ISSN 0967-859X
THE SOCIETY FOR EARTHQUAKE AND CIVIL ENGINEERING DYNAMICS

NEWSLETTER

Volume 16 No 2
October 2002

Idriss on Evaluating Liquefaction Potential

"Review of field-based procedures for evaluating liquefaction potential during earthquakes" by Professor I.M.Idriss of the University of California, Davis. Meeting report by **Juliet Bird**.

The work of Professor Idriss and his colleagues is internationally accepted as state-of-the-practice design by those of us involved in the evaluation of liquefaction potential. Members of SECED and the British Geotechnical Association (BGA) welcomed the invaluable opportunity to hear about his recent work and his thoughts and recommendations on the application of field-based procedures. Professor Idriss presented to a full house at the Institution of Civil Engineers on Wednesday 31st July 2002.

Contents

Soil liquefaction, Niigata, 1964. *Courtesy National Information Service for Earthquake Engineering, University of California, Berkeley.*

Professor Idriss has been involved in this field since 1964, when the earthquakes in Alaska and Nigaata, Japan, first alerted geotechnical engineers to the enormous damage potential of liquefaction, and to the lessons to be learned from such case histories. His presentation focussed on the field-based procedures for evaluating the potential of triggering liquefaction during earthquakes rather than the consequences of liquefaction. Some of the key points introduced by Professor Idriss are presented briefly below.

Estimation of shear stresses induced during an earthquake

The simplified procedure developed by Seed & Idriss (1971) to calculate the maximum shear stress at a given depth in a soil profile is common to all field-based methodologies.

Shear stress is calculated as a function of the maximum horizontal acceleration and a *stress reduction coefficient,* r_d. Recent work by Idriss and Golesorkhi (1997) re-evaluated r_d as a function of depth and also magnitude and found that the values were in good agreement with those of Seed & Idriss (1971) for a magnitude of 7.5 (Figure 1). A second important factor introduced into the simplified procedure is the magnitude scaling factor (MSF) to account for duration, where MSF = 1 for M=7.5. Idriss (1999) presented the following equation:

$$MSF = 6.9\exp\left(-\frac{M}{4}\right) - 0.058$$

which supersedes the relationships presented in Seed & Idriss (1982).

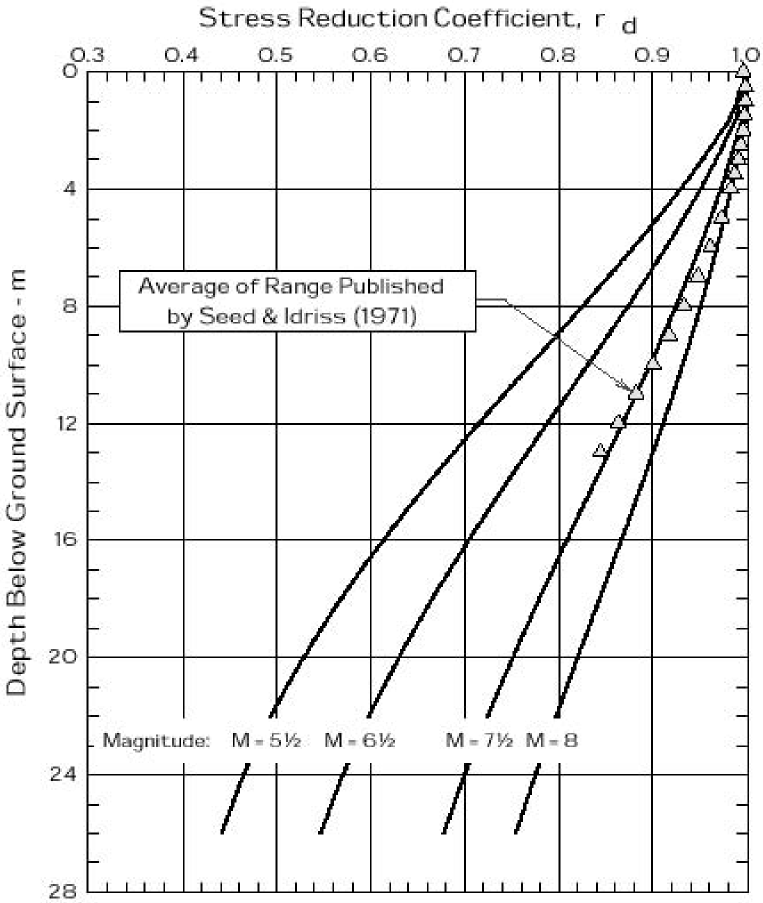

Figure 1: Variations of stress reduction coefficient with depth and earthquake magnitude (from Idriss and Golesrkhi, 1997)

SPT methods for cohesionless soils

Figure 2 illustrates the adjustment to the original data points of Seed et al., (1984) due to the recent changes to r_d and MSF discussed above. The changes are minor and the boundary lines are unaffected. Modified curves were suggested by the NCEER/NSF workshops (1996/1998), the principal modifications (Figure 3) being at $(N_1)_{60} < 5$, and an adjustment to the curve for 15% fines content.

Following fairly extensive liquefaction in the 1999 Chi-Chi, Tawian earthquake, field investigations were undertaken to collate SPT blowcounts and fines contents. Professor Idriss presented a number of curves comparing these new data to the NCEER/NSF curves shown in Figure 3, and noted that the agreement between the measured data and the empirical curves was very good, providing further support to the use of these curves.

Shear wave velocity methods for cohesionless soils

A very brief overview of shear-wave velocity based methods was presented, based on the work by Andrus & Stokoe (2000).

CPT methods for cohesionless soils

In theory the cone penetration test is an ideal measurement for the

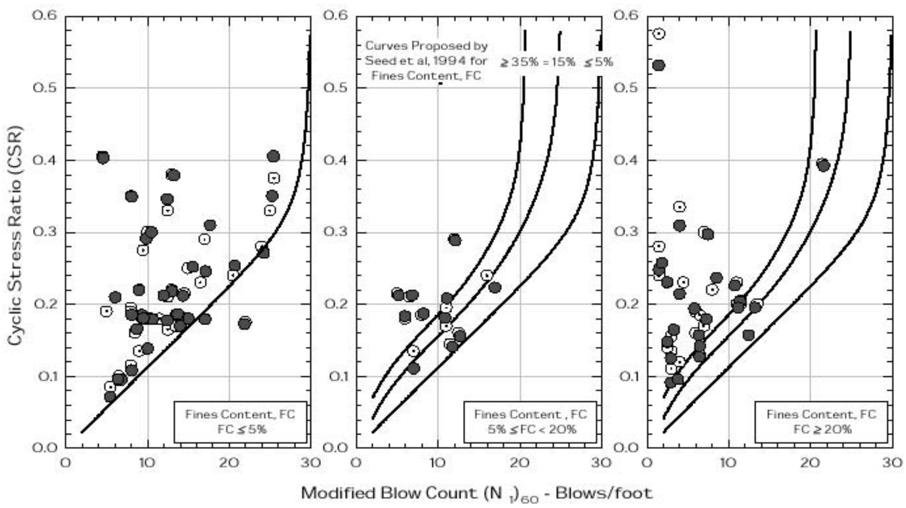

Figure 2: Comparison of Cyclic Stress Ratio (CSR) published by Seed et al., (1984) (open symbols) with those calculated using new relationships for r_d and MSF.

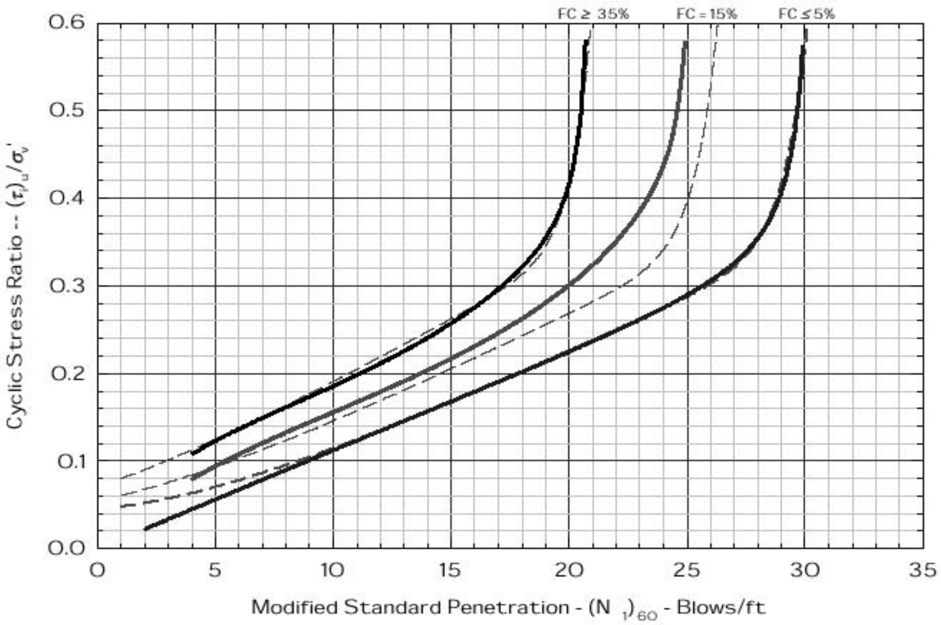

Figure 3: Comparison of curves of Seed et al., (1984) (solid lines), with those agreed by the NCEER/NSF workshop, 1996-1998 (dashed lines)

assessment of liquefaction resistance, since it provides a continuous record, and is less subject to operator error than the SPT. The principal shortcoming has historically been the limited database available for correlation. However, it was noted that this shortcoming is rapidly disappearing, as more and more case histories with CPT measurements become available. Due to the lack of physical sampling from CPT equipment, Professor Idriss warned that he believes it should not be used in isolation.

