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SECED NEWSLETTER

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AN INTRODUCTION TO THE DYNAMIC ANALYSIS OF MACHINE FOUNDATIONS

The first of an occasional series of articles introducing some specialist areas of dynamics.

INTRODUCTION

The purpose of this technical note is to set down some basic definitions, terminology and references related to the dynamic analysis of machinery and other foundations. It is meant as a brief introduction to those unfamiliar with this area, and reflects the personal views of the author.

CLASSIFICATION

Machinery can be broadly classified into three types, namely:
(a) reciprocating, for example diesel engines, piston engines, compressors and crushers;
(b) rotating, for example turbo-generators, electrical machines, motor generators and turbines;
(c) impacting and others, for example forge hammers, drop hammers and stamping hammers.

SPEED / FREQUENCY

Machine speeds are usually quoted in either revolutions per minute N (rpm), frequency f (Hz) or circular frequency w (rad/sec). The interrelation between the three quantities is given by:

$$w = 2\pi f = 2\pi N/60 \qquad (1)$$

Specifications may refer to low, medium and high frequencies, the definitions of which can vary. British Standard CP 2012 implies that low frequencies are below 5 Hz (below 300 rpm), medium frequencies are between 5-25 Hz (300-1500 rpm) and high frequencies are above 25 Hz (greater than 1500 rpm). Barkan, in his classic book "Dynamics of Bases and Foundations", implies low frequencies below 500 rpm, medium frequencies in the range 300-1500 rpm and high frequencies in the range above 1000 rpm, i.e. overlapping ranges.

POWER / SPEED

As a broad generalisation, large industrial reciprocating machines tend to be in the low/medium speed range and of relatively low power rating, say up to 5MW but more usually in the kW range. As a further broad generalisation, large industrial rotating machines tend to be in the high speed range and of relatively high power rating, say above 5MW and typically in the range 5MW-1500MW. Modern large turbo-generators typically run at around either 1800 rpm for US nuclear plant, 3000 rpm for UK fossil plant (to give a 50 Hz supply) or 3600 rpm for US fossil plant (to give a 60 Hz supply).

FOUNDATION LOADS

Static and dynamic foundation loads for machinery are often specified by the manufacturer but can be alternatively sourced from codes, standards and reference books. Reciprocating machines may be subject to the following load types: out-of-balance, short circuit, faulty synchronisation, out-of-step running, surge (including thermal) and abnormal stop. Rotating machines may be subject to dead load, live load, normal torque, thermal, shrinkage/creep, normal machine unbalance, seismic, generator emergency torque, out of phase synchronisation, bowed rotor and/or missing rotor loads. Rotating machinery normal unbalance loads are generally of the form:

$$F(t) = Mew^2 \qquad (2)$$

where M is the mass of the rotating part, e the rotating mass eccentricity and w the machine design operating speed in rad/sec.

A related measure is the balance quality grade G, defined by:

$$G = ew \quad (3)$$

For various types of machinery values of G are given in ISO 1940 (equivalent BS 6861: Part 1: 1987). A typical value for turbine-generator sets is G = 2.5mm/s, leading to e = 0.008mm for a 3000 rpm (314 rad/sec) machine. Barkan, referring to machines of the 1930-1950 era, suggests an e value of 0.050mm for a 3000 rpm machine, a high value compared to modern day figures and an example perhaps of advances in manufacturing and balancing technologies.

WEIGHTS

It should be noted that the rotor weight of a rotating machine may be a small part of the overall weight of a machine. All-up weights can reach 5-10 times the rotor weight.

DYNAMIC ANALYSIS

A full discussion of dynamic analysis of machine foundations is outside the scope of a brief note such as this but the reader is referred again to Barkan's book "Dynamics of Bases and Foundations" for an in-depth discussion. For simplified linear elastic analyses it is necessary to know a number of equivalent linear elastic constants for the underlying soil/rock strata, such as shear wave velocity V_s (m/s), Poisson's ratio v, density d (kg/m³) and Young's modulus E (N/mm²). These properties are related by:

$$E = (V_s)^2 \cdot 2d(1 + v) \quad (4)$$

Typical values for initial assessment/preliminary design purposes are given in Table 1, through it is stressed that an appropriate site investigation will need to be carried out on a project-specific basis.

