be a threat from Cryptosporidium and Giardia normally removed during the treatment process. The water may be turbid and the repair of such facilities may take considerable time.

Main breaks – Major bulk water pipeline(s) and suburban distribution main(s).

Breakdown maintenance teams are well occupied on a normal day-by-day basis. There is some capacity to increase the number of teams but one could speculate that after an earthquake such teams would be immediately overwhelmed with the demand for assistance. Support crews and equipment would be needed from the construction industry as well as from other parts of the State and possibly from interstate.

Inability to supply water for fire fighting.

It may be difficult to predict the scope of just how widespread this problem could be, however access to water is a fundamental need for firefighters. The inability to suppress fires might well prove to be the major contributor to the toll of human injury or death. There may be a need to accept damage from leaks in order to ensure water for this purpose.

Availability and movement of water tankers

It could be expected that perhaps the demand for these could be overwhelming. Initially they could be required for fire-fighting tasks, then the need will shift to supply potable water for human consumption.

Availability of spares for repairs

Prudent risk management will ensure that sufficient supplies are available for normal operational emergencies that arise from time to time. No longer are there large supplies of replacement valves and pipes etc. in conveniently located holding sites. Nowadays there is a far smaller cache of just-in-time supplies and extra supplies would be accessed from interstate sources.

What can be repaired versus what must be replaced? Is the repair going to be a temporary or a permanent fix?

An earthquake which caused considerable damage to piping systems may necessitate a pragmatic approach that sees repairs carried out when in reality replacements should be done instead. Hence there is the issue of additional costs that would be incurred in revisiting the same site some time in the not-so distant future in order to effect the replacement that should have been done in the first place.

SEWER ISSUES

Damage to suburban sewerage collection networks

The repair of such damage may involve a large input of resources, in particular, trained personnel as well as plant and equipment. As a further complication, considerable time may be needed to effect repairs. Under these circumstances we may to accept that discharge to creeks will occur whilst repairs are carried out. There will be a need to mount public education and appropriate signage.

Damage to major transfer mains from major collection points to wastewater treatment plants

Due to lower pressures in much of the sewerage system, compared with the water supply system, detection of breaks may be delayed with the result that, in the meantime, harmful consequences of the leaks may escalate. Often a collapse will be partial and some flow may be getting past so it may not be an immediate problem.

Damage to wastewater treatment plants

This may well lead to the release of raw sewage into the land and marine environments for an extended period of time, and with possible major detrimental impact. Experience has shown that such releases have the capacity to fuel public discontent and outrage. This probably will be tempered by the magnitude of the situation.

Availability of tankers for collection and cartage of sewage.

Depending on where a breach occurred, there may well be a large demand for this resource with no guarantee that such vehicles would be available when urgently needed.

PUBLIC HEALTH ISSUES

Drinking Water if main supply disabled or severely restricted – Tankers and Bottled Water

Given that, as an example, the loss of Happy Valley Dam alone could leave up to 40% of Adelaide without water, there may well be a rapidly deteriorating supply and demand situation with regard to the supply of potable water. At the "watering points" where potable water would be distributed, there would be a need to maintain public order, with a possible extra call on already stretched Police resources.

One possible mitigation strategy could involve the provision of a subsidy to householders for the purchase and installation of rainwater tanks for the purpose of accessing potable water in an emergency.

A response strategy to meet shortfalls in the supply of potable water could utilise an already tried method of directing those beverage bottlers still able to function, to bottle water rather than their normal product, providing their plants are still operable.

Sewer flooding, discharges to water courses and marine environment

It is stating the obvious to speak of the threat to public health from the spillage of raw sewage in buildings, houses and the environment generally. In the event of unfavourable weather this threat could be significantly exacerbated.

What do we service first – Hospitals, Emergency Services?

Given that in the event of a serious earthquake, the State Disaster Act would most likely be invoked, then such prioritisation would ultimately be the responsibility of the State Coordinator under the Act (the Police Commissioner). It is also via the State Coordinator that access to supplementing Commonwealth resources would be accessed.

LOGISTICS

Major Contractors and SA Water will not have sufficient resources if extent of damage is widespread.

Given a substantive lack of resources, accurately and readily assembling the "big picture" of the scope of the problem is essential. An accurate evaluation will then allow an accurate prioritisation of tasks. To do this effectively and efficiently, a considerable pool of expertise will be need to be assembled from within the water industry.

Where do we get other people / contractors skilled in water industry – from interstate perhaps?

Utilising interstate resources is a likely scenario, if the precedent regarding interstate firefighter bushfire support is any guide. What is desirable however, is for such arrangements to be discussed, with the aim to remove bureaucratic hurdles beforehand rather than "on the run".

Within South Australia there would be not enough people (let alone trained people) to manually operate systems, and therefore the Water Industry would be calling on support from State Emergency Operations Centre to meet shortfalls. The State Emergency

Operations Centre, in turn would be appealing to Emergency Management Australia for support from interstate utilities and contractors.

COMMUNICATIONS

There would be heavy reliance on telephone services for dispatch and control systems. The radio telemetry systems currently in use would probably need to have their antennae re-aligned after an earthquake.

The Water Industry would be blighted with the same types of intra / inter-agency and public interface communication difficulties as every other agency. It is stating the obvious to say that a substantial redundancy factor in the telecommunication system is critical to a successful response to earthquake impact. Without robust communications, efforts to respond and recover from earthquake impact will be significantly hindered.

GENERAL

The water industry relies heavily on the power industry to be able to operate. Little stand-by power generation capacity exists or is possible for major sites within water industry.

Like a need for robust communications, so too there is a need for a reliable electricity supply. Without it, the pumping of water and sewage will be impossible, and serious problems will rapidly emerge.

With general downsizing of government agencies coupled with outsourcing the 'reserve' of materials, plant and equipment to undertake significant extra work is virtually non-existent.

Like many other industries, the water Industry no longer has vast inventories of plant and equipment. There is, therefore, a danger of being deluded that a particular item of equipment would be available from an equipment hirer, when several other agencies may believe that the very same item might be simultaneously available to them. As well, when needed, that equipment may have been already been hired out on contract in some distant part of the State. Plant and equipment may well be redirected from existing construction activities to restore these essential services.

Where will the funds come from as the water industry now runs on a commercial basis?

During the period when a disaster declaration is in place, there is provision for the State Government coffers to fund response activities, however, when the declaration is eventually rescinded, such payments cease. At present, there is no clear direction as to what then happens regarding funding.

Summary

It is not the intent of this paper to promote a pessimistic outlook, but rather to flag the need to consider the ramifications of a significant earthquake impact on Adelaide. It would be delusional to suggest that the damage incurred would be addressed with text-book efficiency. The reality would most likely be otherwise, if the experiences of other impacts around the globe are examined.

Overall, what can be said in a constructive sense is that research needs to be done to more comprehensively assess the scope of damage that Adelaide could experience. In keeping with the risk management methodology, this is not just about the size of the earthquake itself but would incorporate the interactions between the source of risk (earthquake impact) and the elements at risk (water pipes/ storage tanks/dams/ sewerage systems) bearing in mind factors of vulnerability such as the type and age of the infrastructure.

Overall there is a need for accurate research. Overstating the problem erodes credibility and gives justification to those who would dismiss the suggestion that Adelaide has a problem with respect to earthquakes. On the other hand, understating the problem poses a threat to the safety of the public.

Often it is that disaster exercises have scenarios in which hazards are dealt with in isolation, that is, one hazard impact is considered at a time. However, an earthquake could impact Adelaide in early December, with a recovery period extending though the following bushfire season. It is not implausible to have a need to respond to the effects of earthquake impact as well as bushfire (or some other hazard) impact. Unlikely though that might be, nevertheless in such a situation, the acquisition and management of resources would indeed be interesting, to say the least.

GPS-GEODETIC MONITORING OF THE SOUTH WEST SEISMIC ZONE OF WESTERN AUSTRALIA: EPOCH ONE

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ABSTRACT.

The south west seismic zone (SWSZ) is a north-west-south-east trending belt of intra-plate earthquake activity that occurs in the southwest of Western Australia, bounded by 30.5°S to 32.5°S and 115.5°E to 118°E. It is currently the most seismically active areas in Australia, with events including the 1968 Meckering (mag 6.9), 1970 Calingiri (5.7) 1979, Cadoux (6.2) and 2001 Burakin (5.2) earthquakes. Since the SWSZ lies no more than 200 km from the 1.4 million population of the Perth metropolitan region, it poses a distinct seismic hazard, which is of concern to Geoscience Australia's Cities project.

Knowledge of contemporary crustal deformation is potentially an important component in understanding the earthquake activity in the SWSZ. Seismic activity suggests that the SWSZ could be deforming by 0.5-5 mm/year. However, little is currently known about the magnitude and orientation of the deformation in the SWSZ. The most efficient means of quantifying contemporary crustal deformation over large areas is through repeat GPS-geodetic measurements. However, the amount of potential surface deformation in the SWSZ presents a technical challenge to GPS-geodetic monitoring techniques.

