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The El Salvador Earthquake of 13th January 2001

Julian Bommer reports on the UK mission sent to observe the damage caused by this earthquake

Following the destructive earthquake that struck the Central American republic of El Salvador on 13th January 2001, a team from the UK made a 10-day visit to the affected areas. The team, funded by the Natural Environment Research Council and the Royal Academy of Engineering, was made up of Julian Bommer (Imperial College), Bill Murphy (University of Leeds) and Joseph Mankelow (British Geological Survey). The team was joined in the field by Carlos Rodríguez, an Imperial College alumnus, from the National University of Colombia in Bogota. Locally the team had an excellent support network as a result of long-standing collaborations with colleagues in El Salvador (Bommer, 1998) and were joined in the field work by Patricia Méndez de Hasbun from the Central American University (UCA), Manuel López Menjívar from the University of El Salvador (UES) and Herman Rosa and colleagues from the foundation PRISMA (Salvadorean Programme for Research on Development and Environment).

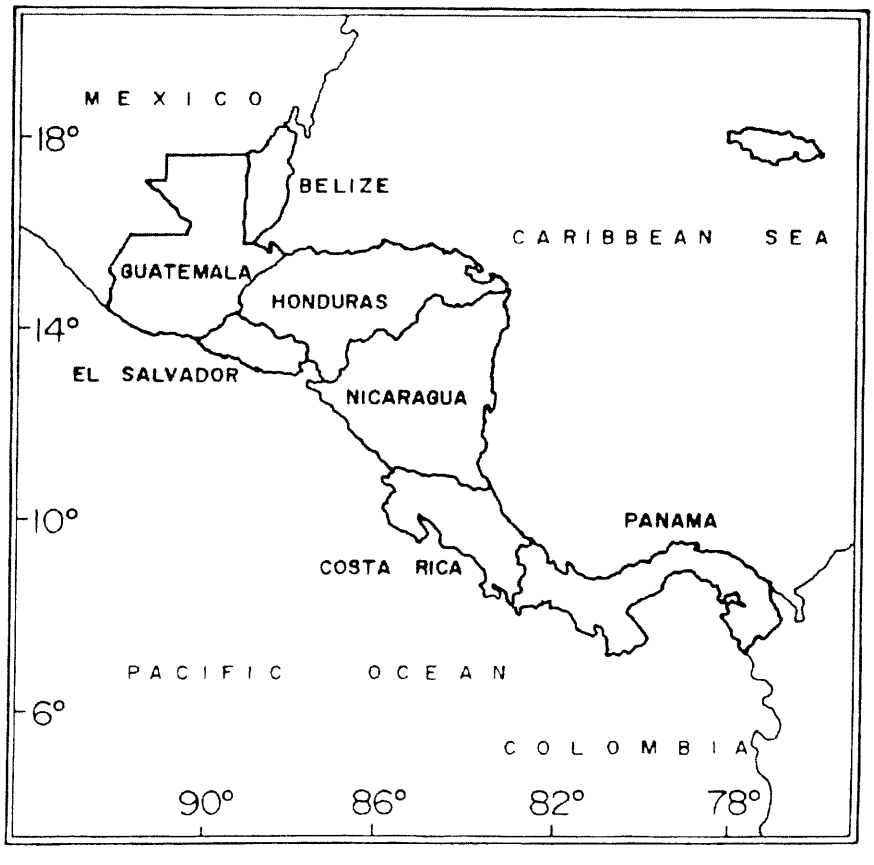

Figure 1 Location of El Salvador in Central America.

Geographical and Seismic Setting

El Salvador is the smallest of the Central American republics (Figure 1) having about the same geographical extent as Wales. The population is estimated at about 6 million, very unevenly distributed throughout the country with well over half the population concentrated in the southwest third of the territory, which happens to also be the zone of highest seismic hazard (Bommer *et al.*, 1998*a*).

The seismicity El Salvador is dominated by the subduction of the Cocos plate below the Caribbean plate in the Middle America Trench at a rate of about 7 cm/year (Figure 2). This process gives rise to two main sources of seismicity, the first being earthquakes in Benioff-Wadati zones within the subducted Cocos plate, which can reach large magnitudes. The second source of seismic activity is within the chain of Quaternary volcanoes that extends from Guatemala to Costa Rica, where shallow focus earthquakes of moderate magnitude occur. These upper-crustal earthquakes are generally tectonic rather than volcanic origin, probably generated by an oblique component of the tectonic convergence between the Cocos and Caribbean plates (White, 1991).

The earthquake of 13 January was the fifth destructive event to hit El Salvador in a period of 50 years, starting with a sequence of three upper-crustal earthquakes in May 1951 that destroyed towns in the east of the country and left a death toll of 400 (Ambraseys *et al.*, 2001). Destructive upper-crustal earthquakes

struck the capital city, San Salvador, in May 1965 and October 1986, causing death tolls of 120 and 1,500 respectively (Bommer & Ledbetter, 1987). On 19 June 1982, a subduction earthquake of M_w 7.3 occurred with an epicentre off the coast of western El Salvador, triggering landslides over a wide area but only causing damage to the weakest houses. The death toll from the 1982 earthquake is reported as 45 (Ambraseys & Adams, 2001).

Earthquake Characteristics and Strong-Motion

The earthquake occurred at approximately 11:30 am local time on Saturday 13th January 2001. The earthquake was located in the subduction zone offshore from El Salvador (Figure 3), within the subducted Cocos plate, with a focal depth estimated between 40 and 60 km. The magnitude of the earthquake

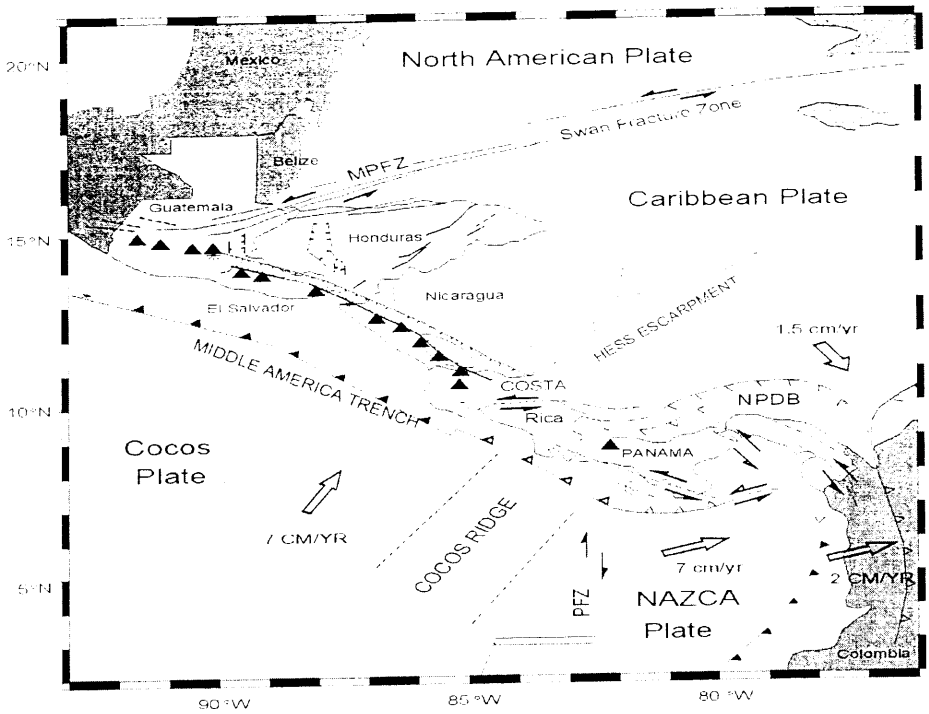

Figure 2 Tectonics of Central America.

