



AEES Newsletter

The Society -David Rossiter (Treasurer)

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Conflicts between design and reality from the President Charles Bubb

I want to use this opportunity to draw your attention to two recent papers, one from New Zealand and one from Australia. Nigel Priestly (Bull NZNSEE Sept 1993) says in his paper *Myths and fallacies in earthquake engineering design - conflicts between design and reality*; "It appears however that the enormous approximations involved in seismic design are perhaps becoming less appreciated rather than more", and again; ".....analysis drives the design process rather than the reverse...."

There is more, see the elastic response analysis fallacy - for example - duration effects are not considered and still more in the refined analysis myth - namely "refinement of the analysis produces more accurate results".

There is much more detail in the paper

and all well worth reading, although the author does admit to some overstatement of the case to make his point clear.

I think we would do well to keep in mind two points Priestly makes in his conclusion. Let me shorten them slightly for our purposes

- Given the wide range of assumptions and approximations inherent in seismic design ... we might be better keeping the design and analysis processes simple enough so that we still understand what we are doing.

- If we accept that displacements are more important than forces, it is time we started basing our design on displacement rather than acceleration spectra.

The second paper is *Response spectra for Australian earthquakes* (see the Australian Civil Engineering Transactions for January 1994). This paper details attempts to generate response spectra based on Australian earthquakes and compare them with those provided in the new Loading Code AS1170.4. For structures with periods longer than about 0.5 s the spectral acceleration predicted by the Code is about 5 times larger than that estimated by their spectrum.

Now, while this result is still subject to public critical review through the Transactions, it certainly gives a special emphasis to Priestly's remarks selectively quoted above.

In Australia, all our earthquake engineering is based on the inadequate data we do have, combined of necessity with adoption of overseas data for attenuation and other engineering characteristics. It is most unlikely that this forced combination of local and overseas data is giving us the best result.

In my opinion, only government supported studies and observations can supply it.

AEES'92 Conference Proceedings

The proceedings from the 1993 conference are not quite ready but there are still copies of the 1992 AGM available from the Hon Sec (ASC, GPO Box 378, Canberra 2601) at a bargain price of \$15 to clear, which includes post to anywhere in Australia.

AEES AGM'94

The dust from the AGM'93 has hardly settled yet now is the time to think about papers and sponsors for this year's seminar in Canberra. We plan to focus on *Lifelines* but will consider papers on other topics. The tentative date is November 14/15 and venue the IEAust headquarters. Sessions on Monday afternoon and Tuesday morning; dinner Monday night. Visit Australian Seismological Centre and/or Science & Technology Centre (shake table) on Tuesday afternoon.

Killari: the quake that shook the world - Leonardo Seeber

(Ed - Leonardo Seeber is a seismologist at Lamont Doherty Observatory, Palisades New York. He was seismologist on the Tarbela Dam Project, Pakistan in the mid 1970s. He may not have written the catchy headline in the New Scientist of 2 April 1994 but the rest of the article raises serious issues for evaluation of earthquake hazard in Australia. I have extracted freely from the article in New Scientist)

WITHIN a few seconds of 3.45 am on 30 September 1993, Killari, a village on the north bank of the Tirna river in central India, along with scores of others, was reduced to rubble. Ten thousand people died in the worst earthquake disaster to hit India in over half a century.

The earthquake that destroyed Killari and surrounding villages killed more people than any earthquake in a "stable" continental area - one that is not part of a plate boundary - with the exception of the 1918 Nanai earthquake in southern China, which reportedly killed a similar number.

Judging by official earthquake hazard maps, Killari is the last place you would have expected a damaging earthquake. In the middle of the Indian sub-continent, far from any plate boundary the maps show Killari had been placed in an area with the lowest risk of earthquakes. Even more disturbing, seismologists using these maps do not seem surprised by such a mismatch between prediction and reality - they have seen large earthquakes popping off where least "expected" many times before.

What causes earthquakes in the interior of tectonic plates? Plate tectonics has been amazingly successful in explaining geological observations. But observations that do not fit easily into the framework of plate tectonics, such as earthquakes within plates tend to be overlooked.

There are, however, good reasons why seismologists may have been so wrong at Killari. Although the hazard map is based partly on geological information - including data on major fault zones thought to be persistent zones of weakness in the Precambrian basement of the continent - it relies mostly on the historic record of earthquakes, about 150 years in India's case. This means that the map, just like those in use in other countries, reflects the assumption that seismic activity is stationary - that is, except for statistical fluctuations, the distribution and level of seismic activity do not change over time.