Previous GPS- and terrestrial-geodetic studies of the SWSZ are inconclusive, due mainly to the imprecision of these techniques in relation to the likely small amount of surface expression of deformation in the SWSZ. Therefore, a new 50-point GPS-geodetic monitoring network has been established across the SWSZ, for which epoch-one GPS-geodetic measurements were made in May 2002. This poster will summarise the scientific and social rationale for the project, and describe the network design and observation schedule used.

THE BURAKIN WA EARTHQUAKE SEQUENCE SEPT 2000 – JUNE 2002

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Paper No. 22

Introduction

The Burakin earthquake sequence has been the most interesting earthquake sequence in Australia in the last decade. The sequence began in September 2000 with a swarm of 1700 earthquakes, the largest of which had a magnitude of 3.6ML. On 28 September 2001 a magnitude 5 earthquake occurred and has been followed by more than 16,000 recorded "aftershocks". The centre of this activity was between 7 and 14 kilometres west of Burakin. Some of the people who live in the source region have felt several thousands of these earthquakes, while people in the town of Burakin itself have felt up to several hundred events. Many buildings within 25 kilometres of the activity have suffered minor damage, although none has suffered major structural damage. This level of damage is what we would expect from earthquakes which all have a magnitude of 5 or less.

Discussion

Figure 1(a) is a plot of the earthquakes, which have been located, and magnitudes calculated. As yet only a small fraction have been located and only since April 2002 have earthquakes of magnitude less than 2.5 been consistently located. The histogram below (Figure 1(b)) shows the number of earthquakes from the sequence recorded at the nearest permanent station of the national seismograph network station (Ballidu) each day. During this time period, 6 earthquakes of magnitude 4.5 or greater occurred (table 1). The sizes of earthquakes recorded at the nearest station ranges from magnitude 5.2 to 0. Most of the earthquakes in the sequence are aftershocks of the six largest earthquakes. This is typical of earthquake sequences in southwest Western Australia.

This is the highest level of seismic activity experienced in Australia since the 1988 Tennant Creek M6.7 earthquake. The last time south west WA was this seismically active was in February and March 1982 when the town of Manmanning experienced a sequence of earthquakes similar to this sequence. Manmanning is 40 km south of Burakin (Fig 2). That sequence was slightly more active than the current sequence, but the high level of activity lasted only two months. In 1979 a M6.0 earthquake occurred near Cadoux (20km south of Burakin). Both the Burakin and Manmanning sequences are thought to be related to the 1979 Cadoux earthquake.

Date	Time UTC	Latitude	Longitude	Magnitude	Locality
28 Sep 2001	02:45:56.6	-30.49	117.05	5.0	Burakin
28 Dec 2001	16:31:36.5	-30.56	117.05	4.5	Burakin
05 Mar 2002	01:47:39.2	-30.49	117.10	5.1	Burakin
05 Mar 2002	03:29:57.8	-30.50	117.08	4.6	Burakin
23 Mar 2002	13:16:24.1	-30.41	117.44	5.1	Burakin
30 Mar 2002	21:15:48.0	-30.41	117.44	5.2	Burakin

Table 1. Table of origin information of 5 earthquakes of the Burakin series with magnitude 4.5 or greater.

Following the first earthquake in September 2001, Geoscience Australia deployed a number of seismographs in the area. For most of 2002 Geoscience Australia has had 9 seismographs within 100km of Burakin. Data from these instruments will allow us to accurately locate these earthquakes. The 2 ML5+ earthquakes in March are the best recorded large earthquakes ever recorded in Australia. This data will allow us to better understand earthquakes in Western Australia and the ground motions excited by earthquakes in Australia. This will allow us to significantly improve earthquake hazard maps that are used as input into the Australian Building Code and the assessment of the vulnerability of existing structures to earthquakes.

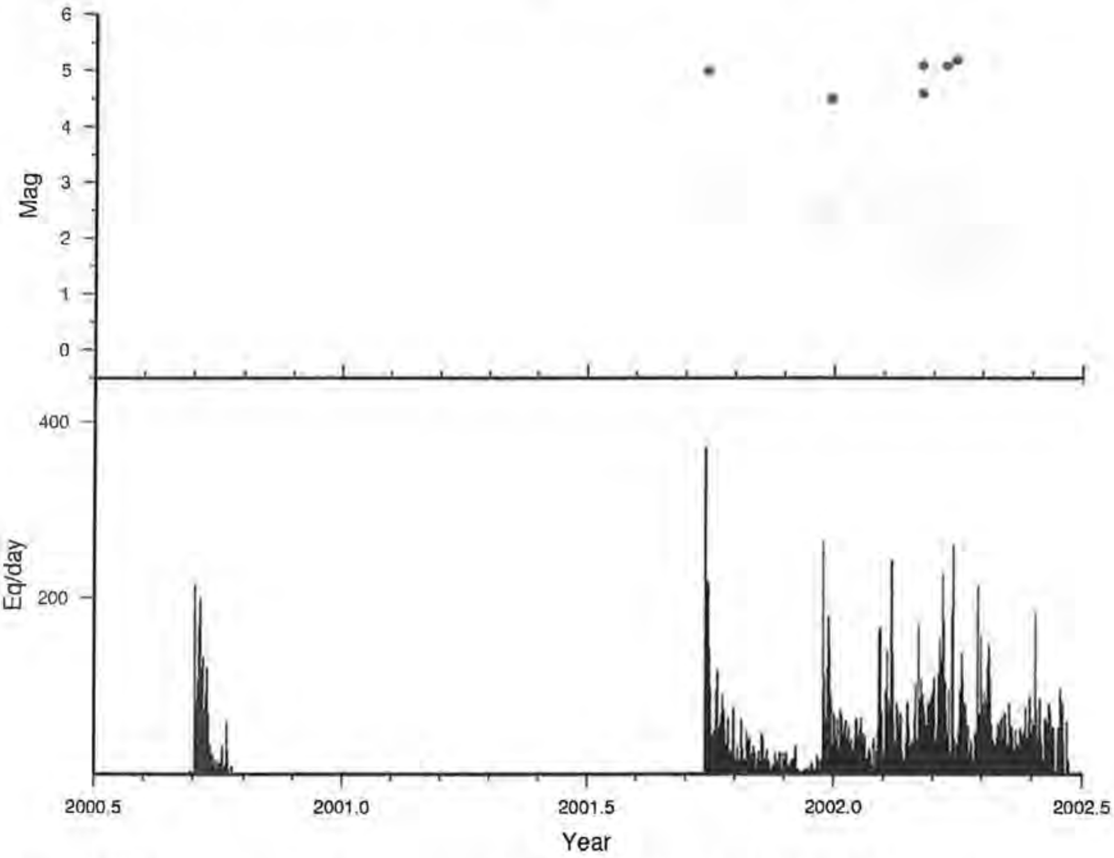

Figure 1. The Burakin earthquake sequence from July 2000 to June 2002. Red dots are the largest six events listed in table 1. The yellow dots represent every earthquake which has been analysed in the sequence. The analysis of earthquakes below Mag 2.5 has been inconsistent during this period. The histogram shows the daily number of earthquakes recorded at the nearest permanent station of the national network (BLDU).

