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NEWSLETTER

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A SUMMARY OF EARTHQUAKES IN 1996

David Galloway and Alice Walker present a summary of seismic activity during 1996.

Overseas

The year 1996 was not exceptional in terms of the earthquakes which occurred world-wide. There was one 'great' earthquake with a magnitude over 8.0, ten 'major' earthquakes (magnitudes between 7.0 and 7.9) and 88 'strong' earthquakes (magnitudes between 6.0 and 6.9). These figures are in general below the long term averages which are one, 18 and 120, respectively. The number of people reported killed by earthquakes during 1996 was 500 against a long term average of 8,700 per annum. This was because most of the major earthquakes occurred in remote, sparsely populated areas (Fig. 1).

Without doubt, the Yunnan, China earthquake was the most disastrous of 1996, accounting for about half of the fatalities. It occurred on 3 February and caused the deaths of some 250 people, injured over 4,000, destroyed 329,000 homes and left over 1,000,000 homeless. Several rockslides were also reported in the Lijiang area. The earthquake was not, however, exceptionally large, with a magnitude of 6.5 Ms, and such events can be expected once or twice a week on average, worldwide. It was the second large earthquake within a few months, in this area of the Yunnan Province, on the eastern edge of the Himalayas, following a magnitude 6.4 event on 23 October 1995 which killed 40 people in the Wuding area.

The one great earthquake of the year, with a magnitude of 8.1 Ms, occurred on 17 February, in Irian Jaya, Indonesia. It resulted in the deaths of 108 people and caused injury to over 400. Some 5,000 houses were destroyed in the epicentral area and extensive damage on the islands of Biak and Supiori was reported due to the earthquake and resultant tsunami, which reached heights of 7 metres in many areas. Hundreds of aftershocks, with magnitudes greater than 4, were detected in the first few days following the mainshock; the largest with a magnitude of 6.7 Ms.

Most of the severely damaging earthquakes in 1996 were in the 'major' or 'strong' categories. There were, however, a number of notable exceptions proving once again that a relatively small magnitude earthquake, with a shallow depth of focus in a highly populated area, can be disastrous. The magnitude 5.8 Mb Ecuador event of 28 March was the most notable of these, killing some nineteen people, causing injury to 58 others and leaving several thousand homeless. It caused considerable damage to houses, bridges and water and gas pipes in the Cotopaxi, Pastaza and Tungurahua Provinces. The smallest earthquake of 1996 to cause injury, with a magnitude of 4.5 Ms, occurred on 15 July in the Annecy region of France. One person was slightly injured and minor damage was reported at Cruseilles. The earthquake was felt strongly at Annecy and Lyon and was also widely felt in the Alps and southern Switzerland.

The year started off with a destructive earthquake on the Minahassa Peninsula, Sulawesi on 1 January. It had a magnitude of 7.7 Ms and killed eight people and damaged over 200 buildings in the Tolitoli area. A local tsunami contributed to much of the damage in the epicentral area.

Two damaging earthquakes occurred in Peru. The first, on 21 February with a magnitude of 6.6 Ms, killed four people, injured several others and left three missing. The deaths and injuries were all attributed to a tsunami which devastated some low lying coastal areas. This local tsunami destroyed about 150 huts (homes) along the coast near Chimbote. The

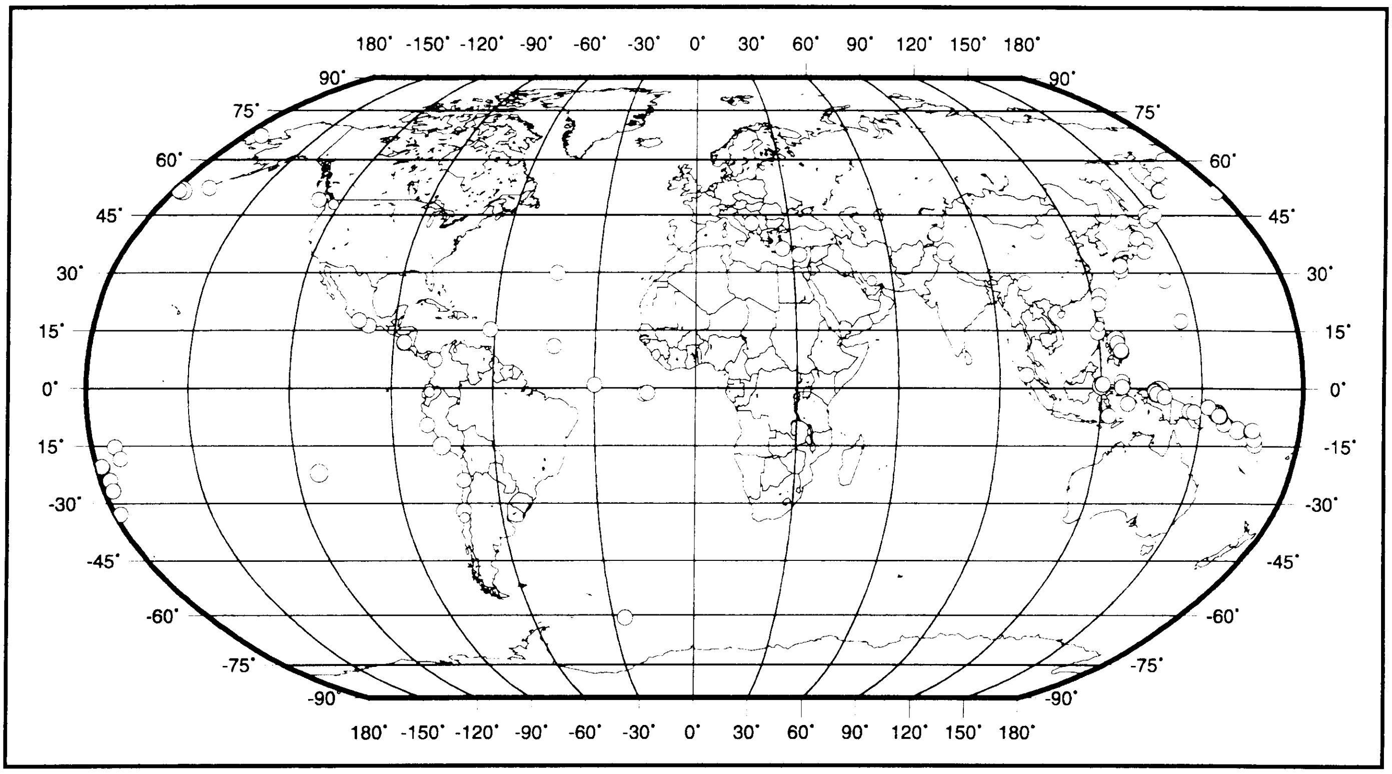


Figure 1. Notable world earthquakes of 1996

Magnitude Key (Ms)
8.0 and above
7.0 to 7.9
6.0 to 6.9
4.0 to 5.9

second event occurred on 12 November, with a magnitude of 7.3 Ms. It killed at least 15 people, injured 700 others and left over 12,000 homeless from Chincha Alta to Acari. Extensive damage occurred at Nazca, where over 4,000 houses were damaged or destroyed, and some occurred in the Marcona region. The earthquake was felt strongly in the Marcona region, at Ica, Palpa, Arequipa and Camana and was also felt by people in high-rise buildings at Guayaquil, Ecuador, and La Paz, Bolivia. This thrust earthquake is associated with the subduction of the Nazca Ridge (a major feature of the Nazca plate) beneath the South American plate. It originated near the southern end of a seismic gap between the large Peruvian earthquakes of 24 August 1942 and 3 October 1974, with the aftershock sequence progressing southward into the zone of the 1942 event.