When "unexpected" earthquakes occur, these do not change the assumption of stationary activity. The hazard maps are simply amended with a bull's eye pattern of relative high hazard around the new epicentre on the premise that these represent stationary sources of earthquakes which were previously overlooked. In other words, the maps reflect the view that if the seismic record went back far enough, seismologists could produce maps that would eliminate all "surprises".

But just how long would that record have to be? The rock formation that characterises the Killari area is the Deccan Traps: a stack of frozen basalt lava flows that covered much of central western India 65 million years ago. These rock layers are still horizontal. So any fault that cut through them would reveal itself by the relative shift of the layers.

We found a very complex pattern of faulting near the surface. We traced the faulting for about a kilometre, but were too late to trace it further west, through a low lying area with deep, soft soil, as this had been tilled since the earthquake.

From our map, we concluded that the fault was a thrust (or reverse) fault that intersected the surface in a west-northwesterly orientation. This kind of fault is usually inclined at intermediate angles.

We cut trenches across some of the scarps to expose the rupture beneath the surface, and measuring how far the fault had moved. Our measurements confirmed the half-metre shortening.

But more interesting still, we found no evidence of a pre-existing fault in the exposed rock. This would imply that the 1993 earthquake probably ruptured previously unfractured rock as far down as the bottom of the Deccan Traps. In other words, any previous earthquakes on this fault would have

to data back more than 65 million years - the age of the Deccan Traps.

Why had the quake occurred here, and why now, after 65 million years or more of quiet (at least from the Killari fault)? Could the earthquake have been triggered by mechanical changes in the Earth's upper crust, caused by the impounding of the nearby Tirna reservoir three years earlier? If so, this would suggest that human activity has to be added to any formula seeking to predict intraplate earthquakes.

Harsh Gupta of the National Geophysical Research Institute in Hyderabad has compiled a record of triggered earthquakes, while B.K. Rastogi, also at the NGRI, compiled data on damaging earthquakes in peninsular India. At least one-third of the damaging earthquakes in the 1980s seem to have been triggered by artificially created lakes. The actual ratio may be even higher. Not surprisingly, the people responsible for building the dams are often fiercely opposed to such hypotheses.

We may never know if building the Tirna reservoir triggered the Killari quake. In particular, where did the seismic activity occur in 1992, and when did it start? These questions will never be answered: no local seismograph was operating at the time.

It is obvious that the historical record cannot give us a complete sample of the possible sources of large earthquakes. Recent investigations of surface earthquake ruptures in other stable continental area have yielded similar results. In 1990, John Adams and his colleagues at the Geological Survey of Canada found that the 1989 Ungava earthquake in northeast Canada had ruptured Archaean rocks that were billions of years old along a new fault. Similarly in 1992, Anthony Crone of the US Geological Survey reported that several historically recent surface ruptures in Australia show little evidence of accumulated slip during the time when these faults were in a stable continental crust. Neither does the prehistoric Holocene rupture along the Meers Fault in Oklahoma. So it seems that even geological data, with their much longer coverage of seismic activity, are inadequate.

Large earthquakes keep happening in stable continental areas with worrying frequency, many of them showing no obvious correlation with the historically recorded pattern of seismicity.

Our experience of the Killari earthquake does, however, hold out some hope of alternative approaches that could help to give

warning of damaging earthquakes. First, the Killari quake was preceded by a burst of seismic activity - a pattern common among many large intraplate earthquakes. More than a hundred earthquakes were felt within a couple of months, a year before the main shock in 1993. Some were large enough to cause damage in Killari and in the same surrounding areas that were destroyed a year later.

And secondly, it seems clear that along with a burst of unprecedented seismic activity, the operation of a reservoir is a phenomenon that we need to monitor and take into account in assigning hazard levels. While data about these would not help "predict" a large earthquake directly, they do seem to increase the probability of large earthquake in the short term. We need to combine information from "stationary" seismic activity associated with geological features with time-dependent seismic activity characterised by changes in the environment.

This approach is not new, but it has never been applied to stable continents. In California, where it has long been observed that foreshocks tend to precede large earthquakes, Lucy Jones, a seismologist at the USGS has looked at the probability of a large earthquake happening in terms of the way seismic activity changes over space and time. The probability of a large earthquake in the near future goes up when an earthquake occurs. Her approach may be useful in stable continents.

