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NEWSLETTER

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The Koçaeli (Izmit) Earthquake of 17th August 1999 (00:01:38.6 GMT)

Paul Greening and Matthew Free describe their experiences and findings from the EEFIT mission to Turkey

The north-western area of Turkey was shaken in the early hours of the 17th August 1999 by an earthquake of magnitude 7.4. The affected area broadly spread around the Izmit bay area shown in figure 1. The earthquake was felt strongly in Istanbul.

Plans for an EEFIT mission developed quickly after the initial event. The visit was scheduled to commence 3 weeks after the original shock. The accessibility of Turkey encouraged a relatively large EEFIT team whose numbers reached around 12. The team of academics and professional engineers was lead by Dr Dina D'Ayala of Bath University and embraced a wide range of skills and experience.

A visit to the Kandilli observatory at Bogaziçi University and a meeting with Professor Erdik provided some useful background information on the scale of the disaster. The total cost of the earthquake is estimated at some $16 billion with some 600,000 people requiring rehousing.

The team's first experience of earthquake damage was in the most badly affected town, Adapazari. The town is around 40km east of Izmit and around 15km from the fault, but experienced the highest measured acceleration of 0.4g. A great deal of demolition and clearing was underway with many of the worst affected buildings having been removed in the three-week period between the earthquake and our visit. Red crosses spray-painted onto a large proportion of the remaining structures indicated that much more demolition was still required.

The damage in Adapazari exemplified much of what we were to see in the following days. A number of interesting structural failures were in evidence as well as damage resulting from foundation failures. The majority of buildings in and around the town centre were reinforced concrete with lightweight masonry infill and typically consisting of 4-6 storeys residential dwellings. The term *beshkat* (Turkish for "five-storeys") had already been coined by Turkish experts to describe this type of building which took the brunt of the earthquake.

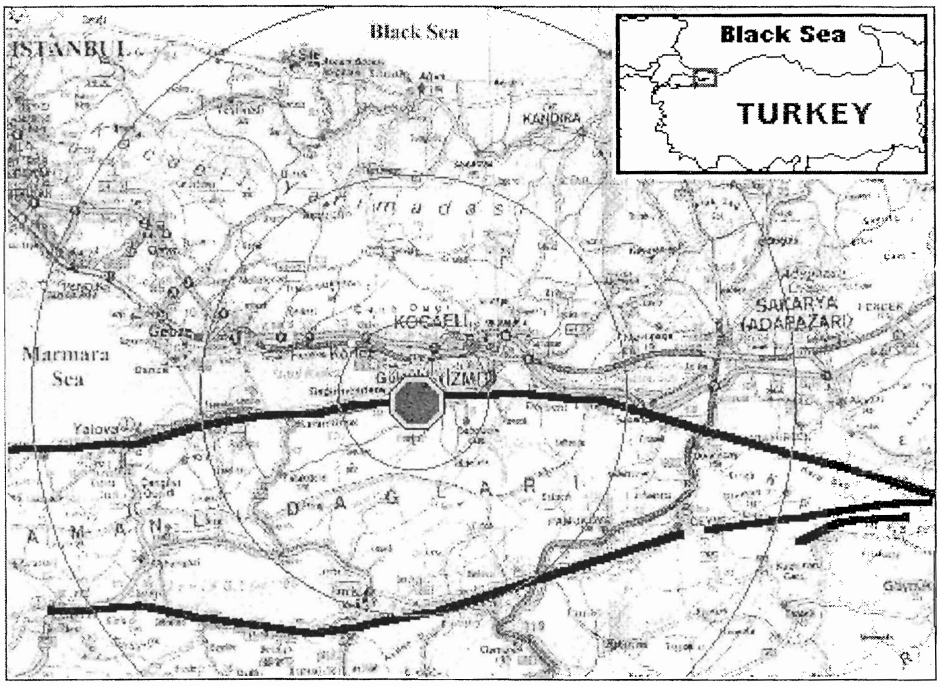


Figure 1 Location of earthquake Epicentre and fault lines

Soft-storey failures were prevalent with the lowest storey generally being the most vulnerable. The weakness of the ground floor was often seen to result from glass replacing masonry allowing the premises to be used as shops. Figure 2 shows one building partially collapsed due to a soft ground floor and a neighbouring building having lost the original ground floor entirely. Pounding of closely spaced neighbouring buildings was also a common sight. Figure 3 shows two adjacent buildings with floor slabs at different levels. The damage resulting from the interaction of the two buildings is seen to have a very serious effect on both buildings.

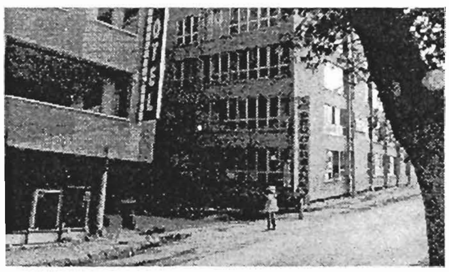


Figure 2 Soft Story Failure

Weak columns appeared to be responsible for widespread pancake failures of buildings and inevitable large loss of life.