A further two earthquakes occurred in China during 1996; the first, with a magnitude of 6.0 Ms on 19 March, in southern Xinjiang killed 24 people, injured 128 and destroyed and damaged over 15,000 houses in the Artux-Jiashi area; the second, on 3 May with a magnitude of 6.0 Ms struck Western Nei Mongol killing at least 18 people and injuring 300 others. Extensive damage occurred in the Baotou region and it was felt at Beijing, Hohhot, Taiyuan, Xian and Yinchuan.

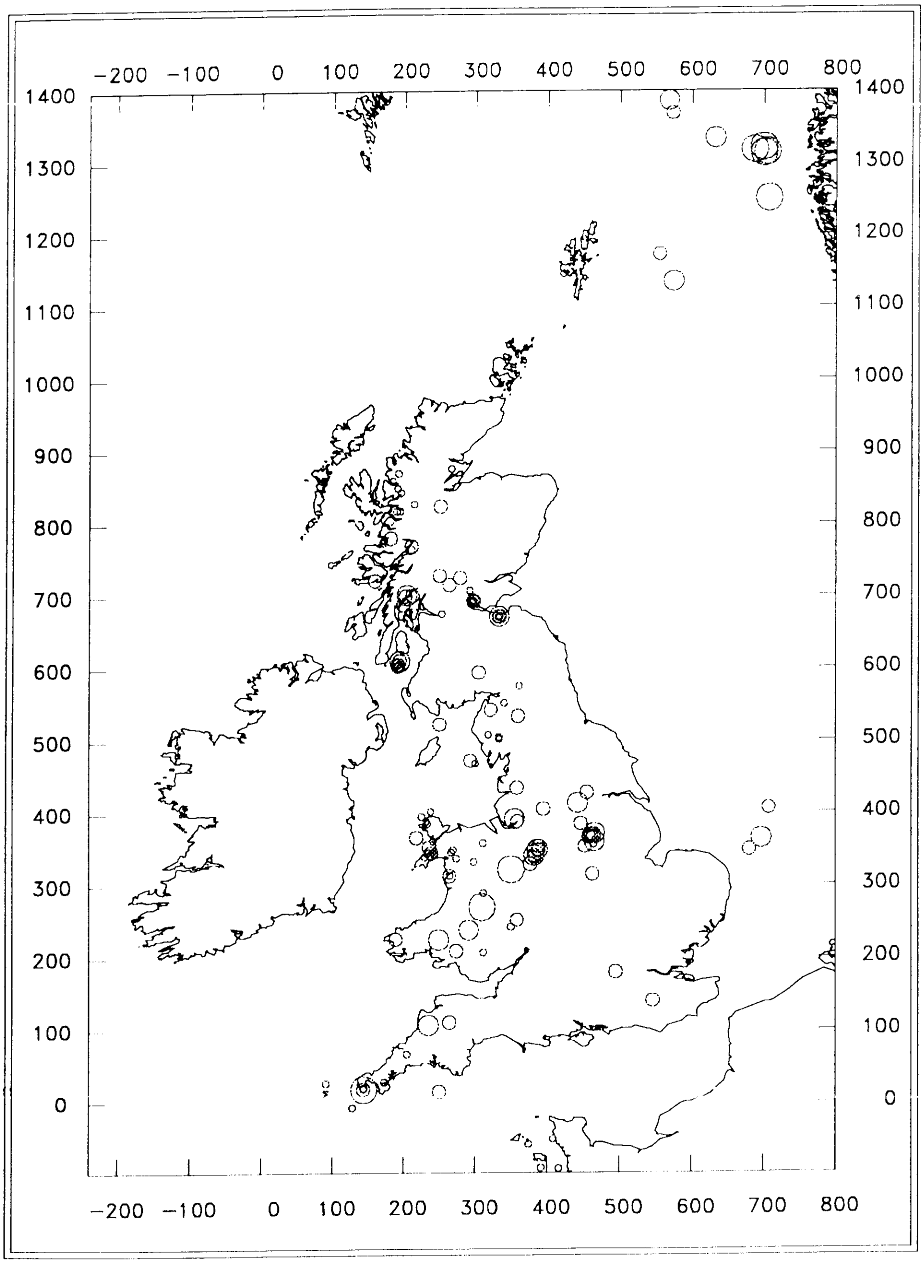
In the Solomon Islands, on 29 April, an earthquake with a magnitude of 7.5 Ms killed one person, collapsed numerous houses in western Bougainville and was felt throughout the island of Bougainville.

A damaging earthquake in the Cyprus region on 9 October, with a magnitude of 6.8 Ms, resulted in two deaths in Cyprus and Egypt. Twenty others were injured on Cyprus. The earthquake was felt strongly on Cyprus and was also felt in Egypt, Israel, Jordan, Lebanon and Syria.

Other notable world earthquakes during 1996 included; Washington State, on 3 May with a magnitude of 5.2 Mb which injured two people and caused slight damage in the epicentral area; Eastern Honshu, Japan, on 10 August (magnitude 6.0 Mb) which injured ten people and damaged some 15 houses; Adriatic Sea, on 5 September (magnitude 6.0 Ms) which injured several people, left 2,000 homeless and caused extensive damage in the Ston-Slano region, Croatia.

United Kingdom

The British Geological Survey detected and located some 200 earthquakes in the British Isles and surrounding continental shelf areas during 1996 (Fig. 2). Of these, 27 had magnitudes of 2.0 ML and greater; 9 in this category were felt, together with a further 25 smaller ones, bringing the total to 34 felt earthquakes for the year. Fifteen of the earthquakes of 2.0 ML and over were onshore. The remaining 12 were located offshore in the North Sea and Norwegian Sea areas.