A lack of consistency was noted in the various published CPT methodologies, in terms of the selection of representative tip resistance, and based on a thorough review of all the available data, the procedure for assessing '*modified tip resistance*' by Boulanger et al., (1995) is proposed to remove this problem.

Some results of analyses comparing data from a number of published databases to curves published up to 1997 were presented. The results, shown in Figure 4 indicate that the curves of Suzuki et al., (1997) provide the best fit, whilst others may be unconservative.

Professor Idriss discussed the question; 'Why are there so many points <u>above</u> the curve?' with respect to figures such as Figure 4. Two important reasons for this were suggested:

Early onset of liquefaction

There is evidence (e.g. from Niigata, 1964) that the onset of liquefaction can occur some time before the end of the earthquake. In effect this means that liquefaction is triggered at fewer cycles than the total number of cycles estimated for a given earthquake magnitude. Adjusting data for this discrepancy has the effect of bringing the data points towards the boundary curve.

Effects of duration

The magnitude scaling factors (MSF) were derived to represent the number of cycles for a given earthquake magnitude. However, an example presented for the Loma Prieta (1989) earthquake showed that some recorded time histories had significantly fewer cycles than would be expected for a magnitude 6.9 event. By applying a reduction factor to represent this trend, the data points would again move closer to the boundary curve.

Noting the above trends, and also re-evaluating the modified tip resistance according to the procedure of Boulanger et al (1995) has the effect of moving the observed data points. Figure 5 shows a new relationship (Idriss et al., 2002) that has been derived to give a better fit to these re-evaluated data.

Conclusions

- It is always useful to check the results using more than one procedure; Prof Idriss's preference is to use CPT soundings and SPT borings (to get N values and to get samples for grain size and other index testing).
- The quality of the data being collected is the most important factor. This observation applies to sampling, laboratory testing, and CPT, SPT, Becker & Vs measurements.
- The use of CPT was strongly recommended for evaluating the potential for liquefaction. However, the use of a CPT-only procedure was advised against for any site at this time.
- For cohesionless soils with high fines content, more work, involving

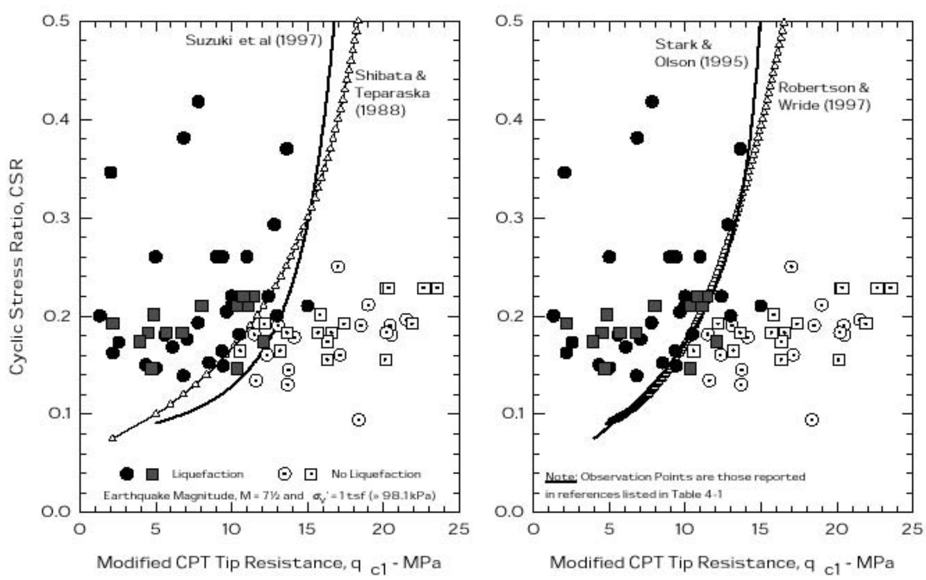

Figure 4: Observed cases of liquefaction and no liquefaction and CPT based relationships available in 1997 for assessing liquefaction potential.

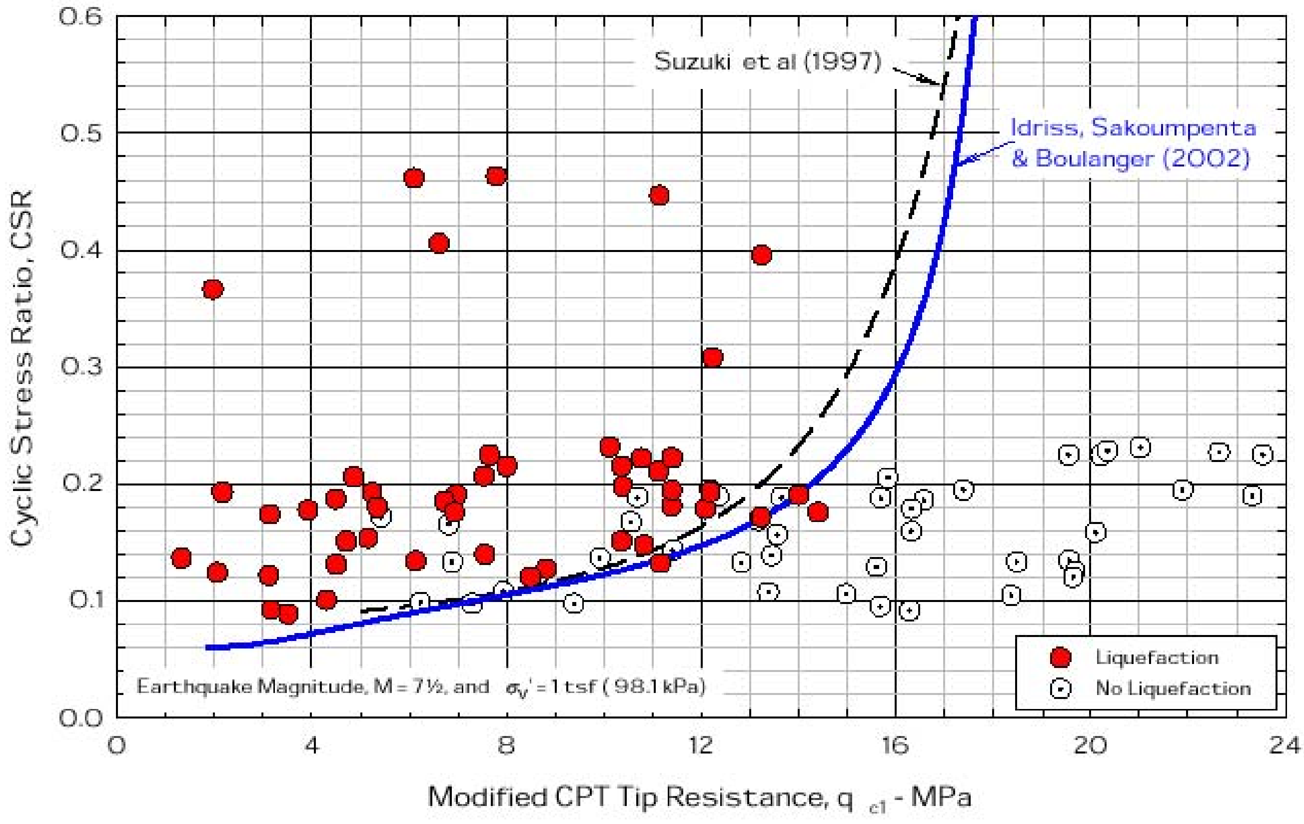

Figure 5: Proposed CPT based curve for assessing liquefaction potential in clean sands

actual case histories, remains to be completed before curves relating the cyclic stress ratio required to trigger liquefaction to normalized CPT tip resistance (qc1) can be used with confidence.

Discussion

An interesting discussion followed the main presentation, with many of the attendees keen to discuss aspects of Professor Idriss's work and other issues related to liquefaction with him. Issues discussed included: the use of probabilistic curves of liquefaction potential; use of small strain in situ measurements such as shear wave velocity to predict a large strain phenomena; assessment of global rather than local potential for liquefaction; and the future relevance of field-based empirical procedures in the light of the increasing analytical capabilities. On this last question Professor Idriss concluded that there will always be a need for simple straightforward engineering approaches where they are sufficient, just as there will always be a need for more sophisticated analysis where the consequences of the results are of high significance.

SECED members may contact the Secretary to obtain copies of the detailed presentation handout provided by Professor Idriss, which contains much useful information, at eunice.waddell@ice.org.uk . The figures used in this brief report are reproduced with the kind permission of the author.

References

Boulanger, R. W., Idriss, I. M., Mejia, L. H. (1995), "Investigation and Evaluation of Liquefaction Related Ground Displacements at Moss Landing during the 1989 Loma Prieta Earthquake," Center of Geotechnical Modeling, Department of Civil & Environmental Engineering, University of California, Davis.

Robertson, P. K., and Wride, C. E. (199 7), " Cyclic Liquefaction and its Evaluation Based on SPT and CPT", Proceedings, NCEER Workshop on Evaluation of Liquefaction Resistance of Soils, National Center for Earthquake Engineering Research, State University of New York at Buffalo, Technical Report No. NCEER -97-0022, December, pp 41 – 88.

Seed, H. B., and Idriss, I. M. (1971), "Simplified procedure for evaluating soil liquefaction potential," Journal of Geotechnical Engineering, ASCE, Vol. 97, No. 9, pp1249-1273.

Seed, H. B., Tokimatsu, K., Harder, L. F., and Chung, R. M. (1984), "The Influence of SPT Procedures on Soil Liquefaction Resistance Evaluations," Report No. UCB/EERC-84/ 15, Earthquake Engineering Research Center, University of California, Berkeley.