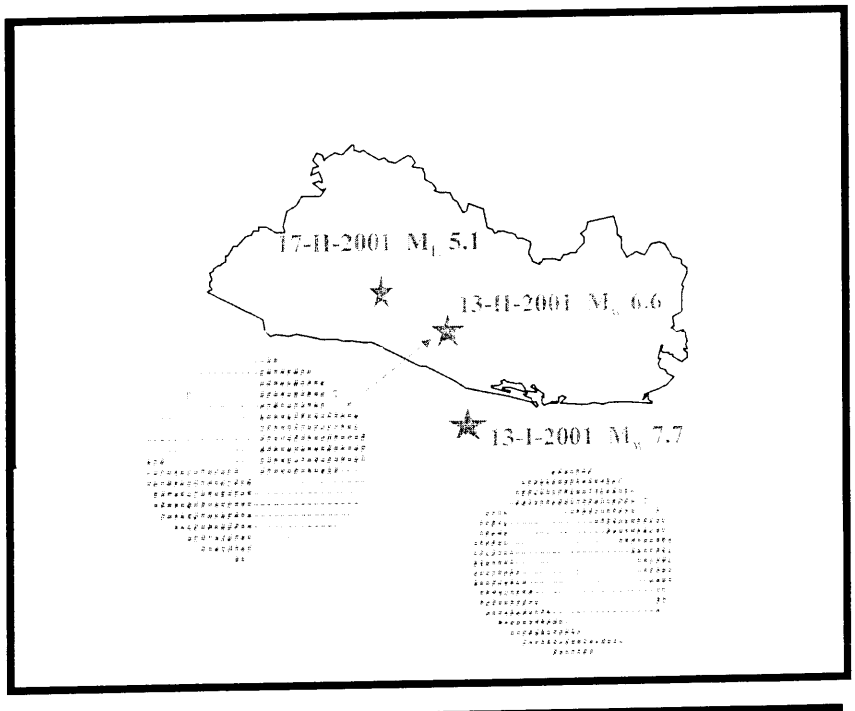

Figure 3

Epicentres of the earthquakes of 13 January and 13 and 17 February. The focal mechanisms of the first two events are also shown.

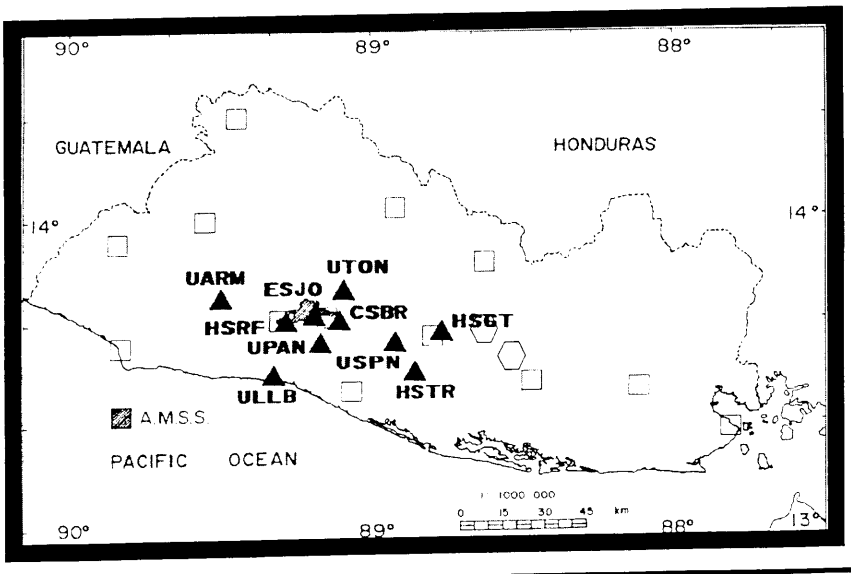

Figure 4

Locations of the strong-motion instruments of the TALULIN network (solid triangles). The open squares are instruments operated by CIG and the hexagons are the instruments of the GESAL network, installed in geothermal fields and hydroelectric dams.

has been determined as M_s 7.6 and M_w 7.7, making it larger than any earthquake in El Salvador during the twentieth century (Ambraseys & Adams, 2001). The earthquake was followed by a series of aftershocks and then a second earthquake occurred on 13 February. The epicentre of this earthquake, which was of magnitude M_w 6.6, was to the southwest of the capital San Salvador. This second event caused additional damage and almost 300 casualties, in addition to the death toll of almost 1,000 in the first earthquake. The earthquake on 13 February was not an aftershock of the main event on 13 January, having a different focal mechanism (Figure 3) and a much shallower focal depth (estimates range from 13 to 30 km), which places it within the overriding Caribbean plate whereas the first event was within the subducted Cocos plate. A third earthquake occurred on 17 February on the outskirts of San Salvador; this event was of much smaller magnitude (M_L 5.1) but was of very shallow focal depth and due to its proximity to the city caused widespread panic as well as some minor structural damage.

The main shock of 13th January was recorded by a digital accelerograph network installed in El Salvador in 1996 (Bommer *et al.*, 1997). The location of the instruments are shown in Figure 4; two of the 10 accelerographs did not record the main event due to malfunction, but eight records were obtained. In addition to these, a record from another SSA-2 instrument installed at the geothermal energy plant in Berlín, in eastern El Salvador, was also kindly made available by the energy company GESAL. The records have been processed by Mauricio Ciudad-Real, a Salvadorean colleague at Kinemetrics Inc., giving a high degree confidence in the data. The peak recorded values of ground acceleration, some of which appear disproportionately high, are shown in Table 1. Two examples of the strong-motion records, from a station on the coast at the port of La Libertad – the closest station to the assumed location of the fault rupture – and another from the town of San Pedro Nonualco, located southwest of the capital on a ridge, are shown in Figures 5 and 6.

