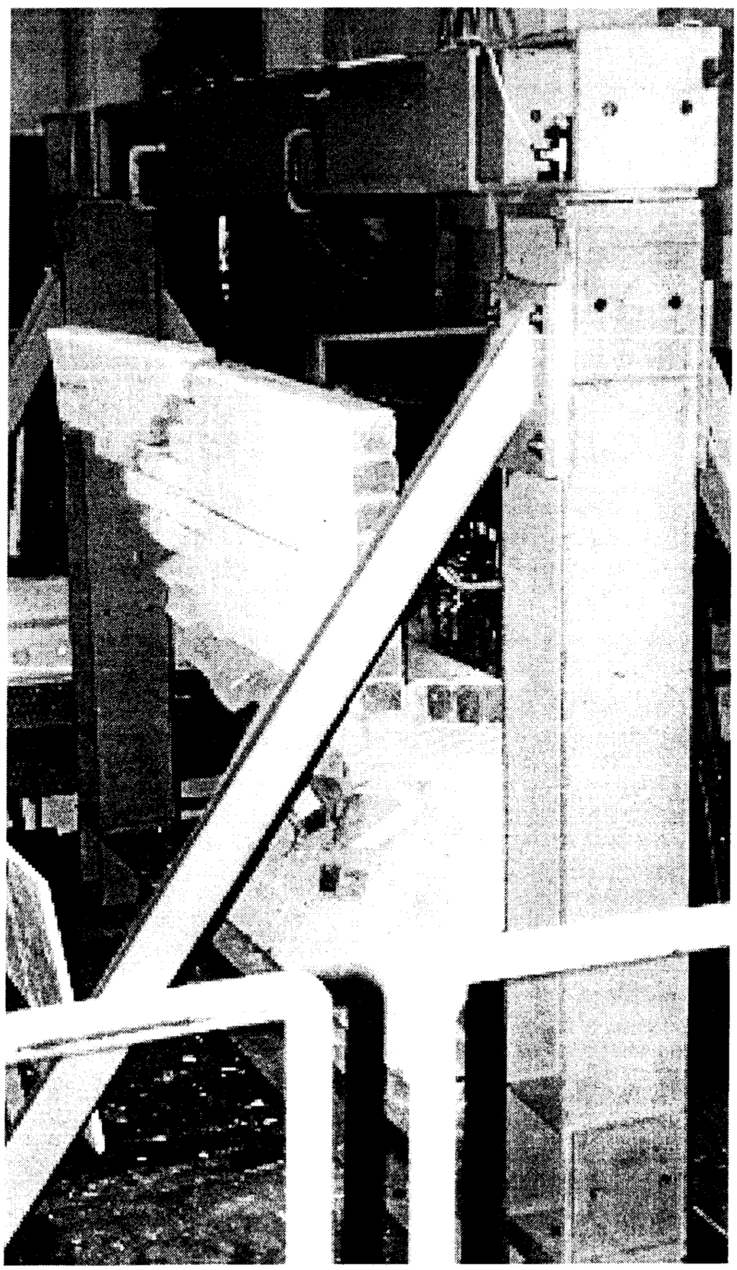
ISSN 0967-859X
THE SOCIETY FOR EARTHQUAKE AND CIVIL ENGINEERING DYNAMICS

NEWSLETTER

Volume 12 No 2
June 1998

Seismic Assessment of Masonry Panels

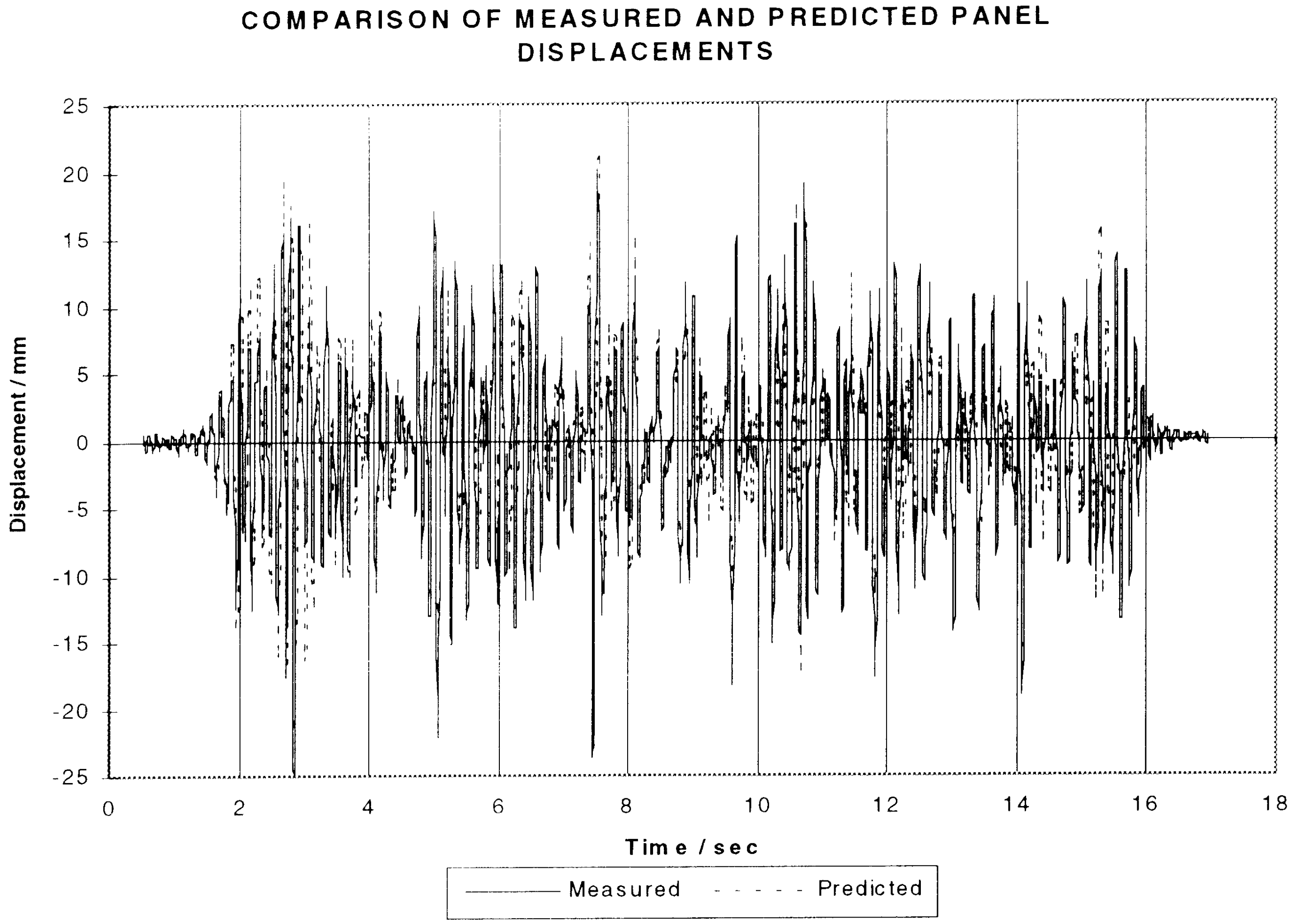
Colin Taylor outlines some of the major findings of a research project looking at the out-of-plane behaviour of unreinforced masonry panels in earthquakes.