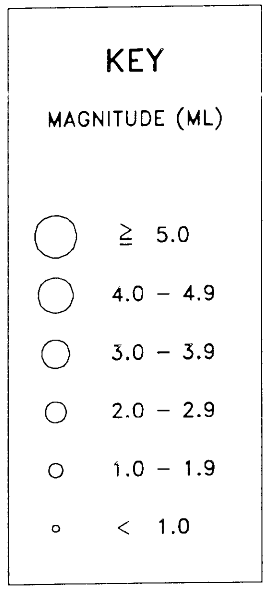


Figure 2. Epicentres of all UK earthquakes located in 1996 (from the BGS Bulletin of British Earthquakes for 1996)

Earthquake activity in the offshore areas was slightly higher than average during 1996, with seven events exceeding magnitude 3.0 ML, as against an average occurrence of four per annum. Only one earthquake in the northern North Sea was reported felt during the year. It occurred on 16 December with a magnitude of 3.3 ML and was felt at Fedje Fyr lighthouse and in Vaksdal, Norway.

During 1996, there were three earthquakes, onshore, in the magnitude range 3.0 to 3.9 ML, consistent with the long-term average, although the total number with magnitudes greater than 2.0 ML was below average; 15 against 26.

The largest UK earthquake, occurred on 10 November in the Penzance area of Cornwall. The magnitude was 3.8 ML and it was felt over an area of 14,000 km^2 (isoseismal 3) in Cornwall and Devon. A maximum intensity of 5 EMS (European Macroseismic Scale) was assessed close to the epicentre where minor damage (cracked plaster) occurred. This is the largest onshore British earthquake since the magnitude 4.0 ML Norwich event of 15 February 1994. Three aftershocks were detected on the same day, but none were felt. Previous events in the area include the 15 July 1757 Penzance earthquake (magnitude 4.4 ML), the 23 July 1966 Helston earthquake (magnitude 4.1 ML) and the 25 February 1981 Constantine earthquake (magnitude 3.5 ML).

On 7 March, an earthquake with a magnitude of 3.4 ML occurred near Shrewsbury, Shropshire. It was felt over an area of some 3,000 km^2 (isoseismal 3), with the strongest reports from the Shrewsbury area where intensities reached 5 EMS. It locates approximately 10 km north of the magnitude 2.4 ML Shrewsbury earthquake which occurred on 10 July 1990.

The third onshore event with a magnitude between 3.0 and 3.9 ML, occurred at Llandrindod Wells, Powys, on 20 September. It had a magnitude of 3.0 ML and was felt in Llandrindod Wells, Knighton, Rhayader, Builth Wells and Llanbister with intensities of at least 4 EMS.

On 6 May, a magnitude 2.8 ML earthquake was detected at Stoke-on-Trent. It was felt throughout the Stoke-on-Trent area (over 900 km^2 at isoseismal 3) and with intensities of 4 EMS in the epicentral area.

A swarm of fourteen earthquakes was detected approximately 10 km south of the Isle of Arran, Strathclyde, during 1996. The largest, with a magnitude of 2.2 ML, occurred on 26 June and was not reported felt. Similar swarms in the area were detected in 1993 and 1995.

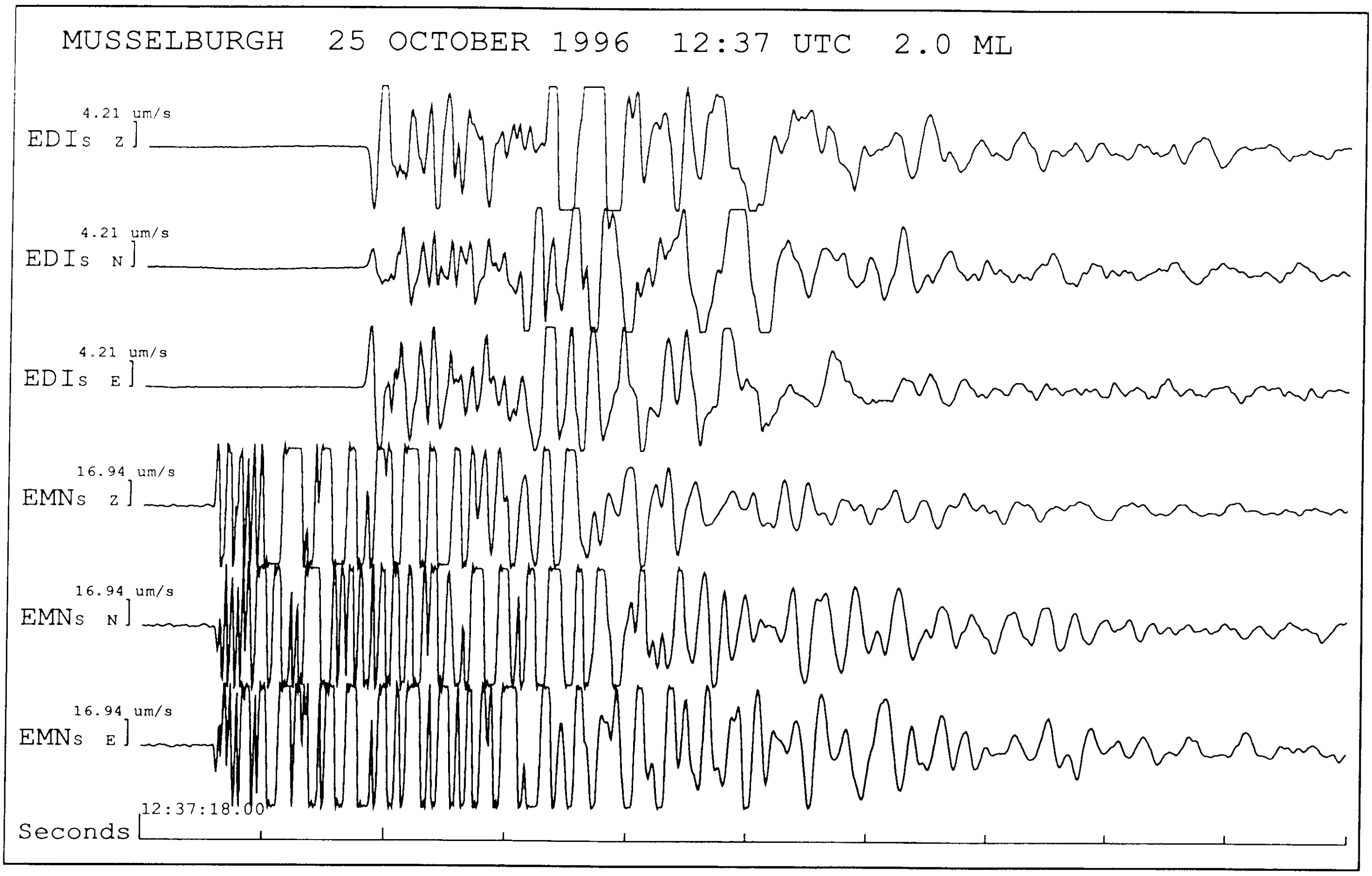


Figure 3. Seismograms recorded on the Lowlands network around Edinburgh from a magnitude 2.0 ML earthquake felt in the Musselburgh area on 25 October 1996. (The three letter codes refer to BGS seismograph stations)

Other notable UK earthquakes of 1996 include the magnitude 2.9 ML Loch Fyne, Strathclyde, earthquake of 18 May and the event near Comrie, in Tayside, on 20 October (magnitude 1.4 ML). Both were reported felt in the epicentral areas with intensities of at least 3 EMS.