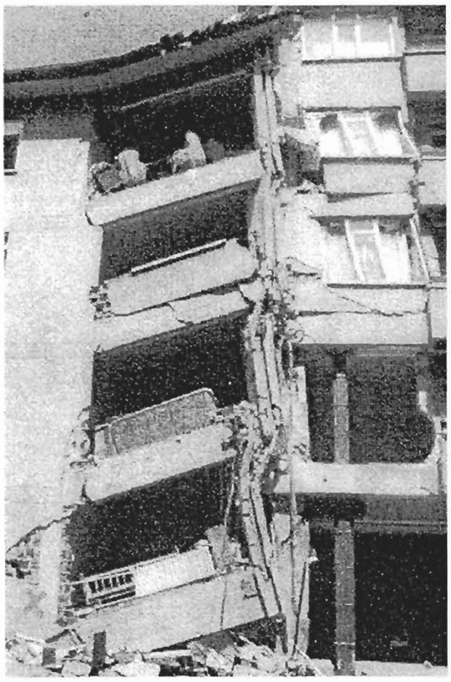


Figure 3 Building Interaction

Steel structures are a rarity in the area being a great deal more expensive than concrete. Where comparison of concrete structures with similar steel structures was possible, as one would expect the steel was seen to perform very much better. Figure 4 shows a typical building under construction using traditional techniques.

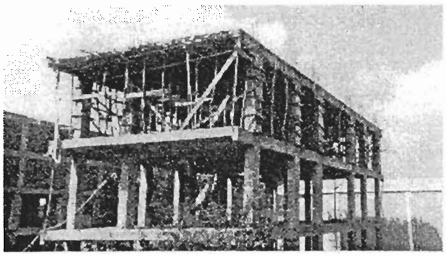


Figure 4 Traditional Construction

The Koçaeli (Izmit) earthquake was caused by the rupture of a 100km to 150km long segment of the North Anatolian Fault Zone (NAFZ). This rupture filled a seismic gap that had been identified by Tokoz, Shakal and Michael (1979) and later by Stein, Barka and Dieterich (1997). Stein et al. (1997) forecast a 12% probability of occurrence of a rupture on this seismic gap over the period of 30 years from 1996 to 2026.

The NAFZ is a right lateral strike slip fault. Over geological time, the right stepping en-echelon structures of the NAFZ have resulted in the formation of fault bounded, elongated, "pull-apart" basins such as those forming Izmit Bay, Sakaraya Lake and Isnik Lake in the region. One reason the earthquake was so destructive may have been that seismic waves were trapped and amplified within these elongated "pull-apart" sedimentary basins resulting in a concentration of damage in the cities of Adapazari and Golçuk and from Yalova through to Duzce. This channelling may also have contributed to the significant shaking felt in Istanbul, which is located over 100km away along strike from Izmit.

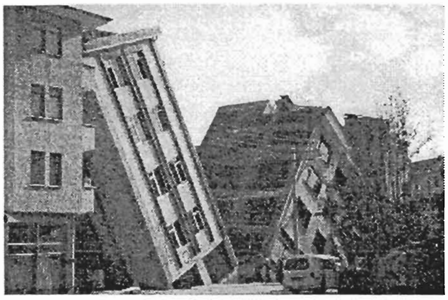


Figure 5 Bearing failure, Adapazari

Figure 6 Waterfront in Golçuk

A significant feature of the earthquake damage was the large number of foundation bearing capacity failures. Professor Erdik of Kandilli Observatory in Turkey referred to Adapazari, a city where damage was particularly severe, as a mini Mexico City. A large proportion of Adapazari is built on a low-lying alluvial plain, and ground conditions comprise a stiff crust underlain by loose sands and silts or soft clays and silts. Evidence for liquefaction of the sands and shear failure of the soft clays is to be found in a number of regions of the city (see figure 5). It should be emphasised that the most common modes of failure of structures are not of the foundations. Soft stories, lack of column confinement and poor detailing practice are among the most common causes of failure of structures. However, amplification of ground shaking due to the presence of the substantial thickness of soil may certainly have contributed to these structural modes of failures.

Dramatic evidence for the tectonic origin of the "pull-apart" basins are the large subsidence structures and associated landslides found at Golçuk and Degirmendere where 2km to 3km sections of coastline have subsided into the Izmit Bay. At Golçuk, a 1.5m to 2.5m subsidence related scarp passes through the town and extends out into the countryside cutting through a number of buildings including a sports hall and narrowly skirting the Ford Otosan car manufacturing plant (see figure 6). A substantial portion of the former shoreline is now inundated with seawater. It is not clear at this stage whether the subsidence scarp follows the main fault rupture or is a secondary feature.

Matthew Free, Ove Arup, HK

The remaining days of the EEFIT mission saw the team splitting up and speeding around the affected area aboard two minibuses.

The team was able to inspect widespread damage to ports and industrial facilities. Many first hand accounts of the earthquake provided useful information. We learnt, for instance, that much of the relatively undamaged hospital in Izmit was not being used because of the anxiety caused by the earthquake. Damage to major civil engineering structures was found to be slight. The fault rupture itself resulted in damage to highways and railways as well as causing a highway bridge to shift from its abutments. Local dams including the recently built dam at Yuvaçik exhibited negligible damage.

The overwhelming impression was that the loss of life might not have reached such tragic proportions had the Turkish design codes been followed and – probably more importantly – been enforced.

Paul Greening, Bristol University

The EEFIT report on the Koçaeli Earthquake is in preparation and will be available early in 2000.