The literature on the out-of-plane seismic response of unreinforced masonry (URM) panels is scant. This is surprising given the vast stock of old buildings in which URM panels are commonly used, for example as infills. Modern design codes generally prohibit the use of URM panels for new build, and there is little guidance available for assessing existing, non-seismically designed panels. This presents a problem in the safety assessment of older nuclear facilities that have a preponderance of URM infill panels. The difficulty here is in demonstrating an adequate safety case for the out-of-plane collapse of non-structural panels that might threaten safety related plant.

In order to improve knowledge in this area, Nuclear Electric, Magnox Electric, Scottish Nuclear, British Nuclear Fuels and the Nuclear Installations Inspectorate have funded a major research programme in the Earthquake Engineering Research Centre at Bristol University. The programme included full-scale shaking table tests of typical panels, as well as the development of simplified analysis techniques. The research has identified the potential out-of-plane modes of failure of URM panels, and has demonstrated the primary structural mechanisms that occur.

A considerable body of research is available on the behaviour of URM panels subjected to static, or monotonic, out-of-plane loading. Much of this work was done in the UK in the 1970's as part of the development of the British code of practice for structural masonry, BS5628. The provisions in this code are primarily concerned with the initiation of cracking due to out-of-plane loads, rather than the ultimate collapse condition. Other research in Canada showed that, under monotonic loads, URM panels crack on classical fracture line patterns that are readily related to the boundary conditions around the panel and any openings in the panel. The Canadian research also showed that arching action is the primary, post cracking, load carrying mechanism. This can be modelled accurately using strip analysis techniques, similar to those



employed in floor slab analysis. A key objective of the Bristol research was to establish whether such mechanisms occur under dynamic loading.

Shaking table tests were performed on prototype URM panels measuring 2m high and up to 3m wide. The panels were built from either dense concrete flat faced bricks, or from frogged fired clay bricks, using a weak 1:1:7 mortar, within a steel frame. The frame was braced to prevent movement in the out-of-plane and in-plane directions. Fourteen specimens were shaken to collapse using synthetic seismic motions in the out-of-plane direction only.

The tests showed that, under seismic loads, URM panels crack in the same fracture patterns as for monotonic loads. The crack paths tended to follow the interfaces between the brick faces and mortar beds. In the case of panels with a free top edge, and restrained side edges, an inverted-Y crack pattern developed, with the vertical crack passing through alternate bricks. Input zero period accelerations causing cracking were of the order of 0.8-1.2g depending on the panel configuration. Collapse zero period accelerations ranged from about 1.0g to over 3.0g. There was little evidence of mortar crushing up to collapse.

Substantial arching action developed if suitable boundary conditions were present. In particular, small shrinkage gaps on the vertical interfaces between the masonry and flanges of adjacent columns were sufficient to prevent horizontal arching in panels that did not have any mechanical connection to the columns. Tests of panels that were fastened to the columns using 'fish tail' masonry ties showed such details to be very effective in producing a pinned connection.

Using the strip method of analysis, the dynamic response of a cracked panel can be modelled as a single degree of freedom non-linear system. The effectiveness of this approach was evaluated using a simple model of a top-bottom supported panel cracked at mid-height. A special SDOF non-linear explicit integration computer programme was developed that included the non-linear material behaviour, as well as the non-linear geometric effects. Close agreement was obtained between measured and predicted panel displacement time histories.

The study has shown that well built URM panels with sound boundary constraints have a substantial capacity to withstand out-of-plane seismic loads.

__Dr Colin Taylor__ is a Reader in the Department of Civil Engineering at Bristol University.

Forthcoming SECED Meeting: 30 September 1998

This topic will be covered in more detail at the SECED meeting on the 30 September when Colin Taylor will talk on '*The behaviour of unreinforced masonry panels subjected to out-of-plane loads*'

The meeting will be held at the ICE starting at 6pm, preceded by coffee at 5.30pm.

Meeting Report: 25 March 1998

Eurocode 8 - A case for radical reform or minor revision?

The purpose of this meeting was to debate changes that might be needed in Eurocode 8, as it undergoes transformation from an ENV (voluntary draft for development) into a full Euronorm. A meeting of CEN (the European Centre for Standardisation) recently voted that this transformation should indeed go ahead, but almost all delegations (including that from the UK) considered that some revision was necessary.

During the extensive period of drafting the current ENV version of EC8, the UK were very active in commenting on the drafts, and were successful in getting a number of important changes made. However, only one UK engineer was included in the Project Teams doing the actual drafting work. For the conversion process into a full Euronorm, this situation will change; there will be one engineer on each of the four Project Teams who will prepare draft revisions for approval (or amendment) by meetings of the appropriate CEN committee. Therefore, the UK is in a good position to ensure that the Euronorm which emerges from the process meets the needs of earthquake engineering and of practising engineers. The four UK engineers on the Project Teams are Amr Elnashai and Andreas Kappos (Imperial College), Bryan Skipp (Soil Mechanics Associates) and Joe Barr (High Point Rendel).

The SECED meeting in Oxford was held to sound out opinion on Eurocode 8, taking advantage of the large number of earthquake engineers gathered for the SECED conference, which started the following day. Fourteen people contributed to the debate, and the discussions were subsequently used as an important basis for the first submission made by the relevant BSI committee on what changes the UK wants to see in Eurocode 8 during its conversion. The following notes highlight some of the main points to emerge from the debate.