The coalfield areas of central Scotland, Yorkshire, Staffordshire and Nottinghamshire continued to experience earthquake activity of a shallow nature which is believed to be mining induced. Over 69 coalfield events with magnitudes ranging between -0.4 and 2.3 ML have been detected in the year, 26 of which were felt. The Musselburgh / Newcraighall area, to the east of Edinburgh, experienced over 50% of these mining induced events, which started in early October and are still continuing. The largest event (Fig. 3), with a magnitude of 2.0 ML, occurred on 25 October and was felt with intensities of at least 4 EMS. Information directly from local residents and through the completion of macroseismic questionnaires, distributed by BGS and published in local newspapers, have shown that the events were felt up to 2 km from the epicentre. Twenty-two events in the series were felt by local residents who described the effects like "a heavy lorry passing outside". Additional instruments were installed in the area and the results showed that the pattern (most events occurring in the working week) and location of the activity was a consequence of mining at Monktonhall colliery. Analysis of acceleration data from a soft ground site 1 km from the epicentre, gave maximum horizontal ground accelerations of up to 55mms^{-2}. The two most likely causes of these events are: the undermining and subsidence of old workings with void and pillar collapses and shearing in strained rock layers; the bridging, and subsequent breaking during subsidence, of a strong rock layer between the mine and the surface (in this case, 900 metres above).

The "**Bulletin of British Earthquakes 1996**" edited by A Walker will be published in April 1997. Copies of this and previous years' reports can be obtained from the Global Seismology Group secretary and from BGS bookshops.
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Near Newcastle-under-Lyme, on 16 March, an event with a magnitude of 2.3 ML was felt with intensities of at least 3 EMS by local residents in Newcastle-under-Lyme and Keele. The signal recorded by the nearest network showed that the source was shallow (surface waves present) and it is thought to be related to nearby mines in the region. Two other shallow events, located in the same area with magnitudes of 1.9 ML, occurred on 20 February and 7 March and were felt with intensities of at least 3 EMS.

__David Galloway__ and __Alice Walker__ are members of the Global Seismology Group of the British Geological Survey.

Meeting Report: 27 November 1996

SEISMIC HAZARD MAPPING :
FUTURE NEEDS OF THE INSURANCE COMMUNITY

An informal discussion on the subject of *'Seismic hazard mapping - future needs of the insurance community'* was held at the Institution of Civil Engineers on 27 November 1996. The meeting attracted an audience of more than 50 people. The meeting was chaired and introduced by Dr. Julian Bommer of Imperial College, who illustrated the high degree of uncertainty associated with seismic hazard assessments by comparing hazard maps prepared by different research teams for the Central American republic of El Salvador. These differed by as much as a factor of three in terms of the level of the 475-year accelerations.

The first speaker was Dr. Anselm Smolka of Munich Reinsurance Company who talked on *'Seismic zoning in earthquake insurance'*. Dr. Smolka identified two specific problems for the insurance industry in terms of hazard assessment: premium calculations and catastrophic loss estimation. Dr. Smolka highlighted lessons from recent destructive earthquakes, including the importance of local soil conditions such as in the Michoacán earthquake in Mexico in 1985 where 85% of the losses occurred in Mexico City due to amplification of ground motions. Other recent lessons included the particularly devastating effects of near-field earthquakes such as Northridge and Kobe, where large events have coincided with heavily populated areas. Dr. Smolka also presented the trend of increasing losses in earthquakes, particularly the examples of US$ 30 billion in Northridge and US$ 150 billion in Kobe. The insured loss in Northridge (US$ 14 billion) is the highest to date; the insured loss in Kobe was actually lower because Japanese law places strict limits on levels of insurance. Comparing earthquake losses from the last decade with the 1960's, total losses have increased by a factor of 15, but insured losses by a factor of 194. Twenty years ago only about 5-8% of property in California carried earthquake insurance, whereas now it is closer to 50%.

Dr. Smolka then presented the thesis of his presentation: "The nature of earthquake losses is widely documented, but not well understood". Specifically, he identified the lack or inaccessibility of reliable and detailed information on the spatial loss profile, the lack or inaccessibility of loss-relevant measurements and data (strong-motion records, geotechnical parameters) and the lack of a tool to analyse spatially the whole range of loss factors. With regards to the final point, Dr. Smolka proposed that Geographical Information Systems (GIS) presented an opportunity for direct correlation between losses and underlying causes in terms of site conditions, thus getting around inadequate parameters such as intensity and peak ground acceleration. Referring back to the introductory comments by Dr. Bommer on hazard maps for El Salvador, Dr. Smolka emphasised that for insurance purposes microzonation studies are far more important than regional zonations.

The second speaker was Dr. John Shepherd of Lancaster University who spoke on *'Capture and mapping of seismic hazard: data sources and uncertainty'*. Dr. Shepherd began his presentation by comparing and contrasting probabilistic and deterministic methods of hazard assessment, highlighting the disadvantage of deterministic approaches that they yield unquantifiable levels of hazard. Since probabilistic approaches indicate the likelihood of earthquakes, these approaches have been adopted for the Pan-American Institute of Geography and History project to produce seismic hazard maps for Latin America and the Caribbean. The object of the project, which Dr. Shepherd is leading, is to unify the assessment of hazard throughout this region and across borders, using a uniform seismic catalogue based on a large number of national and regional catalogues. The project has employed three different methods of probabilistic hazard assessment in order to compare the results obtained, and the applications to the south-eastern Caribbean were illustrated in the form of hazard maps. The three methods employed are the classic Cornell technique, extreme value methods and the historic parametric method. The preferred approach is the historic parametric method which obviates the need for assumptions about seismic source zones and maximum magnitude. The method also allows a more thorough treatment of the uncertainties in the data through random perturbations in the location and magnitude of earthquakes in addition to incorporating the scatter in the attenuation relations. This talk generated some lively discussion about the significance and usefulness of the 475-year return period to define hazard, the length of the complete earthquake catalogue, the use of Kernel functions as an alternative approach to hazard assessment, the incorporation of the results into the Caribbean building code and the identification of active faults in the Caribbean. This final point was raised by Dr. Robert Muir Wood who argued that many faults have been identified in this region on which significant displacements have been measured. Dr. Shepherd argued that these displacements are not necessarily evidence of historical earthquakes and therefore did not make it possible to treat these faults as quantifiable seismic sources.