PILED VS NON-PILED FOUNDATIONS

The effect of piling can be to increase elastic foundation stiffnesses typically by a factor of 2-4. The desirability of piling depends partly on foundation conditions and settlement constraints but more importantly on the level of foundation dynamic response and the possible interaction (resonance) between machine operating speed and overall system frequency. The foundation may need to be tuned to avoid resonance. It is notable in this respect that tuned foundations are defined by the ASCE as follows:

Low-tuned foundation

$$fm/fn > 3.0 \quad (5)$$

Conventional foundation

$$1.4 < fm/fn < 3.0 \quad (6)$$

High-tuned foundation

$$fm/fn < 0.7 \quad (7)$$

where:

fm = running speed of machine (Hz), and

fn = fundamental vertical frequency of the foundation, assuming its based is fixed (Hz).

Tuned foundations are discussed further in the ASCE booklet "Design of large steam turbine generator foundations".

CONCLUSIONS

This technical note has introduced some of the definitions, terminology and references relating to the dynamic analysis of machine foundations. It is not a definitive treatise but it is hoped that it will be of value to the reader and will stimulate technical discussion. The views expressed are the author's own and any comments are welcomed. These should be addressed to the editor who will pass them on to the author of the paper.

Table 1 Dynamic Soil Properties for Linear Elastic Analyses (for initial assessment/preliminary design purposes)

Soil Type	Characteristic Value	Vs (m/s)	v	d (kg/m³)	Edyn (N/mm²)
Sand	(N - blows)				
- loose	0 - 10	100 - 150	0.15 - 0.20	1750	50 - 100
- medium	10 - 30	150 - 200	0.20 - 0.25	1800	100 - 200
- dense	> 30	200 - 250	0.25 - 0.30	1850	200 - 300
Sandy gravel	-	100 - 250	0.15 - 0.30	2000	50 - 300
Silty clay	-	100 - 200	0.20 - 0.40	1800	50 - 200
Clay	(cu - kN/m²)				
- soft	< 20 - 40	100 - 200	0.20 - 0.40	1800	50 - 125
- firm	40 - 75	125 - 200	0.20 - 0.40	1950	100 - 150
- stiff	75 - 150+	150 - 200	0.20 - 0.40	2100	125 - 200

DTA/NAFEMS/SECED CONFERENCE, 3-5 JULY 1996 "STRUCTURAL DYNAMICS MODELLING"

John Maguire reports on the second in a series of international conferences on the subject of structural dynamics modelling:

This event was held at Windermere in Cumbria. It followed on from the first conference, held in Milton Keynes in 1993, on the subjects of test, analysis, correlation and updating (reconciliation). Three societies, including SECED, were involved in the organisation, bringing together theoretical analysts, experimentalists, academics and practising engineers from a wide range of industries. Over 100 delegates were present during the three days, which were widely agreed to have been most stimulating.

Thirteen papers out of the total of 42 which may be of particular interest to SECED members are:

(a) "Dynamic Testing of Reinforced Concrete Beams" by J.Owen, B. Eccles et al (Univ. of Nottingham);
(b) "Frequency Estimation of Long Span Floors" by A. Zaman and L. F. Boswell (City University);
(c) "Modal Participation of Suspension Bridge Structures" by J. Beith and T. Agar (Univ. of Glasgow);
(d) "Dynamic Diagnostic of Transmission Towers" by G. Schroth et al (Brandenburgsche Technische Universitat, Germany);
(e) "Computation and Measurement of the Dynamics of Masonry Bell Towers" by A. Selby and J. Wilson (Univ. of Durham);
(f) "The Role of Correlation and Updating Tools in the Modelling of Engineering Structures using the Finite Element Method" by R. Swindell (Acoustic Technology Limited);
(g) "An Error Indicator Method for System Identification" by Y. Zhang (Jiling Institute, China), T. Ji and B. Ellis (BRE);
(h) "Structuring Test and Analysis Experience" by M. Fox (Nuclear Electric);
(i) "Forced Modal Tests of the Vieux Emosson Gravity Dam" by S. Pietrzko et al (EMPA, Switzerland);
(j) "Vibration Characteristics of a Suspension Footbridge" by J. M. Brownjohn et al (Nangyang Univ., Singapore);
(k) "Optimisation of the Finite Element Modelling of a Reinforced Concrete Bridge based on ambient vibration tests" by Y. Deger et al (EMPA, Switzerland);
(l) "Dynamic Testing of the Second Severn Crossing During Construction" by J. Macdonald and C. A. Taylor (Univ. of Bristol);
(m) "Dynamic Response of Buildings to Bomb Blast" by P. Esper (Taylor Woodrow).

The proceedings (ISBN 0 874376 20 4) are available at a cost of £60 from Anne Creechan, NAFEMS Ltd., Whitworth Building, Scottish Enterprise Technology Park, East Kilbride, Scotland, G75 0QD, Tel: 01355 272639, Fax: 01355 272749.

SHORT COURSE ON PRACTICAL SEISMIC DESIGN

A short course on Practical Seismic Design and Repair of Structures was jointly organised by SECED and Imperial College on 17-18 September. **Julian Bommer** reports:

This course was held at the Department of Civil Engineering at Imperial College and attracted 59 delegates from all over the United Kingdom and also from as far as Greece, Holland and Spain. Three-quarters of the delegates on the short course came from engineering practice representing 34 civil engineering companies. Other delegates came from the Foreign and Commonwealth Office and 8 academic institutions, as well as some who attended in a private capacity.

The course began with welcoming addresses from Dr. John Maguire, SECED Chairman, Professor Amr Elnashai, Head of Engineering Seismology and Earthquake Engineering at Imperial College and Dr. Julian Bommer, Course Chairman. The technical proceedings were then inaugurated by Professor Paolo Pinto of the University of Rome and Chairman on the Eurocode 8 Committee with a brief lecture on "The Current Status of EC8 and Future Activities".

The main body of the course was arranged in four sessions, with the following lectures:

1. **Earthquake Design Loads**
1.1 Assessment of seismic hazard (Julian Bommer)
1.2 Design spectra (Edmund Booth)

2. **Reinforced Concrete Structures**
2.1 Philosophy of design and overview (David Key)
2.2 Design to EC8 and examples (Andreas Kappos)
2.3 Repair and strengthening of earthquake damaged structures (Amr Elnashai)

3. **Geotechnical Aspects and Foundation Design**
3.1 EC8 approach to geotechnical earthquake engineering (Sarada K. Sarma)
3.2 Seismic design of foundations (David Muir Wood)
3.3 Seismic design of retaining structures (Scott Steedman)

4. **Steel Structures**
4.1 Design philosophy and overview (Amr Elnashai)
4.2 Design to EC8 and examples (Ahmed Elghazouli)

In addition to the main lectures, on the evening of the first day of the course a series of four earthquake case histories were presented to illustrate field observations of the principles covered in the course. Presentations were made by EEFIT (Edmund Booth and Adrian Chandler) and EFTU (Amr Elnashai and Julian Bommer) on the Newcastle (Australia) earthquake of 1989, the Luzon (Philippines) earthquake of 1990, the Northridge (California) earthquake of 1994 and the Kobe (Japan) earthquake of 1995. These presentations were followed by the formal course dinner.

A full report on the course, with suggestions for modifications and improvements, based on the written and spoken evaluations of the delegates, is being prepared. The general feedback was very positive and the event was a major success in every respect.