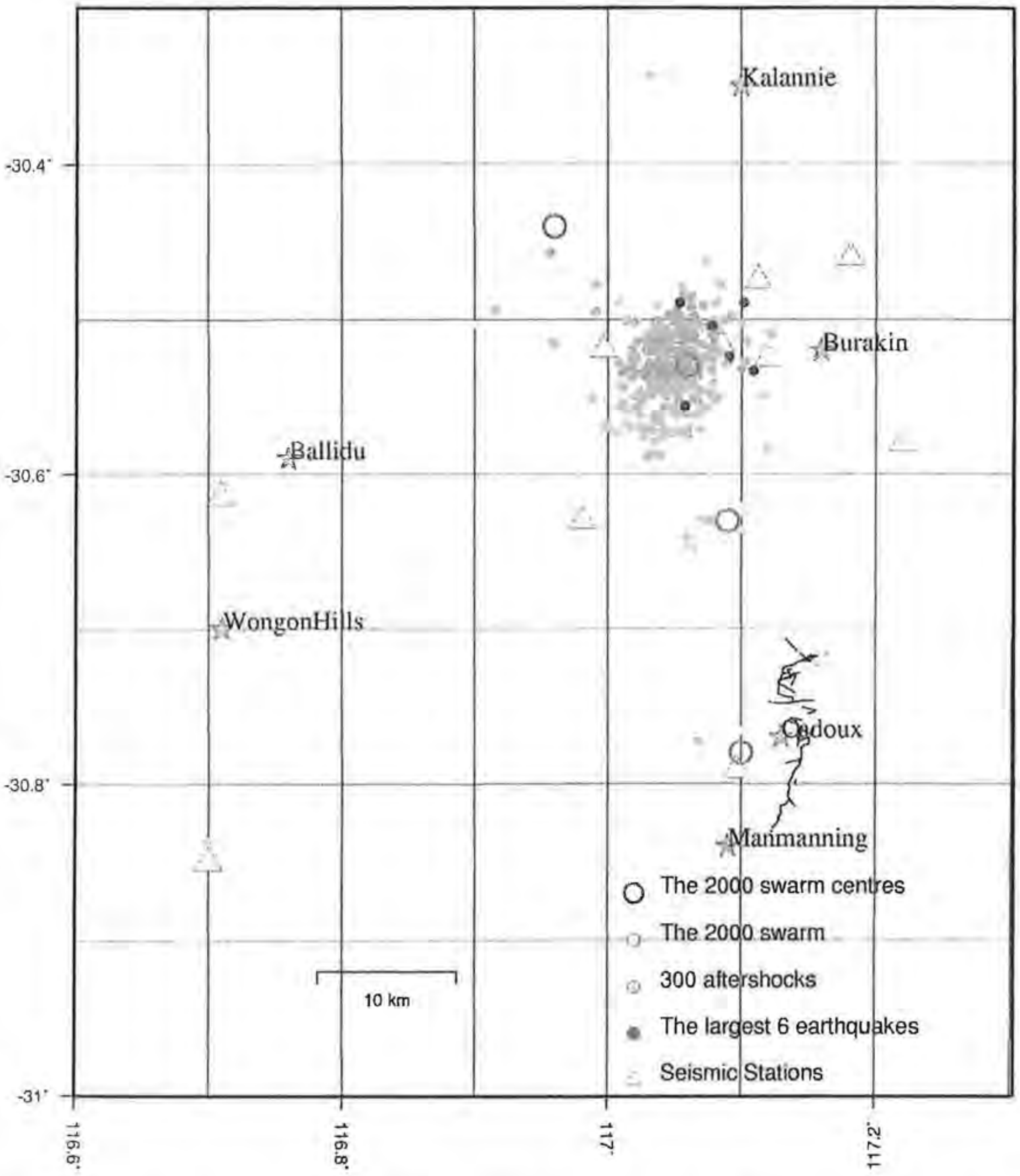

Figure 2 Map of the earthquakes in the Burakin and Cadoux areas since September 2000. The lines near Cadoux are the surface trace of fault scarp formed by the 1979 Cadoux M6.0 earthquake.

Initial analysis indicates that all the earthquakes are in the top 5 kilometres of the crust. Most well located events locate to the top 10km and many events show an Rg phase. There appears to be 2 or 3 types of events one of which don't produce an Rg phase. Figure 3 has four parts. Figure 3a shows the number of earthquakes per day in the 192 days from September 28th 2001 to June 30th 2002 on a log scale. 3b shows the same things for the period between December 25th 2001 to June 30th 2002. Some of the main features of these plots are:

- We probably underestimated the number of earthquakes in the first day. This is due to the fact that many smaller earthquakes could not be seen in the coda of other events. Also the nearest station (BLDU) was down for many hours in the first two days so data was used from the next nearest station (KLBR) and extrapolated to be consistant with the BLDU count.

- The first 89 days show a classic aftershock decay sequence with an Omori decay rate of 1. In other words over a period of 100 days, the number of earthquakes per day is reduced by a factor of 100.
- On day 90 (December 28th) there is a marked jump in activity which coincides with the magnitude 4.5 event. Over the next 40 days there is a gradual decline with an Omori decay rate of about 0.15.
- On February 4th there is another marked jump in activity with no clear decay in the activity over the following 150 days.

Omori decay rates of 0.8-1.8 are typical for aftershock sequences of large earthquakes up to magnitude 6, and decay rates of <1.0 are typical for foreshock sequences. Decay rates >1 are expected for aftershock sequences of a single large (mag.>7) earthquake, for example the 1987 Tennant Creek foreshock sequence had an Omori decay rate of 0.25 and the 1988 aftershock sequence had a decay rate of 1.0. This would suggest that the original M5 event in September is a main shock followed by a typical aftershock sequence lasting until December. Whether the activity in 2002, particularly since February 4th, is fundamentally different to the late 2001 activity is not clear. One possibility is we are observing the aftershock sequences of multiple events. With these aftershock series may be combining to give the appearance of relatively constant activity. This would imply that the 6 largest events are on "new" faults and not reactivating the September 26th fault. Another possibility is that the activity is constant and still comprises a foreshock sequence. Whatever the answer their does appear to be, as yet unexplained, three separate phases to the ongoing Burakin sequence.

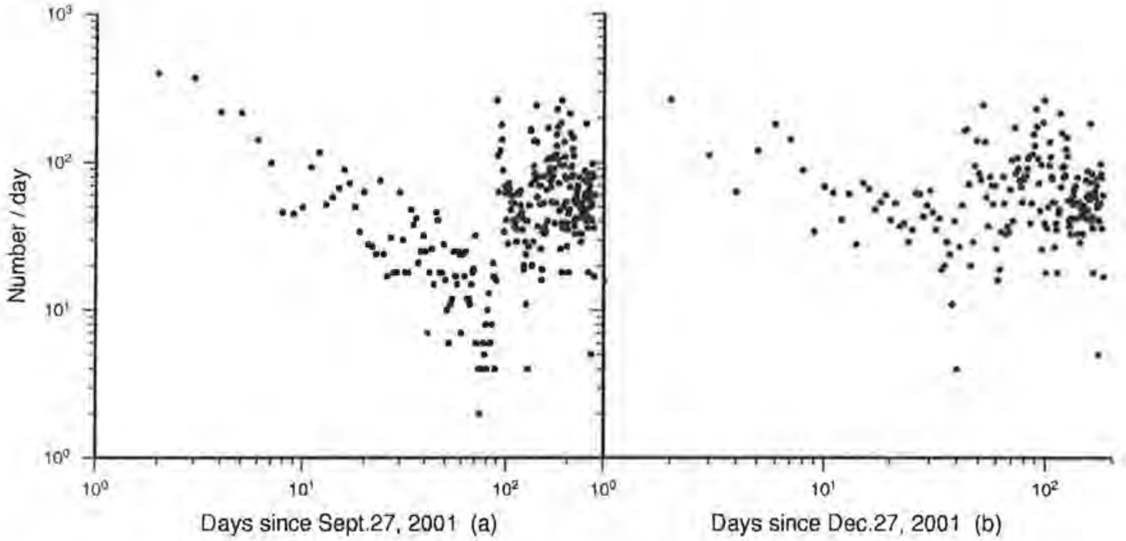

Figure 3 Number of earthquakes observed per day plotted on log-log scales. (a) is for the 300 days since September 27th and (b) is for the 200 days since December 27th.

The b value of the sequence appears to be less than 1. With 8 earthquakes between 4.3 and 5.2 a b value of 1 would predict 500+ earthquakes between 2.3 and 3.2. Even with the limited data analysed so far, we know this is not the case. What the b value is has not yet been determined, but clearly it is less than 1. As yet none of the six largest events have been located with sufficient accuracy to determine if they are in different areas of the source zone. Nor have all the small events to see if they can be allotted a particular large event. Locations to date suggest that the March 2002 M5 earthquakes are about 5 km west of the September 2001 event, but as very little data from the temporary stations has yet been analysed the location uncertainties are larger than 5km.

Future Research

The data collected from both the temporary and permanent stations around Burakin will allow some significant advances in our understanding of the seismicity of Australia. Areas of research include:

- Relocation using techniques such as JHD and Double Difference
- Identifying the fault plane of the five earthquakes
- Quantifying the rate stress transfer and post seismic deformation
- Calculating fault area, stress drop and moment magnitude
- Strong motion attenuation in SW WA
- Statistical analysis of the swarm and aftershock sequences
- Moment tensor calculation and rupture inversion

EARTHQUAKE AND ENGINEERING SEISMOLOGY FOR COMMUNITY AND SCHOOL AUDIENCES

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John Mignone began his career as a teacher in the Education Department. He accepted a temporary position with Mines and Energy SA to do a series of workshops to students in outback and country areas, ahead of a huge airborne survey program. This lead to other opportunites and eventually a full time job. He is currently preparing for workshops in the far north west of the state in Aboriginal communities.

ABSTRACT:

The broad topic of earthquakes, including engineering seismology lends itself well to many areas of the school curriculum. While model building, and 'hands on' workshops require a large amount of preparation, the student learning outcomes are more successful. A model table has been developed to show stress buildup, building style performance, building resonance and liquefaction.

Paper No. 23

EARTHQUAKE & ENGINEERING SEISMOLOGY FOR COMMUNITY & SCHOOL AUDIENCES

Minerals and Energy Resources SA offers a mobile Community Education Service in South Australia which is available to interest groups and schools across the state.

Earthquake Seismology is one of the most commonly requested topics, with age groups ranging from Reception to year 12 in schools forming the audiences. Seismology can be adapted to include curriculum areas like Society & The Environment, Mathematics, Geography and Geology. It is because the scope of the subject is so enormous and affects people in so many ways, that it is easy to tailor to the specific curriculum areas.