The final speaker of the meeting was Mr. David Whiting of EQECAT UK who spoke on *'Future needs of the insurance industry'*. Mr. Whiting first addressed earthquake modelling issues, illustrating the computer aided superposition of hazard (ground motions), soil conditions and exposure, highlighting the problems of integrating different levels of information. With particular reference to California, Mr. Whiting spoke about research into unknown faults that has been triggered by experiences such as the Northridge earthquake. One of the most difficult areas of the work in terms of data requirements was identified as the vulnerability, where information is required right down to postcode level (units of 25 houses). This then raises the question of which vulnerability curves should be applied to each zone.

Julian Bommer

Meeting Report: 11 December 1996

VERTICAL EARTHQUAKE GROUND MOTION:
EVIDENCE, EFFECTS AND SIMPLIFIED ANALYSIS PROCEDURE

An informal discussion on the subject of *'Vertical earthquake ground motion: evidence, effects and simplified analysis procedures'* was held at the Institution of Civil Engineers in London on 11 December 1996. The meeting attracted an audience of 50 and generated some lively debate on this controversial subject.

The first speaker was Dr. Julian Bommer of Imperial College, who spoke on *'Vertical earthquake motions'*. Dr. Bommer began by outlining the treatment of vertical earthquake loading in building codes, pointing out that of the 37 codes in the 1992 World List, only 8 do not consider vertical loads at all but 19 only consider their effect for horizontal elements such as cantilevers and balconies. Where vertical earthquake design forces are specified in codes they appear as a flat spectrum or as a direct amplitude scaling of the horizontal spectrum by a factor of 0.5 or 0.7. The only code that specifies a different shape for the vertical spectrum currently is the French code.

Dr. Bommer then outlined the history of recordings of strong vertical accelerations showing that many vertical accelerations in excess of 1.0g have been recorded. The maximum recorded ratios of vertical to horizontal peak acceleration were also presented, showing that the 2/3 rule-of-thumb has been frequently exceeded, although this level was not surpassed for more than 25 years after the El Centro earthquake in 1940. It was shown that high ratios of vertical to horizontal acceleration are confined to the near-field of earthquakes, which then raises the question of how specifications for strong vertical earthquake loads could be incorporated into building codes which present hazard on a national or regional level. A brief overview was also given of the few existing attenuation relationships that are available for vertical ground and spectral accelerations, and the dilemma of whether to predict mean values of the vertical to horizontal ratio or the vertical acceleration itself.

The second speaker was Professor Amr Elnashai of Imperial College, who spoke on *'Effects and simplified analysis procedures'* showing a number of slides of damage from recent earthquakes such as Northridge and Kobe which strongly suggest the influence of vertical seismic effects. Back-analyses of the behaviour of buildings and bridges in these earthquakes have illustrated two important points: the first is that applied vertical accelerations, as recorded on strong-motion instruments, actually result in net axial tensile *displacements* in structural elements. The second point illustrated by the back-analyses is that some of the modes of shear and flexural failure observed in the field are not encountered when the models are subjected to horizontal acceleration alone but are reproduced very closely when the structures are subjected to the combined effect of the vertical and horizontal accelerations. This illustrates that many modes of failure observed in damaging earthquakes, which do not necessarily exhibit any clear signs of vertical loading, may nonetheless be induced by the reduction in shear and/or flexural capacity caused by the vertical accelerations.

The final part of Professor Elnashai's presentation dealt with a new simplified procedure for modal analysis of the structures subjected to vertical earthquake forces in a manner that is compatible with current code procedures.

The final speaker was Dr. Peter Merriman of British Nuclear Fuels plc whose presentation was entitled *'A view from engineering practice'*. Dr. Merriman argued that in fact vertical accelerations due to earthquakes were generally not important, dismissing many of the field examples presented by the previous speakers as being due to factors other than strong vertical motions. Dr. Merriman presented the example of tests performed on elements of reactor plants that were transported by lorry over uneven road surfaces and it was found that the vertical accelerations that this caused were much higher than the vertical accelerations used in the seismic design of these elements. He concluded by stating that in spite of his opinion that vertical motion in unimportant, most nuclear power plant structures are analysed using horizontal accelerations with 70% of this motion also applied vertically.

A brief presentation from the floor was then made by Dr. Fadi Hamdan of Imperial College who discussed the influence of the vertical earthquake motions in the buckling of liquid storage tanks. He concluded that "absence of evidence is not evidence of absence".

The presentations generated a lively discussion on the issues raised both from the audience and amongst the speakers.

Julian Bommer

SECED/AFPS SEMINAR ON SOIL STRUCTURE INTERACTION:
PERMANENT SOIL DISPLACEMENTS AFTER EARTHQUAKES - IMPLICATIONS FOR DESIGN.

Edmund Booth reports on the second in a series of joint seminars with SECED's sister society in France, AFPS (French Association for Earthquake Engineering).

Forty delegates attended this seminar on the 18th December 1995, and heard six full length papers and three shorter contributions from the floor. Unusually, the speakers were predominantly from industry, with a ratio of six to three over their academic colleagues; this was roughly mirrored in the attendees, so that the 'implications for design' of the seminar's title were kept well to the fore.

The first session comprised two general review papers. Bryan Skipp (Consultant, Soil Mechanics) placed the scale of permanent displacements in soil structures into a global context, while Scott Steedman (Sir Alexander Gibb & Partners) reviewed performance criteria for displacement, particularly for retaining wall and other dock structures. The second two sessions were French contributions directed primarily to dam analysis. Denis Clouteau (Ecole Central de Paris) presented some complex soil structure interaction studies, while Odile Ozanam (Coyne et Bellier) discussed a benchmark analysis of El Infiernillo Dam in Mexico. After lunch, Edmund Booth presented three design studies of pile response undertaken by Ove Arup & Partners for a variety of bridge and building projects, while Alan Pecker (Geodynamique et Structure) gave a detailed presentation on the development of foundation design for the Rion Antiron Bridge (Greece), which is now entering its construction phase.

Three presentations were then made from the floor (Andrew Chan - Birmingham University, Kenichi Soga - Cambridge University and Ade Adefaya - NNC Ltd), followed by a lively discussion. The day concluded with a most enjoyable dinner on the Restaurant Ship Hispaniola, at which the guests of honour were Professor and Mrs Patrick Dowling and Professor Tom Wyatt.