GENERAL

1) There was a widely held view that while major revisions were ideally needed to a number of parts of EC8, much more modest goals would have to be set for achievement during the conversion process.
2) It was proposed that EC8 should provide a number of 'pegs' on which state-of-the-art procedures could be hung by the user, without actually specifying the procedures themselves. This was recommended as a device to prevent obsolescence of the code.
3) On-going maintenance of the code after its conversion was seen as particularly essential, because of the rapidly changing, specialist nature of much of earthquake engineering.
4) A list of the relevant EU funded research reports should be compiled and made available to the conversion process project teams, in order to ensure that all the relevant work was being considered.

PART 1.1 & 1.2

5) Various contributors urged review of a number of features of the design spectra, including the following:
   a) Definition and means of calculation of Effective Peak Acceleration.
   b) Spectral shapes for medium to small magnitude earthquakes.
   c) Refining the definition of soil profiles for standard spectral shapes (both vertical and horizontal profiles).
   d) Review of spectral shapes for periods longer than 3 secs, and for viscous damping ratios higher than 12%, for use with displacement based design.
6) A movement towards performance based engineering and displacement based methods of analysis was generally agreed as a long term goal, although during conversion, no more than the provision of suitable 'pegs' might be possible.
7) More specific treatment of rules for low seismicity areas was recommended, with the possibility of simple prescriptive rules for such areas.

PART 1.3.2 (Concrete)

8) A number of important technical revisions were put forward, including revisions to the confinement provisions, beam shear provisions and shear wall shear strength provisions. An amalgamation of the high and medium ductility class provisions was also proposed.
9) More generally, the current concrete provisions were seen as being soundly based on a long standing tradition of practical seismic design from an earthquake region (Greece). The alternative view (not necessarily opposing) was that certain aspects of the code (e.g. beam-column joint design, shear wall shear design) were over-complex in their attempt to provide a solution based on first principles, without necessarily achieving greater accuracy than much simpler, designer-friendly empirical methods.

PART 1.3.3: STEEL and ANNEX D: COMPOSITE

10) The steel provisions were seen, by contrast, as not based on a well tried tradition from a seismic region, and were felt to be seriously inadequate, particularly in the light of experience from the Northridge and Kobe earthquakes, and in the light of recent European research. Annex D similarly needed significant updating, but the European research programme undertaken by Imperial College and others was felt to provide sufficient material to allow satisfactory provisions for composite construction to be drafted.

PART 2 BRIDGES

11) More guidance on the logic of the seismic design process was requested, including assistance at conceptual design level.
12) Guidance on where specialist input to seismic design of bridges is needed might be desirable.
13) More guidance is needed on piled foundations, and particularly on the treatment of hinge formation in piles.
14) Guidance on the use of dampers and load sharing devices between decks and their supports is needed, since this provides an attractive and increasingly used solution for multi-span bridges.
15) Further consideration is needed on guidance on the all important topic of seismic detailing. Over-complexity in the detailing rules should be avoided, and the aim should be to give clear and straightforward guidance to designers.
16) The guidance on design for spatial variability of motions for the design of long bridges needs careful review in the light of the needs of designers.

PART 5: FOUNDATIONS

17) This was felt to be generally satisfactory, and although ongoing improvements were certainly possible, they were not priority.
18) Guidance on the use of continuum methods of soil-pile-structure analysis should be prepared.

Edmund Booth

Meeting Report: 11 February 1998

The Monserrat Volcanic Eruption

For this reporter at least, it was refreshing to attend a SECED meeting which had a single speaker who, because of this simple fact was able to present a coherent overview of a topic without overlaps or gaps and had the space to present his material at a steady and comfortable pace for the audience. And what a topic it was: rarely can SECED members have been exposed to such a sequence of memorable images as those which Willy Aspinall had assembled. Particularly telling among all the awesome panoramic views from the ground and from the air, were some of the smaller scenes such as the apparently unruffled telephone box (a near-right specimen of the Giles Gilbert Scott design) protruding from a bed of ash which had accumulated outside it to a level well above the mirror, let alone Button B.

As well as covering the phenomenological and monitoring aspects of the disaster, Aspinall was equally informative on the issues faced by the decision-makers responsible for evacuation policies and on the tragedies and general (and continuing) hardship endured by the population of Monserrat.

He began by reminding the audience of the most obvious precedent to the present disaster which was the 1902 Mount Pelée eruption which killed 29,000 people and was where the phenomenon of pyroclastic flow as a separate hazard was first recognised.

This led into a description of the sequence of events that began in July 1995 with the genesis of the dome which eventually started to give out pyroclastic flows, first towards the east then increasingly, to the north and west. These culminated in the fatalities which occurred on the 25 June 1997 and, a few weeks later, in the set of flows which obliterated Plymouth, the main town of the island, and damaged many facilities including the airport buildings (but not quite the runway). By this stage, the main residential areas had been evacuated with some of the evacuees taking their houses with them. Since then, the biggest event was on Boxing Day 1997 when there was major surge damage to the south of the island as a result of a dome collapse and the failure of one of the historic crater walls.

The geodetic and seismological monitoring system were described. The latter system has revealed various types of seismic signals, some of which would be new to SECED members familiar only with conventional seismology. These included long-period events, thought to be caused either by sudden movements of gas or by some esoteric mechanism in a semi-plastic medium and 'hybrid' events having an early high-frequency phase followed by a low-frequency coda. When the Monserrat eruptions started, conventional volcano-tectonic (v-t) mechanisms were, not surprisingly, predominant but their proportion of the total population rapidly dropped away. As the sequence has progressed, and the magma has risen, both the v-t and hybrid events have become increasingly shallow. The seismic monitoring has also revealed an interesting horizontal pattern of events with a distinct cluster off to the side of the centre of the volcano and a marked lineation of events heading out into the sea which is still not fully understood. The tiltmeter results also have been valuable in that observations of the swelling cycle (commonly, 8, 12 or 16 hour period) showed that there was a strong association between peaks in the tilt cycle and the occurrence of earthquakes, rockfalls and pyroclastic flows. With this information, flows could be anticipated with some degree of reliability and scientists in the field withdrawn accordingly.