Shibata, T., and Teparaska, W. (1988), "Evaluation of liquefaction potentials of soils using cone penetration tests," Soils and Foundations, Tokyo, Japan, Vol. 28, No. 2, pp 49-60.

Stark, T. D., Olson, S. M. (1995), "Liquefaction Resistance Using CPT and Field Case Histories," Journal of Geotechnical Engineering, ASCE, Vol. 121, No. 12, pp 856-869. 30. Suzuki, Y., Tokimatsu, K., Taya, Y., Kubota, Y. (1995), "Correlation Between CPT Data and Dynamic Properties of In Situ Frozen Samples," Proceedings, Third International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, Vol. I, St. Louis, Missouri, August.

Seismogenesis and state of stress in the UK from observations of seismicity.

By **Brian Baptie** of British Geological Survey, Edinburgh.

Introduction

Hypocenters of earthquakes in intraplate areas, such as the United Kingdom, typically occur in the upper crust and are rarely deeper than 15-20 km. Earthquakes are contained within a seismogenic zone, within which the crust deforms either by stable or unstable sliding along an existing fault or by brittle failure when applied stress exceeds the strength of the material. The depth of this zone depends on factors such as temperature gradient and mineral composition (Sibson, 1984). The depth distribution of shallow crustal earthquakes can, therefore, be used to determine the transition between brittle and ductile behaviour. Accurate determination of the regional stress tensor in a given area is desirable for understanding the driving forces of current deformation. Fault plane solutions for naturally occurring earthquakes can be used to constrain

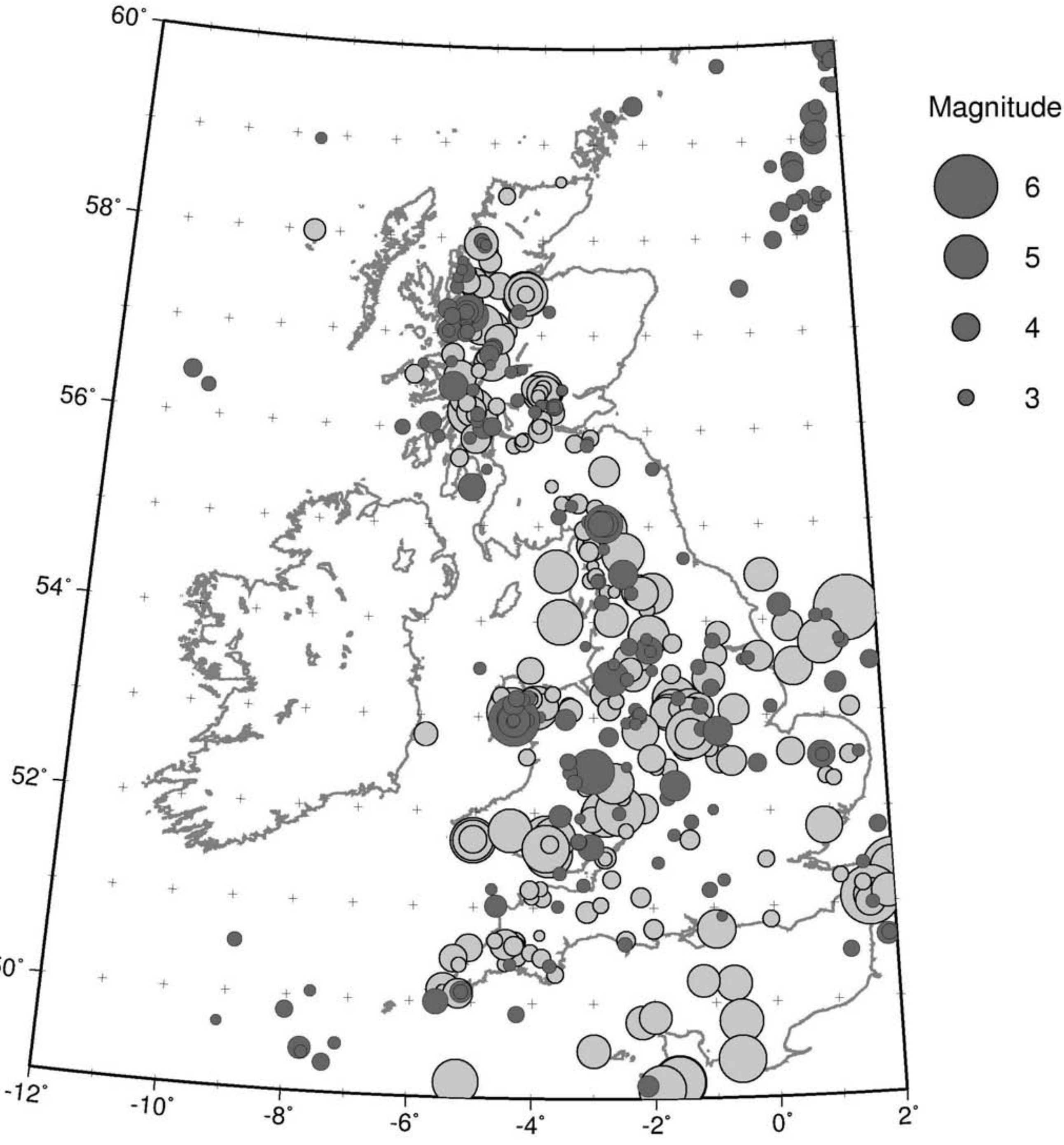

Figure 1. Historical seismicity of the UK (pale grey) from 1382 to 1970 and instrumental seismicity (dark grey) from 1970 to present, for earthquakes of magnitude 2.5 ML and above.

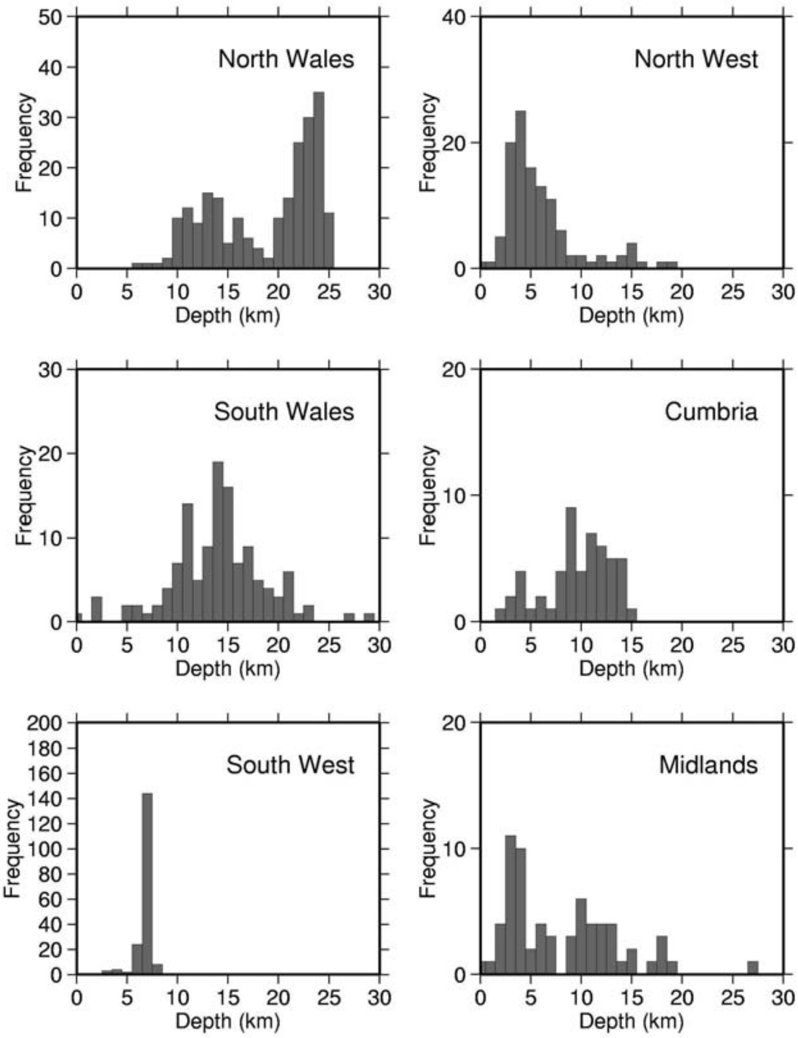

Figure 2. Histograms showing the depth distribution of A/B quality hypocenters in six different regions of the United Kingdom.

the orientation of the stress tensor in the brittle part of the crust (Zoback *et al.* 1989). However, the axes of minimum and maximum compression for a given fault plane solution may vary significantly from the principal stress directions, as slip generally occurs on a pre-existing zone of weakness (McKenzie, 1969). In this paper I examine the spatial variation in focal depths of naturally occurring earthquakes to investigate possible variations in seismogenic thickness across the United Kingdom. In addition, a best-fitting stress tensor is found that lies in the overlap between the families of stresses associated with a population of focal mechanisms for earthquakes in the BGS database.

Earthquake Depth Distribution

The diffuse temporal and spatial pattern of seismicity observed in the United Kingdom is consistent with other examples of intraplate continental deformation. Figure 1 shows both the historical seismicity from 1382 to 1970 and instrumental seismicity, from 1970 to present, for earthquakes of magnitude 2.5 ML and above. However, no historical or instrumentally recorded earthquake in the United Kingdom has produced a surface rupture, therefore it is difficult to relate a given earthquake to displacement along a specific fault.