The perception of earthquake risk in stable continents is probably too optimistic. Perhaps further disasters in stable continental area will change this.

Recent large damaging earthquake

17 February - Sumatera On the Australian Eurasian plate boundary, this magnitude Ms 7 earthquake left 190 people dead, 2000 injured and 75 000 homeless. The earthquake triggered extensive landslides. Most of the casualties were in the district capital Liwa where 6000 homes, shops and government buildings were damaged or destroyed by the shaking or landslides.

No appeal was made by Indonesia for international assistance but Australia did provide 50 marquee tents through Emergency Management Australia acting for AIDAB.

THE NORTHRIDGE EARTHQUAKE: January 17, 1994

ANDREW S. WHITTAKER

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(This article was contributed by Dr Mike Griffith, University of Adelaide)

Introduction

The M_M 6.7 Northridge earthquake occurred at 4:30 a.m. (PST) in the north western San Fernando Valley of Southern California. The main event was assessed as a thrust mechanism at a focal depth of approximately 19 km. Within the first five days, it was followed by several aftershocks of $M > 5$, the largest having M_M 6.0.

The Northridge earthquake is the most recent and largest in a series of significant earthquakes that have occurred since 1987 as expressions of the north-south compressive deformation occurring across the Transverse Ranges of Southern California. The 1987 Whittier Narrows (M_L 5.9) and the 1991 Sierra Madre (M_L 5.8) earthquakes, as well as the 1971 M_L 6.4 San Fernando (Sylmar) earthquake, had thrust mechanisms that occurred on north-dipping planes. A major south-dipping fault system, possibly an eastward extension of the Oak Ridge fault, produced the Northridge earthquake.

The earthquake resulted in more than 55 deaths and 5000 injuries. Approximately 25 000 dwellings were rendered uninhabitable. Preliminary damage estimates, which range from \$15-30 billion, indicate that the Northridge earthquake is the most costly natural disaster in U.S. history.

In the week immediately following the earthquake, a research team of approximately 50 individuals from the University of California's Earthquake Engineering Research Center, Seismographic Stations, and Lawrence Berkeley laboratories undertook an analysis of available data. The following summarises some of the major features of this earthquake and the results obtained by the reconnaissance team as published in the Preliminary Report on the Seismological and Engineering Aspects of the January 17, 1994 Northridge Earthquake (UCB/EERC-94/01).

Strong Ground Motion

The earthquake generated a large number of strong-motion recordings over a wide variety of geologic site conditions, including free-field stations on rock and soil as well as recordings of motions from instrumented structures of varying types of construction.

Although the epicentre was located in the suburban city of Northridge in the San Fernando Valley, peak horizontal accelerations approaching 0.5 g were recorded at sites as far as 36 km from the epicentre in downtown Los Angeles. Recordings at two stations in the epicentral area, Sylmar County Hospital (alluvium) and Tarzana Cedar Hills Nursery (alluvium over siltstone), yielded the largest free-field accelerations on soil sites and unusually high values of peak accelerations. The Tarzana station, 7 km south of the epicentre, recorded peak horizontal and vertical accelerations of 1.82 g and 1.18 g, respectively.

Contrary to results obtained from the 1989 Loma Prieta earthquake, no strong trends in amplification of ground motions at soil sites were apparent for the initial stations studied. Also in contrast to the 1989 Loma Prieta earthquake, where local site effects resulted in significant damage at distant sites, the largest concentration of damage from this earthquake was at the heart of the epicentral region.

Geotechnical Considerations

Damage related to geotechnical considerations was minor but widespread. Incidents of ground failure or deformation occurred within the San Fernando Valley and the Los Angeles basin at distances of up to 58 km from the epicentre. Evidence of soil liquefaction, detected at various sites up to 43 km from the epicentre, included sand boils, ground settlement, and lateral spreading. Soil liquefaction and lateral spreading occurred over large areas in Northridge, near the junctures of highways 5 and 210, and 5 and 405, and Simi Valley, but preliminary results indicate that liquefaction does not appear to have contributed significantly to structural failures of buildings or bridges.