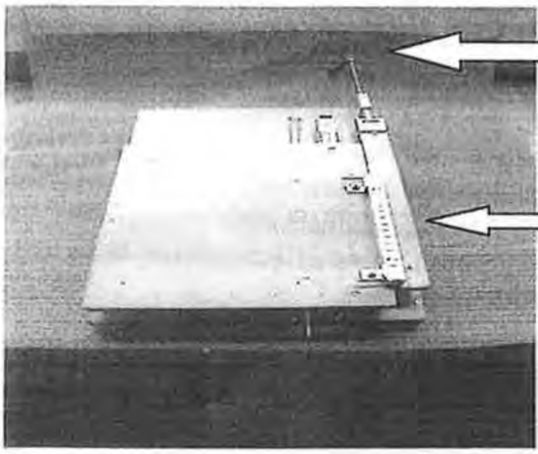
I prefer to take an activity based or "hands on" approach because students participate better and the learning outcomes are more successful. Consequently the workshops require extensive preparation of functioning models such as bench top shake tables, portable seismographs (PS1A), worksheets and audio visuals such as video, Powerpoint presentations and software. This means that complex maths and jargon can be minimised so that the main concepts come through particularly for younger participants.

A typical workshop will contain the following parts:

-
- Ask the students to tell of their knowledge of earthquakes to gauge their level and understanding of concepts.
- Video is used to bring the outside world into the classroom and show the relationship between earthquakes, volcanoes and the Earth's tectonics.
- The shake table pictured below is used to test elements such as:
    - Stability of buildings with varying base of support footprint, height and type of construction ie loose bricks versus metal frame.
    - The effect of liquefaction on buildings using saturated sand or jelly.
    - Predicting when an earthquake will happen using data plotted from a series of stress build experiments.
    - Investigating the effect of resonant frequency on buildings of different height with vertical and horizontal vibrations.
    - Building earthquake proof structures and testing them. Eg suspension bridges, domes, rubber and bearing foundations.

- Portable seismograph experiments including:
    - Simulating an earthquake by breaking a piece of slate as opposed to bending a piece of wood on the edge of a bench.
    - Detecting heart beat.
    - Understanding the functions ie time measurement and amplitude.
    - Reading a seismogram, ie P& S Wave arrivals and their use in calculating epicentre location and relating this to the Richter scale.
- Students can use software to simulate an earthquake on the computer and then calculate and locate its epicentre on screen. The student may then choose to interrogate the computer for its location of the epicentre. Students respond well to this type of tuition and strive to refine their methods for greater accuracy.

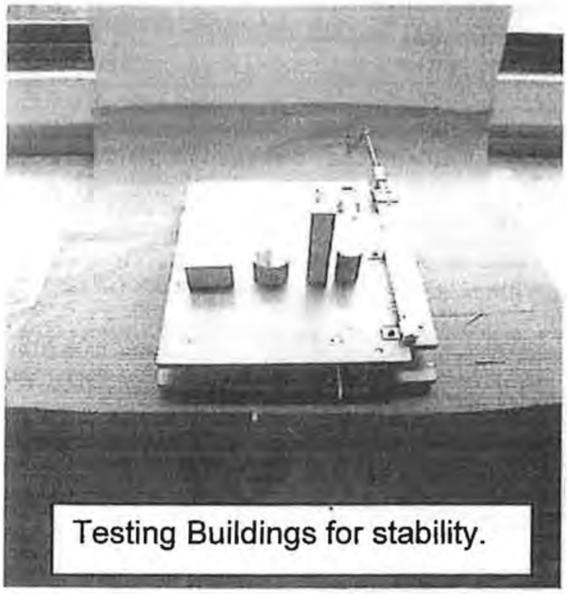
Some action shots are included below:



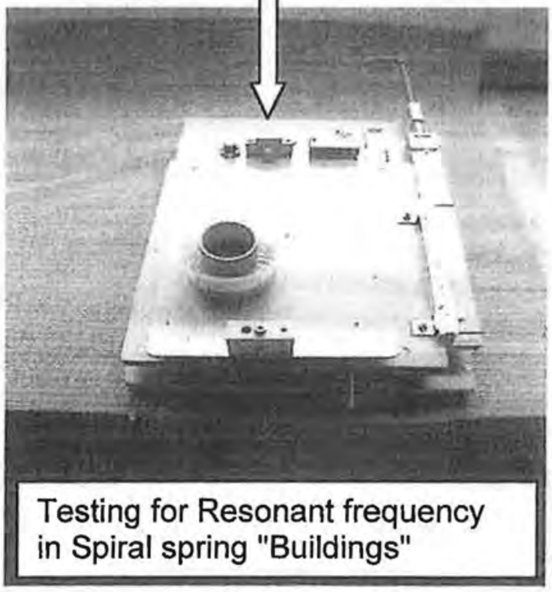
Crank Handle

Spaghetti are placed in the slots to lock the two parts of the shake table together till they break thus simulating an earthquake event.

Vibro- function motor
Shakes the table

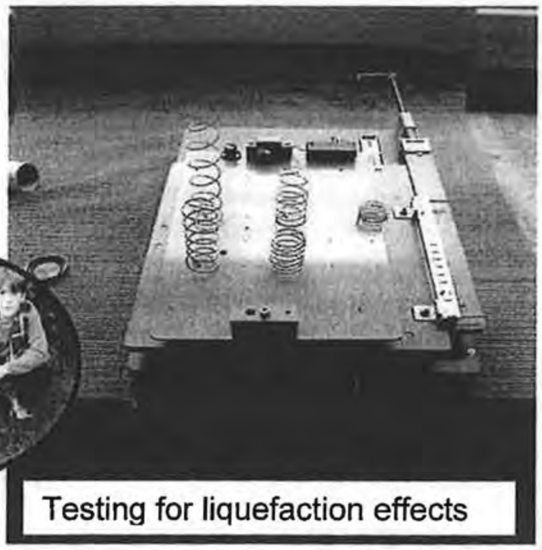


Testing Buildings for stability.



Testing for Resonant frequency in Spiral spring "Buildings"

Students jump for a class earthquake



Testing for liquefaction effects

UNDERSTANDING THE MEDIA

ADAM THOMSON
S.A. COUNTRY FIRE SERVICE

AUTHORS:

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He served as an operational police officer for 11 years, assigned to investigation and patrol sections, and performing public relations and media liaison roles. He lectures on public relations at UniSA.

Mr Thomson is currently completing a marketing degree, and has a Graduate Diploma in Communication (Public Relations) and a Bachelor of Arts (Journalism).

ABSTRACT:

Media interviews are an excellent opportunity to deliver key messages to a mass audience, and in order to achieve this goal interviewees must ensure they are well prepared and able to effectively handle an interview.

Often during times of crisis the presence of journalists, photographers, camera and sound operators are often perceived as unwelcome and little more than a nuisance. To adopt this attitude towards media does not promote a good working relationship and media reports are not likely to contain a glowing account of your efforts, let alone be accurate or complete.

The trick is to turn their presence to your advantage, and effectively handle media interviews and deliver key messages in a professional manner to a target audience.

This paper outlines how the media operates, how to effectively handle media interviews and highlights common pitfalls of dealing with the media.

1. INTRODUCTION

Facing the media – for many people it is their worst fear come true, with the knowledge that they have the power to make or break their career and the reputation of their company all in a thirty second prime-time media interview.

For executives, politicians, and community leaders, facing the media is an inevitable scenario that cannot be avoided. Journalists are trained to solicit responses and use probing questions, which when combined with enhanced technology, can often result in comments being altered or taken out of context.

Media interviews are often a minefield. In many cases the journalist is the one holding the position of power because the interviewee has been ill prepared and has missed the chance to turn the interview into a positive communication opportunity.

This handbook provides a number of basic tips that can assist in the preparation for a media interview and minimise the risk of misquoting or misreporting. Media interviews provide an opportunity to communicate and deliver key messages to a mass audience.

2. UNDERSTANDING THE MEDIA

It is commonly accepted in the media and public relations industry that there are three main areas why interviewees fail to communicate what they wanted to say:

1. Attitude
2. Lack of knowledge
3. Lack of preparation

This discussion paper addresses all three of these areas and provides practical advice on how to successfully participate in media interviews.

The paper also provides an overview of how the media operate and why they approach their job in the manner they do. Crucial to creating a good relationship with journalists is the need to adopt a positive attitude towards dealing with the media – a climate of mistrust will not foster good relationships or allow successful communication to occur.

2.1 The role of the media

The role of the media varies significantly around the world, and this discussion paper will only look at the role of media within a western, democratic society such as Australia.