Hypocenters for instrumentally recorded, naturally occurring, earthquakes within the United Kingdom earthquake catalogue are calculated with the HYPO71 algorithm (Lee and Lahr, 1975), using a series of one-dimensional models of seismic velocity for a given geographical area. These models of the seismic velocity structure in the crust have been obtained from large-scale seismic refraction and wide-angle reflection surveys carried out by various institutions, for example Bamford *et al* (1978). Each hypocenter is assigned a quality factor (A-D) based on both the travel-time residuals and the station distribution. The subsequent discussions are restricted to hypocenters with a quality of A or B, which relates to a hypocentral depth error of less than 3 km.

In order to examine the spatial variability of earthquake depth distributions, the UK has then been divided into six discrete zones, roughly based on the distribution of seismicity: Northwest Scotland, Cumbria, North Wales, South Wales, the Midlands and Southwest England. Histograms showing the depth distribution in these six different zones are shown in Figure 2. Focal depths in Scotland and Cornwall are found to be shallow, with means of 5.7 km and 6.8 km, respectively. However, the seismicity in the southwest is dominated by the Constantine earthquake sequences in

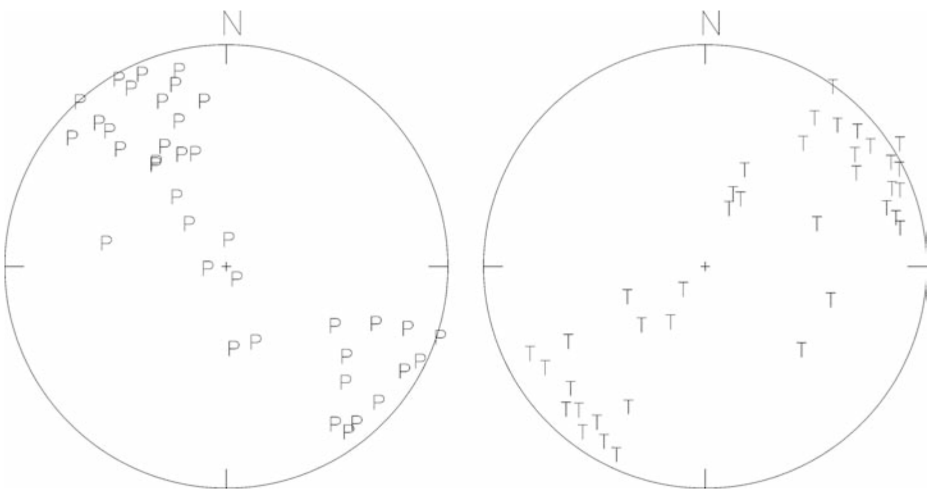

Figure 3. Orientations of the P- and T-axes for the best-fitting fault plane solution for each earthquake with a well constrained focal mechanism.

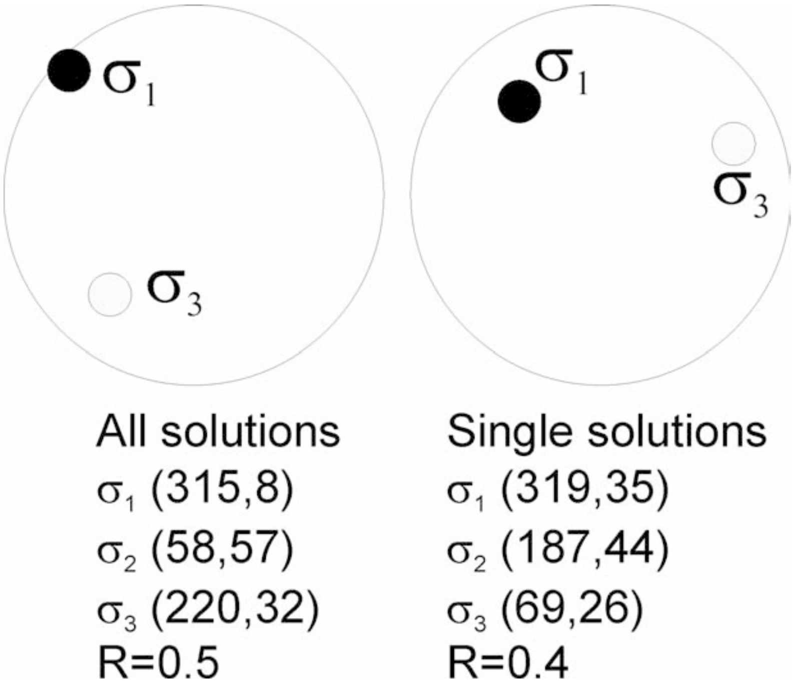

Figure 4. Lower hemisphere equal area projections showing the orientation of the best-fitting σ_1 and σ_3 stress directions obtained using the inversion of the fault-plane solution data, for both multiple and single solutions.

1981 and 1986, and hypocentral errors for many other earthquakes in this area are large, so not included in this analysis. North Wales shows a bimodal depth distribution: a population of deep earthquakes with a mean depth of 23 km dominated by the 1984 magnitude 5.4 Lleyn Peninsula earthquake and the subsequent aftershock sequence; and a second population with a mean depth of 13 km. Earthquakes in south Wales and Cumbria show an intermediate depth distribution with mean values of 14 km and 10 km, respectively. In the Midlands, earthquakes are observed at a wide variety of depths. The shallow nucleation depths observed in Cornwall are consistent with the observed high surface heat flows related to igneous intrusions and an inferred high geothermal gradient. By contrast, the deeper nucleation depths observed in North Wales suggest a lower geothermal gradient.

Focal Mechanisms

Fault plane solutions have been calculated for a number of local earthquakes in the UK earthquake database. These are typically larger events that have a good azimuthal distribution of recordings at different distances from the source. The fault plane solutions are calculated using the grid search method of Snoke *et al.* (1984). This generally results in a number of solutions that fit the observed directions of ground motion and amplitudes at each station. Thirty well-constrained solutions were then used in subsequent interpretation and analysis.

The resulting focal mechanisms show a mixture of strike-slip, thrust and normal faulting. Strike slip motion might suggest that tectonic stress is dominant, while thrust faulting is consistent with glacial rebound origin. The axes of maximum and minimum compression (P and T) for all fault plane solutions (Figure 3) are found to be well constrained in azimuth though not so well constrained in dip.

An estimate of the regional stress field was made using the inversion method of Gephart and Forsyth (1984). This method looks for the best-fitting stress tensor lying in the overlap between the families of stresses associated with a population of focal mechanisms, and gives an estimate of both the orientations and relative magnitudes of the principal stress directions. The inversion results are shown in Figure 4. The principal compression is found to be in the north-northwest south-southeast direction. This result is consistent with expected stress associated with motion of the major tectonic plates, mainly ridge-push from the Mid-Atlantic. The results are also consistent with stress directions found from other methods such as borehole breakouts and hydro-fractures.

Conclusions

There are regional variations in both the depth and thickness of the seismogenic zone in the UK that appear to correlate with overall crustal thickness. No clear relationship has been found between depth and magnitude; however, the events studied are relatively small. P and T axes from individual fault plane solutions are well constrained in azimuth but not in dip. The best-fitting stress tensor obtained from inversion of earthquake focal mechanisms is broadly compatible with compression due to first order plate motions.

References

Bamford, D., Nunn, K., Prodehl, C. and Jacob, B., 1977. LISPB-III. Upper crustal structure of northern Britain. *J. Geol. Soc. Lond.*, **133**, 481-488.

Gephart, J.W. and Forsyth, D.W., 1984. An improved method for determining the regional stress tensor using earthquake focal mechanism data: application to the San Fernando earthquake sequence. *J. Geophys. Res.*, **89**, B11, 9305-9320.

Lee, W. and Lahr, J., 1975. HYPO71 (revised): a computer program for determining hypocenter, magnitude and first motion pattern of local earthquakes. *Open File Report U.S. Geol. Surv.* **75**.

McKenzie, D.P., 1969. The relation between fault plane solutions for earthquakes and the directions of the principal stresses. *Bull. Seis. Soc. Am.*, **59**, 591-601.

Sibson, R.H., 1984. Roughness at the base of the seismogenic zone: contributing factors. *J. Geophys. Res.*, **89**, B7, 5791-5799.

Snoke, J., Munsey, J., Teague, A. and Bollinger, G., 1984. A program for focal mechanism determination by combined use of polarity and P-SV amplitude ratio data. Earthquake Notes, **55**, 3-15.

Zoback, M.L. and Zoback, M., 1980. State of stress in the conterminous United States. *J. Geophys. Res.*, **85**, 6113-6156.

Ekofisk Seismic Event, May 7, 2001

By **Lars Ottemöller of** British Geological Survey, Edinburgh.