As the situation on Monserrat has evolved, it has obviously been necessary to have in place a strategy for, more or less, continuously updating hazard and risk assessments and it is in this area that the work described by Aspinall (see also his introductory notes) has been particularly innovative. The systematic semi-quantitative employment of expert judgement is, of course, a topic of major current concern in many areas of interest to SECED members but rarely can it have been necessary to design and make work a procedure under such pressure. Updates had to be issued on two time scales : (i) short term hazard alert levels had to be provided to the civil authorities on a regular basis (perhaps two or three times a week), and (ii) longer-term risk outlooks had to be available for the planning of reparation efforts and the safe movement of people. While the short-term assessments were concerned just with the state of the volcano, the longer-term risk estimates involved the construction of a probabilistic logic-tree representation of the hazards (explosion: dome collapse: pyroclastic flows, etc.) coupled with some modelling of the effects of these hazards on the population and on the built environment (for example, considering roof strengths in terms of their ability to withstand impacts or ash loading).

Not surprisingly, this last topic attracted a good deal of interest among the audience which, one is pleased to report included a number of ex-residents of Monserrat. In fact a number of important issues were raised during the discussion period, among them the vexed question which has received so much publicity in the UK, of aid. Aspinall was at pains to explain that the sums of money which have been mentioned in the British press are, to-date, no more than earmarked for aid and since, in any event, the bulk of the money will have been spent on the military presence, with a commendable contribution towards science, very little money has so far reached the population of the island.

In conclusion, for this reviewer, Aspinall's presentation was all the more impressive for having been arranged at very short notice (to replace an out-of-town event which had had to be cancelled), a fact rightly acknowledged by Bryan Skipp in his closing remarks. It is a great pity that, because of the short notice, SECED members had very little time to rearrange their diaries and the publicity that could be given to the event in other groups concerned with the IDNDR, or volcanology in general, was limited: otherwise one is confident that an even larger and more diverse audience would have attended.

David Mallard

Earthquakes among the dreaming spires:

The Sixth SECED Conference, March 1998

SECED's highly successful sixth conference "Seismic design practice into the next century", was held in March in Oxford. It provided a lively and enjoyable format for 187 delegates to discuss the latest developments in seismic design practice and research. Three quarters of the delegates were UK based, but 25 other countries from many parts of the world were also represented. Two thirds of the delegates were from industrial organisations and one third from universities, with the 62 refereed papers coming in almost exactly the opposite proportions so SECED certainly seems to be fulfilling one of its roles, that of bringing up-to-date research to industry.

The format largely followed the pattern of SECED's 1995 conference in Chester. Eight keynote lecturers, from the UK, France, USA, Japan and Turkey, gave 25 minute lectures on a wide range of topics. Most of the other published papers were presented in two parallel oral sessions, with 15 minutes allowed per paper. Although there was debate on many of the papers, a common observation was that there was insufficient time allowed for discussion. Various ways of addressing this for the next

(L to R) John Maguire (SECED outgoing chairman)
Jun Kanda (Keynote speaker)
Edmund Booth (Conference sub-committee chairman)
Darius Amir-Mazaheri (Keynote speaker & AFPS president)
Peter Merriman (SECED incoming chairman)

conference are being considered, including an increased number of poster presentations, rapporteur plus discussion sessions and fewer keynote lectures. Your views on this would be most welcome and should be addressed to the Newsletter Editor.

There was a lively poster session, where despite rather cramped and dark conditions, some excellent debate and interaction took place. A new feature this year was that in addition to the four published poster papers, 16 'work-in-progress' posters were presented. These latter were not submitted in advance, nor published in the proceedings. The general opinion was that the ability to present interesting current work, not necessarily even brought to a final conclusion, added considerably to the immediacy of the conference. Again, your views on this feature would be welcome.

Another innovation was the Bursary Scheme, which awarded travel, accommodation and attendance grants to 8 delegates from former Soviet Block and Eastern European countries. Free attendance was also granted to 6 UK-based student members of SECED; all of these presented a 'Work-in-Progress' poster paper. The scheme enabled delegates to attend the conference who would otherwise have been unable to do so, and was judged a success. It was funded by a £10 levy on the attendance fee of full price delegates, by an additional £1500 from SECED's funds, and by generous donations from Nuclear Electric Ltd, Allott & Lomax and Technology Transfer Associates. The SECED committee supports the idea of repeating the Bursary Scheme for its next national conference, when it may be extended to cover delegates from any country with a significant seismic problem whose nationals might find financial difficulty in attending. Your views are sought on how the Scheme should be run and funded in future; for example, what proportion of the money should come from SECED, from the profit on the conference, and from external organisations?