The functions of the media are best described in what is termed the social responsibility theory, outlined by media analyst Fred Seibert. He defines the role of the media as part of this model as:

- Enlightening and informing the community to enable it to self-govern
- Servicing the political system by providing information, discussion and debate on matter of public interest
- Providing entertainment
- Safeguarding the rights of the individual by maintaining a "watchdog" role against the government and large organisations
- Servicing the economic system, primarily by bringing sellers and buyers of goods together by the medium of advertising
- Maintaining its own financial self-sufficiency so as to remain free from the pressures of special interest

One area of major impact on the media industry over recent years is the creation of significant infrastructures by large corporations and governments that are primarily responsible for distributing what is essentially propaganda. Billions of dollars are spent every year on advertising the positive aspects of products and services.

Equally, many organisations have seen the strategic benefit of having a public relations component to their corporate team. Staffed by professional communicators, their sole function is to put a positive spin on information they distribute on behalf of their employers and clients. Whilst this is largely done with ethical considerations in mind, the fact remains that these public relations practitioners work to put a positive spin on news and attempt to manipulate messages for the corporate good.

Government has also recognised this benefit, and has created information offices and appointed press secretaries to ensure they distribute key information from the government's point of view.

Operating in this atmosphere, journalists believe they must provide a balance by consciously and aggressively search for bad news amongst the information which they are bombarded with by advertising, public relations practitioners, government information sections, and the 'spin doctors' in industry and other professional associations.

2.2 Difference between radio, television and the press

A common misconception is that interviews with a print journalist can be more relaxed and informal than radio or television interviews. In reality the statements should not be any longer, because often just a few paragraphs will be used containing your comments.

Whereas the bright lights and pool of cameras and recording equipment of electronic media are often very confronting, the seemingly quiet way of the print journalist armed with only a pad and pen can often lull people into a false sense of security.

The biggest difference when dealing with television media is the need for visual impact. This is the best medium to use when you have a story that needs to be shown rather than told. TV media like action, movement and illustration, and is an excellent communication medium to reach massive areas of the population – particularly during peak viewing periods.

The drawback of television is the compression of information to fit into a 30-minute timeslot. Out of that time, nearly one third of it will be taken up with advertising, weather and sport stories. In most television interviews an interview 'grab' will last between 10 and 15 seconds, and reinforces the need for clear thinking and an ability to make a point succinctly.

Whereas a small percentage of TV air time features news and current affairs, radio goes to air 24 hours a day and has regular newsbreaks and talkback radio to highlight news and current affairs.

With a ratio of one radio for every four people on earth – translating to more than one billion radio receivers worldwide – the ability to relay information immediately puts radio in good stead as a communication medium. No other media has the ability to broadcast an interview or breaking news minutes after it happened.

Perhaps the most notable feature of radio is that it is a personal medium, which people use to fill in background to their work, homes and social environment. It is a 'warm medium' compared to the coldness of print, and interviews should be delivered as if you are talking to people rather than at them – particularly during a talkback program or similar.

A common element that radio shares with television is the aspect that a quote is merely a fleeting moment – and reinforces the need for people to be able to grasp the key message in one pass of the information. Where radio becomes the poor cousin to television is that there is no visual reinforcement, or hard copy to check again later as in the case of print.

Despite changing technology and the introduction of the Internet, newspapers continue to be a popular communication medium, and magazine titles and circulations have substantially increased over the past decade. One attraction is the ability to obtain comprehensive information in a cheap manner. For less than two dollars a newspaper can supply you with current events, gossip, nightly television programs, stock market information, comics and a range of other information.

An important fact to highlight is that on average only 10% of a newspaper's circulation will read any one particular story. Some people don't read the paper at all, and most simply skip read and select items of interest. Of those who do read a particular story, most will remember only 10% of the content.

This means that an average article in a newspaper with a circulation of 100,000 will only be read by 10,000 people and out of those only 1,000 will remember what they read.

2.3 "Devil's advocate role"

The media regard themselves as a lonely sentinel safeguarding what is true and right and are obliged to seek out any wrongdoing, failing or flaw.

One needs to keep this "devils advocate" role in mind when confronted by tough interviews. On many occasions the journalist may agree with your point of view, but still asks hard questions in order to perform their job effectively.

2.4 Why negative stories become news

The "devil's advocate" role embraced by media is often why negative news makes greater headlines than positive news stories. Journalists often argue that they need to present a balance against the daily influences of advertising, propaganda and public relations campaigns that the community is exposed to.

Another factor that contributes to why media focus more on negative news is the argument that the public has a palate for the macabre and the horrific. The box office success of horror movies, high sales of murder mystery books and the popularity of certain television shows reinforce this view.

The interest at vehicle crashes or building fires is a clear indication that death, disaster or disability fascinates people.

2.5 What is news?

The ethic of the "objective" model of journalism has been strictly defined as "to report the news, not make or evaluate it."

Critics of the modern school of journalism argue that media objectivity is a myth – highlighting that what is news is very much a subjective issue. Regardless of the subject, someone in a media organisation decides if the story will be broadcast or published. When a news conference is called a chief of staff or someone similar must make the decision as to whether it is worthy of sending a news crew. The journalists then what words to use, and what "grabs" to take from an interview. Finally a sub-editor may decide what angle the story needs to take and where the story is placed in a newspaper or television/radio run down.

This model of journalism then developed into what is known as "evaluative journalism" – which calls for serious analysis and interpretation by journalists, whilst maintaining the requirement for accuracy and facts embraced by the objective school.

This intellectual approach, when combined with the "devils advocate" role of the media previously discussed has created an atmosphere where journalists are geared towards seeking the bad news rather than positive, and this influences the media's interpretation as to what is newsworthy. News is not necessarily about what is new.

News also requires topicality, and needs to contain some announcement, fresh facts or information, or at least an updated perspective on an issue. It does not necessarily need to be new, but it has to be topical.

News, by its very nature must be interesting. This is particularly important when considering what key messages you need to get across in an interview – sharpen the message but strive to maintain your level of credibility. Don't go over the top with a statement just to make headlines.

One characteristic of news is that is has an insatiable desire for details. One thing a journalist wants is numbers – dates, statistics, and facts and figures. Be precise and give details.

An important fact to also highlight is that the news value declines as a function of time and distance. A light plane crash that killed two people locally will hold more news value that the crash of a jumbo overseas. In this case it is relevant to people because it happened in a neighbouring area, and may even involve someone they knew, whereas a plane crash in another country is far away and intangible.

News is fundamentally about what affects and interests people. Whilst it is true that drama and conflict are interesting, people are also interested in areas such as taking a trip, buying a house, losing weight, saving money and a range of other areas. Within this diverse range of interest lies the opportunity to promote stories about your organisation and its products and services.

Regardless of the core business of the organisation, it is vitally important to identify what the relevance of the information being promoted has on the target audience. The media will want to know what it means to the local community, so you will need to 'translate' what things mean in broader terms. This is called an 'angle' – which is essentially an explanation of the relevance. It is looking at it from the audience perspective rather than a personal perspective.

In summary, news is:

- **Dramatic**
- **Topical**
- **Specific with details, especially numbers; and**
- **Relevant to the target audience**

2.6 Avoiding a siege mentality

Entering into communication with the media with a suspicious attitude and the assumption that journalists are deliberately biased and out to get you will result in poor media relations.

This "siege mentality" serves only to promote hostility and gives rise to a defeatist attitude that begins to imagine underlying bias in every media story.

It is important to remember that media are not a group that shares a unified view of the world. While there are occasions that media focus en masse on a particular event, this is often driven by news and market research findings that indicate what the public want.

As highlighted previously, media outlets are often engaged in fierce competition. It is unlikely that the media are out to get you. When you face the media, you are not facing an organised army, but rather an imperfect institution.

2.7 Don't shoot the messenger

As well as avoiding the 'siege mentality' it is also important to remember that what is often perceived, as media bias is in fact a reporter reporting what a third party has said. In this scenario, the journalist is acting the role of the messenger, and is not making an ethical or moral decision as to what is truth and what is not, but highlighting the view of another and seeking a response.

3. MANAGING THE INTERVIEW

One concern shared by many senior executives and CEOs is the fact that editorial content is owned by the media concerned, and therefore cannot be controlled. Some argue that there is too much of a risk in giving interviews and comment because of this situation, but fail to recognise that you cannot prevent or avoid media coverage. Media will write and talk about the organisation or issue whether you cooperate with them or not.

Despite the reality that organisations have little control over editorial comment, the fact remains that you can significantly influence outcomes through effective situation management.

3.1 Interviewer styles

3.1.1 'Baseliners' and 'net rushers'

This description of interviewer styles, derived from a tennis analogy, suggests baseliners hold back and throw questions at you, waiting for you to make a play or mistake. In comparison, net rushers serve up the first question and then come back at you with a rush.

A common misconception is to feel comfortable during base line interviews and fear net rushers, but the reality is both are fraught with pitfalls for the unwary.

A baseliner interview could be similar to this:

Question: "Can you tell me why the building collapsed?"

Answer: "You see often there are a number of reasons why buildings collapse, and recent studies outline….."

The interview is off track and is not addressing the specific issue. In comparison a 'net rusher' interview could be:

Question: "Why did the building collapse?"