The proceedings of the conference, with an introduction by Professor David Muir Wood (Bristol University) will be published later this year as a special issue of the Institution of Civil Engineers' "Journal of Geotechnical Engineering". Further details can be obtained from Edmund Booth (phone/fax +44 181 925 0011/12, e-mail 101350.34@compuserve.com).

THE NEXT SECED CONFERENCE, EASTER 1998

"Seismic design practice into the next century - research and application"

CALL FOR PAPERS

The next SECED conference will take place in Oxford on Thursday 26th & Friday 27th March 1998. It follows on from the highly successful conference in 1995 at Chester, where the theme was 'European Design Practice'. This time, the scope will be even more international, and will include presentations by distinguished keynote speakers, from UK, Europe, USA and Japan, on their view of how life will be for the earthquake engineer in the year 2000 and beyond.

The setting will be Oxford University, one of the most beautiful and ancient seats of learning in Europe, and home to probably its newest dynamics research laboratory, currently being set up by SECED members Tony Blakeborough and Martin Williams.

The first announcement and call for papers has now been sent out, and abstracts are required by 15th April 1997. The conference cost will be around £350, with bed and breakfast accommodation available at Magdalen College from £31.50 per night. Student members of SECED can attend at the reduced rate of around £150 (excluding accommodation) and sponsorships will be offered for both student delegates and those from former Soviet Union, and Central and Eastern European countries.

We hope you will be able to join what promises to be a memorable and stimulating event. Further details are available from:

Ms Rachel Coninx,
Thomas Telford Conferences Ltd.,
Institution of Civil Engineers,
One Great George Street,
London SW1P 3AA, UK
Telephone + 44 (0) 171 665 2312
Fax + 44 (0) 171 233 1743
Email coninx_r@ice.org.uk

and from the Thomas Telford website:

Internet http://www.t-telford.co.uk/co/coindex.html

TERTIO MILLENNIO ADVENIENTE

With a new millennium rapidly approaching, **Dr Gordon Woo** of EQE International comments on the future of earthquake forecasting.

Few who are as yet unaware that this is the International Decade for Natural Disasters Reduction will be too excited to hear that it is. The man on the Clapham omnibus is bemused and surprised to hear about IDNDR. With the seventh year of the decade having just ended, a cynic would say that there are just three years left of the most disaster-ridden decade in modern times. After the North European windstorm, Hurricane Andrew, and the Northridge and Kobe earthquakes, insurers would be glad to see the end of the decade, if they were not already apprehensive about what natural horrors the new millennium might bring.

With major building plans under way to celebrate the millennium in grand architectural style, it is an opportune time for engineering seismologists to ponder their future in the next decade. Preparations are already under way in the world-wide earthquake engineering community: the sixth U.S. National Conference on Earthquake Engineering, next year, is to focus on seismic design and mitigation for the third millennium.

The first decade of the millennium promises to be a busy time for engineering seismologists. There is a public expectation that the dawn of the new millennium will be heralded by a proliferation of spectacular natural events. It was thus at the turn of the last century, which witnessed a series of cataclysmic earthquakes and volcanic eruptions around the world. With the centenaries of the 1906 San Francisco and 1908 Messina earthquakes to be marked in the first decade of the new millennium, (both of which events were seminal in the development of earthquake engineering), future failures of engineering seismology can hardly be excused as the follies of an infant technology.

Six years ago, when I first visited the offices of EQE Inc. in San Francisco, there was hardly a decent computer to be seen. A 'pizza-box' was the cardboard Domino's used for making deliveries. Having personally just taken delivery of the latest Silicon Valley UNIX workstation, I kept quiet. Today, EQE is in the computer software business, starting from nowhere.

The reputation and business of EQE had been built in the late 1980's in identifying the practical advantages of field earthquake damage evaluation and using a database of this experience to assess qualitatively the loss potential of comparable types of engineering. The underlying logical paradigm has proven valuable: in attempting to forecast the future behaviour of a complex nonlinear phenomenon, use of data on empirical analogues can afford much insight.

Apart from its practical usage in assessing earthquake vulnerability, the same general paradigm works well in natural hazard forecasting. Everyone knows that chaotic systems defy deterministic predictability. However, some degree of success in probabilistic forecasting of critical events is possible if a sufficient library of past similar experience is available. This is the case with some meteorological forecasts, e.g. snow physicists use computerised historical databases of mountain weather conditions to make reasonably successful avalanche forecasts. The same applies in principle to assessing patterns of volcanic eruptive behaviour and potentially to earthquake forecasting as well.

In the centenary of the great geologist Charles Lyell, we should be mindful that not only is the present the key to the past, but that the past offers a key to the present, through the power of 3rd millennium computer technology. Guided by new generations of supercomputers, advanced satellite monitoring etc., the dawn of the new millennium will herald an era of earthquake forecasting, in which probabilistic hazard forecasts will be commonplace. Forecasting as an empirical nonlinear science should be distinguished from the art of prediction, which may well be incompatible with the complex dynamics of fault rupture. The future is bright; the future is forecasting.

TAMING THE TREMBLER:
AN EARTHQUAKE STRATEGY APPROVED BY THE COMMISSION

Brussels issued the following Press release on 17 December 1996

The ground trembles, walls come down, bridges fall - our planet's internal tensions released in an earthquake. Once or twice every year thousands of people experience the terror of solid ground having turned into a gigantic quivering rubber mat by the seismic forces. On average, more that 20,000 people are killed every year due to this violent force of nature. In the European Union, about 5,000 people have been killed by earthquakes during the last 15 years and the corresponding economic damage caused is estimated to be over ECU 430 million. For the safety of its citizens, which is a theme highly valued by Mrs Cresson, Commissioner for research, education and training, the European Union has funded and fostered earthquake research for over a decade. Today, the Commission approved a strategy calling for the reinforcement of this research and effective international co-operation in this field. This strategy will give new impetus both to the actual seismic research and the applied civil protection measures.

Earthquakes are among the most common natural disasters. About one third of the world's population lives in earthquake prone areas. And the risks from earthquakes are rapidly increasing due to rising population densities and the appearance of high-risk objects like dams, pipelines, nuclear power plants etc. A major earthquake striking a European city today would have catastrophic consequences. Therefore, prediction, prevention, preparedness and emergency management are needed. The Commission strategy highlights a wide range of RTD activities and the relevant positive measures currently operative in the EC as an effective means to mitigate the risks posed by threat of earthquakes to the safety of the citizens.

Within the current fourth Framework Programme, earthquake research is part of the following programmes:

1) Environment and Climate
2) Industrial and Materials Technologies (Brite-Euram)
3) Training and mobility of Researchers (TMR)
4) Measurement and Testing
5) Joint Research Centre

A summary of the research in these five areas is given below.