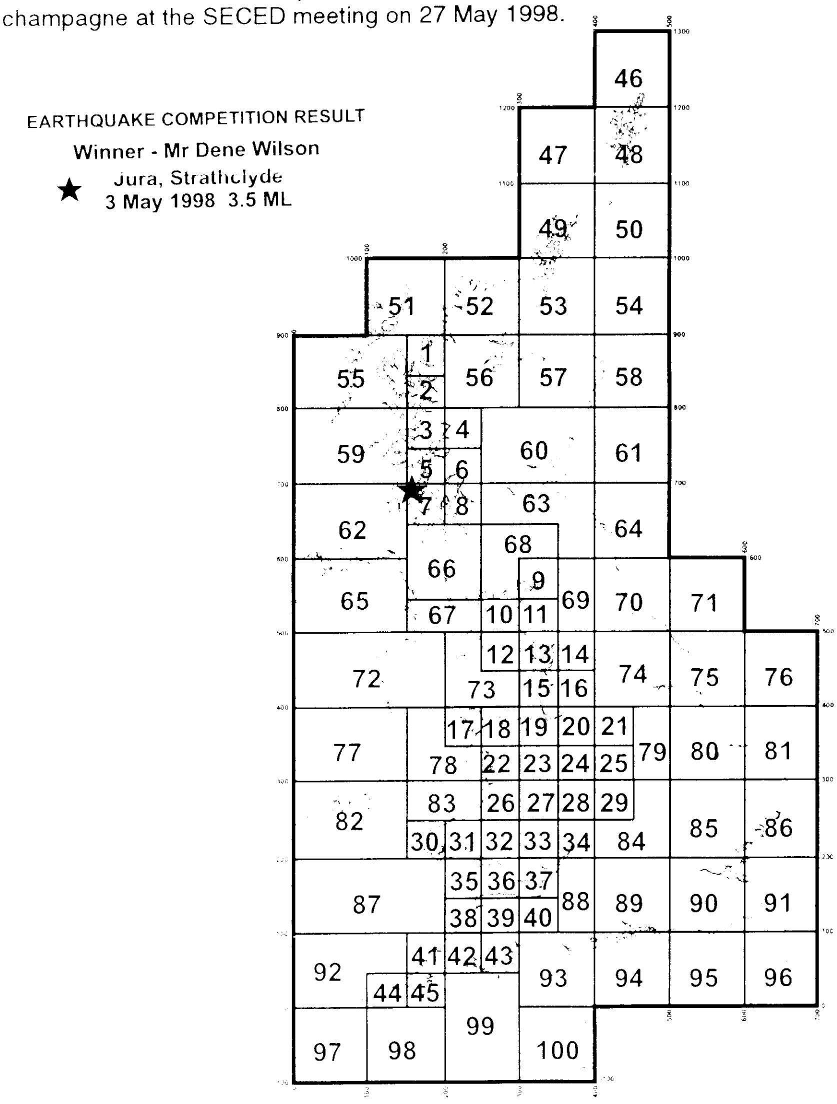
A successful conference is made not only by excellent technical papers (and there were plenty of these at Oxford) but by the social interaction between delegates. The beautiful city of Oxford provided an excellent setting for this latter aspect. The New Cross building provided good lecture theatre facilities, while sleeping accommodation and food were provided by Magdalen College, one of the oldest in the University. The Conference Banquet took place in Magdalen College Hall, with excellent food and wine, a speech from Guy Houlsby, Professor of Civil Engineering at Oxford, and entertainment from a barber shop quartet, who had written a special earthquake number for the occasion. 'What a location! with splendid food and entertainment' commented one of the delegates.

Overall, the conference was a great success, arguably SECED's most successful to date. This is borne out by the questionnaire returns, in which 78% of respondents thought the technical content and professional relevance excellent or good. Thanks are due to the organising committee, and to the sterling work done by Rachel Coninx and her team of administrators from Thomas Telford Conferences. The conference proceedings are published by Balkema (http://www.jcn.nl/ima/balkema) and are available from booksellers at a cost of £70.

Edmund Booth

EARTHQUAKE PREDICTION COMPETITION

For those of you who attended the SECED AGM and entered the earthquake prediction competition we can now confirm that Mr Dene Wilson correctly predicted the location of the next significant earthquake to occur in the UK. The location and size of the earthquake which occurred just 4 days after the AGM is shown on the map below. Mr Dene Wilson received a bottle of champagne at the SECED meeting on 27 May 1998.



SECED Chairman's Annual Report

May 1997 to April 1998

1 INTRODUCTION

1997/98 has been another active year for SECED. In this brief report I will pick out some highlights of the last year and look forward to next year. My two year term of office as Chairman expired in April 1998, and I thank you all for the support you have given to myself and SECED.

2 LOOKING BACK

2.1 Meetings - our ten meetings of last year can be categorised as follows:
(a) 5 evening meetings, all in London;
(b) 2 half day meetings, one in London and one in Bristol;
(c) Mallet-Milne lecture (Prof. Roy Severn) in London;
(d) two day conference in Oxford, preceded by afternoon Eurocode 8 meeting.

The evening meetings each attracted between 30 and 80 attendees, the half day meetings between 25 and 35, the Mallet Milne lecture over 100 and the Oxford conference attracted 187 delegates (a new record for SECED). Special thanks are due to Edmund Booth for chairing the conference organising committee, Julian Bommer for organising the half day "Research Needs" meeting and Adam Crewe for the half day "Shaking Table Control & Testing" meeting in Bristol.

2.2 Newsletter - we are very conscious that our members rate the Newsletter as our most valuable deliverable, and the quality of this was maintained and improved through the year by our editor Adam Crewe, to whom our continued thanks go. Members are encouraged to submit articles for possible publication, either in full or initially in synopsis form.

2.3 Directory of Practitioners - during the year we published the 6th edition of our Directory, distribution being to selected clients, consultants, contractors, researchers, academics, libraries and others. As well as a useful information resource the Directory made a positive contribution of funds to SECED's accounts.

2.4 Membership - over the last few years our membership has remained fairly steady at around 250. This number, coupled with our financial resources of over £25k, gives us a continuing solid base from which to operate. Continued thanks are due to Chris Browitt, our treasurer, for keeping a close eye on our accounts.

2.5 Interaction with the ICE - we have continued to support the ICE via our involvement in the Structural and Building Board. Our joint venture with the Wind Engineering Society, an ICE Design and Practice Guide entitled "Dynamics - An Introduction for Civil & Structural Designers" is essentially complete and in the process of production through Thomas Telford Limited.

2.6 Interaction with other Societies - as well as our joint meetings held with other ICE societies we have continued to work closely with EFTU (Imperial College) and with EEFIT (IStructE). Discussions are nearing completion to rationalise the overlapping interests of SECED, EFTU and EEFIT, via a mutually agreed memorandum of understanding.

2.7 Secretariat - in February Alison Bullen, our secretary from 1997-98, left to develop her career with Price Waterhouse. On behalf of all members the Committee thanked her for her efforts and we wish her well in the future. In her place we now have Kate Davies, albeit on a temporary basis, to whom we extend a warm welcome.

3 LOOKING FORWARD

3.1 Meetings - we are planning for at least 8 technical meetings in 1998/99, one of which will be outside of London, probably in Manchester.

3.2 Newsletter - we are planning for 4 issues per year in the foreseeable future, with parallel publication of extracts on the World Wide Web.

3.3 Mallet-Milne lecture - preparations are in hand for Professor Cinna Lomnitz's lecture in May 1999.

3.4 European Conference 2002 - we will continue to progress our bid to host the European Association of Earthquake Engineering (EAEE) conference in 2002 here in the UK. Professor Amr Elnashai has co-ordinated our bid which will be presented at the 1998 EAEE conference in Paris in September.

3.5 Register of Members - at the time of writing we are about to issue our first Register of (Individual) Members as an information service. This initiative has demanded a significant amount of effort from Chris Sharman, and we thank him for the time he has taken to make it a complete, up to date and useful document.