On May 7, 2001, a seismic event was strongly felt at the platforms (operated by Phillips Petroleum Company Norway) in the Ekofisk oil field, which is located within the Central Graben in the Norwegian sector of the North Sea (Figure 1). The felt reports indicated that even heavy objects moved and that it was difficult to stand upright. A macroseismic intensity of VI-VII (EMS98) was assigned to the platforms in the central part of the Ekofisk field. The magnitudes determined were M_W=5.0, M_b=4.4 and

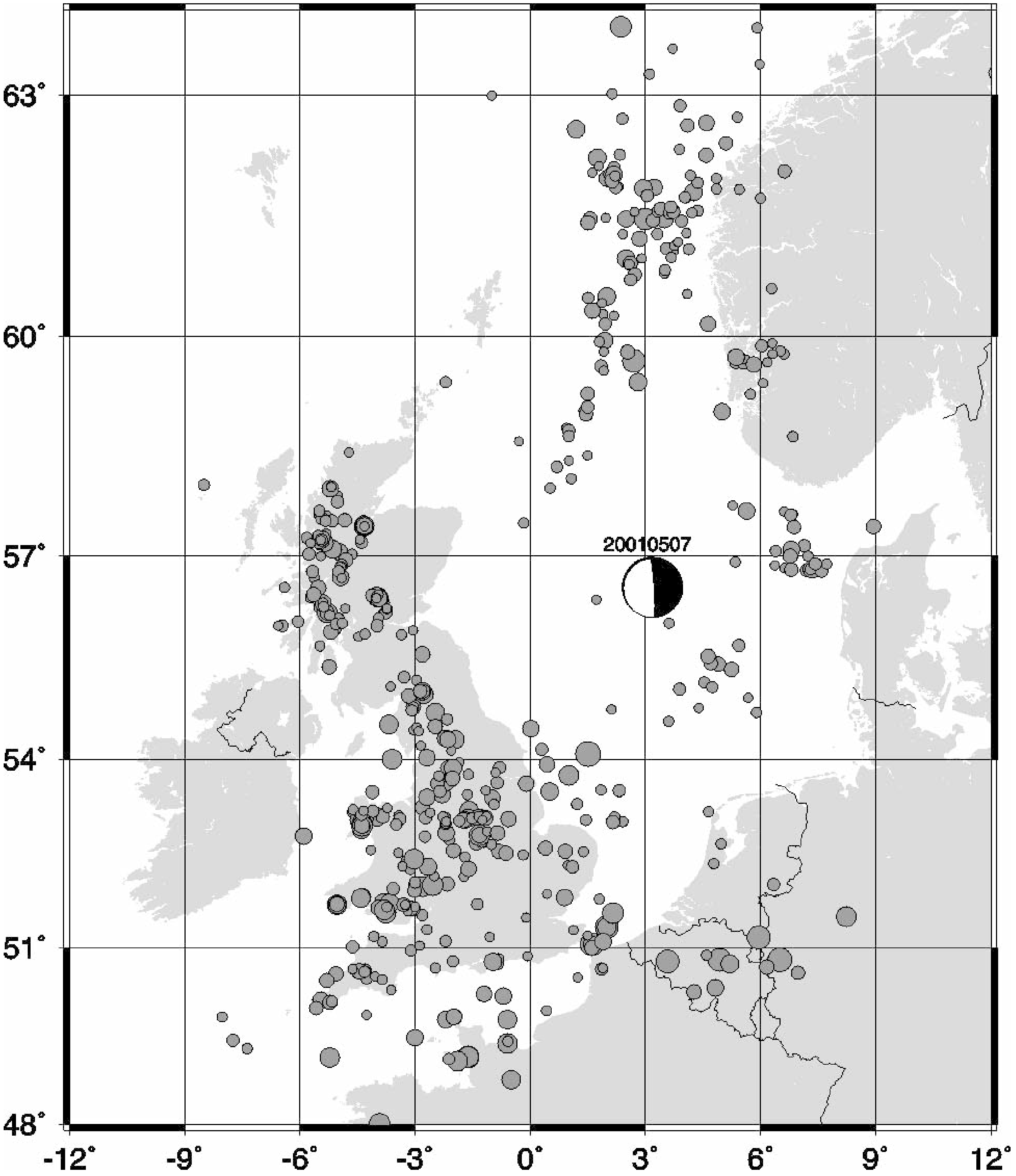

Figure 1. Location and mechanism of the May 7, 2001 Ekofisk event and regional seismicity with M_L=3 from the BGS catalogue. The focal mechanism obtained shows normal faulting along NS striking planes.

M_S=4.6, and thus the event was the largest in the region in over 30 years.

The event was recorded on seismic stations in most parts of Europe at distances of up to 2500 km and was analysed using the large number of regional seismic stations available. The epicentre was determined at 56.565ºN and 3.182ºE, with an error bar of about 5 km in both directions. The main difficulty in the analysis of the event, especially with respect to depth determination, was that no data from close distances were available, since the closest station was more than 300 km from the epicentre. The seismograms were dominated by long-period surface waves while the body waves showed emergent onsets, which, possibly, indicate a shallow source in relatively soft rocks. Determination of the spectral source parameters revealed that the event had a low stress drop of less than 0.5 bars, which would be expected for a slow earthquake located in near-surface sedimentary layers.

The producing Ekofisk reservoir is located at a depth of about 3 km. In order to examine if and how the event was related to the hydrocarbon extraction at Ekofisk, knowledge of the hypocenter depth is essential but the lack of near-by stations precludes its direct determination. Due to the emergent onsets, it was not possible to determine the focal mechanism based on first motion polarities. Instead, we carried out a moment tensor inversion, based on data from regional broadband stations, in order to resolve the source mechanism, but also to obtain an estimate of the source depth. We obtained a normal faulting solution with north-south trending nodal planes (Figure 1). A best fit between observed and synthetic waveforms was obtained for a shallow hypocenter depth of less than 5 km. The EW direction of the axis of maximum compressive stress is in agreement with the regional stress pattern related to the mid-Atlantic ridge push force.

Among previous events located near Ekofisk were the 1988 and 1998 events (both M_L=2.5, M_W=2.9). The 1988 event was felt at Ekofisk and had previously been considered induced, while the 1998 had been mostly unnoticed.

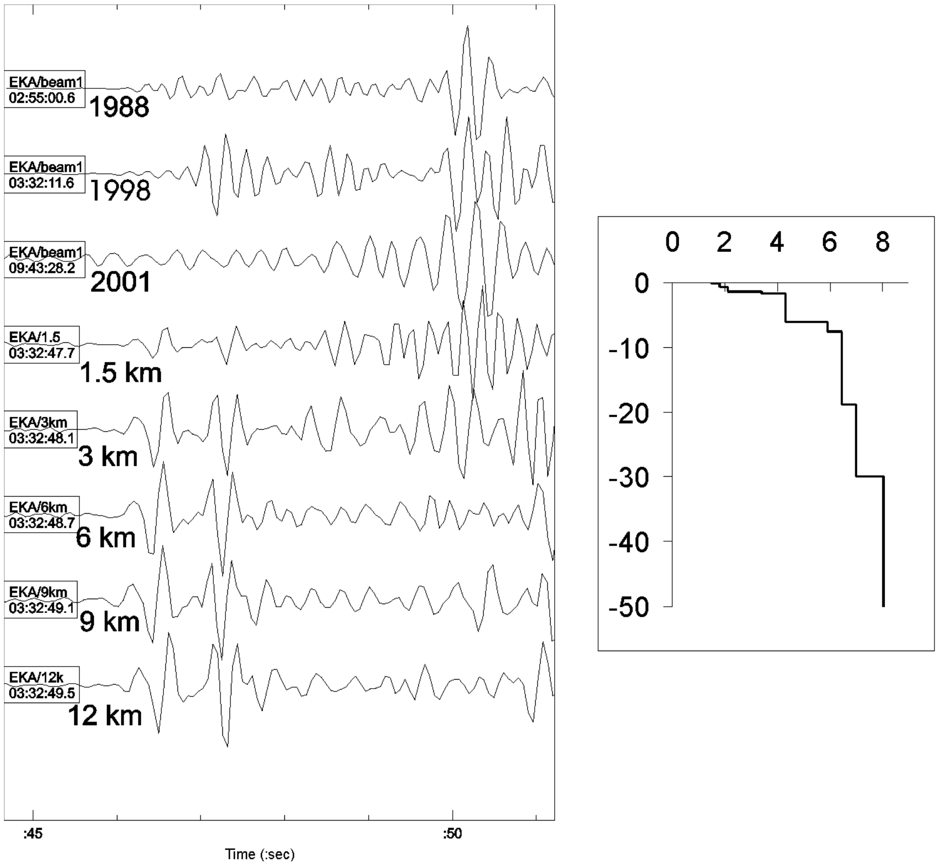

Figure 2. Comparison of seismograms observed (beam) at the Eskdalemuir seismic array for the 1988, 1998 and 2001 (top three traces) events located near Ekofisk and synthetic seismograms for various source depths between 1.5 and 12 km (bottom five traces). The P velocity model used in the synthetic modelling is shown on the right hand side.

Source spectral analysis showed that both events were of low stress drop, similar to the 2001 event. Seismogram data from the Eskdalemuir array (EKA) for the three events were compared, showing similarities for the first five seconds of P waves. For the three events, the first P onset was followed by a stronger amplitude phase after about 3.5 seconds. Additional clear phases were seen for the 1998 event. Analysis of the array data showed that the P phases had almost the same apparent velocity, indicating that the later arrivals are probably surface reflected Pn waves, which are sensitive to the source depth. Waveform modelling for EKA showed that the seismograms could be explained by a source depth of less than 3 km (Figure 2). The strong similarities in the seismogram data for EKA suggest that the events were possibly located closely in space and had similar source mechanisms.

A final conclusion on the relation between the event and hydrocarbon extraction at Ekofisk has not yet been made. Generally, three mechanisms related to hydrocarbon extraction are considered to trigger or induce earthquakes:

i) Local fluid injection decreases effective normal stress and induces seismic cracks M<3 within the reservoir.
ii) Fluid withdrawal causes pore pressure to decrease within the reservoir, stresses are transferred to surrounding region where M<5 occur above or below reservoir.
iii) Isostatic compensation after load removal through hydrocarbon recovery can cause M>6 at larger distance.

At Ekofisk, a source depth above the reservoir (3km), where there are potential faults, could possibly be related to stress changes due to ongoing hydrocarbon extraction, water flooding of the reservoir and drill cuttings re-injection into the overburden. It seems unlikely that the event was related to the deeper and active deep faults in the region, although they possibly can generate earthquakes of this size.

The Seismos Awards 2002

The 12th European Conference on Earthquake Engineering found strong support for the new TV documentary awards, **Robert May** reports.