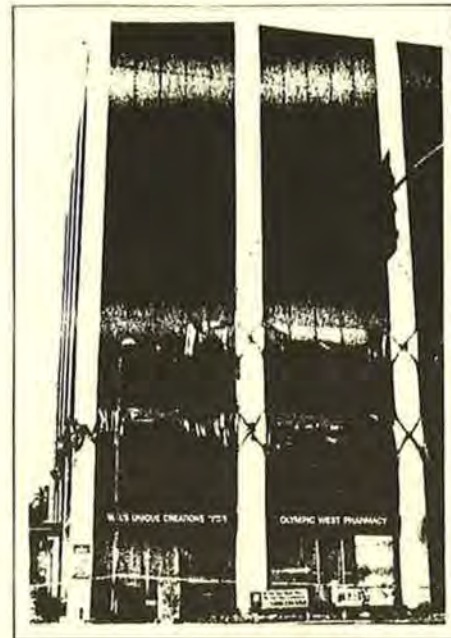
Bridges

Most of the 600-mile freeway system in the Los Angeles basin survived the Northridge earthquake with minimal or easily repairable damage. Extensive damage or collapse of approximately ten freeway bridges occurred. Of the collapses, five were of 1960s designed bridges and contained recognised deficiencies; four of these were scheduled for retrofitting. Two bridges on Route 118 (1976 construction) suffered extensive damage and collapse, illustrating that certain details used in the few years immediately following the landmark 1971 San Fernando earthquake may be inadequate. Bridges

designed to current standards and those retrofitted by Caltrans since the 1989 Loma Prieta earthquake performed very well.



Column failure at Bull Creek Canyon Channel bridge



Non-ductile RC building in Santa Monica showing shear cracking in columns. The building was demolished within 2 days.

Conventional Buildings

Several two and three-story apartment buildings in the epicentral vicinity suffered extensive structural damage. Many suffering damage were wood-frame buildings with inadequate lateral-load-resisting elements in the open parking story at ground level. Inadequate elements appeared to include narrow plywood-sheathed panels, gypsum wallboard, and stucco. A soft first-story mechanism was commonly observed following the earthquake. The partial or total collapse of these stories was responsible for the majority of deaths.

Preliminary assessments of engineered buildings indicate that the majority performed well from a life-safety perspective; however, there was significant and costly structural and non structural damage over a wide geographic region, suggesting a need to reconsider broader aspects of seismic performance. The most obvious damage occurred in concrete and masonry buildings. Though many had proportions and details not satisfying current requirements, many others are considered to represent modern construction. Most notable in this regard was the damage and collapse of parking structures, many of which were of precast construction. Though no collapses occurred in steel buildings, a significant population of steel buildings suffered concentric brace buckling and fractures, fractures at welded beam-to-column connections, base plate fractures, and fractures at welded beam-to-column connections. The possibility for weld fractures has been identified in earlier research reports (e.g., reports nos. UCB/EERC-86/10 and -88/19). Instrumental records are available for a cross section of buildings.

Three seismically isolated buildings in the Los Angeles area were subjected to strong ground shaking during the earthquake. The University of Southern California (USC) hospital, east of downtown Los Angeles and approximately 36 km from the epicentre, had peak foundation acceleration of 0.37 g. The peak structural accelerations were 0.13 g and 0.21 g at the base and roof, respectively, indicating amplification ratios of 0.32 and 0.57. Preliminary evaluations using linear elastic response spectra suggest that the isolation systems successfully shifted the fundamental periods to spectral regions of lower acceleration response. The evaluations also suggest that the ground motion had low energy at long periods, so this earthquake is not likely to have fully tested the mechanical characteristics of the bearings at design displacement levels. Nonetheless, this event has been the most severe test to date of a full-size seismically isolated building. The data obtained promise to provide a valuable resource for further study of this type of building.

For further details on the reconnaissance results, see UCB/EERC report 94/01, Preliminary Report on the Seismological and Engineering Aspects of the January 17, 1994 Northridge Earthquake.

Australian Earthquakes, ML \geq 3.0 January - April 1994

(from ASC, MGO, SRC-RMIT, SADME, TASUNI, UQ & UCQ)

In *January* a solitary earthquake in WA made it into the listing, only just. In *February* activity picked up somewhat. The two aftershocks at Tennant Creek on 8 February were felt in town and caused some excitement but no damage. Both were near the western end of the 22 January 1988 fault. The small event near Tumut on 2 February did not trigger the ACT accelerographs but was felt locally.