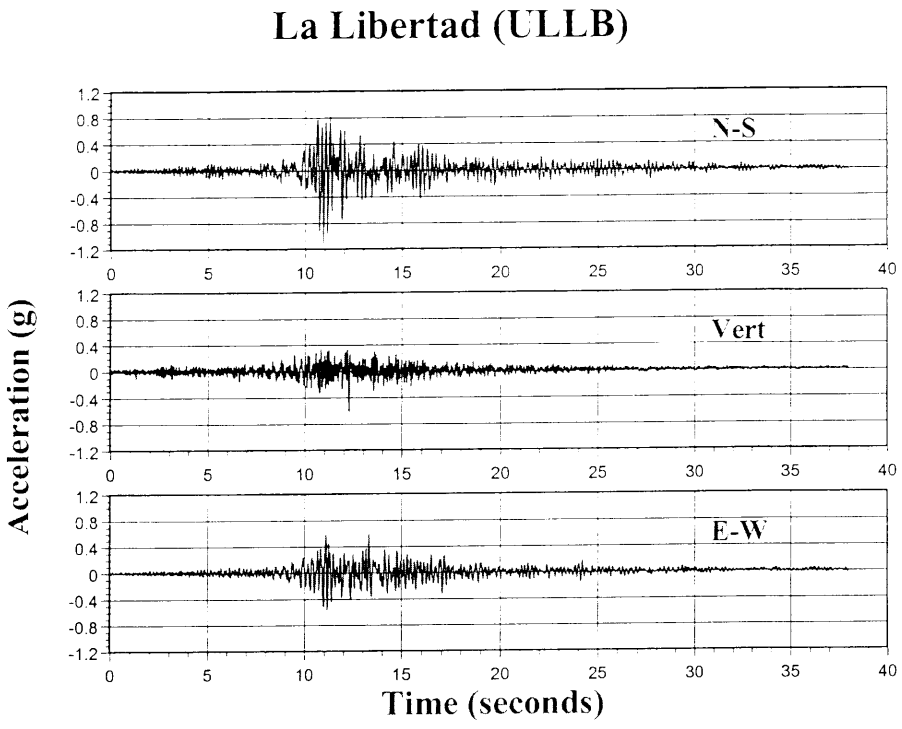

Figure 5 Strong-motion accelerogram from La Libertad station.

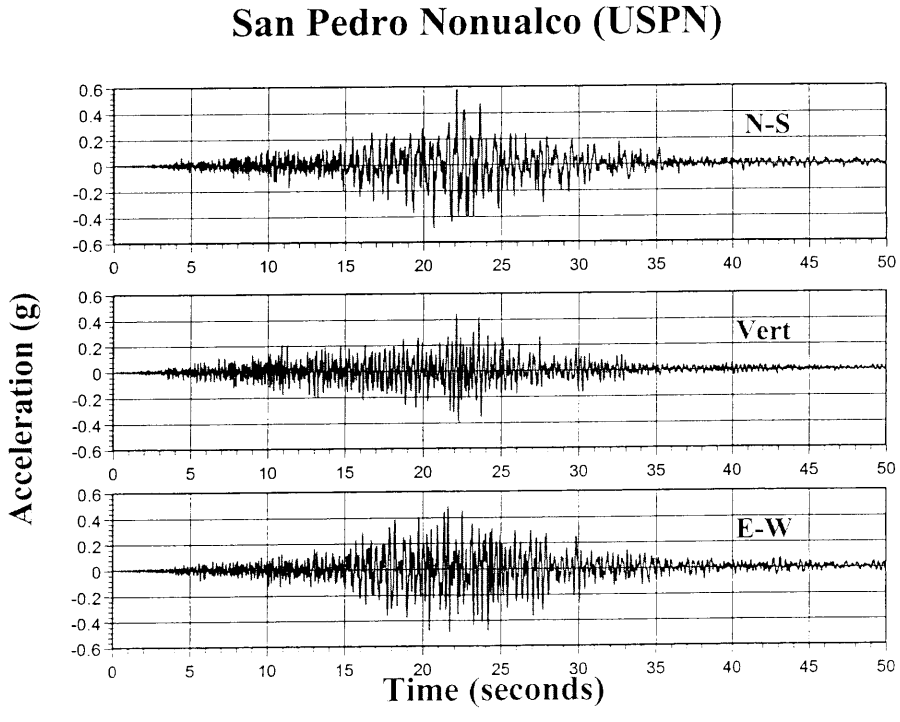

Figure 6 Strong-motion accelerogram from San Pedro Nonualco station.

Table 1. Recorded values of peak ground acceleration, PGA.

STATION	COORDINATES		PGA (g)		
	N	W	L*	V*	T*
ULLB	13.468°	89.327°	1.113	0.617	0.575
UARM	13.744°	89.501°	0.601	0.454	0.223
HSRF	13.671°	89.279°	0.496	0.243	0.487
UPAN	13.614°	89.179°	0.117	0.089	0.154
UPSN	13.602°	88.927°	0.580	0.439	0.488
CSBR	13.705°	89.106°	0.157	0.166	0.199
ESJO	13.707°	89.207°	0.301	0.154	0.278
UTON	13.778°	89.114°	0.263	0.205	0.234
Berlin	13.50°	88.53°	0.459	0.235	0.370

* Components: L – longitudinal, V – vertical, T – transverse.

Damage to Buildings

Surprising, despite the very high7 accelerations, damage to engineered structures was very limited. In fact, even reinforced masonry generally fared well and heavy damage was mainly encountered in adobe (clay brick) houses (Figures 7 and 8). Damage was generally higher in rural areas, where vulnerability is greater, and in towns and villages located on ridges or slopes. There were also many cases of damage, including total collapse, in *bahareque* houses, which are made from timber vertical members, bamboo horizontals, infilled with mud and covered with stucco. *Bahareque* construction generally displays good seismic resistance when recently constructed but the action of the tropical climate and insects rapidly deteriorates the building materials causing vulnerability to increase with age.

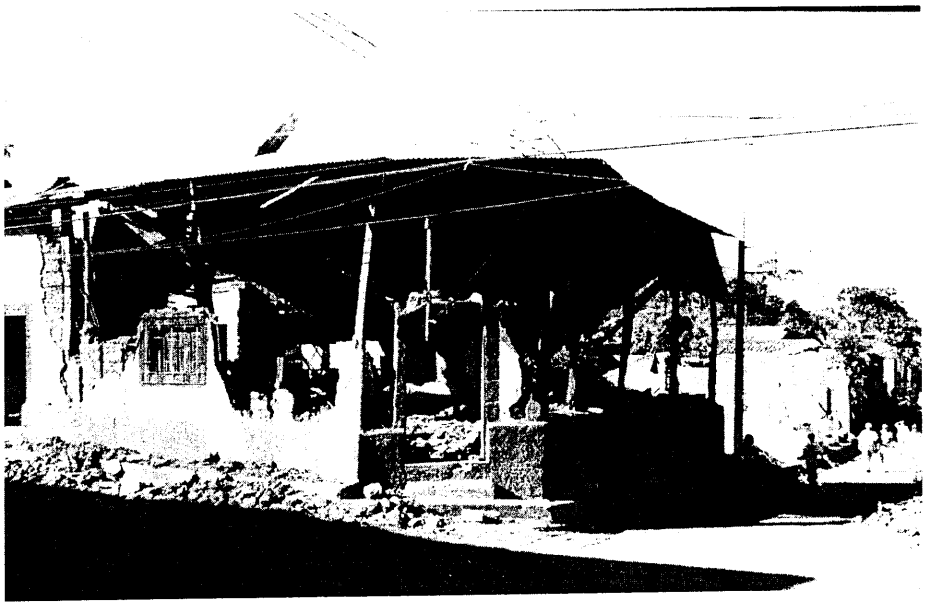

Figure 7 Damaged adobe house in Santiago de María. (*Photo: Manuel López Menjívar*).