A great deal of information about the earthquake is available from the Internet. Links to useful sites as well as a database of photos, videos and other material gathered by the EEFIT mission is available at http://www.turkey.bris.ac.uk/

The EEFIT team:

***Dina D'Ayala**, University of Bath*
***Abbas Al-Hussaini**, Westminster University*
***Roger Bilham**, University of Colorado*
***Russ Evans**, British Geological Survey*
***Paul Greening**, University of Bristol*
***Berrak Teymur**, Cambridge University*
***Alan Stewart**, Babtie*
***Paul Doyle**, Allot & Lomax*
***Matthew Free,** Ove Arup HK*
***Richard Thompson**, New Civil Engineer*
***Tim Courtney**, WS Atkins*
***Keith Waterhouse**, WS Atkins*
***Robert May**, Alexander Gibb*
***Dale Vince**, Alexander Gibb*

The 7th Mallet Milne Lecture: The Road to Total Earthquake Safety

Some 180 members and friends gathered at the Telford Lecture Theatre of the ICE on 27 May to hear Professor Cinna Lomnitz give the seventh Mallet-Milne Lecture.

Professor Cinna Lomnitz was introduced by Professor N Ambraseys who outlined the lecturers distinguished career in the earthquake hazard field and as an adviser on the sites of nuclear installations, mainly in America and Mexico. His attitude on earthquakes was summarised from his book 'Fundamental of Earthquake Prediction' 1994. 'Earthquakes are not disasters in themselves. Structure makes them so. Technology advances but the poor designs will always be with us. Our problem is to know, not when the next earthquake will strike but what kind of structure it takes to survive the earthquake when it comes – here and not half a mile away.'

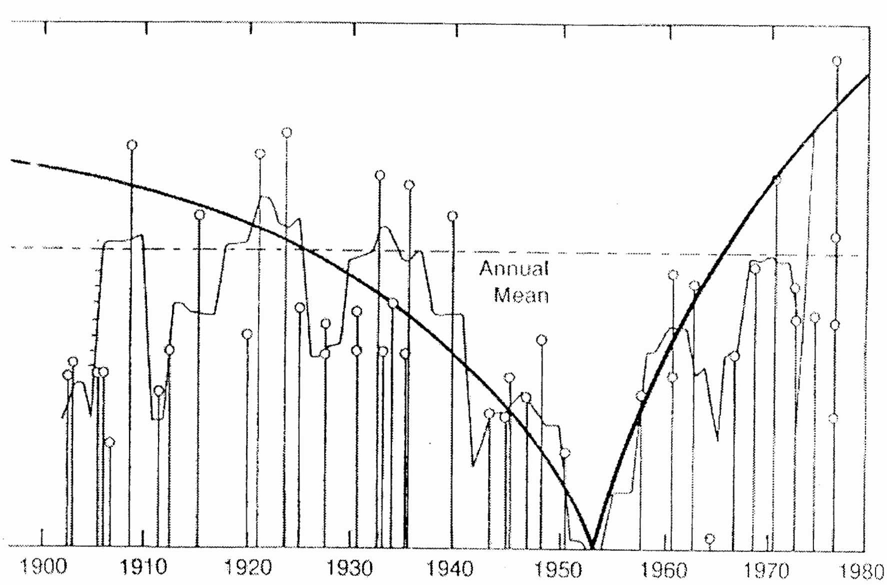


Figure 1 Annual number of deaths in earthquakes (after Mogi)

The lecturer set out by asking how it is that we can require motorcars to withstand high g forces, but not buildings in seismic regions where the maximum g from earthquakes does not exceed 2g. He showed a graph illustrating the increase in annual loss of life since 1955, which he related to urbanism, construction on soft ground and high-rise buildings, figure 1.

With the slogan – "Know the Input - Bound the Output - Mitigate the Difference" as his guide he moved on to present the thesis that the failure of many structures on ground where a soft layer rested upon a stiffer base could be best explained by invoking a "new" type of wave, a coupled wave which set up standing wave codas, had prograde particle motion, was monochromatic and had very low attenuation with distance. This was physically similar to the "ground roll" discovered by an American in the 1960's which was due to coupling between a sound wave in air and a Rayleigh wave on the surface of the ground.

To such motions, generated from Lg teleseismic waves in the underlying tuff at Mexico City interacting with a surface layer of such low Vs and high water content that it is almost a fluid, Professor Lomnitz ascribed the damaging inputs of the 1985 Mexican Earthquake. The motion was enhanced by the fact that the coupled wave could not propagate beyond the lake boundaries and therefore was totally reflected increasing the amplitude of the modes. In support he showed strain records from Dr Roger Bilham's strainmeters in the soft Mexico City clay. These showed that a monochromatic coda persisted well beyond the duration of the signal on a nearby rock location, Figure 2. It was