Answer: "You see often there are a number of reasons…."

Question: "But why did this building collapse?"

Answer: "Well early indications are the foundations were poorly designed and contained serious structural flaws…"

3.1.2 The midwife approach

This style of interview is usually reserved for programs that have longer time for the interviewee to be nurtured and talk at a leisurely pace. The interviewer sits back and lets you do the talking, and gets the subject to do all the work and is content to take a passive role and add the occasional word of encouragement.

3.1.3 The ambush approach

This is perhaps the most daunting of interview styles, and occurs when a journalist catches you completely off guard with a surprise question or attack. This reinforces the need for the subject of the interview to be well briefed and on guard. These types of interviews frequently occur on current affairs shows and is a legitimate tactic by the media, providing the information is obtained legally and the journalist does not lie or use deceit to obtain the interview.

4. BASIC ELEMENTS OF MEDIA INTERVIEWS AND RELATIONSHIPS

4.1 Access

An important step to promoting a good working relationship with media is to make yourself or someone within the organisation accessible to media – often at very short notice. Some practical steps to build this positive relationship includes:

- Brief reception to fast-track media calls to a nominated person to ensure a quick response
- Return media calls immediately – even if it is to advise that you don't know the answer to the enquiry but you will endeavour to find out
- Nominate appropriate spokesperson(s) – and ensure that someone is available as a back-up should it be needed
- Ensure media spokespersons are trained in communication skills and the techniques of media interviews
- Provide an after-hours contact details for media

4.2 Brevity

Given the time limitations that media stories are forced to adhere to, it is vitally important that any interview statement is framed to provide a brief and concise response. A succinct statement that makes a point is more likely to be used by media and reduces the risk that it will be edited and the original meaning altered or misquoted.

4.3 Keep it simple

Because it is the media's role to explain a topic to a wide audience, it is important that interviews address the lowest level of that particular audience. Often technical language is difficult to understand, and it is commonly accepted standard that the average mental capacity of newspaper readers is 10 years of age – so answer need to be able to be understood from at least that level of maturity.

4.4 Don't use the interviewer's name

A common fault made by people who are giving a media interview is to refer to the journalist's name in an answer in an effort to be polite and courteous. Whilst this is a friendly approach, you need to be aware that whilst you are talking to the journalist, you are actually talking to a much wider audience. The use of a journalist's name in a "grab" can often result in the grab not being used in favour of another one, and in turn becomes an opportunity missed.

4.5 Honesty, sincerity and compassion

These are three vitally important ingredients that should be a part of all media interviews. Whilst it is important that you be honest with the media, that does not mean that you need to tell them everything – but ensure you tell the truth in what you do say.

4.6 What to say when you don't know

If you are asked a question that you do not know the answer to – do not be afraid to say you don't know. Rather than bluffing your way through a response, advise the journalist you don't know and you will endeavour to find out what the answer is.

5. SEVEN TOOLS FOR SUCCESSFUL MEDIA INTERVIEWS

5.1 Objectives

Always go into an interview with an objective in mind. Know the subject and have a broad outline of the issues for discussion. The primary objective of any interview should be to communicate to a specific audience the main points that you or your organisation wants to make about the topic being discussed.

5.2 Frame or reference

Go into an interview with a clear idea as to who makes up the audience that you need to reach with your message. This knowledge will allow you to shape the style and content of your communication.

5.3 Must says and like to says

With your objective and audience in mind it is vital that you work out prior to the interview what you must say on the topic of the interview. Writing several key dot points serves as a handy reminder, and helps to frame these points into succinct and deliverable statements.

In most interviews you will be able to successfully communicate from one up to a maximum of three major points, but it is also effective to have a number of other secondary statements that you would like to say should time permit. When identifying the list of "must say" statement remember to include any positive issues.

5.4 Bridging – the 10/30 principle

This principle occurs when a question is asked during an interview that deviates from the topic you want to discuss, but then link it back to a "must say" using a key-bridging phrase. When used successfully this approach spends 10 seconds addressing the question and then 30 seconds saying what you want to say.

5.5 Stand alone statements

Misquoting and misreporting statements are the most common complaints about interviews. In an endeavour to overcome these problems it is essential that statements during an interview do not directly answer questions. Rarely in media stories does the audience hear what question the journalist asked, but the audience does hear what your response was. The phrasing of an answer needs to be a standalone statement that makes sense without knowing the question that prompted it. Often during an interview people fall into the habit of using the words of the journalist in their answers, and repeat an allegation or key phrase that they would have normally avoided. As a rule "yes" and "no" do not serve any useful purpose and should be avoided.

5.6 Reiteration

Repeating key phrases more than once serves as a method to clarify a meaning. Repetition is saying exactly the same thing, but not always with the same words. It highlights to journalists the key points that you want to make, and also reduces the risk of misunderstanding by the journalist. Reiteration used this way is essentially a quality-control mechanism that improves communication – particularly if your statement is used more than once in an interview. A point to consider is to ensure that during an interview you use reiteration not repetition, which serves to frustrate journalists.

5.7 Avoid "red herrings"

One thing that often puts interviewees off track and makes them forget their "must say" statements is when a journalist asks a question that draws the topic off in another direction. A "red herring" during an interview is essentially anything that is not either a "must say" or a "like to say" statement.

6. GROUND RULES FOR DEALING WITH MEDIA

6.1 Off the record

Legally there is no such thing as a conversation that is "off the record" so whenever communicating with journalists. The concept of making a comment in these circumstances is essentially a convention that has developed over the years. If you want to supply background information, but it is warranted that it be in such a form that it is off the record, then it is essential that a journalist agrees that this will be the case. Despite this agreement not being legally binding, it brings with it a level of moral responsibility. This agreement should be used sparingly and only with journalists that you have an excellent working relationship with.

6.2 Non- attributable

Whereas off the record essentially means the comment never occurred, there may be occasions when you want a journalist to report something with no direct attribution back to you as the source.

6.3 Background

This term, used by the media, refers to information that is off the record, on the record or from a non-attributable source. This may refer to information that is not exciting enough to publish, but provides an understanding of an issue.

6.4 Exclusives

An "exclusive" refers to a story that is provided to one journalist or media outlet to the exclusion of all others, and can often be a minefield for the unwary. When an exclusive is offered it pleases one journalist and upsets all the competitors, and risks putting other journalists off side with your organisation. As a rule it is more beneficial to an organisation to treat journalists fairly and equally and generally avoid exclusive story arrangements.

One rule to be aware of is if you initiate a story it is for all, but if a journalist initiates a story then there is no obligation to share this information with other media.

6.5 Embargoes

The use of embargoes on information supplied to media is not legally binding. An embargoed media release is commonly used when an announcement occurs close to a media deadline, or where media require time to research and prepare for a story.

6.6 Leaks

A "leak" refers to a deliberate or accidental release of unauthorised information to media. Generally the practice of leaking information to the media should be discouraged, but there are circumstances where leaks form part of a strategy and are justifiable.

These occasions are normally handled by senior management and decided because of the perceived benefit it holds to the public, despite not being approved for release. In reality there are few occasions when leaking information to the media is justified, and remains fraught with danger.

6.7 Asking questions in advance

Prior to an interview it is appropriate to ask a journalist to state in broad terms what they want to talk about, but a journalist will rarely supply a list of questions. This is why comprehensive research and knowing the subject is vitally important before an interview. Even where a list is supplied, questions can still be asked that are not included.

6.8 Reading back copy

One strategy sometimes used to reduce incidents of misreporting or misinterpreting is to request a journalist to supply the copy for reading prior to it being published. This runs the risk of insulting the journalist by implying a lack of trust and ability, and often results in a refusal to the request. Where a journalist does supply copy to read, only highlight corrections and do not try to re-write the story. If you have serious concerns regarding the portrayal of a story it is advised to contact the journalist and discuss your concerns.

6.9 Copyright

As the ability to widely distribute information grows with advancing technology, the issue of copyright is becomingly an increasingly important issue. Whilst copyright is not an issue regarding what a person says, it can be an issue if handouts or printed information are supplied to media, and it is important to investigate whether your company owns the copyright to distribute. While it is a breach of copyright to quote sentences or use graphs and charts from a report which the organisation does not own copyright on or has permission to copy, it is not illegal to use facts or redraw charts – providing the charts are different to the originals.

6.10 Defamation

In Australia the law regarding defamation is complex, and there is no national standard to follow. Because of this lack of uniformity, a statement made by national media can result in a legal action in any or all of the eight states and territories.

With advances in technology such as the Internet, which can see an article published globally, it is now possible to breach defamation laws in another country.

Defamation can take the form of either libel or slander. Libel is a defamatory statement that is made in a permanent form such as writing or film, whereas slander is made in a non-permanent form such as the spoken word.

Defamation can be made directly to the person concerned, or by imputation.