It has been noted previously that the ground motions produced by subduction earthquakes in El Salvador are generally not damaging to engineered structures and it is believed that this is due to the fact that the rate of energy input is relatively low. Recordings of the 1982 subduction earthquake obtained in San Salvador had almost exactly the same total Arias intensity (integral of the square of the acceleration) as the records from the local earthquake (M_w 5.7) that occurred on 10 October 1986. The reason that the motions in the latter case were so much more destructive seems to be due to the much shorter duration of the shaking, whereby the energy was imparted to structures over three seconds as compared with 30 seconds in the case of the subduction event (Bommer & Martínez-Pereira, 1999). However, for brittle materials with low initial strength and strongly degrading dynamic

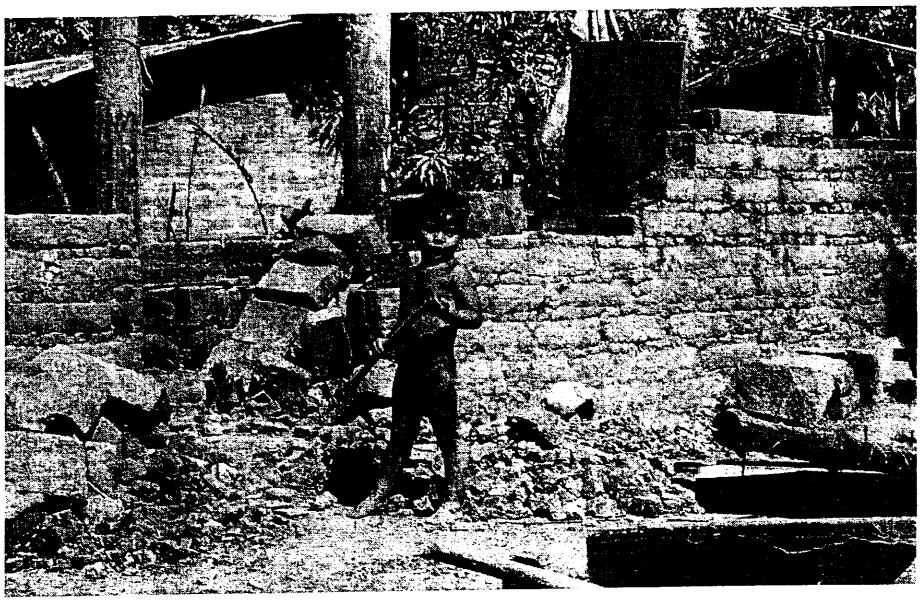

Figure 8 Collapsed adobe houses in San Agustín.

Figure 9 Debris flow that buried houses in the Las Colinas neighbourhood.

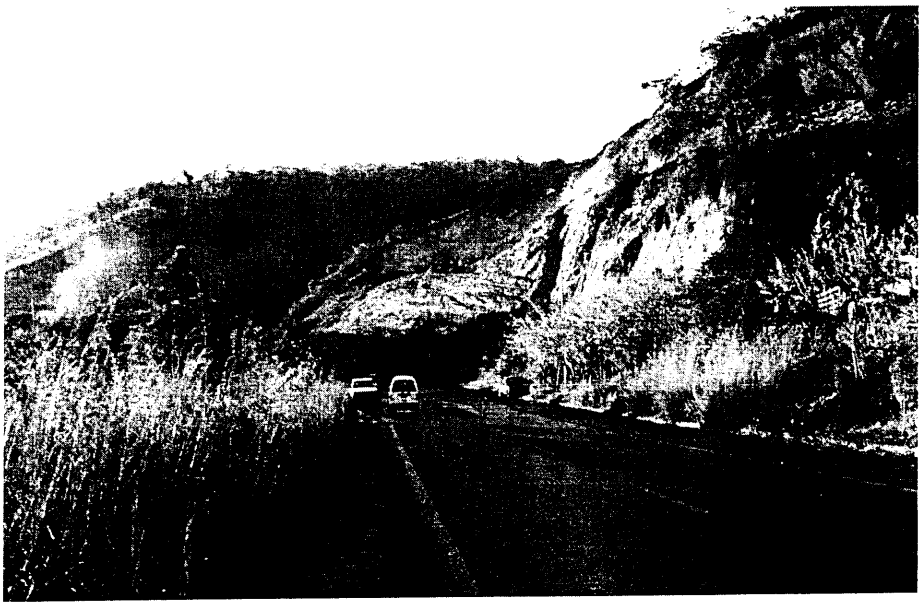

Figure 10 Major landslide at Las Leonas blocking the Pan-American Highway.

response characteristics, such as adobe, the total energy of the shaking seems to be the most important parameter in controlling the overall level of damage. It has also been found that the total Arias intensity is a good indication of the capacity of the ground motion to trigger landslides (Harper & Wilson, 1995).

Landslides

The main impact of the earthquake, in terms of death toll and disruption, was the very large number of landslides triggered by the earthquake, including the infamous case of the debris flow at Las Colinas in Santa Tecla, just to the west of San Salvador. This catastrophic slope failure buried as many as 500 people (Figure 9) and many as another 105 died in another landslide at nearby Las Barrioleras.

Landslides of similar size occurred in many locations and caused great destruction, as well as blocking many roads; a huge slide on the Pan-American Highway at Las Leonas completely blocked this important transportation route for several weeks (Figure 10), and also buried several vehicles and their occupants. Hill slopes in the area west of San Salvador showed numerous debris flow failures that are the subject of ongoing investigation.

Smaller landslides also occurred in great numbers, often in near-vertical

slopes; although these falls were generally small, they frequently produced significant damage as a result of the density of settlement (Figure 11).

Landslides were triggered across most of the southern half of El Salvador, with particularly high concentration in the Cordillera del Bálsamo to the southwest of San Salvador (Figure 12). Numerous instances of slope instability were observed on the volcanoes distributed along the central valley that runs from west to east across El Salvador, affecting many coffee plantations on steep slopes. The earthquake occurred during the coffee harvesting period and a number of pickers were buried by these slides. Occasional rockfalls and rockslides also occurred, particularly along the coastal road. Liquefaction and lateral spreading were encountered near to the coast in a number of locations, on the shores of Lake Ilopango and also at some locations on the banks of the Lempa River (Figure 13).

A major part of the work being undertaken as part of the investigation of this earthquake is detailed investigation of the seismic behaviour of steep slopes in the volcanic ash deposits encountered in most of the densely populated areas of El Salvador. Undisturbed block samples of the most commonly encountered volcanic ash deposit, *tierra blanca*, were recovered from a construction site to the southwest of San Salvador (Figure 14). These will be used to

Figure 11 Fall in near-vertical cutting causing collapse of house, Santiago Texacuangos.