Meeting 30 October 1996: Soil Properties

DETERMINATION OF SOIL PROPERTIES FOR SEISMIC DESIGN

This meeting was a joint venture between SECED, the Babtie Group and the Scottish Geotechnical Group, hosted by the Babtie Group at their headquarters in Glasgow. An audience of around 40 was treated to a mixture of theoretical and practical presentations by Professor David Muir Wood of Bristol University/Babtie Group and Tom Aldridge of Fugro Limited.

Professor Muir Wood started the evening with a 20 minute general introduction to the basic theories of soil stiffness and strength. simple models of soil response were introduced in which stiffness degradation and soil damping were allowed for in an appropriate way, together with more elaborate models used in computer programs such as FLAC.
Tom Aldridge followed with a 35 minute practical presentation on soil parameters for earthquake resistant design. The differences between earthquake and other forms of loading were highlighted, leading on to a discussion of appropriate forms of site investigation, laboratory testing and engineering analysis. Seismic piezocone, pressuremeter, seismic cross-hole and other site testing methods were described. Laboratory techniques mentioned included bender element, resonant column, cyclic simple shear and cyclic triaxial tests. A number of analytical approaches, including both time and frequency domain methods, were also discussed.

David Muir Wood concluded the presentations with a 10 minute discussion of better soil models for earthquake prediction, concentrating on those related to small strain stiffness. Recent research at Bristol University on bender elements was described.

The formal presentations were then followed by a question and answer session which touched on the balance between field and laboratory tests, full scale results, best practice guidelines, reconstituting materials for laboratory tests, model specifications, costs of testing, in-situ anisotropy, the benefits of study via shear wave splitting and looking at polarisation diagrams, earthquake directionality effects and recent earthquakes in the UK.

SECED have not held many meetings outside of London in recent years and this event was an experiment in holding a meeting north of the border. The number of delegates and the quality of presentations were both encouraging and SECED will consider positively such meetings again in the future. Thanks once more to the organisers, especially the Babtie Group for hosting the meeting.

FORTHCOMING MALLET-MILNE LECTURE 1997

Our sixth Mallet-Milne lecture, a major occasion in the earthquake engineering and civil engineering dynamics calendar, will be given by Prof. Roy Severn, past president of the Institution of Civil Engineers and a long-time supporter of SECED, at the Institution of Civil Engineers on 21 May 1997 (make a note in your diary!).

The Mallet-Milne lecture is a prestige biennial lecture given by an internationally-renowned professional in the field.

Previous lecturers have been
Prof. Nick Ambraseys (1987),
Prof. George Housner (1989),
Prof. Geoffrey Warburton (1991),
Prof. Tom Paulay (1993) and
Prof. Bruce Bolt (1995).

"Structural Response Prediction Using Experimental Data"

The design process for dynamic loads always involves calculation at some level of complexity, and few would argue that that level currently often goes beyond the support offered by observed dynamic behaviour, whether in real conditions, or in simulated conditions in the field or in the laboratory. In the ideal design situation, only rarely achievable, calculation and measurement go forward together. More usually, time, and type of structure under consideration, dictate that reliance must be placed upon calculation and experience only. In this case, the contribution of experimentation has been achieved earlier, by studies on similar structures to produce dynamic characteristics and material properties which can be used either as input to the calculation, or as checks on its output.

Of course, there is a mutual dependency between calculation and measurement. The possible errors attributable to the former are now well appreciated by those with experience, whilst only those without experience of physical measurement processes would suppose that they can be used without qualification for accepting, or rejecting, the results of calculation. The reasons for this are not hard to find. If the experiments are made at full-scale, it is very unlikely that full-scale input forces can be applied having the correct distribution, whereas if models are to be used scaling laws relating to material properties cannot be fully satisfied, and here again the correct pattern of input forces can only rarely be applied to the model. This last problem becomes even more uncertain when the behaviour of the model structure moves into the non-linear range - a usual requirement in earthquake engineering. In collecting data from dynamic experiments there are also many opportunities for procedures leading to false conclusions, even when the more obvious of them are avoided.