6.11 What to do about misreporting

Misreporting will at times still occur, and this may be because of human error, laziness or the result of a deliberate act. When dealing with this issue it is imperative that you determine that you have in fact been misquoted or misreported. Often when a story does not have the preferred angle it is construed as misreporting, and this is not the case. Provided a journalist does not substantially alter the meaning of your quotes it is not misreporting.

If you believe that misreporting has occurred it is then necessary to decide if it is serious enough to warrant further action. Follow-up action could come in the form of contacting the journalist direct, writing a letter to the editor, seeking a formal retraction or making a formal complaint to one of the regulatory bodies that govern media behaviour. Other options include a complaint to the ombudsman, or to the journalists' association or union.

The most effective strategy to dealing with misreporting is to proactively manage the interview process to prevent misreporting in the first place.

6.12 Over exposure

The decision as to whether you are over-exposed is not the decision of colleagues or friends – it rests in the hands of the audience. The media will let you know by simply not wanting to interview you any more.

The success of media exposure rests with quality rather than quantity.

7. INTERVIEW CHECKLIST

7.1 Before the interview

- Consider the purpose of the interview and the focus of questioning
- Will it be live or pre-recorded?
- What is the expected duration of the interview?
- Consider the target audience and phrase answers in terms they will understand
- Consider whether you are the most appropriate person for the interview
- Mentally prepare yourself
- Establish a list of "must say' and "like to say" statements in priority order
- Make notes – can do this during radio but not a television interview
- If the interview is for television then consider your appearance
- Don't try to work out all the interview questions – mentally prepare but don't rehearse your answers

7.2 During the interview

- Don't say "no comment"
- Be sincere, confident and competent
- If you don't know – admit that
- Don't look directly at the camera – look at the interviewer
- Avoid wearing sunglasses
- Be aware of nervous habits
- Give short and succinct answers – don't ramble
- Use common, everyday words and avoid jargon
- Relate your points back to how they affect the audience
- Be natural/friendly and do not be evasive
- Do not be intimidated by the interviewer

7.3 After the interview

- Often at the end of a television interview, the camera crew may want to do "two shots". This is so they can obtain some staged vision of the interviewer asking a question, or other shots that can be used as overlay to the story. Be aware that the camera can still record any discussion you have with a journalist during this stage.

- Don't pressure a journalist into using particular grabs.
- Don't complain to the journalist or editor when the interview is not used – there is often a good reason for this decision.

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BUILDING CERTIFIER'S PERSPECTIVE ON SEISMIC UPGRADING OF BUILDINGS

Ian Dodd
Katnich Dodd

(Paper not available at time of printing)

Paper No. 25

SEISMIC UPGRADE OF HISTORIC MASONRY STRUCTURE THE STATE LIBRARY OF SOUTH AUSTRALIA, JERVOIS WING

PETER MCBEAN AND MARK GILBERT
WALLBRIDGE & GILBERT

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SUMMARY

The Jervois Wing is one of Adelaide's most beautiful public buildings and houses a priceless state treasure. It will become, as part of the Redevelopment of the Sate Library, a focal point for tourists, students and researchers. It is an intrinsic part of North Terrace and is much loved by all South Australians.

In recognition of its importance, the buildings seismic performance has been extensively upgraded. This paper describes the structural performance evaluation process undertaken prior to the upgrade, together with implementation of the chosen strategies.

Key structural issues included:

- Stability of perimeter masonry walls and piers
- The use of tie rods to prestress masonry arch floors
- Introducing passive reinforcement into existing masonry piers
- Timber floor diaphragm performance
- The introduction of strategic building separation joints to improve structural response

A number of the processes used in the upgrade had not been attempted on this scale in South Australia before.


The completed project

HOW THE SA GOVERNMENT IS MANAGING EARTHQUAKE RISKS IN A COST-EFFECTIVE MANNER WITHIN THE CONTEXT OF STRATEGIC ASSET MANAGEMENT

GEORGE IANNOS AND DAVID NESS
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ABSTRACT:

Much attention has been focussed upon the design of new buildings to resist earthquakes, using Australian Standard AS 1170.4-1997: SAA Loading Code - Earthquake Loads. This paper deals with the assessment and rehabilitation of existing buildings that comprise the majority of the building stock and the greatest risk. It explains how the South Australian Government arranged for earthquake risks to be assessed and prioritised in a broad sense, followed by more detailed investigations of high-risk assets. In consultation with international consultants, DAIS developed a methodology and generic brief to enable this work to be undertaken by local private engineering firms.

Importantly, the DAIS methodology adapted and extended the risk management process in the Australian and New Zealand Standard AS/NZS 4360-1999: Risk Management, and is consistent with strategic asset management principles and asset performance assessment processes used for other purposes. The approach enables seismic risks to be considered in the context of other asset risks and for the level of upgrading to be commensurate with the purpose and criticality of particular buildings. An important concept is that some risks may be acceptable and manageable. These ideas are illustrated using case studies of a warehouse building and a major city hospital.

The paper then advocates changes to the Building Code of Australia (BCA) and Australian Standard AS 3826-1998: Strengthening Existing Buildings for Earthquake.

1. BACKGROUND

South Australia is prominent on the earthquake map of Australia and reinsurers have a great interest in how the government is managing the risks associated with its public buildings.

In 1996 the SA Government Captive Insurance Corporation (SAICORP) engaged EQE International to broadly assess the seismic resistance of government buildings located in and around the Adelaide CBD. EQE rated these buildings according to high, moderate or low risk, and recommended further investigations related to 6 high risk buildings. DAIS was then asked to manage this earthquake study and subsequent remedial actions. The study included the development of a generic brief to enable private engineering firms engaged by the SA government to undertake assessments and upgrading in a manner acceptable to EQE and hence the international reinsurers. It also led to the development of a DAIS Policy on 'Strengthening Existing Buildings for Earthquakes' that included the generic brief and a Seismic Upgrading Guide for Existing Government Buildings. The guide is in the form of a matrix that suggests performance levels for various building types and structural classifications – along the lines of the 'importance levels of buildings and structures' recently included in the BCA.

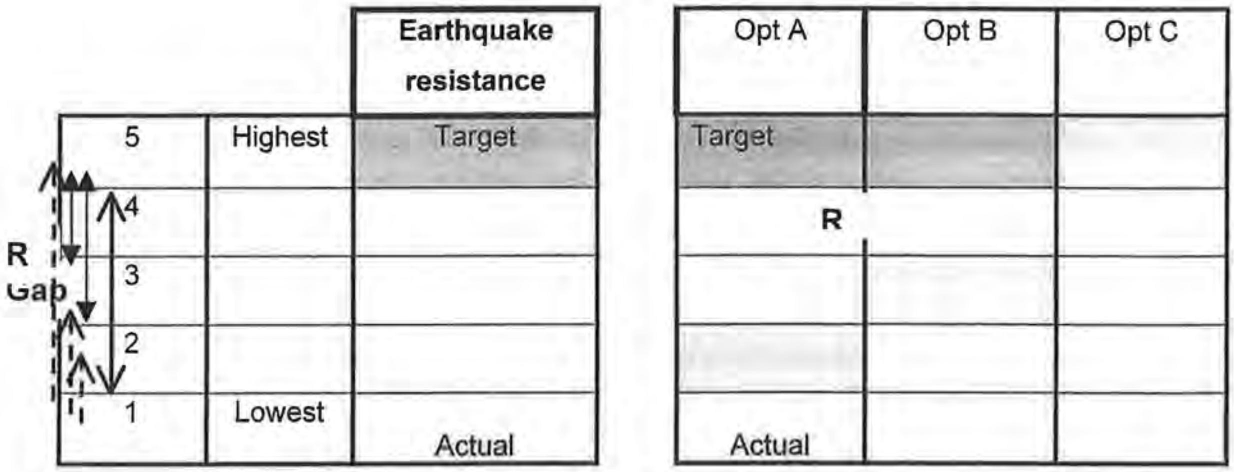
The SA Government centrally funded the upgrade of the buildings identified as high risk to the tune of $4.3 million. In addition, in July 2001, Treasury Circular 314 was issued to agencies, endorsing the DAIS Policy and requiring seismic assessments and earthquake mitigation works to be included as part of any significant alterations proposed to existing government assets. Appropriate allowances for earthquake mitigation works must be included in project budgets. In addition to placing some obligation on agencies, this supports the DAIS role in ensuring that appropriate assessments are carried out by consultants as part of redevelopment projects managed by DAIS on behalf of agencies.

2. RISK MANAGEMENT

The risk management process is outlined in AS/NZS 4360-1999, and includes; establishing the corporate planning context and criteria, identification of hazards, analysing and prioritising risks, assessment of various remedial options (including risk acceptance or transfer), and the development of risk treatment plans. These correspond to the steps in the DAIS Strategic Asset Management Framework, and risk treatment plans should be considered as part of asset management plans.

In accordance with the DAIS Policy on Earthquake Strengthening, consultants should establish an agreed benchmark for analysis, based upon the DAIS Seismic Upgrading Guide. After the seismic assessment, the consultant should assess the risks associated with any gap between the actual structure and the desired benchmark. Importantly, various options for bridging the gap should be presented to the building owner/agency, with the residual risks associated with each option described in non-technical terms (see Figure 1).