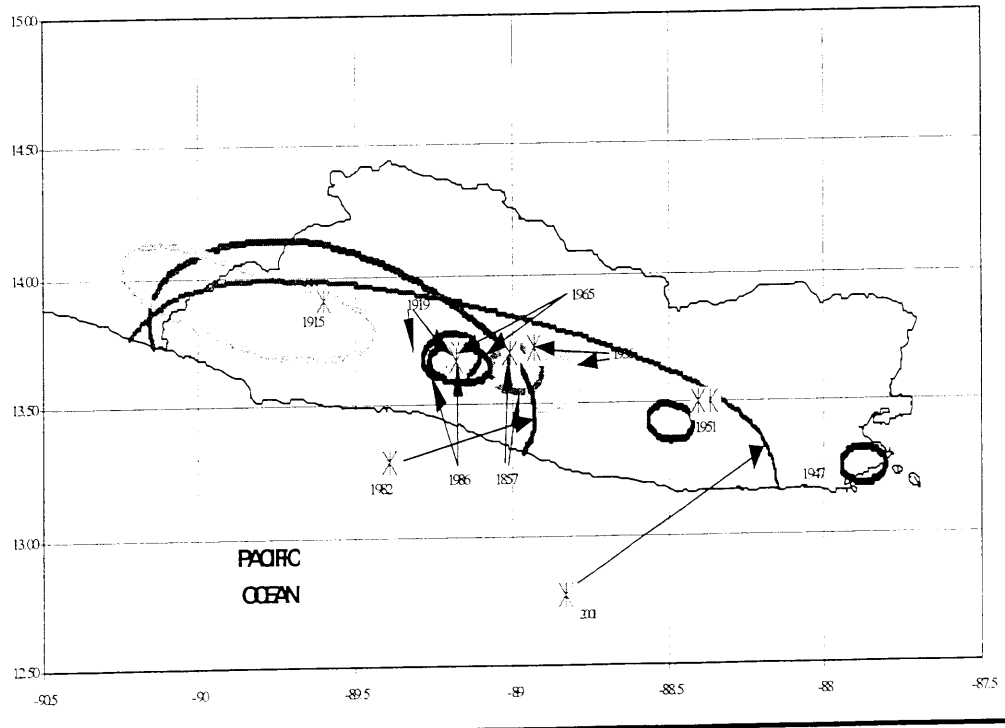

Figure 12 Areas affected by landslides in earthquakes in El Salvador, including the 13 January 2001 event.

extend work undertaken previously on samples recovered in and 2000, which were used for a series of experiments at Imperial College (Bommer *et al.*, 1998*b*; Mavrommati, 2000). The geotechnical data collected from these samples will be incorporated within a geographic information system (GIS) along with field observations. The aim of the GIS-based analysis is to identify geological and geomorphological criteria for future hazard analysis, and seeking to improve current techniques for the assessment of earthquake-triggered landslides hazard such as that developed by Mankelow & Murphy (1998).

Figure 13 Failure of railway bridge pier due to liquefaction-induced lateral spreading on the banks of Lempa River (*Photo: Manuel López Menjívar*).

Conclusions

The earthquake of 13th January, and the events that have followed it, have revealed disturbing patterns of rapidly increasing seismic risk in El Salvador. The very severe impact of the earthquake-induced landslides, despite the earthquake occurring during the dry season, point to the effects of uncontrolled urbanisation, inappropriate land use and deforestation, especially when the impact is compared with the landslides triggered by the 1982 earthquake. As the rainy season begins in May, there are fears that many more landslides will be triggered that will cause additional destruction and loss of life. In September 1982, three months after the previous major subduction earthquake, four days of sustained rainfall led to a mud flow on the slopes of the San Salvador volcano that buried more than 500 people.

There are also serious concerns about the safety of large engineered structures that appear to have survived these earthquakes unharmed. Destructive earthquakes in El Salvador occur on average once every decade hence many structures are subjected to severe seismic loads more than once and cumulative damage is an important factor in the seismic risk equation. It is known that a large number of the buildings that collapses in the 1986 earthquake had been severely weakened in the similar earthquake 21 years earlier; it is less well-known to what extent these buildings were further weakened by the subduction zone earthquake of 1982.

Figure 14 Extracting undisturbed block samples of *tierra blanca* volcanic ash.

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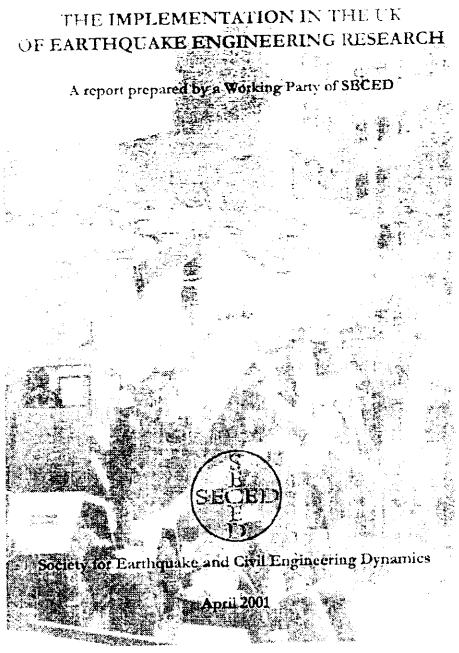
The Implementation in the UK of Earthquake Engineering Research

A final draft of the report by the Research Working Party on the "The Implementation in the UK of Earthquake Engineering Research" is in the final stage of review by the SECED committee. The draft report can be found on the SECED website (http://www.seced.org.uk) and comments from members are requested. It is hoped that a paper version of the full report will be published in the near future.



New Publications

"The Seismicity of Central America: A descriptive catalogue 1898-1995" is a new book by N. Ambraseys and R. Adams. It combines information from felt earthquakes and instrumental recordings to reassess the location and size of more than 700 events since the beginning of the instrumental era. The 250-page book is published by Imperial College Press and distributed by World Sci. Publications. It is available for £42 with special prices for those in developing countries and some Eastern European countries. For orders contact: World Scientific Publishing, 57 Shelton Street, Covent Garden, London WC2H 9HE; Fax +44-(0)20-7836-2020, E-mail: sales@wspc.co.uk

"Re-appraisal of the seismicity of Iceland", by N. Ambraseys and R. Sigbjörnsson, a 183-page book published by Polytecnica and available from the Earthquake Engineering Research Centre of the University of Iceland, Reykjavik, Iceland.

"Third National Seismic Conference and workshop on bridges and highways"

The latest advancements in earthquake design and retrofit will be the focus of presentations at the Third National Seismic Conference and Workshop on Bridges and Highways, April 28 through May 1, 2002, in Portland, Oregon, Buffalo, NY. The conference will feature as many as 60 presentations and 25 poster presentations on new and innovative technologies, including the latest research and developments involving earthquake engineering for bridges, highway systems, and components.