This lecture is essentially a personal odyssey through the development of dynamic structural testing during the last 40 years, as an aid to the design process, involving the three-pronged approach of field measurements, laboratory testing and corroborative calculation. One example used, is that of concrete dams, where the field measurement of natural frequencies, model shapes and damping, using multipoint excitation, led to confident prediction of seismically induced displacements and stresses, which, in conjunction with model studies allowed dams to be built even across known faults. the design issue of whether the reservoir water is compressible, or not, has only recently been capable of experimental study using greatly improved transducers.

For suspension and cable-stayed bridges the response to wind is a key design factor, requiring the same basic dynamic parameters to be obtained by site measurement. But here, data is provided by the real exciting force, allowing design information, such as lift and drag coefficients, to be obtained on the real bridge for comparison with any which may have been produced from laboratory models. Such studies, carried out for the straits of Messina crossing, require the measurement of transient displacements, instruments for which have been developed in the author's own laboratory, capable of accuracies of 1 mm over 750 m. With displacement methods currently taking on increasing importance in earthquake engineering design, displacement field measurements will become even more valuable.

In the laboratory, similar progress has been made during the last 40 years. During the 1960s, multipoint excitation facilities, with phase control between them, became available, allowing isolation of individual modes in complex structures and the resulting simplification of resonance testing. Control engineering technology of electronic-mechanical-hydraulic machines also developed rapidly, allowing shaking tables to be constructed which could input recorded earthquake motions with reasonable fidelity. Very recently, it has become possible to control shaking table motion in 6 axes, in real-time and with the test-piece behaving non-linearly. Details will be given of these advances, which have contributed significantly to the development of the design features which are embodied in Eurocode 8. With regard to reaction-walls, used for pseudo-dynamic testing of full-scale structures, similar developments in control of the actuators promises to improve the rate at which forces can be applied, thereby removing one of the major criticisms of this testing procedure.

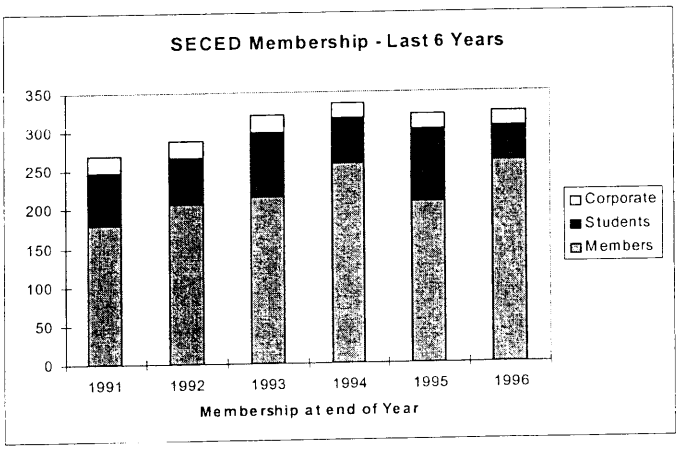
Prof. Severn is the Director of the Earthquake Engineering Research Centre, University of Bristol, UK

PRESENTATION OF HONORARY SECED LIFE MEMBERSHIP TO PROF. DAVID KEY

On the 25th September 1996 Professor David Key was formally presented with a certificate of honorary life membership of SECED. David's contributions to the earthquake engineering community have included chairmanship of SECED from 1984 to 1986, authorship of the I.C.E. guide on "Earthquake Resistant Design" and input to Eurocode 8 development on a national and international level. He is the fourth in a line of distinguished recipients of honorary membership, following Prof. Nick Ambraseys in 1987, David Howells in 1990 and Dr. Bryan Skipp in 1993. We thank him for his special contributions over many years and look forward to his continuing support.