The new strategy does not call for any additional funding. The proposed action lines are designed to reinforce existing activities associated with earthquake research, mitigation, civil protection, emergency aid and other relevant actions:

- The necessary measures should be taken to help bring all the available earthquake records together and process the earthquake data in a uniform manner with a view to providing the European scientific and engineering community with access to comprehensive strong motion data and their detailed seismological and engineering information. Utilisation of integrated communication and information systems is necessary to carry out this task.

- Experimental application of Eurocodes, which are in the form of European building pre-standards, should be reviewed in the context of the completion of the internal market; especially Eurocode 8 for the design and construction of buildings and civil engineering works in seismic regions. All appropriate measures should be taken to ensure the national application of Eurocodes.

- All the necessary measures should be taken to advance and reinforce international co-operation, in particular with Japan and the United States of America, in the areas of civil protection and in the research actions identified in this communication. To this end exploratory discussions will be held with the appropriate Government Departments in these countries.

- While discussions continue on the structure of the EC's Fifth Framework Programme for RTD, earthquake research needs to be given further attention with a view to including it under the appropriate theme.

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A SUMMARY OF RESEARCH ACTIVITIES BEING FUNDED BY THE EU

Earthquakes cannot be prevented, and reduction of loss of lives and property must rely on reduction of the damage (earthquake engineering), and on education to ensure alertness and rational response of the population and the authorities at the moment of crisis.

Where seismic loads have been underestimated, earthquakes can cause buildings to suffer damage and collapse by hundreds, sometimes thousands, resulting in substantial death and damage that takes years to recover from. Where there is good construction practice, large earthquakes principally cause economic damage but not large loss of life. However, a large number of constructions were built before appropriate design criteria were prescribed by the codes.

In the European Union, it is mainly the southern countries - especially Italy, Greece and Portugal - which have repeatedly been hit by earthquakes, although other Member States have also been struck by earthquakes causing significant damage (see Table 1). The severity of the issue is manifested by the fact that these statistics could be suddenly changed if a large earthquake strikes a big city. Since 1976, 340,000 people have been killed by earthquakes and the total estimated damage is $185 billion out of which about $15 billion are insurance losses (source: German IDNDR-Committee and German re-insurance companies).

The last decade has seen an increase in the need for earthquake resistant design of engineering structures, not only in the more active seismic regions such as Italy and Greece but also in the less earthquake prone parts of the Union. The earthquake engineering is being increasingly involved in an ever wider range of projects.

An increasing number of investors, industries, and insurance organisations are becoming conscious of earthquake risk and require its assessment, even in regions of relatively low seismic hazard, such as Northwest Europe, for such installations as gas containers, chemical plants, off-shore structures, dams and power plants and large tunnels whose failure can directly cause large losses of life and environmental and economic damage.

The failure of structures such as hospitals and highway bridges can lead to severe consequences due to the lack of basic services for the community. The decision-maker has to determine the acceptable level of risk based on detailed technical evaluation.

Community research on earthquakes concentrates, on one hand, on the epidemiology of seismic events and strives for a better understanding of them, and on the other hand, on seismic engineering and other civil protection measures.

Within the programmes for research and technological development preceding the current programme, starting in 1986, the European Community have supported a total of 47 research projects in the area of seismic risk (engineering seismology and earthquake engineering) with a total Community contribution of ECU 25.6 million. The objectives of research within the seismology and earthquake engineering areas have been to provide the first stage of high quality, long-term, earthquake data for the European area that may be used to test the tectonic activity of the region, to evaluate long-term strain rates utilising advanced space-based remote sensing technologies, and to assess the long-term earthquake hazard in the region.

The Environment and Climate programme (DG XII, 1994-1998) funds projects like HOPE (Hospital Protection from Earthquakes), TOSQA (Earthquake protection for European historic town centres), GITEC (Genesis and Impact of Tsunamis on European Coasts) and EURO SEISTEST - a project which is running a 10,000 m^2 test site in an area of high seismic activity.

The programme on Industrial and Materials Technologies (Brite/Euram) focuses mainly on anti-seismic structural design which is assisted by advanced design elements (specific seismic isolation techniques and devices such as elastoplastic, viscous dampers, hydraulic couplers, viscoelastic dampers, etc.) Efficient design tools ensure a more cost effective and precise analysis of a structure, allowing it to withstand the shock loads prescribed by local regulations. Furthermore, construction techniques are being developed to allow the integration of suitable materials and equipment which produce the structural behaviour required by the design.

The research and development supports several types of organisations:

- end-users, often national authorities concerned with seismic risks and the heavy losses associated with them. Various industrial sectors are involved such as those involved in managing hazardous or vital technologies (e.g.: nuclear, chemical, petrochemical, electricity generation).
- construction companies involved in the construction of buildings, bridges, industrial infrastructure, dams, etc. and equipment and material suppliers.
- research laboratories and universities with particular expertise in seismic protection technology.

Table 1: Most significant earthquakes in the European Union (1980-1995)
(Source: World Data Centre for Solid Earth Geophysics)

DATE	PLACE	MAGNITUDE	LIVES LOST	DEGREE OF DAMAGE	LOSS IN MILLIONS
1980	Portugal, Azores	6.8	56	400 injured. Extensive damage	≥10
1980	Aegean Sea	6.4	1	Extreme	≥25
1980	Southern Italy, Iripinia	6.8	4580	9000 injured. Extensive damage. 250000 people homeless	≥25
1981	Greece, Athena-Corinthos	6.8	16	Considerable damage	>25
1981	Greece, Alklonides		20	Extensive damage	>25
1983	Greece, Vonitsa	6.2	7	Extensive damage 160 houses damaged	between 5 and 10
1983	Belgium, Liege	4.7	2	26 injured. hundreds of buildings damaged	≥20
1984	Central Italy, Perugia	5.3	0	Extensive damage. 7500 people homeless	≥25
1984	Southern Italy, Abruzzo	5.4	3	63 injured. Moderate Damage	≥10
1984	Southern Italy, Abruzzo	5.8	7	100 inured. Extensive damage	≥25
1986	Greece, Kalamata	5.9	20	300 injured. 1500 houses damaged. 2500 people homeless	>25
1988	Greece, Killini	5.8	0	25 injured. Extensive damage	≥25
1992	Netherlands, Roermond	5.9	0	25 injured. Extensive damage	>130
1995	Greece, Grevena	6.5	0	12000 people homeless. 6300 houses destroyed	>25
1995	Greece, Aigion	6.5	26	Extensive damage	>25
	TOTAL		≥4738		≥430

The Training and Mobility of Researchers programme supports two specific activities.
The first of these is a research training network including 18 European earthquake engineering laboratories (PREC8 network). The research activities in this network are concentrating on the underpinning of Eurocode 8.