Additionally, the program will include an International Forum comprising invited speakers from countries that have implemented advanced earthquake design and mitigation technologies and techniques. It will also include a Technology Showcase involving as many as 40 exhibitors of contemporary products and services for seismic design and retrofit.

The conference is expected to attract worldwide participation from bridge and highway engineers, design consultants, researchers, and federal, state and local transportation agency owners.

The conference theme is "Advances in Engineering and Technology for the Seismic Safety of Bridges in the New Millennium."

It is sponsored by the Federal Highway Administration, Oregon Department of Transportation, and the Washington State Department of Transportation. It is organized by the Federal Highway Administration's Western Resource Center, and the Multidisciplinary Center for Earthquake Engineering Research (MCEER) headquartered at the University at Buffalo.

The conference will provide a forum for information on current practices and research for seismic-resistant design and retrofit of bridges and highway systems in all seismic zones. Presentations will focus on the latest advances in engineering and technology for seismic safety.

Session topics include:

- Effects of near-field earthquakes on bridges
- Displacement based design
- Lessons learned from recent earthquakes (since 1998)
- Design on major new long span bridges in high or moderate seismicity areas
- Design strategies for major ground movements under bridges
- Emerging seismic design and retrofit technologies
- Seismic response modification devices

Members of the conference steering committee include: Roland Nimis, FHWA, Western Resource Center (Chair); Michel Bruneau, Multidisciplinary Center for Earthquake Engineering Research; Ian Buckle, University of Nevada, Reno; James Cooper, Federal Highway Administration; Mark Hirota, Oregon Department of Transportation; James Roberts, California Department of Transportation; Frieder Seible, University of California, San Diego; Jerry Weigel, Washington State Department of Transportation; and Michael Higgins, Pure Technologies (Secretary).

Conference cosponsors include: the California Department of Transportation, Mid America Earthquake Center, MCEER, Pacific Earthquake Engineering Research Center, and the Transportation Research Board.

A call for papers will be issued later this spring. For more information contact: Michael S. Higgins, P.E., Regional Manager, Eastern Region, Pure Technologies US Inc., 10015 Old Columbia Road, Suite B-215, Columbia, MD 21046; Tel: 410-309-7050; Fax: 410-309-7051; Email: mike.higgins@soundprint.com

"Strong Motion Research"

The major task of compiling a comprehensive and up-to-date databank of strong motion records from earthquakes in the European and adjacent regions has been complete by the Engineering Seismology and Earthquake Engineering Section at Imperial College. The data and their associated seismological parameters were collected and processed over the last decade by members of the ESEE Section (N. Ambraseys, J. Bommer, J. Crowther, G. Eleftheriades, M. Free, J. Menu, S. Sarma, K. Simpson, M. Srbulov), and more recently with the addition of data from the Ente Nazionale per l'Energia Elettrica (ENEL Rome), the Ente per Nuovi Technologie, l'Energia el'Ambiente (ENEA, Rome) and from the Institut de Protection et de Sûretè Nuclèaire (IPSN Paris).

With the support of the Environment and Climate Research Programme of the European Commission, a CD-ROM is now freely available. It contains a database and a databank of 1070 uncorrected and uniformly corrected strong motion records, including corresponding spectra and reappraised associated seismological parameters generated by earthquakes of all magnitudes up to 7.4 in the region from the Azores Islands to Iran and from Iceland to Algeria. The associated software and CD-ROM were produced with the assistance of Drs F. Cotton and P. Smit.

To facilitate distribution of the CD-ROM, requests from the European area, west of 10°E may be addressed to Dr. F. Cotton (fabrice.cotton@ipsn.fr); east of 10°E, and north of 45°N, to Dr. R. Berardi (berardi.raniero@enel.it), east of 10°E, and south of 45°N, to Dr. D. Rinaldis (dario.rinaldis@casaccia.enea.it), and from the UK and from outside the European area, to Prof. N. Ambraseys (n.ambraseys@ic.ac.uk) and Dr. P. Smit (p.smit@ic.ac.uk). The supporting agency may supply, on request, additional CDs (Director, Environment and Climate Research Programme, DGXII, European Commission, Rue de la Loi 200, Bruxelles 1049, Belgium).

The second phase of this project, which is in progress, aims at the establishment at Imperial College a European Internet-Site for European strong motion data with mirror sites at Reykjavik, (Prof. R. Sigbjornsson), Triest (Prof. P. Suhadolc) and Thessaloniki (Dr. B. Margaris). The coordinator of the Project is Prof. N. Ambraseys and the technical manager is Dr. P. Smit (ICSTM). The aims of this 5th Framework EC sponsored project are: (a) to retrieve, process and preserve by storing on the platform strong motion data recorded by analogue instruments before the mid 1990s, as well as to process and store all strong motion records generated during the period of the project, (b) to install the platform on the Internet with similar sites at the Institutes and organisations participating in the project, and (c) to establish a freely accessible platform of a reliable strong-motion databank and associated database of seismological parameters of earthquakes in the greater European area.

Two recent, pertinent Research Reports produced with EPSRC support:

Ambraseys N. and Douglas J. (2000) "Reappraisal of the effect of vertical ground motions on response", ESEE Report no.00-4, Imperial College, and

Douglas J. (2001) "A comprehensive worldwide summary of strong-motion attenuation relationships for peak ground accelerations and spectral ordinates 1969 to 2000" ESEE Report no.01-1, Imperial College, are available from:
http://www.esec.cv.ic.uk/reports.htm

EERI Special Earthquake Reports

New CDs and reports are now available covering the Bhuj, Kocaeli and Nisqually earthquakes

Images from the Bhuj, India, Earthquake of January 26th, 2001.
A new CD is available from EERI which contains over 400 images illustrating geotechnical damage, liquefaction effects, emergency response and relief, and damage to structures, bridges, lifelines, historic monuments, industrial facilities, dams, railways, and ports. The CD includes photos of typical construction materials and construction techniques, as well as aerial views, full-color figures and maps. Image resolution is 300 dpi. The CD contains a .pdf file with thumbnail images and captions for each image, separated into 13 major categories and various subcategories. The EERI Special Earthquake Report on the earthquake describing its initial impact (which is also available on-line at http://www.eeri.org/Reconn/bhuj_India/Guraratinsertc.PDF) is also included on the CD. An order form for the CD can be found at http://www.eeri.org/Publications/CDS.PDF (EERI Members $US 40, Non-members $US 50)

Kocaeli, Turkey Reconnaissance Report and Separate Full-Colour Images
This CD-ROM includes the full text of the 457-page 1999 Kocaeli, Turkey, Earthquake Reconnaissance Report. This final, comprehensive report contains the conclusions emerging a year after the magnitude 7.4 Kocaeli earthquake of August 17, 1999, and the 7.1 Duzce earthquake of November 12, 1999. It includes many colour photographs, figures, and observations on seismicity, fault rupture, tsunami, strong motion, ground failure and geotechnical effects, structures and industrial facilities, building code enforcement, lifelines, and societal impacts and emergency response. All figures are supplied in full colour separately for easy insertion into presentation software. (Members $US 60, Non-members $US 80)

The Nisqually Earthquake
The Nisqually earthquake clearinghouse website has been upgraded with information on geotechnical and other aspects of the February 28 earthquake.