Figure 1. Analysis of upgrade options



R = residual risk

DAIS has developed a proforma to enable consultants to describe each option, highlighting the indicative costs, any disruption to the occupants, the residual risk after the upgrade and the means of managing this risk.

3. WHOSE RESPONSIBILITY FOR ACCEPTING RISK?

The role of DAIS is to provide strategic asset management policy advice to government agencies and to manage project risks on their behalf. Agencies themselves are responsible for managing their existing building assets and the associated risks. Under Treasury Circular 314 and the related DAIS Policy on Strengthening Existing Buildings for Earthquakes, any decision to strengthen an existing building shall be the responsibility of the client agency, in consultation with DAIS and the consultant, with regard to the costs of remedial work, the reduction of risk and the acceptability of any residual risk. The Policy establishes a base level of earthquake resistance for public safety based on AS 3826, and over and above this is the client agency's decision based upon consideration of the business or service requirements, including the significance and criticality of the building and its contents. For example, as in the case of the SA Museum described elsewhere in this Conference by Peter McBean of Wallbridge and

Gilbert Consulting Engineers, the upgrading level was influenced by the need to protect precious Aboriginal artefacts and the heritage-listed building.

It should be noted that each agency needs to evaluate earthquake risks in relation to the many other risks and imperatives under a plethora of legislation that confronts them as building owners, including fire safety, asbestos, Legionella, environmental, and the like. Earthquake upgrading should be considered holistically in relation to other risks. For example, the earthquake upgrading of Her Majesty's Theatre was undertaken in conjunction with fire safety and other asset improvements. In some instances, a property may be unsuitable for its purpose and it may be preferable to dispose of it rather than upgrade.

4. STANDARDS AND POLICIES

New buildings should be constructed to meet the full requirements of AS 1170.4-1997: SAA Loading Code - Earthquake Loads. On the other hand, AS 3826 recognises the difficulty and often impracticability of upgrading existing buildings to current standards and establishes the principle that a lower benchmark may be acceptable. This aims to minimise the risk of loss of life and injury from structural collapse but not to prevent damage to the building. The DAIS approach has attempted to extend the principles in AS 3826 by linking the level of upgrading with assessment of risks as detailed in AS/NZS 4360-1999.

5. DAIS APPROACH

5.1 CASE STUDY: NETLEY COMMERCIAL PARK

The DAIS approach is for earthquake risks to be seen in the context of strategic asset management and the range of other risks confronting building owners, and for all these risks to be broadly scoped at a wider portfolio level before focusing on particular buildings.

The approach was first developed and tested in relation to the upgrading of the main building at Netley Commercial Park, in conjunction with Consulting Engineer Jim Wilson. The 1970s building of over 19 000 square metres, used mainly for storage purposes, was found to be at high risk in a major earthquake due to its unorthodox construction. The agency/owner wished to achieve a reasonable level of life safety and a base level of property protection – in other words, some property damage was considered acceptable provided risks to life were minimised.

This formed the context of the investigations by Jim Wilson, the first to be based on risk management principles. Earthquake risk was assessed for various magnitudes of earthquake and threshold loads as quoted in AS 3826 i.e. 1/3, 2/3 and 100% respectively of the design loads adopted in AS 1170.4. The assessment was based on the construction, the 50-year anticipated building life, and the likelihood and consequence of earthquakes of various magnitudes in Adelaide. These were considered using Appendix E from AS/NZS 4360: 1999 that establishes various levels of risk based upon likelihood and consequences.

From the above assessment, the highest risk scenario was for an earthquake of 2/3 threshold loads. Consequently, upgrading of the building to sustain 2/3 threshold loads was strongly recommended. This involved additional roof and wall bracing at this level plus some detailing requirements. After such upgrading, the residual risk for all levels of earthquake would be reduced to 'moderate'.

However, in accordance with the DAIS 'holistic' approach, earthquake risk was evaluated in relation to other risks. Using Appendix E, fire safety was seen to represent 'extreme' risk (in comparison to 'high' for earthquake), and thus most funds were initially targeted to fire safety improvements. In Year 1, the bar was raised to 1/3 level, and in Year 3 further improvements were made to achieve the 2/3 level.

Table 1. Action plan to treat risk

Item	Risk	Program		
		Year 1	Year 2	Year 3
Fire safety	Extreme	\$328 000	\$346 000	
Earthquake	High	\$52 000		\$177 000

Again in accordance with AS/NZS 4360, key stakeholders such as the site OHS committee, the Fire Service and SAICORP were consulted. They were all able to 'sign off' on the plan.

5.2. CASE STUDY: ROYAL ADELAIDE HOSPITAL

The risk management approach was applied to the upgrading of the main blocks at the Royal Adelaide Hospital, as part of the hospital's major redevelopment. These were constructed in the 1970s and comprised the Outpatients Building, the Services and Teaching Block, and the Theatre Block. Whilst all new buildings would be in full compliance with the earthquake code, these substantial existing structures presented particular and complex upgrading problems.

In this case, the building certifier and the engineering consultants had originally determined that a 1/3 level upgrading would suffice as this would meet AS 3826 – a legitimate approach at the time. However, subsequent application of the DAIS methodology revealed that this would still represent a high risk for the government and possibly cause concern to reinsurers. DAIS believed that the resistance of the buildings to earthquake was better than expected, and this was verified by more detailed investigations with the cooperation of the engineering consultants, Brown and Root (now Halliburton KBR), and in particular Forbes Fowlie who undertook the analysis.

At the outset, it was felt that full upgrading to AS 1170.4 would be impracticable, causing major disruption to the hospital, and too costly. However, this option was examined along with other alternatives of 2/3 and 1/3 threshold loads, in relation to several upgrading options:

A. No modifications to existing building structure, but with local strengthening around doorways to lift shaft. Cost $115 000
B. Addition of steel angle sections within both lift and stair shaft, and with local strengthening around door openings to lift shaft. Cost $266 000
C. External bracing to building perimeter, in conjunction with local strengthening and angles noted above. Cost $649 000. However, this option was found to be impractical as provision of external bracing compromised planning to adjacent abutting structures forming part of the redevelopment.

The analysis in relation to Option B (selected) is illustrated below, with the performance of the structure under each scenario being expressed in non-technical 'plain English' to facilitate the understanding of hospital and government decision-makers:

CASE 1: Earthquake loads of 1/3 threshold load

RISK – LOW

Expected structural performance

- Possible minor cracking to shaft walls in general which may require cosmetic repair following the event
- Possible minor cracking to masonry partition walls which may require cosmetic repair following the event
- Building stability and function should remain unimpaired
- Escape from the building should remain unimpaired

CASE 2: Earthquake loads of 2/3 threshold load

RISK – MODERATE

Expected structural performance

- Possible cracking to shaft walls in general particularly around door openings to the shafts which may require structural repair following the event
- Possible cracking to masonry partition walls which may require demolition and rebuilding following the event
- Possible collapse of longer masonry partition walls unstiffened by cross walls
- Building stability and function should remain unimpaired
- Escape from the building should remain unimpaired

It was decided by the hospital, in consultation with SAICORP and DAIS, to upgrade the buildings where necessary to sustain 2/3 threshold loads (Case 2). This was considered the most reasonable and cost-effective solution in relation to public safety and the overall project budget. However, this option would result in some residual risk in the event of a major earthquake imposing 100% loads, and work is being undertaken to minimise and manage this risk. This includes, for example, strengthening of partition walls as part of the redevelopment works.

6. CONCLUSIONS AND RECOMMENDATIONS

The work undertaken by DAIS in conjunction with private engineering firms has demonstrated the success of the risk management approach. The benefits have included improvements in life safety and property protection, and but also it has been easier for SAICORP to secure reinsurance. The approach also shows that the government is exercising 'due diligence' in the management of its assets. These actions have been received positively by the Government's reinsurers.

The credibility of the approach was reinforced by the involvement of EQE International, and DAIS was able to build the expertise of EQE into the generic brief and thereby impart this to local engineering firms. DAIS introduced the notion of applying risk management analysis according to AS/NZS 4360.

In this regard, the rehabilitation of existing buildings is inadequately covered by AS 1170.4 and the BCA, except where there is a major change to a building. It is therefore recommended that risk management principles as per AS/NZS 4360 should be incorporated in an amended version of AS 3826 that is called up by the BCA.

The DAIS Policy on 'Strengthening of Existing Buildings for Earthquakes' is currently being reviewed in the light of the recent amendments to Part B1 of the BCA, but it is pleasing that the concept of 'importance levels' is generally consistent. However, it is recommended that risk assessment in BCA and AS 1170.4 should be standardised in relation to the determination of building performance level and the criteria for establishing priorities.

Finally, the experience of DAIS, government agencies and consultants has shown that earthquake risks can be addressed as part of strategic asset management, and considered holistically in relation to other building risks.

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