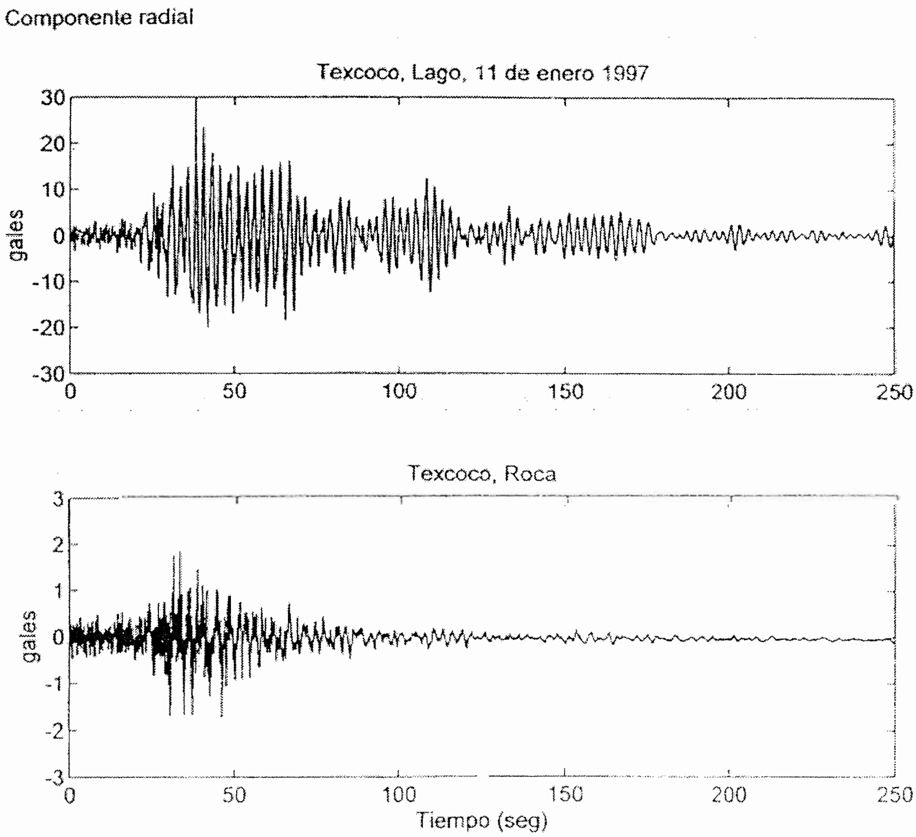
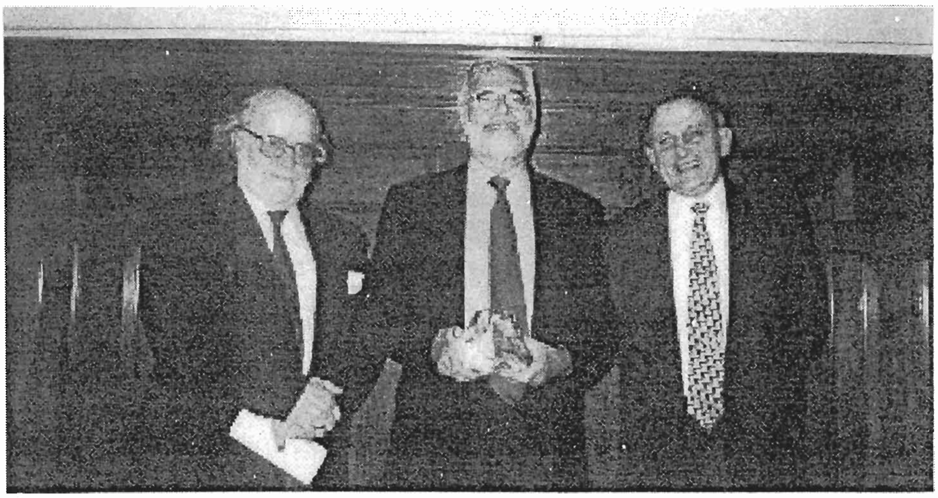


Figure 2 The Mexico earthquake of 11 January 1997

emphasised that past records of earthquakes would have illustrated the period of the ground to be approximately 2.5 seconds and that the buildings with a height of 7 to 18 storeys which fell down would have been the most vulnerable.

He went on to argue, controversially, that the Cypress structure failure in the 1994 Loma Prieta earthquake was best explained by longitudinal buckling of the deck structure rather than transverse failure of elements, and arose from a coupled monochromatic wave. (Discussions at the reception afterwards confirmed that his views were not accepted by all present – the mode of structural failure and the evidence of the long monochromatic motion occurring being questioned). Even more controversially he suggested that similar phenomena were to be seen at Kobe in 1995.

Professor Lomnitz went on to deal with "mitigation" and by analogy with the damping levels customary in mechanical design for cars or submarines suggested that the levels could approach 30%. He illustrated this point with the 57 storey Chapultepec Tower now being constructed in Mexico City with incorporates 96 massive viscoelastic dampers in a novel structural frame designed to provide 12% critical damping.



L to R: Dr Bryan Skipp, Professor Cinna Lomnitz, Dr Peter Merriman

Dr Bryan Skipp gave the vote of thanks, recollecting the lecturer's influential books, his propensity to revisit forgotten ideas, his reluctance to dismiss observations of visible surface undulations in earthquakes and his re-presentation of Kolmogorov's "small paper" of 1941, which contained the elements of fractality.

Professor Lomnitz he observed was likely to descend from the mountains like a haidut to stir up the staid plains and had done so again.

The occasion was closed by the Chairman of SECED, Dr Peter Merriman who urged all present to purchase the more extended monograph of the lecture which provided full details of the wave codas.