Date	ML	Place
April		
07	3.0	Arafura Sea
19	4.1	Tennant Creek NT
26	4.5	Bonnie Rock WA
March		
20	3.0	Tennant Creek NT
23	3.7	90 km W Port Hedland WA
23	3.0	990 km WSW Perth WA
February		
28	3.2	NW Kununurra WA
27	3.6	Tennant Creek NT
23	3.6	Tennant Creek NT
20	3.2	Laverton WA
11	3.3	Tennant Creek NT
11	4.3	680 km NNW Exmouth WA
08	4.3	Tennant Ck NT
08	3.8	Tennant Ck NT
02	2.3	Near Tumut NSW
01	3.8	Boolarra Vic
January		
07	3.0	Norseman WA

The small earthquake on 23 March west of Perth gives some indication of the improved location capability around Australian cities. There were 2 magnitude 4+ earthquakes in *April*, the WA event grabbed lots of media attention but caused no damage.

In the past

In 1923 Professor Omori, a leading Japanese seismologist, attended the Pan-Pacific Science Congress in Sydney. On 1 September he visited Riverview and while he was inspecting the observatory he saw a large earthquake being recorded on the Weichert seismographs. He did not realise it was the terrible earthquake which destroyed his home city, Tokyo.

(Ed. - This article is re-printed from an obituary to Father Frank Rheinberger published by St Ignatius College Riverview).

COURSES & CONFERENCES

(copies of flyers from Hon Secretary if available)

- IDNDR World Conference on Natural Disaster Reduction. 23-27 May 1994, Yokohama Japan. IDNDR Secretariat, Palais des Nations, CH-1211, Geneva 10, Switzerland, fax 41 22 733 8695.
- 2nd International Conference on Earthquake Resistant Construction & Design. ERCAD Berlin 15 - 17 June 1994. Prof S Savidis Fax: 49 30 314 24492
- First World Conference on Structural Control. Los Angeles, Ca. 3-5 August 1994. Uni S Calif., Los Angeles, Ca. 90089-2531, USA. fax: 213 744 1426 or e-mail: uspanel@vivian.usc.edu
- The 10th European Earthquake Engineering Conference: 28/8 - 2/9 1994, Vienna, Austria.
- Australasian Structural Engineering Conference, 1994, Hilton Hotel Sydney 21-23 September 1994. AE Conventions Pty Ltd PO Box E181, Queen Victoria Tce, ACT 2600
- AEES Annual Seminar, November 14/15 1994, Institution of Engineers Aust, Canberra. 'Lifelines' is the theme of the afternoon-morning seminar. Contact: K McCue fax: 06 249 9969
- 9JEES'94 The Japan Earthquake Engineering Conference, Tokyo, 12-14 Dec 1994.
- 7th Canadian Conference on Earthquake Engineering June 5 - 7, 1995 Montreal Quebec. Fax: 0011 1 514 340 5881
- 3rd Int Conf on Recent Advances in Geo-technical Earthquake Engineering and Soil Dynamics, St Louis, Missouri, USA April 2-7, 1995. Abstracts by Jan 31, 1994 to Prof Shamsher Prakash, Civil Engineering, University of Missouri-Rolla, Rolla MO USA. fax: 314 341 4992, e-mail Prakash@novell.civil.umar.edu
- 5th International Conference on Seismic Zonation, Nice, France, Oct 17 - 19 1995. French Assoc. for Earthquake Engineering and Earthquake Engineering Research Institute.

• AEES & NZNSEE
Pacific Conference PCEE '95
20-23 November 1995
Melbourne Vic Australia

Predicting quakes 'near impossible'

by Alan Samson (Science Reporter) The Dominion (NZ newspaper), 11 Jan 1994

Trying to predict earthquakes was a meaningless exercise, Berkeley University professor of seismology Bruce Bolt said yesterday. Declaring an international "war" on earthquakes and other disasters, Dr Bolt said the emphasis - rather than try for near-impossible

predictions - was increasingly to be placed on preparedness for disaster.

Dr Bolt, a key delegate at the International Association of Seismology and Physics of the Earth's Interior conference that started in Wellington (NZ) yesterday, reported on the 1990s as the decade designated for disaster reduction.

He told *The Dominion* he was optimistic the day was not too far distant when earthquakes everywhere were experienced routinely with "acceptable" losses, meaning relatively light damage and life risk not greater than crossing a busy street. The battle was to be waged on several fronts, including generating uniform and probability-based maps of earthquake hazards for the whole world to make understanding and planning possible, he said. New technology made it possible - given a certain sized quake - to show where earthquake intensities would occur, making planning eminently more useful than before for cities and utilities.