SECED MEMBERSHIP NUMBERS

The chart opposite shows how membership of SECED has grown over the last few years.



CALL FOR ARTICLES FOR THE SECED NEWSLETTER

Everybody who has any articles that they feel would be of interest to SECED members is invited to send them to the Editor. All contributions are welcomed.

1997/1998 SECED MEETINGS PROGRAMME

The committee will be starting to plan the 1997/1998 meetings programme in the spring of 1997. If there are any events you would particularly like to see happen or if you have any suggestions for topics for meetings please could you send them to the Secretary.

LIST OF SECED AND RELATED PUBLICATIONS, 1985-1996

1. <u>Conference Proceedings</u>

1.1 Earthquakes and Earthquake Engineering in Britain, 1985. Published by Thomas Telford, price £26, ISBN 07 277 02467.

1.2 Civil Engineering Dynamics, 1988. Published by University of Bristol, ISBN 08 629 23271.

1.3 Earthquake, Blast & Impact, 1991. Published by Elsevier Applied Science, ISBN 1 85166 705 9. (No longer available)

1.4 Natural Disasters - Protecting Vulnerable Communities, 1993. Published by Thomas Telford, price £70, ISBN 07 277 1936X.

1.5 European Seismic Design Practice, 1995. Published by A. A. Balkema, price £84, ISBN 90 5410 588 7.

2. **Mallet-Milne Lectures**

2.1 Prof. N. N. Ambraseys, Engineering Seismology, 1987. Published in the journal "Earthquake Engineering & Structural Dynamics", Volume 17, Number 1, September 1988, pages 1-105.
2.2 Prof. G. W. Housner, Coping with Natural Disasters, 1989. Published by Thomas Telford Ltd., price £10.50, ISBN 0 7227 1572 0.
2.3 Prof. G. B. Warburton, Reduction of Vibrations, 1991. Published by John Wiley & Sons, price £27.50, ISBN 0 471 93597 2.
2.4 Prof. T. Paulay, Simplicity and Confidence in Seismic Design, 1993. Published by John Wiley & Sons, price £19.95, ISBN 047 194310X.
2.5 Prof. B. Bolt, From Earthquake Acceleration to Seismic Displacement, 1995. Published by John Wiley & Sons , price £14.95, ISBN 0 471 96133 7.

3. **Earthquake Engineering Field Investigation Reports**

All the following EEFIT reports are available through the Institution of Structural Engineers trading organisation, SETO Ltd.

1985 Chile (£15 to EEFIT members, £25 to non-members).
1985 Mexico (£15 members, £25 non-members).
1986 San Salvador (£15 members, £25 non-members).
1989 Loma Prieta ((£30 members, £45 non-members).
1989 Newcastle, Australia((£25 members, £35 non-members).
1990 Vrancea, Romania (£12 members, £20 non-members).
1990 Luzon, Philippines (£15 members, £25 non-members).
1990 Manjil, Iran (£15 members, £25 non-members).
1990 Augusta, Sicily (£12 members, £20 non-members).
1992 Erzincan, Turkey (£15 members, £25 non-members).