Peter Merriman

Earthquake Engineering on the Frontline

On 12th August Dr. Brian Tucker addressed an informal discussion at the Institution of Civil Engineers on the topic of *Dealing with Earthquakes in Cities of Developing Countries.* Dr. Tucker was formerly Deputy Director of the State of California's Division of Mines and Geology but in 1991 formed GeoHazards International (GHI), a non-profit organisation working for earthquake safety in urban areas in the Third World. *In 1950, 50% of the world's urban population living in seismically exposed areas were in developing countries; by the year 2000, this proportion will have risen to 85%.* The presentation focused on the risk management projects carried out by GHI, in association with local professionals, in Quito (Ecuador) and Kathmandu (Nepal). The latter project, which was outlined in the May 1999 issue of the SECED Newsletter (vol.13, no.2), began with an evaluation of the seismic risk in Kathmandu Valley and estimation of possible losses in a future earthquake, such as a repetition of the 1934 event. These evaluations were then discussed with politicians, community leaders, critical facility managers and technical specialists, and plans of action were devised to mitigate the very high level of risk in this rapidly growing and extremely vulnerable city. The project led to the formation of the National Society for Earthquake Technology-Nepal, which is carrying the mitigation work forward, and the establishment of an Earthquake Safety Day on the anniversary of the 1934 earthquake.

Dr. Tucker highlighted the problems faced by such vulnerable urban communities and the difficulties encountered in promoting seismic safety where it is so critically needed. Despite the fact that the meeting was held in middle of summer, 42 people attended and a very lively discussion followed the formal presentation. One of the issues that were discussed was the extent to which earthquake mitigation is hampered by fatalistic attitudes among vulnerable communities and lack of appreciation of the fact that earthquake safety can often be obtained through relatively simple and inexpensive measures. This then led to discussion about the prevalence of similar attitudes amongst donors in developed countries, who always seem willing to provide emergency aid following major earthquake disasters but invest far less in risk mitigation.

Julian Bommer

Dr Robin Adams receives Life Membership of SECED

It was with great pleasure that I asked Robin Adams to become an Honorary Life Member of the Society at the Mallet-Milne Lecture on the 27th May.

Robin's formative years were spent in New Zealand, where he obtained first degrees in both mathematics and physics. Then he studied in the Department of Geodesy and Geophysics at Cambridge to obtain his PhD in observatory seismology and marine geophysics in 1957. On his return to New Zealand, Robin worked initially at the Naval Research Laboratory in Auckland, during which time he led a marine geophysical cruise to the Ross Sea, in Antarctica.

His first major position in seismology was at the Seismological Observatory, Wellington; where as Superintendent from 1964 to 1978 he was responsible for both the operation of the New Zealand seismograph network and the research programme carried out. The area covered included territories in the South West Pacific and Antarctica, as well as the main islands of New Zealand. The Observatory's duties included advising the New Zealand Government on matters relating to seismicity and seismic risk. During this period he was actively involved in setting up our equivalent group ~ the New Zealand National Society for Earthquake Engineering. His experience led Robin to becoming a UNESCO consultant to the Pakistan Government on the possible seismic effects of impounding the Mangla Dam. Never keen to stay in one place for long, in 1970-71 he visited Berkeley, where he worked with Bruce Bolt, and with him carried out the first field studies of the San Fernando earthquake. Another success was in 1975, when he was the first foreign scientist to be invited into China to report on the prediction of the Haicheng Earthquake, still the only major earthquake to have been predicted.

Now fortune lent its hand!! He returned to UK with his English born wife, Thelma, and joined the International Seismological Centre at Newbury in 1978. As Senior Seismologist, he was responsible for aiding and advising the Director in technical seismological matters relating to earthquake analysis and location, and in the preparation of material to be used in studies of earthquake hazard.

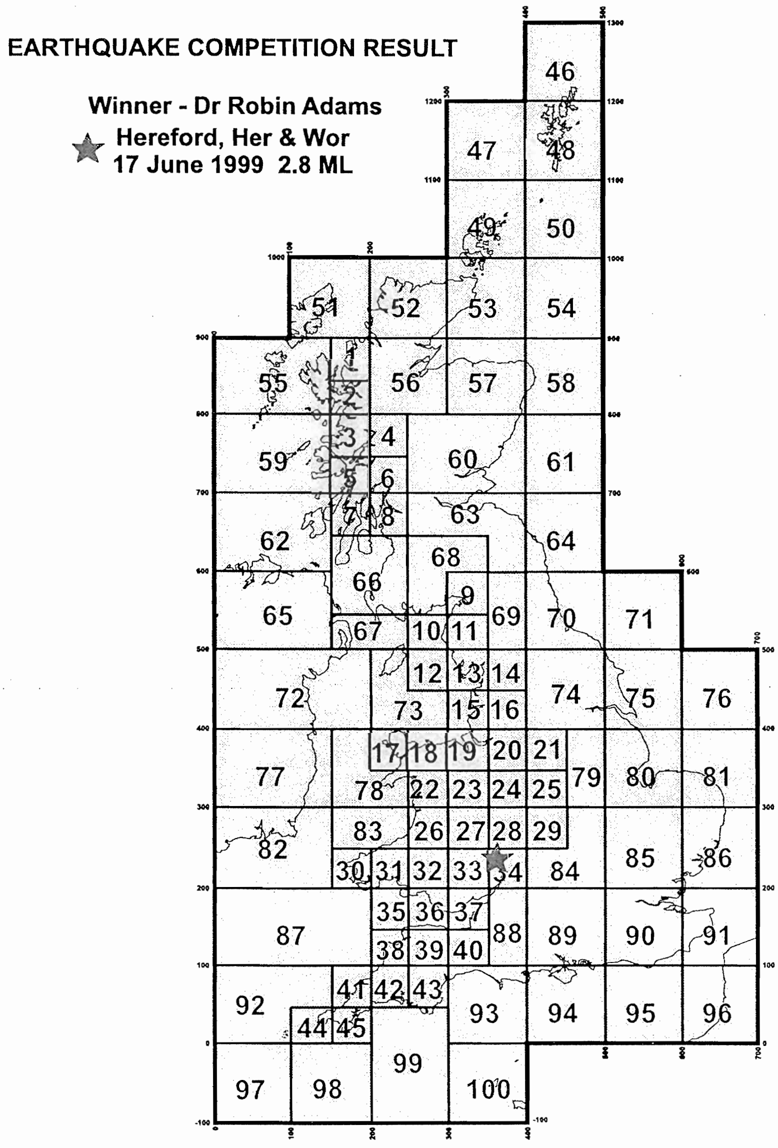
A major pleasure for him was his role as Secretary-General of the International Association of Seismology and Physics of the Earth's Interior (IASPEI) from 1979-1991. This involved the planning and co-ordinating of international seismological activities, particularly in the field of seismological networks and reduction of natural hazards. He worked extensively with developing countries, and was Principal Coordinator for the UNESCO Programme for Assessment and Mitigation of Earthquake Risk in the Arab Region, as well as being involved with several training courses in Africa and elsewhere.