3.6 Technical Rapporteur Contributions - we look forward to topical reports, on an ad hoc basis, from our technical rapporteurs Tianjin Ji, Andrew Chan, Gordon Woo, Alan Watson and David Smith.

4 YOUR CONTRIBUTION

I will repeat my words of last year - any club is only as good as its members and their input; and you will have seen that many individuals and companies have put a lot into SECED in recent years. I have mentioned a number of names in the preceding sections, and I would like to add a few more, namely some of our experienced members such as David Mallard and Brian Skipp who have helped keep us on the right track, the membership committee under John Inkester, some of our more recent committee members such as Andreas Kappos and Graham Roberts who are contributing particularly to our technical meetings, and others such as Dina D'Ayala and Bill Murphy whose support we continue to value. I would also like to record again thanks to Peter Merriman for his support and for keeping things going when I have been unavailable. To the rest of our members I encourage you to contribute to SECED wherever and whenever you can, especially in present times when it often seems difficult for employers to see the importance of continued support to learned societies.

5 CONCLUSION

1997/98 has been another active year for SECED, and we can look forward to the future positively. We hope that the incoming Chairman, Peter Merriman, and our new Vice Chairman, Julian Bommer, will have a stimulating and rewarding tenure, and that the membership will benefit accordingly.

John Maguire
SECED Chairman
April 1998

Meeting Report: 27 May 1998

Are Vertical Earthquake Motions Important?

An informal discussion on the topic of vertical earthquake ground motions, the second within a period of 18 months, was held at the Institution of Civil Engineers on Wednesday 27 May. The meeting was well attended, with an audience of 35, confirming the interest that this subject is generating in the earthquake engineering community.

The meeting was introduced by Dr. Bryan Skipp, who posed a number of questions about the causes, nature and importance of earthquake ground motions. At the same time Dr. Skipp referred to work which suggests that the vertical response spectra in EC8 is likely to underestimate the amplitudes for short periods. In passing, Dr. Skipp mentioned that there are concerns about the horizontal response spectra in EC8 as well, since there is very little transparency regarding its origin and derivation.

The main presentation of the evening was made by Professor Nicholas Ambraseys of Imperial College who presented early results from an EPSRC funded research project into vertical earthquake ground motions. Professor Ambraseys began his presentation by illustrating the errors that can arise in deriving attenuation equations in general through the use of a point source model, and then went on to show regression results on both horizontal and vertical ground motions. These results illustrate that the often assumed ratio of 2/3 for the ratio of vertical to horizontal *zero period accelerations* holds for most of the dataset but there are important exceptions and at short periods and short distances the ratio can in fact exceed 1. Professor Ambraseys pointed out that when considering these ratios for *spectral ordinates* it is very important to bear in mind that the natural periods of any structure are different in the horizontal and vertical directions and furthermore the maximum response in each direction occurs at a different time. Results were presented that show that if these factors are taken into account, the ratio of vertical to horizontal simultaneous response is usually less than 0.5. Further results were shown of response spectral ordinates calculated taking account of both horizontal and vertical acceleration and the effect of the gravity field on the system, showing that the effect is generally to reduce this ratio and the horizontal response at the expense of displacement.

Professor Ambraseys concluded by stating that for ordinary buildings the effect of vertical acceleration for codified design purposes is not as important as one might have thought, but that for non-standard buildings and engineering structures, particularly in the near-field of large normal or thrust earthquakes - that can produce significant ground motions in the horizontal and vertical directions - these motions should be taken into account in an appropriate design, particularly in the non-linear range.

Dr. Skipp then took the floor again to close the formal presentations, stating that it is probably now not possible to influence the shape of the EC8 spectra but that guidelines could be included to identify circumstances under which vertical motions should be considered. The floor was then opened to questions and an animated exchange of ideas and opinions was carried on for more than half an hour.

Julian Bommer

ICE "Structures and Buildings Journal"

All members of SECED are reminded that the editors of the ICE Journals are always on the look out for interesting papers. SECED members are invited to submit papers for the "Structures and Buildings Journal" and it should be noted that short (technical note) contributions are especially welcomed.

An Introduction to Load Sensors

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

1. Introduction

The following paragraphs are adapted extracts from a draft European wind turbine document (ref: EWTS WGIV Recommended Measurement Methods & Brochures for Loads on Wind Turbines, draft 17, 15 Feb 1996). In view of their usefulness and educational value they are reproduced here. Comments are welcomed and should be addressed to the Editor, who will be able to pass them on to the authors.

2. General

It is useful to consider:

- what different types of load sensor exist,
- what general considerations apply to deciding where to place them,
- what procedures should be used to ensure accurate and reliable performance.

These points are dealt with in turn in the following sections.

3. Types of Sensors

A load sensor is a device which directly or indirectly measures the load experienced by a system or component. Typical devices include, but are not limited to:

- load cells/torque tubes (including piezo electric cells),
- strain gauge bridges,
- accelerometers, velocity and displacement transducers.

For many structures it will seldom be possible to place a load cell in a main load path and for this reason an indirect approach is normally required. Strain gauges are generally favoured. These of course measure strain, which most commonly would be related to a stress via knowledge of the host material's characteristics. However, for the present purposes, it is common practice to relate the strain gauge output directly to an applied load level. This is achieved by establishing static calibration relationships. It is important to realise that dynamic behaviour of the structure or component can modify this relationship so that the strain gauge will indicate gross internally generated, rather than externally applied, loads.

Accelerometers or displacement transducers can also be used to measure applied loads indirectly, this method relying upon a knowledge of the structure's inertia or stiffness respectively. For a dynamic system, interpretation will depend upon whether the device is well below, at, or well above a resonant frequency.

4. Choice of Location

A number of principles apply when selecting positions for the measurement of gross structural loads, these being to identify a location which:

- does not have a particularly low strain level (i.e. the strain can be measured),
- has a generally high load level (i.e. is structurally important),
- is in a region of uniform stress (i.e. is not subject to high stress/strain gradients),
- has space to apply sensors,
- allows temperature compensation,
- avoids localised stress raisers or concentrations,
- is made of material having uniform properties (e.g. steel is preferable to composite materials),
- is made of material to which measurement devices can be easily fixed or bonded (again implying that metal surfaces are to be preferred to composites).