Among the innovations introduced by SECED for the 12th European Conference on Earthquake Engineering was a new competition for TV documentaries on earthquakes. Termed the Seismos Awards, they brought together earthquake professionals, documentary producers and broadcasters to celebrate excellence in earthquake programmes. Three special categories were identified: Science of Earthquakes; Earthquake Engineering and Earthquake Disaster Relief with an award in each. A further award was made for overall best documentary. The special categories were judged by an expert panel while the overall best documentary was voted on by the delegates to the 12ECEE.

Eleven documentaries submitted for the awards. British production companies featured strongly together with several Italian entries and one American production (Vantage Point). An excellent distribution of entries was achieved across the award categories and the diversity of sources produced a fascinating range of perspectives and styles.

With most of the documentaries timed between 50 minutes and an hour, the six judges put in a very substantial viewing effort. A summary of their scoring and comments on the films can be found on the SECED web site: www.seced.org.uk. The competition was adopted enthusiastically by the 12ECEE delegates, with over 500 votes cast for the overall best documentary. There was considerable speculation as to whether the delegates, predominantly from continental Europe, would agree

Title	Producer	Broadcaster	Category
Earth Story – Ring of Fire	BBC	BBC	Science
Earth Story – Roof of the World	BBC	BBC	Science
Equinox: A Sense of Disaster	Granada	Channel 4	Science
Horizon: Volcano Hell	BBC	BBC	Science
Stormproof: Engineering against Earthquakes	Granada	Discovery Channel	Engineering
Advanced Tested Technology for Earthquakes	ENEA	Radio Tele Europa	Engineering
The Shapes of Memory	ENEA	Radio Tele Europa	Engineering
Why Buildings Collapse – Safe as Houses	Darlow Smith Productions	Channel 4	Engineering
Assisi – Il Cantiere Dell' Utopia	Giotto Film	Rai Uno – Radio Televisione Italiana	Disaster Relief
Raging Planet: Earthquake	Pioneer Productions for Discovery Communications	Channel 4	Disaster Relief
Great Quakes: Turkey	Vantage Point Productions	Discovery Channel	Disaster Relief

Seismos Award Winners

Overall Best Documentary
"Il Cantiere Dell'Utopia"
Restoration and seismic retrofit of the earthquake damaged Basilica of St Francis in Assisi.

Science of Earthquakes
"Earth Story, Ring of Fire"
Role of Alaska Earthquake in the development of plate tectonic theory.

Earthquake Engineering
"Why Buildings Collapse, Safe as Houses"
Includes discussion of liquefaction and the collapse of the Cyprus Elevated Freeway in San Francisco.

Earthquake Disaster Relief
"Raging Planet, Earthquake"
The effects of earthquakes and associated fires and tsunami on populations in many parts of the world.

with the choice of the British judges. The answer was no – and yes. While the overall best documentary selected by the delegates was not one of the judges' category winners, nevertheless several of the same films were highly rated by delegates and judges alike.

The competition has shown various interesting trends. Comparing films from different countries it is apparent that European and American approaches to earthquake design have notable differences of emphasis. Italian practice is moving towards the seismic isolation of conventional low rise housing on economic grounds while seismic isolation is still seen as the preserve of major structures in the US. While the best documentaries made telling points about the failure of reinforced concrete structures, others contained hazy or even incorrect details. Few addressed the reasons for failures of masonry or adobe structures and the measures that can be taken to improve their performance, despite the fact that such structures still account for more earthquake fatalities than all other sources combined.

Following the competition, numerous requests have been received for video copies of the documentaries. Details of those that are available are given on the SECED web site. The awards have generated much interest and enthusiasm. It is hoped that they will have helped to improve future earthquake documentaries. And it is hoped that their message will reach those who need to hear it most – those who live and work in earthquake zones.

Motivation for the Awards

The idea for the awards grew from observations of recent devastating earthquakes in Turkey and India. Both countries have modern seismic building codes yet many thousands of individuals died in collapsing structures which had failed to conform to the most basic seismic requirements. The solution to this problem requires initiatives on many levels – raised awareness among the general population to the dangers and solutions has surely got a role to play.

The T K Heish Award

This year the T K Hsieh Award was won by P D Smith, G P Whalen, L J Feng and T A Rose for the paper entitled "Blast loading on buildings from explosions in city streets". The paper was published in the Structures & Buildings Journal – February 2001.

Presentation of the authors' certificates will be held at the Awards Ceremony on Tuesday 5 November 2002 at 11.30 am in the Telford Theatre.

The T K Hsieh Award was established in 1979 in memory of Dr Tso Kung Hsieh. The award of £50 is made annually to the author(s) of the best paper published by the ICE in the field of structural and soil vibration caused by mechanical plant, waves or seismic effects.

The European Strong-Motion Database - Internet Site

Following on from the successful European Commission funded CD ROM 'Dissemination of European Strong-Motion Data' project [see SECED Newsletter V14/3], a project to establish an Internet site where European strong-motion data could be downloaded was undertaken. This project was again funded by the European Commission (contract EVR1-CT-1999-40008). As with the CD ROM project, the Internet Site for European Strong-Motion Data (ISESD) was a collaborative project between four European partners. These partners were: Imperial College of Science, Technology and Medicine, London, UK; University of Iceland, Reykjavik, Iceland; University of Trieste, Italy; and Institute of Engineering Seismology and Earthquake Engineering, Thessaloniki, Greece. University of Trieste employed Institute of Earthquake Engineering and Engineering Seismology, University Kiril and Metodij, Skopje, Macedonia as a subcontractor to provide and process strong-motion records from the former Yugoslavia. The project ran from April 2000 to March 2002.

The Internet Site for European Strong-Motion Data (ISESD) project established an Internet site for the free dissemination of European and Middle Eastern strong-motion data with associated seismological parameters in a uniform data format. This project has improved the accessibility of European strong-motion data, which in the past has often been difficult to obtain. It also seeks to increase cooperation between operators of strong-motion networks and the end users of the data by providing up-to-date details of network operators.

Four mirror Internet sites are established at the four partners' institutions. The URLs of these sites are:

http://www.isesd.cv.ic.ac.uk/
http://seismo.univ.trieste.it/
http://smbase.itsak.gr/
http://www.isesd.hi.is/

At present there are 1,968 records from 805 earthquakes recorded at 622 different stations available for download using an easy-to-use selection procedure. There are associated parameters of an additional 1,268 records on the Internet site which are not currently available for download due either to the poor quality of the records or because permission has not been given by their owners to disseminate the records. The basis of ISESD is the CD ROM 'Dissemination of European Strong-Motion Data' produced by Ambraseys N., P. Smit, R. Berardi, D. Rinaldis, F. Cotton and C. Berge-Thierry (2000) and funded by the European Commission, Research-Directorate General, Environment and Climate Programme (contract ENV4-CT97-0397). However, we have updated many of the associated parameters of the records that were contained on this CD ROM and also have added

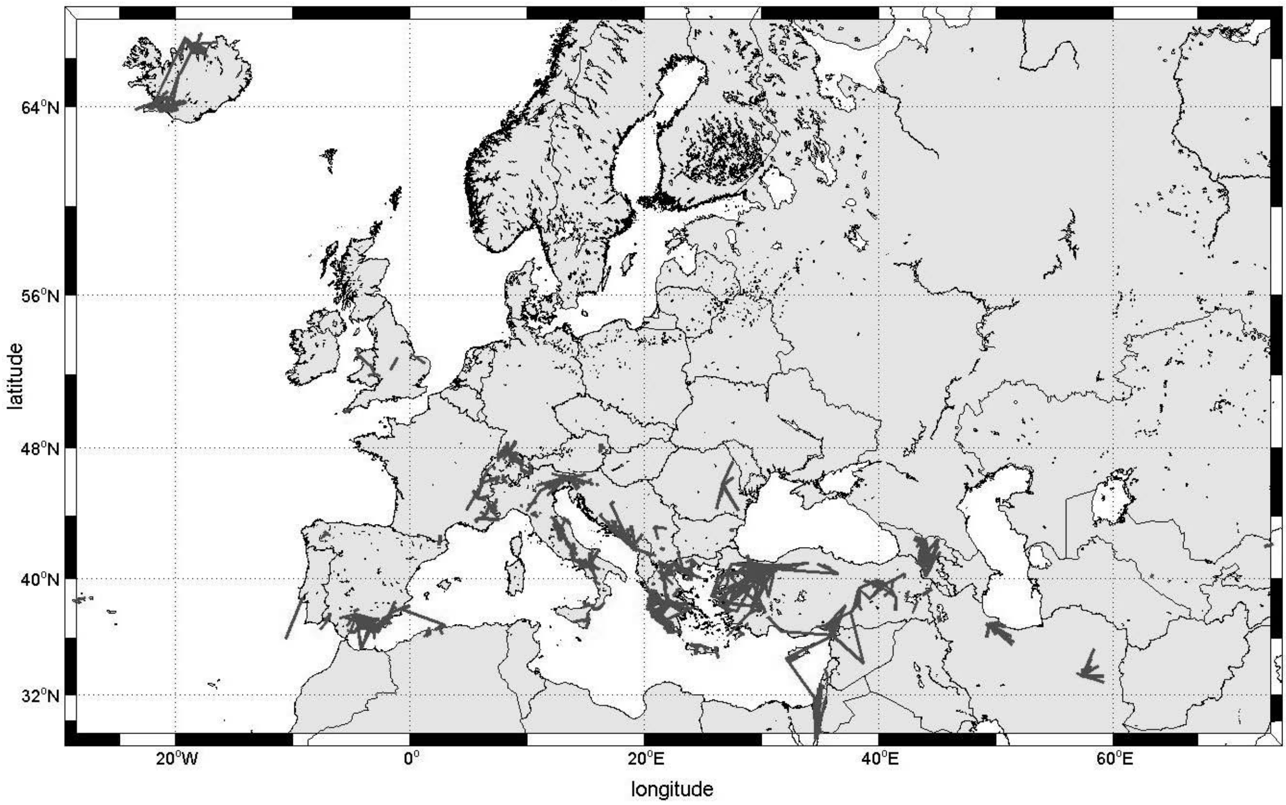

Figure 1: Geographical distribution of the ISESD databank.

more than 900 additional, mainly triaxial, strong-motion records. Figure 1 shows the geographical distribution of the strong-motion data currently catalogued on the site and Figure 2 shows the distribution of data in terms of magnitude, distance and site category.