NOTABLE EARTHQUAKES APRIL - OCTOBER 1996

Reported by British Geological Survey

YEAR	DAY	MON	TIME UTC	LAT	LON	DEP KM	MAGNITUDES ML	MB	MS	LOCATION
1996	16	APR	00:30	24.07S	177.08W	110		6.2		SOUTH OF FIJI ISLANDS
1996	16	APR	10:27	61.75N	6.00E	15	3.3			NORWEGIAN COAST
1996	19	APR	00:19	23.74S	69.96W	49		6.0	6.1	NORTHERN CHILE
				Felt at Calama, Antofagasta and Tocopilla.						
1996	21	APR	02:27	53.61N	1.35W	4	2.5			BARNSLEY, SOUTH YORKS
1995	29	APR	14:40	6.52S	155.04E	44		6.3	7.5	SOLOMON ISLANDS
				Slight damage occurred in western Bougainville.						
1996	03	MAY	03:32	40.77N	109.66E	26		5.5	6.0	NEI MONGOL, CHINA
				At least 18 people killed, 300 injured and extensive damage in the Baotou area. Felt throughout Beijing, Hohhot, Taiyuan, Xian and Yinchuan.						
1996	06	MAY	03:49	53.04N	2.20W	3	2.8			STOKE-ON-TRENT, STAFFS
				Felt throughout the Stoke-on-Trent area of Staffordshire.						
1996	18	MAY	21:01	56.15N	5.20W	2	2.9			LOCH FYNE, S'CLYDE
				Felt throughout Furnace and Inveraray.						
1996	24	MAY	06:35	27.85N	53.59E	33		4.9	4.7	SOUTHERN IRAN
				Twenty people injured and damage occurred throughout the Khonj area.						
1996	02	JUN	02:52	10.80N	42.25W	10		6.1	6.9	N MID-ATLANTIC RIDGE
1996	10	JUN	15:24	51.30N	176.76W	26		6.2	7.2	ANDREANOF ISLANDS
				Felt strongly throughout Adak.						
1996	11	JUN	18:22	12.63N	125.13E	33		6.0	7.0	SAMAR, PHILIPPINE ISLES
				Felt throughout the Philippine Islands.						
1996	17	JUN	11:22	7.19S	122.68E	565		6.7		FLORES SEA
				Damage occurred throughout Flores Island.						
1996	25	JUN	03:37	61.43N	3.57E	15	3.9			NORTHERN NORTH SEA
1996	15	JULY	00:13	46.02N	5.95E	5	5.1	4.5		FRANCE
				One person slightly injured and minor damage occurred at Cruseilles. Felt strongly at Annecy. Also felt in parts of Switzerland.						

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YEAR	DAY	MON	TIME UTC	LAT	LON	DEP KM	ML	MB	MS	LOCATION
1996	23	JULY	22:30	50.68N	6.16E	10	4.1			LIEGE, BELGIUM
1996	1	AUG	20:55	55.07N	4.53E	15	3.3			CENTRAL NORTH SEA
1996	2	AUG	12:55	10.73S	161.42E	33		6.2	7.1	SOLOMON ISLANDS
1996	14	AUG	01:55	40.75N	35.38E	10		5.3	5.6	TURKEY
										Nine people were injured by a landslide at Oymaagac, Amasya. Some damage occurred in the Amasya area. Felt strongly in the areas of Cankiri, Samsun, Sivas and Tokat.
1996	05	SEP	08:14	22.12S	113.44W	10		6.2	7.0	EASTER ISLAND REGION
1996	05	SEP	23:42	21.89N	121.49E	20		6.4	6.6	TAIWAN REGION
1996	06	SEP	00:28	62.50N	0.05W	15	2.6			NORTHERN NORTH SEA
1996	11	SEP	03:36	51.38N	1.78E	5	5.1	5.0		GERMANY
										This earthquake was a mining event in a disused potash mine near the town of Teutschenthal, 10 km west of Halle an der Saale. The event awakened and frightened the local inhabitants of Halle but no casualties have been reported. Considerable damage occurred in Halle, particularly in the older part of the city, to household equipment and furnishings.
1996	20	SEP	04:04	52.31N	3.32W	14	3.0			LLANDRINDOD WELLS
										Felt in Llandrindod Wells, Knighton, Rhayader, Builth Wells and the village of Llanbister.
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 Nidrie 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

Issued by Bennett Simpson, British Geological Survey, November 1996

SECED Newsletter

The SECED Newsletter is published quarterly. Contributions are welcome and manuscripts should be sent typed on one side of the paper only. Copy on a PC compatible disk 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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Forthcoming Events

29 January 1997
Repair and Strengthening of Structures Following an Earthquake (SECED) ICE 5.30pm

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

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