In the UK he acted as consultant to the Department of Environment on seismological investigation requirements in Great Britain, and his advice helped to establish the present system of seismological recording undertaken by the British Geological Survey.

Robin has published over 70 research papers, many with Professor

EARTHQUAKE PREDICTION COMPETITION

For those of you who attended the SECED AGM and entered the earthquake prediction competition we can now confirm that Dr Robin Adams correctly predicted the location of the next significant earthquake to occur in the UK.



Ambraseys, and one book. He is still an Advisory Editor to *Physics of Earth and Planetary Interiors*, and has been on the editorial boards of *European Earthquake Engineering* and *Natural Hazards*.

In 1982 we were fortunate when he joined the Committee ~ a position he stayed in for fifteen years. What were his strengths?

Robin's special contribution was to keep the Society in touch with developments at the highest level in seismology. He was one of the most regular committee attendees and frequently gave useful reports in his field – the ideal Rapporteur. His overall knowledge and experience, combined with his good humour allowed him to make many contributions to the committee's discussions, keeping us on the rails where necessary. From a personal point of view, I found him always very willing to listen to other members' opinions before he gave calm and authoritative advice on the possible ways forward. On one occasion when there were only 20 papers submitted by the deadline of a conference – he assured us that there was no problem as they were all quality submissions!! – by the end over 100 were received.

On behalf of the Society I thank Robin for his invaluable work in the past and hope that he will contribute in the future in his new position as Honorary Life Member.

Peter Merriman

FORTHCOMMING MEETING:

STRONG MOTION RECORDS FOR ANALYSIS AND DESIGN.

Wednesday 24 November 1999, ICE, at 5.30pm

In seismic design, the earthquakes are usually represented by response spectra, but there are many situations for which acceleration time-histories are required. This meeting will examine the different options currently available for obtaining strong-motion records for analysis and design, and discusses their respective advantages and disadvantages.

Real accelerograms: is the current databank sufficient for engineering use?

Julian Bommer & Stephen Scott, Imperial College

Since the first accelerograms were obtained in 1933, the global databank of strong-motion records has grown exponentially and now numbers several thousand. The databank can be searched to identify records obtained under conditions comparable to a design scenario to provide the input to engineering analysis. The feasibility of being able to rely on the databank of real records depends on the representation of the possible values of independent variables that define design scenarios, including magnitude, focal depth, source-to-site distance and site conditions, amongst others. A minimum of three accelerograms would be needed for each possible design scenario, according to most seismic design codes, but the current databank does not provide sufficient cover of all combinations of the independent variables. The usefulness of the databank therefore depends on the relative influence of different parameters on the nature of the strong-motion records and the ability for scaling techniques to compensate for imperfect matching of the design scenario and the characteristics of the accelerograms.

Synthetic time-histories for design

Ian Morris, British Nuclear Fuels Ltd.

Synthetic time histories are used when it is necessary to have a time-history that produces a response spectrum closely matching a design basis spectrum. Criteria for assessing the match are important but these are not the only factors to be considered in creating synthetic time-histories. This talk reviews the features entering the generation of synthetic histories and the major question of whether what one has generated is usable for design. Examples of synthetic time-histories compatible with UK design basis earthquakes are shown and some curious features of these time-histories are also noted.

Microearthquakes as empirical Green's Functions: a small step in the right direction?

Willy Aspinall, Aspinall & Associates

Throughout its history, there have been occasions, albeit very infrequent, when moderately large and widely felt earthquakes have been experienced in Britain. In special circumstances, related primarily to safety-critical industrial sites, the effects of such earthquakes have to be considered in detail for design and operational safety but, as yet, very few indigenous instrumental strong-motion records exist which can be used for this purpose. In their absence, one approach for improving the quantitative basis for estimating strong ground motions in Britain is to infer response effects empirically from real records of much smaller earthquakes. The talk will describe an investigation of the 'empirical Green's Functions' technique by which real recordings from microearthquakes can be used to generate realistic synthetic time histories for larger magnitude earthquakes. An investigation of the technique, using high-quality digital data from the Hinkley Point network in Somerset, has explored which seismological factors may be most important in controlling ground motion attenuation under British conditions, and simulations of ground motions at higher magnitude levels have been generated. The results, in terms of peak acceleration and spectral response, are compared with the predictions of established attenuation relationships for Britain and Europe. The technique can be applied to earthquake engineering issues in other areas of the world where real strong-motion records are sparse.