The website can be found at http://www.ce.washington.edu/~nisqually The website will be updated frequently, so feel free to check it periodically.

The EERI preliminary reconnaissance report, published recently, can also be downloaded from this website or from http://www.eeri.org

Imperial College launches new Masters course in

"Earthquake Engineering and Risk Management"

The ESEE Section of Imperial College is launching a new Master course in Earthquake Engineering Risk Management. The course is based on the most up-to-date concepts in hazard assessment, seismic design and risk management. It builds on the international success and high profile of the MSc in Earthquake Engineering and Structural Dynamics, run by Imperial College since 1987 and provides a most important element to the training, with new modules in theory of risk management, disaster mitigation of engineering planning and assessment of safety-critical structures.

There is a strong contribution from Industry to the teaching and running of the course and the Engineering and Physical Sciences Research Council of the UK has given the Section funds that allows them to offer 4-5 scholarships to suitably qualified individuals.

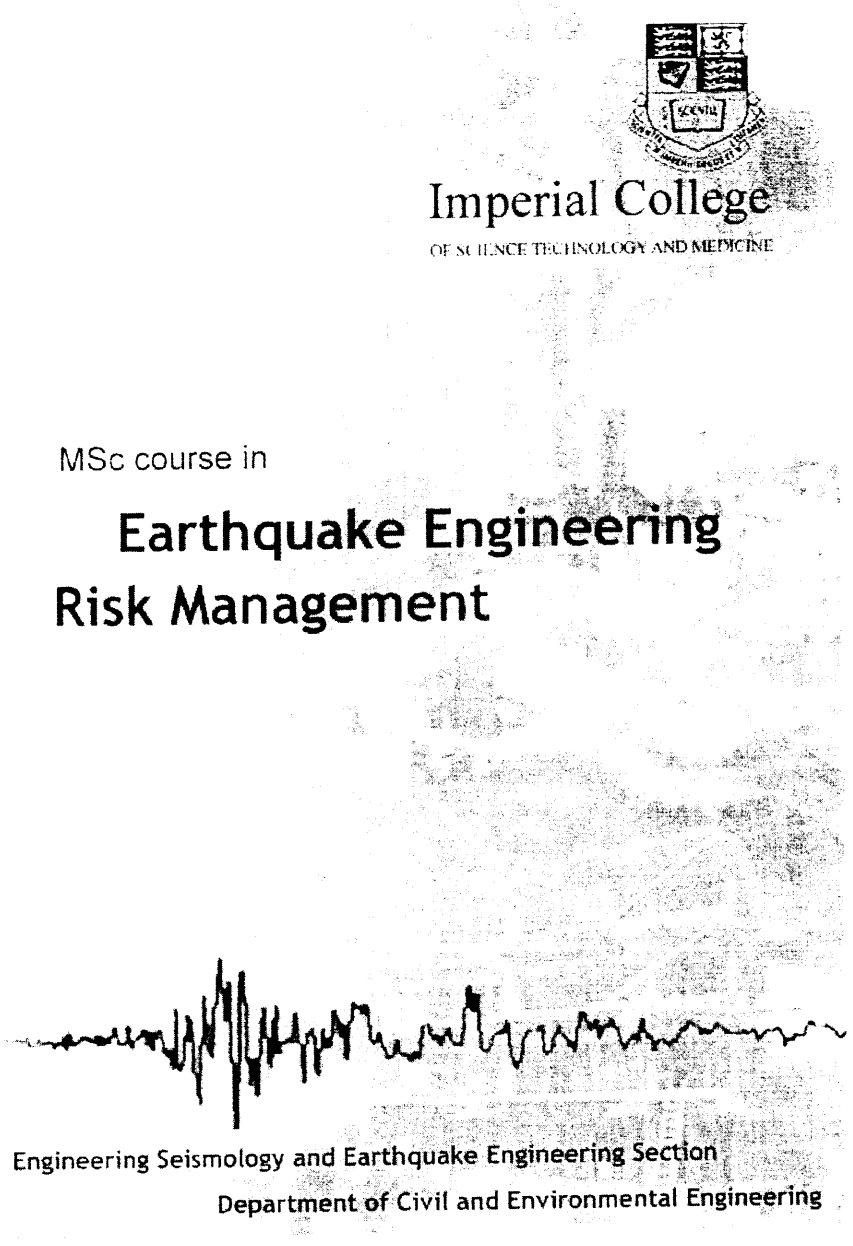
Course Objectives
The objectives of the course are to train high quality engineers, capable of dealing with earthquake risk assessment and mitigation problems from the earthquake source through to structural design, assessment, strengthening, insurance, and disaster management.

Method of Delivery
The course is designed to allow full time attendance for 11 months (October to September), or on a part-time basis for two years or three years. Also, individual modules may be attended by practising engineers without registering for a degree.

Industrial Involvement
An Industrial Advisory Committee has been assembled for this course, comprising the following companies and institutions:

Ove Arup, EQE, Whitby Bird, BNFL, WS Atkins, Allot and Lomax, High Point Rendel, SECED, ICE, IStructE, NII, BRE, SCI.

Who may apply
The course is suitable for civil engineers. It can also be of interest to graduates of geophysics and mechanical engineering. It is essential that applicants have a strong technical education background. Practical experience, though not mandatory, is desirable.



Employment Prospects
Earthquake engineering is rapidly increasing in importance, due to the increased cost exacted by earthquakes on developing and developed societies alike. The number of formally trained earthquake engineers is much smaller than the growing demand. Moreover, the new modules offer the opportunity of working in the insurance industry.

Financial Support
A limited number of scholarships are available for highly qualified candidates, and are granted on a competitive basis.

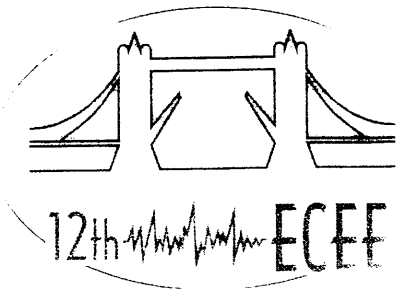
Further information about the MSc course in Earthquake Engineering Risk Management can be found at http://www.esee.cv.ic.ac.uk/eerm.htm

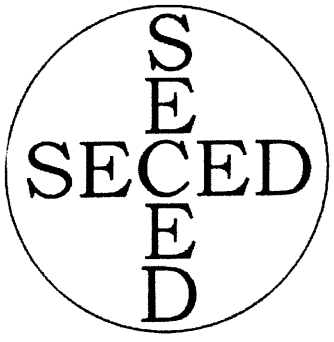
Prof. N. Ambraseys is awarded Honorary Membership of the EERI

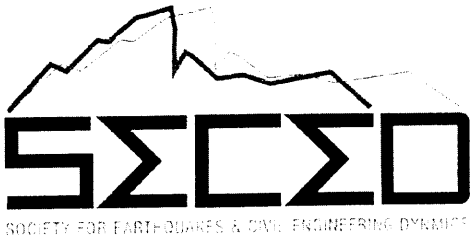
The Earthquake Engineering Research Institute has awarded an Honorary Membership to Prof. N. Ambraseys in recognition of his significant contributions to earthquake engineering. This is the first honorary membership awarded by the Institute to an engineer outside the United States.