5. Strain Gauge Practice

Working outdoors can cause problems and thus, indoor application is advisable. It can be awkward to gain access to particular locations on structures, and if the weather is unpleasant, as it often can be at windy sites, then it can be difficult for the strain gauge technicians to concentrate fully on achieving best results. Greater care than normal is required when working outdoors, especially since outdoor temperatures and humidity can adversely affect bonding and soldering, which can cause problems which may not be immediately apparent.

It can be difficult to apply strain gauges successfully to some structural materials. Steel towers and other steel components are often galvanised. To attach strain gauges either requires the galvanising to be removed down to the parent metal, which may compromise the original material protection and manufacturers' guarantees, or the surface to be prepared with an intermediate chemical agent to provide a surface onto which the strain gauge glue will bond.

Similarly, composite material can cause problems. Gel-coat surfaces must normally be removed to get to the parent structure. Local voids in the matrix may reduce bonding success and disturb the local stress field. Composite materials typically exhibit highly directional behaviour, meaning that gauge positions and calibration procedures are to be chosen with great care. Composite structures can also pick up appreciable static charge during operation, which can cause damage in the electrical measurement chain, e.g. strain gauge amplifiers, unless best practice in shielding and earthling is applied.

As for any application, strain gauges should be chosen carefully to match the requirements, and help should always be sought from selection guides or from the gauge manufacturer's technical advisors. Considerations include:

- choosing the gauge position (normally a position of high global rather than localised strain),
- selecting the gauge size (bigger gauges are easier to handle and are less influenced by local faults),
- selecting the gauge material (the coefficient of thermal expansion

should be similar to that of the specimen),
- deciding upon the gauge's resistance (high resistance gauges have better signal to noise ratios and use less power which is important for the use on rotating systems),
- ensuring the gauge has an acceptable maximum elongation (certain structures can exhibit very high strain levels),
- using a suitable glue (heat cured glues have best adhesion and longevity but are impractical for large structures or components, and hence 'super-glues' on cyanid-acrylate basis are more generally used).

Wherever possible full strain gauge bridges should be used. Pre-fabricated multi directional gauges (gauge backings containing more than one gauge grid) are useful for ensuring correct mutual orientation.

The location and the direction of the strain gauges have to be defined and implemented carefully, especially when using bending strain bridges.

Although in normal circumstances the heat cured glues are to preferred, it will normally be impossible to use them to bond gauges to many structural components. For this reason, the choice will fall to using 'instant' cyanid-acrylate glues or cold curing epoxy adhesives. The latter are to be preferred for long duration installations, but it may be difficult to ensure even temperature distribution and absence of loads during the cure cycle. 'Instant' bonding methods are therefore more likely to be preferred. In all cases it is important to adhere stringently to the manufacturer's instructions on surface preparation and application of the glue.

The strain gauges have to be well protected against moisture, accidental damage and electric charge. The protection material may have to be connected to the shielding system of the data acquisition system in order to avoid high differences in potential. The wires within the bridge should be as short as possible and for each bridge should be of the same length. Before covering the position of the strain gauges the wiring (colours of cables) as well as the connectors should be documented carefully and the wires should be labelled. Also resistance checks should be carried out before covering the gauges.

Mechanisms of Industrial-Academic Interaction in Earthquake Engineering:

A Consultation Document

This report has arisen from a half-day Workshop held at the Institution of Civil Engineers in February 1998. The Workshop was attended by many academics and practising engineers, as well as representatives of EPSRC and AFPS (The French Association of Earthquake Engineering), and discussed problems and possibilities for increasing the interaction between research and practice in earthquake engineering in the UK. The report includes an introduction and background to the Workshop, a keynote lecture by Dr. Scott Steedman, the views of both industrial and academic participants and the experience of the AFPS in this field. The report also includes the conclusions of Working Groups on the mechanisms of academic response to industrial requirements in earthquake engineering research, mechanisms of communication of earthquake engineering research results to industry, and mechanisms of industrial involvement in the course of earthquake engineering research. The report concludes with a number of suggestions and proposals for future actions to improve industrial-academic interaction in earthquake engineering.

The report is being distributed amongst the earthquake engineering community in order to widen the input to the discussion and also to promote the formation of groups to carry forward the ideas through co-ordinated actions that will enhance the potential for mutually beneficial co-operation between researchers and practitioners in the field of earthquake engineering.

To obtain a free copy of the report, send a self-addressed envelope to the SECED Secretary at the Institution of Civil Engineers, marking, 'Mechanisms of Interaction' on the top left hand corner of the envelope.

The TKHsieh Award

SECED members are invited to comment on suggestions for widening the scope of this award.

The TKHsieh Award was established in 1979 in memory of the late Dr. T.K. Hsieh, a fellow of the Institution of Civil Engineers. A donation of £1,000 was made by the trustees of Godfrey Mitchell Charitable Trust, sponsored by Wimpey organisation, to the Institution for the establishment of the annual award. The award was to be made to the author of "the best paper published by the Institution in the field of structural and soil vibrations caused by mechanical plant, winds, wave or seismic effects".

The first award was made in 1980 and the committee of the SECED was invited to recommend a suitable candidate for the award, for consideration by the Awards Sub-committee. For the 1996 and 1997 awards, a selection working group was formed by the five technical rapporteurs of the society together with Dr. Brian Skipp who provided the continuation of the experience from previous years.

Nominations were made by the working group members and invited from the committee members. Each nomination was reviewed by at least two of the working group members and discussions were conducted through electronic and fax communications. In 1997, the award was given to N. Makris, G. Gazetas and E. Delis for their paper "Dynamic soil-pile-foundation-structure interaction - records and predictions" published in Geotechnique in 1996. However, in 1998, no award was given for 1997 as it was felt that there was insufficient number of highly quality entries that met the stated objective of the award.

The difficulties encountered in 1998 highlighted one problem with SECED relevant publications. For the moment, there is no journal published by the institution dedicated to Civil Engineering dynamics and other suitable topics for the award. It is therefore understandable that members of society would submit their papers to other more relevant journals. And for various good reasons, the publications of the 1998 SECED International Conference was given to A.A.Balkema thus rendering the papers not eligible for the TKHsieh award.

In view of this, discussions have been initiated in the committee to see whether the award can be widened in scope. Suggestions include the following:

1. Introduce a second (SECED funded) prize, to be awarded to the best paper each year by a SECED member on earthquake or civil engineering dynamics, with no restriction on publisher. Thus, papers published other than by Thomas Telford would become eligible for an award.
2. Invite the SECED membership to submit their nominations for he TKHsieh award, and also the SECED award, if the latter goes ahead.