EURODYN'99

The Fourth European Conference on Structural Dynamics (EURODYN'99) was held in Prague, Czech Republic, between 7 and 10 of June 1999. The first three EURODYN conferences took place in Bochum, Germany (1990), in Trondheim, Norway (1993) and in Florence, Italy (1996). This is a major conference on structural dynamics held every three years which attracts engineers, research workers and university lectures and others to present their work on structural dynamics, exchange information and discuss subjects of mutual interest. In addition to the keynote lectures, nearly 200 papers were selected for presentation from 260 originally submitted papers.

The opening ceremony was at the Bethlehem Chapel, one of many churches in the Old Town. Prof. L, Fryba, President of the European Association for Structural Dynamics, gave a talk on Past, Present and Future of Structural Dynamics. No doubt, it was a difficult topic to cover.

As a start of the morning sessions on the following days, keynote lectures were given on different branches of structural dynamics. The nearly 200 papers were divided into thirteen themes. These themes together with the number of papers in each subject were:

- Theory of vibration (19)
- Stochastic dynamics (18)
- Non-linear vibration (9)
- Vibration of structural elements (10)
- Wave propagation (6)
- Material properties and noise (17)
- Experimental methods in dynamics (12)
- Dynamics of bridges (29)
- Railway and highway track dynamics (7)
- Dynamics of building (15)
- Ground vibration (15)
- Wind effects (7)
- Seismic effects (24)

For presenting such a large number of papers in three days, four parallel sessions were arranged. Each paper was located twenty minutes including question time. Two volumes of proceedings were issued on registration.

Seven delegates (bold face below) from Britain presented their papers in the conferences. The authors and the titles of the papers are listed as follows:

- Petyt, M. and **Jones, C. J. C.**, University of Southampton. *Modelling of ground-borne vibration from railways*
- **Littler, J. D.**, BRE. *The dynamic response of a three tier cantilever grandstand*
- **Papatheodorou, M.**, Taylor, C. A. and Lieven, N. A., University of Bristol. *Optimal sensor locations for dynamic verification*
- **Madabhushi, S. P. G.**, University of Cambridge. *Centrifuge modelling of bridge foundations on liquefiable soils*
- Eccles, B. J., **Owen, J. S.**, Choo, B. S. and Woodings, M. A., University of Nottingham. *Non-linear vibrations of cracked reinforced concrete beams*
- **Canisius, T. D. G.** and Ellis, B. R., BRE. *Dynamic analysis of the Cardington concrete building during construction*
- **Ji, T.** and Ellis, B. R., UMIST and BRE. *The evaluation of sports stadia grandstands for dynamic crowd loads at pop concerts in the United Kingdom.*

If anyone is interested in their work, please contact the authors directly.

I was left with an impression from the conference that there was increasing number of publications on considering stochastic characteristics of input and system identification of civil engineering structures. The former tries to find out certainty from uncertainties. The uncertainties may come from the loads applied, the material properties and dimensions of structural elements. Normally it requires more computational efforts. The latter includes the determination of location and severity of damages, identification of parameters of structures and updating of finite element models. Dynamic experimental methods have already been developed to assess dynamic behaviour of structures, but system identification requires a combined experimental and theoretical investigation, which allows many different identification methods to be suggested. Although there was no particular session for system identification at the conference, over twenty papers on this topic were presented under different subject headings.

This conference received more papers than last three in the series. The location and beauty of Prague might have attracted more delegates. The conference was well organized and the presentations went smoothly although in some instances, the quality of presentations was limited by the facility available.

The next conference will be held in Munich, Germany, in late August or early September 2002.

Tianjian Ji, UMIST

Book Review: "Introduction to finite element vibration analysis", by Maurice Petyt

Cambridge University Press, 1998, ISBN: 0 521 63417 2, 558pp

The use of finite elements in dynamic analysis is now widespread in civil, mechanical and aeronautical engineering. Most structural dynamics textbooks cover the analysis of single-degree-of-freedom systems, simple continuum elements such as beams and lumped-parameter systems such as multi-storey frames. They generally avoid any detailed treatment of the rather more complex topic of analysing vibrating continua using finite elements. Similarly, the numerous introductory texts on finite elements generally cover dynamic analysis briefly or not at all. To my knowledge, this book is the first to make a serious attempt to bring together these two important topics fully and in depth. This is a demanding brief, but one which the author has achieved with considerable success.

The bulk of the text covers the formulation of mass and stiffness matrices for numerous element types: rods, beams, membranes, solids and plate bending elements. The problems of combining different element types in an analysis are illustrated and resolved in a chapter on stiffened and folded plate structures. There follow chapters on the solution techniques for free vibration and response to various forms of forcing, and the book concludes with a brief chapter on modelling and analysis considerations aimed at the user of a commercial software package.

The book assumes no previous knowledge of finite elements but does require some prior knowledge of the fundamentals of dynamic behaviour. Otherwise one is likely to get rather lost in the mathematical approach taken to the derivation of the equations of motion for the various element types.

The text is clear and concise throughout, and the coverage is admirably comprehensive. There are numerous worked examples and problems for solution, and a very full list of references for those who wish to go into greater depth. This book is ideal as a course book for taught Masters' students, or as a reference for researchers and practising engineers. It may also be suitable for some advanced undergraduate courses.