This project is not possible without the unselfish support of the providers of the strong-motion data; we thank them very much for their help. Please see the acknowledgements page of the website for details. We are grateful for the support we received from a grant from the European Commission 5th Framework Programme (contract EVR1-CT-1999-40008). We also thank the European Commission 4th Framework Programme (contract ENV4-CT97-0397) and Engineering and Physical Sciences Research Council for financial assistance during the preliminary compilation of a data subset.

We hope that ISESD will prove useful to engineers and scientists alike. If you have any suggestions or comments please contact one of the partners. We are always grateful for new information or new strong-motion data; if you want to contribute to ISESD please do not hesitate to contact us. We hope to continue updating the data archived on the Internet site so that ISESD continues to be up-to-date.

If you use data from ISESD please cite:

Ambraseys, N., P. Smit, R. Sigbjörnsson, P. Suhadolc, and B. Margaris (2002). Internet-Site for European Strong-Motion Data, EVR1-CT-1999-40008, European Commission, Directorate-General XII, Environmental and Climate Programme, Bruxelles, Belgium.

• N. N. Ambraseys: Dept of Civil & Environmental Engineering; Imperial College of Science, Technology & Medicine; London; SW7 2BU; UK. n.ambraseys@ic.ac.uk.
• J. Douglas: Dept of Civil & Environmental Engineering; Imperial College of Science, Technology & Medicine; London; SW7 2BU; UK. john.douglas@ic.ac.uk
• B. Margaris: Institute of Engineering Seismology & Earthquake Engineering; Ministry of Environment and Public Works; Thessaloniki; Greece. margaris@itsak.gr
• R. Sigbjörnsson: Earthquake Engineering Research Centre; University of Iceland; Reykjavik; Iceland. ragnarz@afl.hi.is
• P. Smit: Dept of Civil & Environmental Engineering; Imperial College of Science, Technology & Medicine; London; SW7 2BU; UK. Now at National Emergency Operation Centre; P.O. Box, 8044 Zürich; Switzerland. p.smit@bluewin.ch
• P. Suhadolc: Dipartimento di Scienze della Terra; Universita degli Studi di Trieste; Trieste; Italy. suhadolc@dsterra.univ.trieste.it

John Douglas

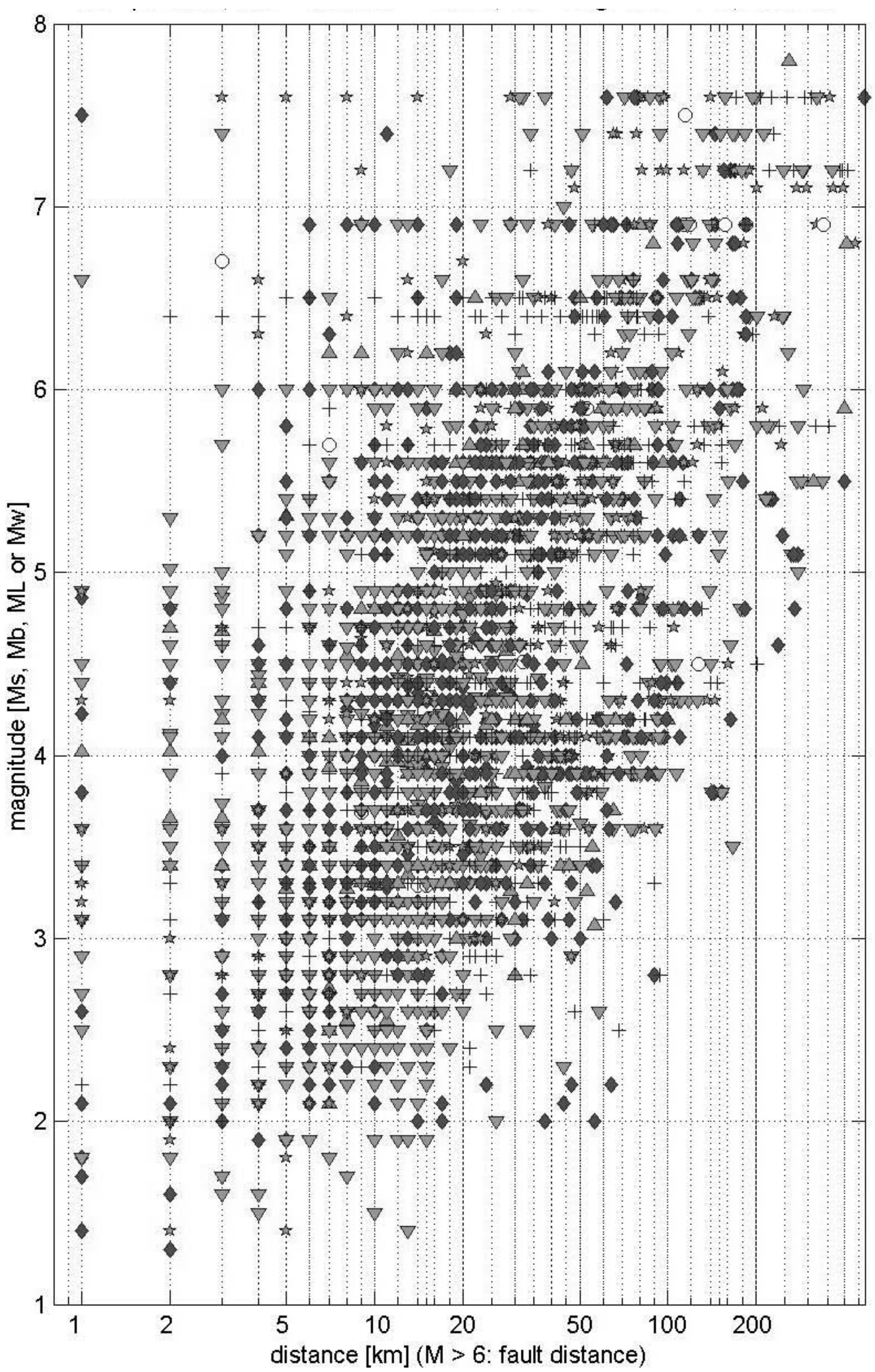

Figure 2: Distribution of the ISESD databank in terms of magnitude, distance and site category (cross is unknown, diamond is rock, upwards triangle is alluvium, downwards triangle is stiff soil, pentagram is soft soil and circle is very soft soil).

Eurocode 8 Enters Its Final Stages

Report by **Edmund Booth** on Vienna Meeting of July 2002**.**

Parts 1 and 5

A meeting of 30 engineers from a dozen European countries met in Vienna on 18-19th July to agree the final technical changes to two of the most important parts of Eurocode 8 (Design of structures for seismic actions) before their publication in their EN (Euronorm) version. The parts involved were Part 1: General rules, seismic actions and rules for buildings and Part 5: Foundations, retaining structures and geotechnical aspects. Part 1 specifies how the seismic hazard is defined, lays down the principles for analysing and assessing seismic performance, and gives some general rules for buildings. It also provides detailed rules for design of buildings in concrete, steel, steel-concrete composite, timber and masonry, and also give general rules for base isolated structures. It runs to 200 pages, and at least some of those will be essential to any seismic design using Eurocode 8 (EC8). The fact that all structures have foundations, and the unique role of soil in earthquake problems (it acts as both supporting *and* loading medium) together ensure that Part 5 is also key to any EC8 design. The achievement in Vienna was to reach an agreement on all remaining technical points in these two parts. The documents will now be revised to incorporate the agreed changes and will then be subjected to a comprehensive editorial review before being submitted to a formal vote, expected later this year.

This will complete the conversion of EC8 Parts 1 & 5 from their ENV (draft for development) versions published in 1995 into EN versions which have an effectively mandatory force under certain circumstances. It has been the result of an intensive pan-European effort over 5 years, in which the British have played a full part. The bargaining in Vienna was equally intense, while nevertheless (as confirmed by a Japanese observer) remaining remarkably cordial. The fact that sessions carried on over two days, sometimes with more than 4 hours between breaks, and that debate was conducted in a language (English) native to only two of the 30 delegates makes this even more impressive. Sometimes the discussion got bogged down in obscure details; for example, there was much debate over a factor called k, which usually had the value 1.0 and which nobody could quite remember the purpose of. In the end (wisely) we threw k out of the code altogether. Sometimes, in the interests of reaching agreement, 'nationally determined parameters' were allowed to be set, so that individual countries could effectively specify certain modified clauses to apply within their territories. Perhaps most significantly, this affects the definition of soil types under a site, which is an important factor in seismic design, and also the definition of the threshold value of seismicity below which seismic regulations need not apply (about which more later). A common European seismic zoning map is also a project for the (perhaps distant) future. By and large, however, a common set of rules has been established, and it is reported that we reached more consensus than was achieved with Part 1 of the concrete Eurocode, EC2, which attained a similar stage recently. Even where national alternatives can apply, recommended values are still given, which will be important when applying the code outside Europe.