The committee places importance on the publication of high quality papers within the society. Recommendations on how to further this aim and comments on the above suggestions are therefore very welcome; please send them to me via the SECED secretariat at the Institution of Civil Engineers or by E-mail to A.H.Chan@bham.ac.uk.

Andrew Chan
Reader, Department of Civil Engineering, Birmingham University

NEWS RELEASE

Earthquake Engineering Centre changes name to emphasise multidisciplinary nature of its work

The National Centre for Earthquake Engineering Research (NCEER), headquartered at the University at Buffalo, has recently been re-named the Multidisciplinary Centre for Earthquake Engineering Research, a national centre of excellence in advanced technology applications. The change in name will also include the centre's Information Service, which will now be called the Multidisciplinary Centre for Earthquake Engineering Research Information Service.

"This new name," says George C. Lee, Ph.D., Samuel P. Capen Professor of Engineering at UB and director of the centre, "emphasises what we feel is the key to our success - past, present and future - the integration of diverse disciplines to solve engineering and societal problems caused by earthquakes." Lee notes that the centre is credited with making pioneering efforts in organising and empowering multidisciplinary teams to address earthquake engineering problems, and with developing and adapting advanced technologies to reduce earthquake losses. "In the months and years ahead the centre seeks to increase multidisciplinary participation by further engaging manufacturers, practitioners and government officials to assist in the research and application processes," he adds. "Our hope is that the new name will help encourage this collaboration."

Fourth International Conference on Case Histories in Geotechnical Engineering: March 9-12,1998

The Fourth International Conference on Case Histories in Geotechnical Engineering was hosted by University of Missouri-Rolla, Department of Civil Engineering. Over 150 papers from 35 countries were contributed. In addition, ten state-of-the-art reports, four special lectures and ten general reports were presented.

The Keynote Lecture was delivered by Prof. Ralph B. Peck. In his lecture Prof. Peck emphasised that by making a few, small mistakes, we have learnt a lot of useful information about the behaviour of soils. He cited examples of expansive soils in Texas and permeability of dykes in the Dead Sea, in which what appears to be obvious today was not so obvious in the early years. Dr. Robert Mair presented instructive and exhaustive case of deep tunnelling in London and for the Jubilee lines. Dr. John H. Schmertmann brought out a very interesting point, that is, the piles could be tested up to 15,000 tons capacity by using the Osterberg Cell. In the absence of this new technique the gravity loading of this order was almost impossible.

The proceedings of the conference are available from the following address:

University of Missouri-Rolla,
Department of Continuing Education,
103 ME Annex Building,
Rolla, MO 65409 (USA),
Tel: 573-341-4200
Fax: 573-341-4992
E-mail: suep@shuttle.cc.umr.edu

Price: - US$ 300.00
Overseas Airmail: - US$ 20.00

NOTABLE EARTHQUAKES JANUARY - MARCH 1998

Reported by British Geological Survey

YEAR	DAY	MON	TIME UTC	LAT	LON	DEP KM	ML	MB	MS	LOCATION
1998	08	JAN	15:56	56.69N	5.25W	16	1.7			ONICH, HIGHLAND
				Felt throughout the village of Onich, with maximum intensifies of 3 EMS.						
1998	10	JAN	03:50	41.08N	114.50E	30		5.8	5.7	NE CHINA
				At least seventy people were killed, approximately 11,500 injured and 44,000 families left homeless.						
1998	04	FEB	14:33	37.10N	70.20E	33			6.1	NE AFGHANISTAN
				At least 15,000 people killed and 15,000 people left homeless in the remote Tahkar province of NE Afghanistan. The town of Rustaq and many villages are reported to be devastated.						
1998	08	FEB	05:51	49.97N	5.49W	14	2.4			PENZANCE, CORNWALL
				Felt throughout SW Cornwall with maximum intensifies of 4 EMS.						
1998	11	FEB	20:39	51.63N	3.01W	6	2.3			CWMBRAN, GWENT
				Felt throughout Cwmbran and Newport with maximum intensifies of 3 EMS						
1998	19	FEB	14:14	4.40S	129.00E	33		6.5		BANDA SEA
1998	05	MAR	20:17	56.46N	4.37W	8	1.9			KILLIN, CENTRAL
				Felt throughout Killin, Balquhidder and Glendochart with maximum intensifies of 3 EMS.						
1998	05	MAR	20:21	56.46N	4.36W	5	1.7			KILLIN, CENTRAL
				Felt throughout Killin, Balquhidder and Glendochart with maximum intensifies of 3 EMS.						
1998	07	MAR	02:08	56.41N	5.26W	9	2.7			OBAN, STRATHCLYDE
				Many felt reports received from throughout the Oban area of Strathclyde, where intensifies reached 4 EMS.						
1998	14	MAR	19:40	30.08N	57.61E	33			6.9	SE IRAN
				At least 5 people killed, 50 people injured and many buildings in the town of Golbaf suffered some degree of damage. This earthquake also damaged 15 other villages, where electricity and water supplies were cut off						
1998	25	MAR	03:12	63.65S	150.60E	33			7.9	BALLENY ISLANDS REGION
1998	26	MAR	20:52	56.25N	3.75W	5	2.2			BLACKFORD, TAYSIDE
				Felt throughout the Blackford area of Tayside with maximum intensifies of 3 EMS.						

Issued by Bennett Simpson, British Geological Survey, April 1998

Forthcoming Events

30 September 1998
The behaviour of unreinforced masonry panels subjected to out-of-plane loads. *ICE 5.30pm*

28 October 1998
Large-scale testing *ICE 5.30pm*

25 November 1998
Monitoring of structures. *ICE 5.30pm*

Contents

Selected extracts from previous SECED Newsletters can now be found on the World Wide Web at the Institution of Civil Engineers:

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

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

SECED Newsletter

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

Diagrams should be sharply defined and prepared in a form suitable for direct reproduction. Photographs should be high quality (black and white prints are preferred). Diagrams and photographs are only returned to the authors on request.

Articles should be sent to:

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@bristol.ac.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:
The Secretary,
SECED,
Institution of Civil Engineers,
Great George Street,
London SW1P 3AA, UK.