Martin Williams, Oxford University

NOTABLE EARTHQUAKES APRIL - JULY 1999

Reported by British Geological Survey

YEAR	DAY	MON	TIME UTC	LAT	LON	DEP KM	MAGNITUDES ML	MB	MS	LOCATION
1999	05	APR	03:13	59.33N	1.55W	15	2.9			NORTHERN NORTH SEA
1999	05	APR	11:07	05.30S	149.80E	33			7.0	NEW BRITAIN REG, P.N.G
1999	08	APR	13:10	43.60N	130.53E	560			7.2	NE CHINA BORDER REGION
1999	13	APR	10:38	21.40S	176.5W	160			6.6	FIJI ISLANDS REGION
1999	15	APR	08:31	57.02N	5.42W	4	2.9			MALLAIG, HIGHLAND
			Felt throughout the Arnisdale, Loch Hourn and Glenn Garry areas of Highland with maximum intensities of 3 EMS.							
1999	20	APR	19:04	31.8S	179.1W	100			6.5	KERMADEC ISLANDS
1999	30	APR	00:51	55.07N	7.40W	10	1.7			DONEGAL, IRELAND
			Felt throughout the epicentral region with intensities of 3 EMS.							
1999	10	MAY	20:33	5.20S	150.93	139			7.1	NEW BRITAIN REG, P.N.G
1999	16	MAY	00:51	4.77S	152.37E	33			7.0	NEW BRITAIN REG, P.N.G
1999	17	MAY	10:07	4.56S	152.96E	33			6.9	NEW BRITAIN REG, P.N.G
1999	29	MAY	00:31	62.28N	4.58E	7	4.1			NORWEGIAN COAST
			Felt with intensities of 3 EMS along the Norwegian Coast.							
1999	29	MAY	11:49	57.25	3.85W	6	2.2			AVIEMORE, HIGHLAND
			Felt throughout the Boat of Garten area with intensities of 3 EMS.							
1999	15	JUN	20:42	18.41N	97.34W	80			6.7	CENTRAL MEXICO
			Latest reports indicate that 20 people have been killed and approximately 200 injured. The epicentre of this earthquake is near the city of Puebla, approximately 120 southeast of Mexico City. Throughout Puebla apartment buildings were destroyed and power and telephone services were cut.							
1999	17	JUN	02:20	51.99	2.57W	21	2.8			HEREFORD, HER & WORCS
			Felt in the Cradley area with intensities of 3 EMS.							
1999	03	JUL	01:43	47.08N	123.46W	41		5.4	5.5	WASHINGTON
			At least 7 people injured and buildings damaged in the Aberdeen-Satsop area.							
1999	07	JUL	14:31	51.70N	3.22W	2	1.9			BARGOED, MID GLAM
			Felt throughout Blackwood with maximum intensities of 3 EMS.							
1999	11	JUL	14:14	15.81N	88.34W	10		5.9	6.6	HONDURAS
			At least 2 people were killed and 40 injured.							
1999	13	JUL	16:33	49.21N	2.32W	10	1.8			JERSEY, CHANNEL ISLANDS
			Felt throughout Jersey with maximum intensities of 3 EMS.							
1999	19	JUL	17:58	56.38N	4.18W	3	2.0			LOCH EARN, CENTRAL
			Felt throughout St Fillans.							
1999	21	JUL	17:43	18.34N	101.47W	67		6.0		GUERRERO, MEXICO
			At least 600 houses were damaged at Coahuayutla, Guerrero.							
1999	24	JUL	02:03	55.10N	3.64W	11	1.3			DUMFRIES, D & G
			Felt Tinwald with maximum intensities of 3 EMS.							
1999	30	JUL	09:31	51.69N	3.20W	6	2.7			BARGOED, MID GLAM
1999	31	JUL	03:15	56.14N	3.69W	1	1.4			CLACKMANNAN, CENTRAL
			Felt Forest mill with maximum intensities of 2 EMS.							

Issued by Bennett Simpson, British Geological Survey, August 1999

Forthcoming Events

28 October 1999
Machine Foundations - Modelling and Measurements.
ICE 5.30pm.

24 November 1999
Strong Motion Records for Analysis and Design.
ICE 5.30pm

19 January 2000
Zone-Free Hazard Modelling.

23 February 2000
TBA

Contents

SECED Newsletter

The SECED Newsletter is published quarterly. Contributions are welcome and manuscripts should be sent on a PC compatible disk or directly by Email. Copy typed on one side of the paper only is also acceptable.

Diagrams should be sharply defined and prepared in a form suitable for direct reproduction. Photographs should be high quality (black and white prints are preferred). Diagrams and photographs are only returned to the authors on request. Diagrams and pictures may also be sent by Email (GIF format is preferred).

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SECED

SECED, The Society for Earthquake and Civil Engineering Dynamics, is the UK national section of the International and European Associations for Earthquake Engineering and is an affiliated society of the Institution of Civil Engineers.

It is also sponsored by the Institution of Mechanical Engineers, the Institution of Structural Engineers, and the Geophysical Society. The Society is also closely associated with the UK Earthquake Engineering Field Investigation Team. The objective of the Society is to promote co-operation in the advancement of knowledge in the fields of earthquake engineering and civil engineering dynamics including blast, impact and other vibration problems.

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