Under the "access to large installations" part of the programme, four European shaking table laboratories (ECOEST project) and the Joint Research Centre (ELSA reaction-wall facility) are collaborating for intensifying the use of their installations for testing the strength and vulnerability of buildings and constructions, to assist in the validation of Eurocode 8, and to contribute to the standardisation of seismic testing methods.

The Measurements and Testing programme supports the elaboration and validation of the structural Eurocode 8 for design of earthquake resistant buildings and structures.

The scope of Eurocode 8 is to provide principles and rules of application for the design and construction of buildings and civil engineering works in seismic regions. Eurocode 8 is intended to contain only those provisions that, in addition to the provisions of the other relevant Eurocodes (9 in total), must be observed for the design of structures in seismic regions.

EUROPEAN UNION LARGE-SCALE FACILITIES PROGRAMME
ACCESS TO LARGE SHAKING TABLES AND REACTION-WALL FACILITIES

The Commission currently provides funded access for researchers to the large shaking tables and reaction-wall facilities listed below under its Training and Mobility of Research (TMR) Programme. Application for such access from nationals of a Member State of the Community or Associated State is invited. Applicants with interests in research in earthquake engineering should apply in writing to the Director of one of the laboratories for consideration by a Management Panel appointed by the Commission. Details should be given of the research proposed and the likely amount of access required. Approved users will receive travel and subsistence costs from the host laboratory. More precise details are available from the Director of each of the following laboratories:-

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ESEE RESEARCH PUBLICATIONS, 1996

The following publications from Imperial College may be of interest to SECED members.

- **Engineering Prediction of Earthquake Strong-Motion Duration**, J.J. Bommer and A. Martinez, ESEE-96/1, February 1996.
- **Re-appraisal of Large Central American Earthquakes**, N.N Ambraseys and R. Adams, ESEE-96/2, February 1996.
- **Seismicity of the Eastern Mediterranean and the Middle East, Part 1**, N.N Ambraseys and D. White, ESEE-96/3, June 1996.
- **An Earthquake Catalogue for Iran**, N.N Ambraseys and C. Melville, ESEE-96/4, June 1996.
- **Effect of Model Conditions an the Response of Large RC Bridges**, S. Dodd, A.S. Elnashai and G.M. Calvi, ESEE-96/5, August 1996.
- **DRAIN-2D/90. Program for the inelastic analysis of plane structures subjected to seismic input - User's manual**, A.J. Kappos, ESEE-96/6, November 1996.
- **Experimental and Analytical Investigations into the Seismic Behaviour of Semi-Rigid Steel Frames**, A.S. Elnashai, F.A. Danesh Ashtiani and A.Y. Elghazouli, ESEE-96/7, December 1996.
- **Repair and Strengthening of RC Walls Using Selective Techniques**, A.S. Elnashai and R. Pinto, ESEE-97/1, January 1997.

Experimental WWW Version of Newsletter

The last SECED Newsletter can now be found on the World Wide Web at the Institution of Civil Engineers:

http://www.ice.org.uk/ice/public/pubindex.html

Comments are welcomed and should be sent to:
A.J.Crewe@bristol.ac.uk

NOTABLE EARTHQUAKES OCTOBER - DECEMBER 1996

Reported by British Geological Survey

YEAR	DAY	MON	TIME UTC	LAT	LON	DEP KM	MAGNITUDES ML	MB	MS	LOCATION
1996	09	OCT	13:10	34.50N	32.10E	200			6.3	CYPRUS
				Two people killed and 80 injured, 300 houses damaged in the Limasol area.						
1996	14	OCT	23:26	7.00S	155.50E	33			7.0	SOLOMON ISLANDS
1996	20	OCT	12:48	56.40N	3.99W	3	1.4			COMRIE,TAYSIDE
				Felt throughout the village of Comrie, Tayside.						
1996	25	OCT	12:37	55.94N	3.08W	1	2.0			MUSSELBURGH, LOTHIAN
				Felt in the Musselburgh, Newcraighall, Joppa, Portobello and Niddrie areas of Lothian. This event is the largest of 62 events detected in the Musselburgh area during October with 15 of them being reported felt.						
1996	31	OCT	12:52	61.58N	3.65E	21	3.8			NORTHERN NORTH SEA
1996	31	OCT	12:57	61.62N	3.84E	24	3.9			NORTHERN NORTH SEA
1996	31	OCT	23:47	61.65N	3.65E	15	3.7			NORTHERN NORTH SEA
1996	04	NOV	14:25	55.93N	3.08W	1	1.4			MUSSELBURGH, LOTHIAN
				Felt in the Musselburgh and Newcraighall areas of Lothian. This event is the largest of 42 events detected in the Musselburgh area during November with 7 of them being reported felt.						
1996	10	NOV	09:28	50.00N	5.58W	11	3.8			PENZANCE, CORNWALL
				Felt over a wide area of SW Cornwall, with the strongest reports from the Penzance area where intensities reached 5 EMS.						
1996	12	NOV	16:59	14.99S	75.68W	33		6.5	7.3	COAST OF PERU
				At least 14 people killed, 560 injured and 12,000 left homeless from Chincha Alta to Acari. Over 4,00 houses were damaged or destroyed at Nazca. Felt throughout Peru, Ecuador and Bolivia.						
1996	19	NOV	10:44	35.35N	78.13E	33		6.1	7.1	EASTERN KASHMIR
				Felt throughout Hotan, Shule, Wushi and Yecheng, China.						
1996	02	DEC	22:17	31.79N	131.31E	49		6.0	6.6	KYUSHU, JAPAN
				Felt throughout southern Miyazaki. Felt from Fukuoka to Kagoshima. Minor local tsunami observed along the southeast coast of Kyushu.						
1996	16	DEC	04:09	61.01N	3.67E	14	3.3			NORTHERN NORTH SEA
				Felt along the Norwegian coast.						

Issued by Bennett Simpson, British Geological Survey, January 1997

Forthcoming Events

26 February 1997
Alternative Methods for Blast Analysis on Structures (SECED/OES) ICE 5.30pm

26 March 1997
Field Observations of Earthquakes (SECED/EEFIT/EFTU) ICE 5.30pm

23 April 1997
Passing on Experience - a Master Class ICE 2pm (Half day meeting followed by AGM at 5pm)

21 May 1997
Mallet-Milne Lecture "Structural Response Prediction using Experimental Data" ICE 5pm

26 to 27 March 1998
The Next SECED Conference: *Seismic design practice into the next century - research and application.*

Contents

SECED Newsletter

The SECED Newsletter is published quarterly. Contributions are welcome and manuscripts should be sent on a PC compatible disk. 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.

Articles should be sent to:

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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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