It should be possible, he said, for all buildings in at-risk regions to be made quake-resistant. The mapping, requiring fine detail, of rock structures and other land features, was "well under way" and included New Zealand within a Pacific-Asian region. That meant it should be possible to predict everywhere how quake motions would affect a city such as Wellington, given a quake of a certain site and magnitude.

"That's of immense importance," Dr Bolt said. "It means there can be codes so that engineers can construct buildings appropriately." The drive toward management and preparedness represented a shift away from 10 years ago when the attention was mainly focused on predicting quakes.

"Physical conditions are so complicated that only in a very few cases is it likely we will be able to predict in a useful way," he said. "I'm not saying (with the planned preparedness) there won't be surprises. But the probability is they will not be seriously affected."

Obituaries

Dr Emilio Rosenblueth died on 11 January 1994. As professor at the Engineering Institute of the Autonomous University of Mexico, co-author of one of the first textbooks on earthquake engineering and many papers on earthquake engineering and seismic risk, and through his active role in the

IAEE he was rightly considered to be one of the godfathers of earthquake engineering. His presence, knowledge and advice will be sorely missed.

Vicki Klein was interested in all things natural. Her house at Dalton was a veritable animal hospital, birds, horses, dogs, cats and emus, mostly injured animals brought to her from far and wide for love and attention. The large garage out the back housed the country fire brigade. The seismograph was in a back room off the kitchen so she could listen to the radio time pips to correct the seismograph clock. Vicki kept records of all the felt earthquakes as well as changing the seismogram daily and keeping tabs on the local accelerometer network with Marion Leiba. Vicki died suddenly in Adelaide on 21 April to our great shock - such a vital, active person who will be greatly missed by husband Gerry, family Adam and Danielle and her colleagues at the ASC.

Recent publications

- *The Tornado, its structure, dynamics, prediction and hazards*. Eds Church, Burgess, Doswell, & Davies-Jones. Geophysical Monograph Series 79. US\$85.00 (US\$59.50 for members AGU).
- *GIS and their applications in Geotechnical Earthquake Engineering*. ISBN 0-87262-973-2 ASCE Ed J David Frost & Jean-Lou A Chameau.
- *Strain Compatibility for Continental Interiors and Implications for Intraplate Earthquake Prediction*. R.E Melchers University of Newcastle Dept of Civil Engineering and Surveying, Research Report 086.05.1993. (We hope to present a review in the next newsletter).
- *Earthquake tremors felt in the Hunter valley since white settlement* can be purchased for \$18.50 (+ \$1.50 postage) from Hunter House Publications, PO Box 536, Raymond Terrace, NSW 2324. (see review NZNSEE Bull. 2 1993)
- AGSO (BMR) Bulletins and reports on earthquake activity in Australia can be purchased from the AGSO Sales Centre. The Australian Seismological Centre publishes an annual report featuring the year's seismicity with summary, glossary and description of the larger events.
- Australian Seismicity (1900 - 1992) and Earthquake Hazard maps; 1:10M scale in colour. (available from AGSO Sales Centre, GPO Box 378, Canberra ACT. \$21 incl postage in Aust.)

AEES'92 Conference Proceedings

Copies are still available at \$15, order with the 1993 Proceedings which can be purchased from the Hon Sec (GPO Box 378, Canberra ACT 2601)

PCEE '95

PACIFIC CONFERENCE ON EARTHQUAKE ENGINEERING

Organisers:

Australian Earthquake Engineering Society

New Zealand National Society for Earthquake Engineering

NEWS/PRESS RELEASE

The Australian and New Zealand Earthquake Engineering Societies are jointly organising PCEE '95 - the Pacific Conference on Earthquake Engineering, to be held at the University of Melbourne, Australia 20-22 November, 1995.

A wide range of topics is to be discussed including seismic isolation, building codes, lifelines, retrofitting of existing structures, steel/concrete/URM structures, earthquake engineering in areas of low to moderate seismicity and recent large/damaging earthquakes.

The first circular inviting both submissions of abstracts of papers on topics including the above and expressions of interest in conference attendance, will be widely distributed in August/September 1994.

At this stage queries may be addressed to:

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March 1994