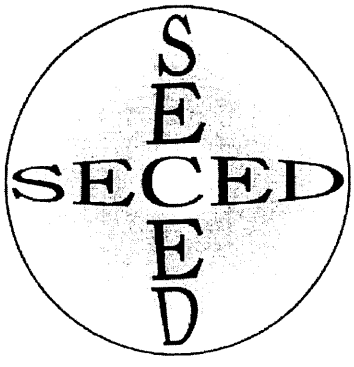
A New Logo for SECED ?

Following the success with the 12ECEE logo (shown on the right), SECED members are invited to comment of a few ideas for a new logo for SECED. What do you think of these - do you have some great new ideas? Please send your comments to Liz Marwood Email: liz.marwood@ice.org.uk.









The SECED Website

For those members of SECED who have not yet had a chance to browse the SECED website this is a brief summary of the key information that is now available on-line.

Forthcoming events:
On-line fliers and details of each meeting as soon as they are finalised.

Subscription Information:
Current subscription rates and application forms for individual and corporate membership that can be printed out and filled in.

SECED Directory of practitioners, Millennium Edition:
A summary table of the SECED Directory is on-line, as is a sample from the printed version.

Corporate Members 2000-2001:
A list of all corporate members and links to their web sites.

Twelfth European Conference on Earthquake Engineering, September 2002, London:
Full lists of all the people involved on the various organising committees.

Earthquake Engineering Research in UK:
Links to the main Universities who are doing research in Earthquake Engineering in the UK.

Mechanisms of Industrial-Academic Interaction in Earthquake Engineering:
Details of the progress SECED is making in improving the links between design and research communities in the field of earthquake engineering.

SECED related pages: such as meeting reports:
The statutes of the society can be found here, as can any reports produced providing follow-up to a SECED meeting.

Access to research infrastructures in European Community:
Details of the European Community - Access to Research Infrastructures Action of the Improving Human Potential Programme can be found here. Contact information is provided for anyone wishing to gain access to a large shaking table or reaction-wall facility for research purposes.

SECED mailing lists for virtual debate:
This section of the site provides links to the SECED discussion lists at http://www.mailbase.ac.uk/lists/seced-discussions/ where it is possible to continue any discussions started at technical meetings on line. It is hoped that this will become a forum for debate and exchange of ideas in the future. All members of SECED are invited to contribute to ongoing topics or start new discussion threads.

Seminars, Short Courses and Conferences:
Details and links to seminars, short courses and conferences that will be of particular interest to SECED members.

Other links of Interest:
This area provides links to information on recent earthquakes and links to various Earthquake Associations and Earthquake Research Centres around the world.

Further Information:
Full contact details for SECED.

USEFUL WEB LINKS

The SECED Website
http://www.seced.org.uk

Bhuj information from the EERI:
http://www.eeri.org/Reconn/bhuj_India/gujarat_india0101.html

Nisqually information from the EERI:
http://www.eeri.org/Reconn/Nisqually_Wa_2001/Nisqually.html

The EERI March Newsletter:
http://www.eeri.org/News/2001_pdf/mar01.PDF

IDEERS – Beginners Earthquake Engineering:
http://www.ideers.bris.ac.uk

NOTABLE EARTHQUAKES JANUARY - APRIL 2001

Reported by British Geological Survey

YEAR	DAY	MON	TIME UTC	LAT	LON	DEP KM	MAGNITUDES ML	MB	MS	LOCATION
2001	01	JAN	06:57	06.97N	126.60E	33		6.5	7.3	MINDANAO, PHILIPPINES
			Minor damage occurred throughout the Davao area.							
2001	04	JAN	21:31	59.80N	1.92E	19	3.1			NORTHERN NORTH SEA
2001	13	JAN	17:33	13.06N	88.79W	39			7.8	EL SALVADOR
			At least 827 people were killed, approximately 4,500 people were injured and over 93,000 houses were destroyed. A large number of the casualties and damage was caused by large landslides in the Santa Tecla area.							
2001	26	JAN	03:16	23.32N	70.31E	23		6.9	7.9	SOUTHERN INDIA
			At least 14,240 people have been confirmed killed, more than 61,600 people injured and approximately 600,000 people have been left homeless.							
2001	13	FEB	14:22	13.61N	89.07W			5.6	6.5	EL SALVADOR
			At least 283 people were killed, approximately 3,000 people were injured.							
2001	19	FEB	12:45	59.39N	6.08W	15	3.0			NORWEGIAN COAST
2001	23	FEB	00:09	29.52N	101.14E	33		5.7	5.4	SICHUAN, CHINA
			Ten people were killed, approximately 100 people were injured and 60,000 houses were damaged or destroyed.							
2001	24	FEB	07:23	1.46N	126.27E	35		6.6	7.0	N MOLUCCA SEA
2001	28	FEB	18:54	47.15N	122.72W		6.4			SEATTLE
			One person was killed and over 160 people were injured. Most of the damage occurred in and around Seattle, about 50 km northeast of Olympia. A state of emergency was declared for western Washington where damage to buildings and roads is estimated to run into billions of dollars. Mudslides hit Mount St Helens in southwestern Washington.							
2001	14	MAR	22:20	58.25N	0.69E	20	3.4			CENTRAL N SEA
2001	18	MAR	01:43	51.47N	1.91W	9	2.7			SWINDON, WILTS
2001	19	MAR	05:52	3.91S	127.97E	40		6.1	6.5	SERAM, INDONESIA
2001	24	MAR	06:27	34.07N	132.53E	33		6.4	6.5	HONSHU, JAPAN
			Two people were killed and 161 people were injured.							
2001	03	APR	14:57	34.92N	138.05E	30		5.1	4.8	HONSHU, JAPAN
			At least eight people were injured.							

Issued by Bennett Simpson, British Geological Survey, May 2001

Forthcoming Events

26 September 2001
Seismic Design of Composite Structures
ICE 5.30pm

31 October 2001
Soil Structure Interaction
ICE 5.30pm

28 November 2001
Human Excitation on Structures

30 January 2002
Seismic Qualification of Equipment by Experience Methods

27 February 2002
Seismic Design of Earth Retaining Structures

27 March 2002
Rail Induced Vibration

25 April 2002
The Year's Earthquake

29 May 2002
Flow Induced Vibrations in Hydroelectric Penstocks

Contents

SECED Newsletter

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

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

Articles should be sent to:

Adam Crewe,
Editor SECED Newsletter,
University of Bristol,
Department of Civil Engineering,
Queen's Building,
University Walk,
Bristol BS8 1TR,
UK.

Email: A.J.Crewe@bris.ac.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

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:
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Institution of Civil Engineers,
Great George Street,
London SW1P 3AA, UK.