Part 1 is a very different document from its ENV predecessor of 7 years ago, and in my view the changes make it a practical document which places it among the leading international seismic codes. Much credit for achieving this goes to Michael Fardis of Greece, the EC8 committee chairman, and Eduardo Carvalho of Portugal, its long-standing secretary. The changes include a transformation of all the material specific requirements and of the design spectra, the introduction of requirements for base isolation, and details of method for carrying out non-linear static (pushover based) methods of analysis, as an alternative to conventional linear response spectrum techniques. Revisions to Part 5 are less radical, but there are significant changes which keep this as an extremely useful document providing information currently found in no other seismic code.

An obvious question for British engineers is: "Will EC8 apply in the UK?" This is left to the decision of the British authorities, through the British Standards Institute, which can specify the threshold level of seismicity for application of the code. The (non-binding) advice in EC8 is a threshold peak ground acceleration of 4%g on rock or 5%g on soil for a return period of 475 years. The soil figure is important, since soil can amplify seismic motions by 50% or more. Something close to the rock value probably applies to around one third of the UK, and the soil value is likely to be slightly more generally exceeded. Whether it would be sensible to require EC8 to be applied in these places, or whether the UK should effectively raise the threshold to exclude itself from EC8 completely is an interesting point, on which comments are sought (see below). It should be noted that even if EC8 were to apply in the UK, simplified methods would be acceptable and no seismic detailing would be required.

Parts 2, 3, 4, and 6

Parts 1 and 5 are now set in stone, at least for a period of some years, but there are four other parts in which technical changes are still possible. Part 2: Bridges and Part 4: Silos, tanks and pipelines are expected to be finalised in the next six months, while Part 3: Strengthening and repair of buildings and Part 6: Towers, masts and chimneys will reach that stage some six months later. Almost nothing remains of the previous rules for strengthening which were (to my mind) brave but fatally flawed.

Comments Please

As the UK national technical contact for EC8, I am anxious to receive as many UK comments as possible on all these parts, for consideration by the relevant BSI committee. I would also like to gather opinions on whether or not to exclude UK entirely from the scope of EC8. Please contact me by e-mail at edmund@booth-seismic.co.uk.

NOTABLE EARTHQUAKES MARCH 2002 – AUGUST 2002

Reported by British Geological Survey

YEAR	DAY	MON	TIME UTC	LAT	LON	DEP KM	MAGNITUDES ML	MB	MS	LOCATION
2002	03	MAR	12:08	36.54N	70.42E	256		6.6		HINDU KUSH REGION
			At least 150 people were killed and 400 houses were damaged or destroyed.							
2002	05	MAR	21:16	6.06N	124.21E	33		6.3	7.2	MINDANAO
			At least 15 people were killed, more than 100 people were injured and many buildings were damaged or destroyed.							
2002	25	MAR	14:56	35.93N	69.19E	8		5.9	6.2	HINDU KUSH REGION
			At least 1,000 people were killed, 4,000 people were injured and approximately 1,500 houses were destroyed in the Nahrin area.							
2002	28	MAR	04:56	21.66S	68.33W	125			6.1	CHILE-BOLIVIA
			Landslides blocked roads and power outages occurred at Pica, Chile.							
2002	31	MAR	06:52	24.28N	122.18E	33		6.4	7.4	TAIWAN,REGION
			At least five people were killed and 200 people were injured. Three buildings collapsed and 100 houses were destroyed in the T'ai-pei area.							
2002	12	APR	04:00	35.96N	69.42E	10		5.8	5.9	HINDU KUSH REGION
			At least 50 people were killed, 150 people were injured and buildings were extensively damaged in the Do Abi-Nahrin area.							
2002	20	APR	10:50	44.51N	73.66W	5			5.0	NEW YORK,USA
			Roads, chimneys, bridges and water mains were damaged in Clinton and Essex Counties.							
2002	24	APR	10:51	42.44N	21.47E	10		5.6	5.6	BALKAN REGION
			One person was killed and at least 60 people were injured in Kosovo.							
2002	24	APR	19:48	34.64N	47.40E	33		5.2	5.2	WESTERN IRAN
			At least 2 people were killed, 56 people were injured and 10 villages were destroyed.							
2002	25	APR	17:41	41.77N	44.96E	10		4.8	4.3	NW CAUCASUS
			At least 5 people were killed, 52 people were injured and 2,400 buildings were damaged or destroyed at Tbilisi.							
2002	26	APR	16:06	13.10N	144.62E	86		6.5		MARIANA ISLANDS
			At least 5 people were slightly injured and some minor damage occurred to buildings on Guam.							
2002	02	MAY	01:48	57.02N	4.79W	3	2.3			LOCH LOCHY
			Felt with intensities of 3 EMS.							
2002	03	MAY	18:44	57.33N	5.33W	4	2.3			SHIEL BRIDGE
			Felt with intensities of 3 EMS.							
2002	03	MAY	18:46	57.33N	5.33W	3	2.0			SHIEL BRIDGE
			Felt with intensities of 3 EMS.							
2002	03	MAY	21:35	57.33N	5.33W	4	1.4			SHIEL BRIDGE
			Felt with intensities of 2 EMS.							
2002	15	MAY	03:46	24.64N	121.92E	10		5.5	6.2	TAIWAN
			One person was killed and 2 houses were damaged at Tung-shan.							
2002	28	MAY	04:04	28.94S	66.78W	22		6.0	5.7	ARGENTINA
			Twenty-seven people were injured and at least 40 houses were destroyed.							
2002	20	JUN	17:26	51.57N	3.08W	16	2.8			CARDIFF,S GLAM
			Felt with intensities of 3 EMS.							
2002	22	JUN	02:58	35.63N	48.95E	10			6.5	WESTERN IRAN
			At least 227 people were killed and approximately 1,600 people were injured and extensive damage occurred in the Buin Zahra-Avaj area.							
2002	24	JUN	01:20	35.76N	9.87E	10		5.4		TUNISIA
			Twelve people were injured and some houses collapsed in the Kairouan area.							
2002	31	JUL	00:16	7.99N	82.78W	10			6.5	SOUTH OF PANAMA
			At least eleven people were injured and some houses were damaged in the Baru area.							
2002	15	AUG	05:30	1.25S	121.36E	33			6.2	SULAWESI
			Approximately fifty people were injured and 500 houses were destroyed.							
2002	19	AUG	11:01	21.70S	179.51W	580			7.6	FIJI ISLANDS REGION
2002	19	AUG	11:08	23.88S	178.41W	694			7.7	S OF FIJI ISLANDS

Issued by: Bennett Simpson, British Geological Survey, September 2002.

Earthquake Engineering in the UK – Information Needed !

The collective capacity of the UK in the field of earthquake engineering, in both practice and research, is stronger than ever and the UK may now be considered an important international player in this area. The UK standing in seismology and earthquake engineering is illustrated by many examples, ranging from the location of the International Seismological Centre in Berkshire to major engineering projects design by UK consultants for seismically active regions; from being a major international centre of earthquake insurance and reinsurance to leadership in earthquake risk mitigation projects in the developing world; from the manufacture of seismic recording instruments and damping and isolation devices to participation in European and international research projects. The hosting of the very successful Twelfth European Conference on Earthquake Engineering in London in September has further raised the profile of the UK contribution to the field.

In line with its mission statement to promote UK earthquake engineering, SECED is sponsoring a Special Supplement of the New Civil Engineer (NCE) on this topic, to be published in the Autumn. SECED has also agreed to purchase a bulk order of the supplement to distribute copies to all Conference delegates and to key institutions and organisations in the UK and overseas, such as DfID, DTi, the British Council, UNESCO and the World Bank. In total we estimate that 85,000 copies of this statement of capabilities for the UK earthquake engineering community will be distributed and it is really important that the coverage it gives is as comprehensive as possible. Proposals for projects or activities to be featured in the articles in the supplement should be sent before the end of October to Edmund Booth, fax 020 8925 0012, E-mail: edmund@booth-seismic.co.uk. Advertising space, at very reasonable rates, will be available in the NCE special supplement – for details contact Antony Oliver, Editor, New Civil Engineer, 151 Rosebury Avenue, London EC1R 4GB, fax: 020-7505-6667, e-mail: antony.oliver@construct.emap.com.

Julian Bommer

Online Reports

Two new publications from the California Seismic Safety Commission (CSSC) are now available for free download at www.seismic.ca.gov:

- A Homeowner's Guide to Earthquake Safety has been updated to include several gas safety recommendations.
- A related publication is titled "Improving Natural Gas Safety in Earthquakes" and was adopted by the CSSC in July 2002.

Forthcoming Events

30 October 2002
Seismic Design of Port Structures. International Guidelines.
(Joint One Day Seminar with the International Navigation Association)
Entrance by ticket only.
ICE 9.30am to 5pm

27 November 2002
Dealing with Uncertainties in Earthquake Engineering - Professor Duarte, Lisbon.
ICE 5.30pm

29 January 2003
The Earth as a Musical Instrument - Frank Scherbaum.
ICE 5.30pm

26 February 2003
Seismic Walkdown - a Technique for Evaluating Seismic Capability.
ICE 5.30pm

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).

Articles should be sent to:

John Sawyer,
Editor SECED Newsletter,
Scott Wilson,
Scott House,
Basingstoke,
Hants,
RG21 4JG,
UK.

Email: john.sawyer@scottwilson.com

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.

For further information about SECED contact:
The Secretary,
SECED,
Institution of Civil Engineers,
Great George Street,
London SW1P 3AA, UK.

SECED Website

Visit the SECED website which can be found at http://www.seced.org.uk for additional information and links to items that will be of interest to SECED members.
Email: webmaster@seced.org.uk